Chapter 31

The McDonald's logo on the construction of knowledge

https://doi.org/10.56238/methofocusinterv1-031

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ABSTRACT
This work describes how it is possible to create a significant learning environment during the study of the polynomial function of the 2nd degree, with the objective of giving meaning to the rules and formulas, memorized, in the study of the graph. It was carried out with students from a public school in Salvador, from the 1st year of high school, created around the construction of the McDonald's M logo where the student was the author of this construction itself. The material used was elaborated with the purpose of articulating studied concepts, reflections, interpretation and construction of an object that was part of the students' reality. The resources used were: the McDonald's M figure (reduced size), geogebra software, computer lab, textbook, factsheet of challenging questions (guiding research) during the use of GeoGebra. After performing the activities, it was possible to verify that when working with an object of the student's real context, the difficulties in reflecting on the definitions and concepts were overcome, for the most part, and the usefulness of knowledge, recognized. The role of the teacher (making returns) and the forms, record of the guiding thread of the investigation, were determinant for the involvement of the students once they reflected on their knowledge and reconstructed them. The study went further when the students applied the concept of vector (horizontal translation) called by them by movement of the constructive parable of this environment, and neither the teacher nor the student can stop asking and investigating.

Keywords: 2nd Degree Function, Technologies, Learning, GeoGebra, Research, Translation

1 INTRODUCTION

According to the National Curriculum Parameters (PCN, 2000), Mathematics must go beyond its formative, instrumental character; thus, it is necessary for the student to understand that the definitions, demonstrations and concepts are interconnected with others, validating and giving meaning to techniques applied in different situations ddaily life . In the classroom context when considering knowledge, experiences and knowledge, the teacher may be able to create situations favorable to learning. This is a condition defended by Ausubel (2000) at the moment when he places as a basic condition for the occurrence of a significant learning, the material to be learned; andit must be potentially significant, which relates logically to the well-structured ideas of existing knowledge in a non-literal and non-arbitrary way.

It is understood to be significant when it results from a process in which the interaction between relevant ideas exists in the cognitive structure of the learner and the material being worked; therefore, it should never be chosen randomly without taking into account the interests, knowledge and reality of the students. Memory is a very important element, but the classroom should not be a space with works focused on memorization, but to make the student think, discover, learn by doing, exploring, questioning, criticizing.

According to Tikhomirov (1981), computers mediate human relations at the moment that creates possibilities for new ways of performing activities. In order to reorganize intellectual activity, technical, social and psychological conditions must be met, enabling an advance of creative content adapted to the intended human activity.

According to Moreira (2006) significant learning [...] occurs when new concepts, ideas, propositions interact with other relevant and inclusive, clear and available in the cognitive structure, being assimilated by them and contributing to their differentiation, elaboration and stability. (p.136)

Moreira's theory of meaningful learning places basic conditions for its occurrence which are: the non-arbitrariness where the material is considered potentially significant when it makes interconnections with knowledge already existing in the cognitive structure of the learner and those that are more relevant, said subsunçores, in addition to the substantiality that refers to new ideas and not the words used to express them. This was the motivation that led to the elaboration of this block of activities.

One of the proposals of mathematics teaching is to develop skills so that students can be able to solve problems from the application of a concept already studied, mobilizing cognitive resources, that is, that has meaning for them, that they like and value. Then came the idea of thinking about an activity where students could construct and interpret mathematical concepts with something outside the classroom.

According to Polya (2006), in his book Art of Solving Problems, the teacher must challenge the curiosity of students with problems that are in accordance with their level of knowledge, helping them with questions that motivate and stimulate reasoning. In order to create an investigation scenario that involved students, we thought of a visual stimulus, the McDonald's logo, that would refer them to the need to apply knowledge about the function of the 2nd grade. In this context came the invitation: Let's study the mathematics that exists in the McDonald's logo? The challenge was to discover mathematics, apparently imperceptible, but present in a visual element that was part of the reality of the students. For this, it was necessary to reflect on what would be a problem for the students, that is, something they did not know how to do, that arouse interest and that required mathematical knowledge, seeking new information and establishing connections with knowledge already acquired.

The proposal was to associate a mathematical model with a real situation and later through the application of mathematical concepts, techniques and procedures, (re) build the McDonald's logo, using GeoGebra.

This activity was held at the State College Deputado Manoel Novaes, in Salvador, Bahia, in a class of 1st year of high school of the afternoon shift, with 35 students, planned and held in three stages, in a total of six classes.

Step 1: It was held in two 50-minute classes and divided into two moments. At first, the invitation was made, which was very well accepted by the students and at the second moment activities were distributed for them to perform as a group.

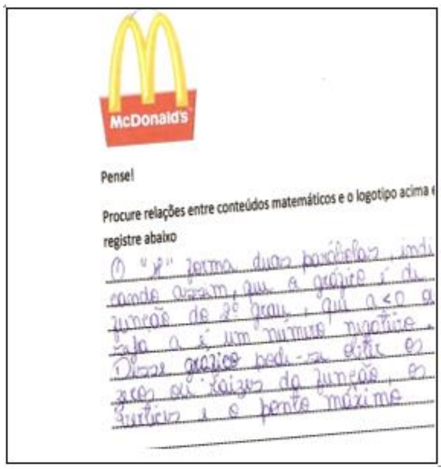
Step 2: This was held in two classes of 50 minutes, each, and in it was discussed the relationship between the coefficients and roots, which determines their possible displacement, opening and positioning, in addition to the importance of the algebraic representation of the function, when we intend to build its graphic representation, using the computer.

Step 3: In this, two 50-minute classes were used for students (re) to build the McDonald's logo, using GeoGebra, in the computer lab.

2 DEVELOPMENT

Step 1 – Initially, the McDonald's logo was placed on the board, very large, printed on a craft sheet, with the aim of attracting attention and all reacted with animation, commenting aloud: (A) - McDonald's! At this time the invitation was made to the whole group. (P) - Let's study the existing math on McDonald's logo? The students were surprised, demonstrating that they did not understand what they were going to do, but soon afterwards reacted excitedly. This initial reaction can be explained by the fact that the students are not accustomed to this type of posture. Many of them expected a recipe for how to do it, and the invitation was open. But, this was the proposal; perform activities that would provide students with discoveries, through actions, formulations and reformulations, thus validating a subsequent institutionalization of the mathematical object in question, the McDonald's logo (A) – What are we going to do? They were asked to meet in groups of five students. For each group, the McDonald's logo was delivered in small size and a script with the activities: 1. Think! Look for relationships between mathematical content and the McDonald's logo. Record your findings, 2. Could this logo be the graphical representation of a function? Which? Most of the students did it immediately, association with polynomial function of the 2nd grade, others were confused and after flipping through a few pages of the notebook, said it was a function of the 2nd grade as shown in Figure 1, below.

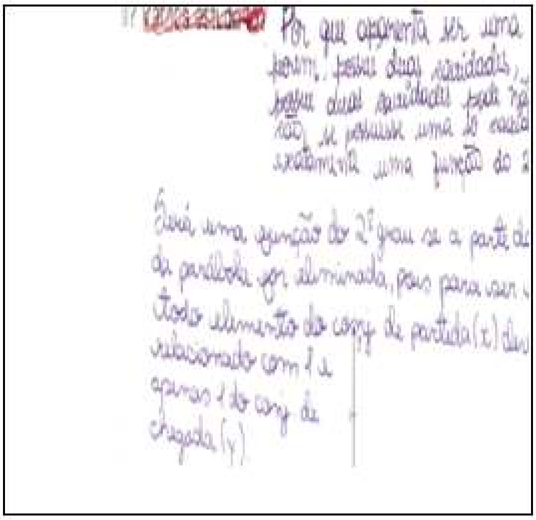
FIGURE 1 - Student Response



Think!
Look for relationships between mathematical content and logo above. Register below.
The "**M**" forms two parables thus indicating that the graph is of the 2nd degree function, **that a<0**, that is, **a** is a negative number. From this chart you can obtain the zeros or roots of the function, the vertices, and the maximum point.

According to Helle and Skovsmose (2006, p.70), the teacher should act as a facilitator when asking questions with an investigative posture, trying to know how the student interprets the problem. At this moment [1]the teacher asked them to reflect on the concept of function and asked some questions, instigating them to think. (P)- Think about the definition of function; could the logo be the graphical representation of a function?. Response from a student in Figure 2

FIGURE 2 - Student Response



Because it appears to be a parabola, but they have two cavities, and since it has two cavities it may not be a function, if it had a single cavity it would be exactly a function of the 2nd degree.
It will be a function of the 2nd degree if the middle part of the parabola is eliminated, because to be function every element of the conj. must be related to 1 and only 1 of the arrival set (y).

The provocations continued: - (P) If we draw a Cartesian plan and put the logo, can you say that we will have a real function? - How about positioning and designing the McDonald\'s logo on the Cartesian plane and studying it! At this time, many have spoken out. Some students stated: – (A) Teacher, it is not a function. Others said: - It is a function of the 2nd degree and I have two parables. (Q) - Who do you think is not a function? Could you justify it? Most believed that they were facing a 2nd degree polynomial function graph, even after asking them to think about the function definition. Some verbalized: (A) – Teacher is a function when every element of set A is related to only one element of set B. Others said: (A) – Teacher, if I trace parallelto the **axis of y I** will find several points touching this line, then it is not function. At this point it was clear that they needed to learn to argue about their work hypothesis, whether it was consistent or not; The teacher asked questions for the students to reflect on their findings, that is: to act, formulate and validate, that is, to argue. (Q) - In this case, what is the justification? Why do you claim that it is not a function graph, using the definition?

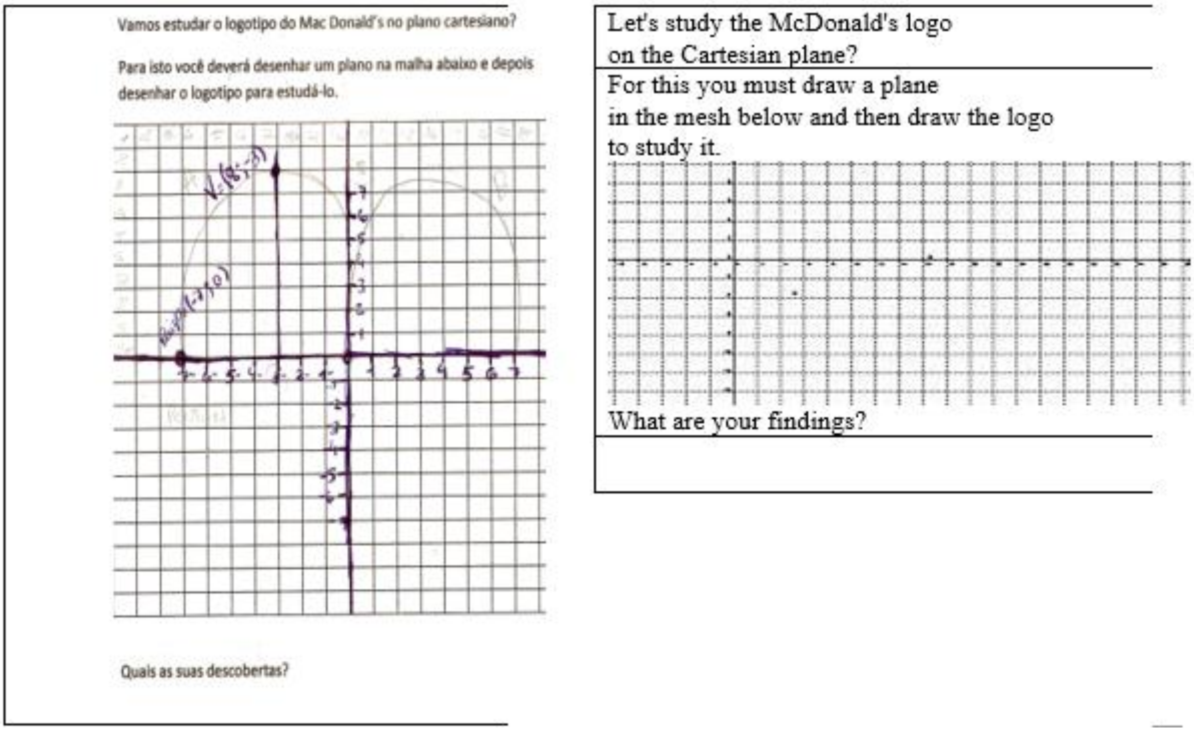
Taking advantage of the definitions given, the teacher went to the picture in an attempt to clarify the doubts that arose, requesting help from the students in a way that used the definition in that specific situation, with questions. (Q) - What is the function definition?

For a moment they were silent, perhaps afraid to be experiencing a change in the teacher's attitude, at a time when she was not giving ready answers but, leading them to think about the content studied and

[1] The teacher is one of the authors of this article.

trying to make connections with what was being placed at the time. After a while they reacted and after a few discussions reached a consensus on the chart that was put to them. The teacher continued with the provocations, because they, at that moment, were indispensable for the proposed objective to be achieved. (Q) - After the considerations made and everyone has drawn the logo on the Cartesian plane, what points are important for obtaining the algebraic representation of the parable?

FIGURE 3 - Student Response



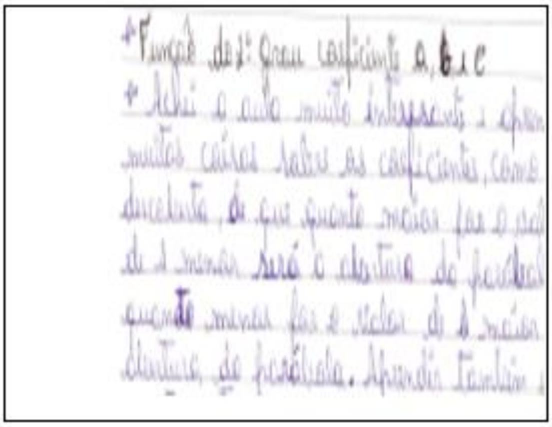
Further questioning arose and the dialogue continued. (Q) - What is the algebraic representation of this chart that you (each group) drew? Most placed as important points the vertex of the parable built by each group and the roots of the function that gave rise to it. With this they built the algebraic representation of the function drawn by each group. Only two groups did not complete and asked for guidance. At this time the teacher requested that a student from another group, who had finished, help the others to find the algebraic representation of the function designed by the group. The student was having difficulty and the teacher was attentive to what she was doing. The student commented: - Oh! This one's different from mine. So I don't know how to do it. At this point an ideal situation arose for students to validate their work hypotheses. So we exploited this situation by making new provocations. (Helle and Skovsmose, 2006) (Q) - Different how? – (A) Ah, teacher! I drew the parable by cutting the y-axis and where I cut, I have **c**. Without the **c I do** not know how to do. (Q) - What points (in the traced parable) did you identify as important? (A) - The vertex and roots. (Q) - Are we going to use them?

They began to use the formulas in order to find the vertex coordinates, but due to the positioning of the parabola he felt very difficult, because the calculations were laborious. So they wouldn't give up, the teacher did the calculations for them. She noted that all students who were experiencing difficulty were attentive, asking when questions arose. Interest and participation were excellent. Many observations were made based on the students' questions, thinking of various positions of the parable. In the face of this climate, they were asked if they liked the activity. Most of them said no because it was difficult. This reaction surprised the teacher because she noted that the groups were involved, showing great interest. On the other hand, she knew that, because they were accustomed to solving exercises using models made by the teacher, the difficulties they were having were expected. Their enthusiasm and curiosity to design the McDonald's logo, using the computer, provided us with an appropriate environment for us to work on the importance of algebraic representation.

Step 2: The initial objective was to emphasize the importance of algebraic representation when using software to draw the graph of a function. The basic question was: Are we going to draw the graph of the function you found in the previous class using GeoGebra? How should I enter the function for the program to draw the McDonald's logo? What language does GeoGebra recognize? Why is that? For this, the multimedia projector, the computer with the Geo Gebra software and the script ofthe previous class containing the algebraic representation of each group were used. The class began by presenting the software to the students, because many of them did not know the program, had never had contact with GeoGebra. They were very interested and some asked to save on flash drive. Excellent reaction. The teacher concluded that she could move forward. The main question was: - What is the importance of the algebraic representation of the function, when we intend to build its graphic representation using the computer?

The students agreed that the computer has its own language and remembered that when using Excel, introducing formulas, it is indispensable to know the language that should be used. The teacher started from the algebraic representation of the function obtained by each group in the previous class. The students realized that each team had a specific situation, consequently obtained graphs of the most varied positions. When they saw the graphics all together, they made observations such as: - That graph was so thin! - Look at the other one, big one! In view of these observations, the teacher saw that she had an ideal situation for the students to revalidate their work hypotheses. Then, the teacher explored this situation by making new provocations. (Helle and Skovsmose, 2006) by throwing the following question: Why do some parables drawn at that time have greater openness than others? The silence was total after the question was thrown. They began to observe the chart strokes in more detail. As they look at the charts of each team, some students began to think about what determines the displacement of the parabola, why it is shifted to the right or left, and why the parabola sometimes becomes more open or closed. Here is in practice the opportunity to institutionalize the mathematical language, the mathematical sentence of the object in question, the McDonald's logo(P) - To find these graphs, we start from what? They were a little confused, and it was necessary to rephrase the question. (Q) - How did I get the computer to display each of the graphics? What have I done? (A) - He wrote the "function" that we had found. (Q) - If we compare the functions you found, what differentiates one from the other? (at this moment the teacher did not find it pertinent to work on language refinement since the mathematical sentence of the polynomial function of the 2nd degree was written and not the function, as was verbalized). (A) - O **a**, **b** and **c**. (P) - Ah! The coefficients, right? (in this case, the teacher chose to work on the language). (A) - Right, and how do I know what they do? (Q) – I have a suggestion, let's choose a fixed value for coefficients **b and c** and start varying the **coefficient a**, to see what happens? At this moment, with great enthusiasm, examples have stauled. The teacher chose only five and obtained the corresponding graphs. Without much difficulty they realized that the opening of the parabola depends on the value of the coefficient **a** and were drawing their conclusions.

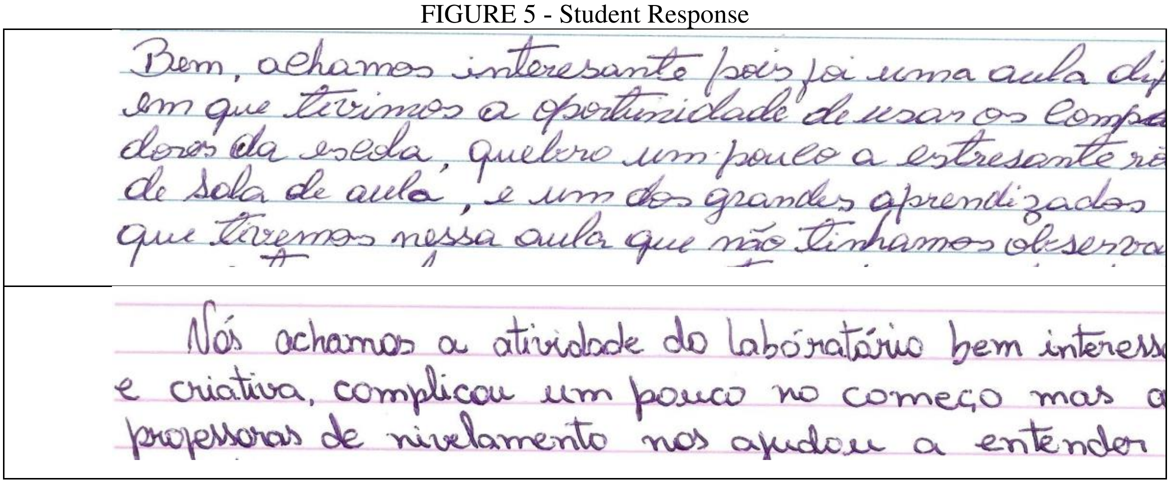
FIGURE 4 - Student Response


*Função do 2º Grau coeficiente a, b e c
* Achei a aula muito interessante e apren
muitas coisas sobre os coeficientes, como
descoberta de que quanto maior for o val
de a menor será a abertura da parabol
quanto menor for o valor de a maior
abertura da parábola. Aprendi também

Function of the 2nd degree coefficient A, B and C.
I found the class very interesting and learned a lot about coefficients such as the discovery that the higher the value of the lower the opening of the parabola and the lower the value of the greater the opening of the parabola.

At this point the class ended, but most did not go to the break and continued in the room, wanting to discover the behavior of the other coefficients. For the teacher, it was a very important moment. They were interested, formulating ideas, questioning and drawing conclusions, thinking about the various possibilities of graphs that we could draw. Feeding curiosity the teacher requested an exchange of hours with the art teacher to take the boys to the computer lab in order to continue the study of the coefficients of the function. They continued to investigate the behavior of the graph of the polynomial function of the 2nd degree in relation to its coefficients in the computer laboratory. At this point the[2]monitors helped, guiding them. Students drew several conclusions as records below in figure – 5

FIGURE 5 - Student Response


Bem, achamos interesante pois foi uma aula di
em que tivimos a oportunidade de usar os Compu
dores da esola, quebro um pouco a estresante rô
de sala de aula, e um dos grandes aprendizados
que tivemos nessa aula que não tinhamos observa

Nós achamos a atividade do laboratório bem interess
e criativa, complicou um pouco no começo mas a
professoras de nivelamento nos ajudou a entender

[2] These monitors are part of the Institutional Project of Scholarship of Initiation to Teaching (PIBID) of the UFBA

Step 3: This class took place in the computer lab where the students worked in groups of two or three students mostly. At this moment the teacher presented once again the tools and resources that should be used in GeoGebra.

The students, at first, explored the tools and commands used to clarify the doubts that would arise. They later started work.

The idea was to make the students type the algebraic representation of the functions found, so that the graphic representation could be traced by GeoGebra in order to observe their positioning, reflect and analyze what was happening with the graphic representation of the function (designed by GeoGebra) and seek explanation in the formulas they learned to find points that they considered important in the study of the polynomial function of the 2nd grade and its coefficients.

The final proposal was to build mcdonald's logo. Several discussions arose; they immediately thought about putting a function they found when they put the logo on the Cartesian plane and initially did not know what to do to get the other parabola that along with the **previous one would form the m**. At this point they became insecure and restless, though involved. They were given time to think and as they were unable to reach any conclusion, the teacher decided to interfere. (Q) -- What is your goal? (A) - Draw the other leg of the **m**. (Q) - What is needed? Total silence. (P) - You want to draw in what location exactly. (A) - I want it here. He showed on the screen where he wanted to trace and the teacher continued to tease. (Q) - could you give me exactly the location? Say it in words. (A) - I want to put going through number **4** and **5**. (Q) - Where are these numbers? What name would you give them? What do they represent in the design of your function? Quiet again. The discussion was expanded and came to the conclusion that they would be the roots. The teacher continued to question in the direction of resuming the discoveries made by the students. (Q) - What did it take to chart the chart? (A)- The function written in the form **f(x).** (Q) - Great, we need the algebraic representation of the function every time we want to betray it, right? (A) - Right and with these numbers that are going to be roots I take and do so that sum and multiply. (P) - Excellent idea! Are we going to work? One of the students said: - I only know how to **find the b and the c.** At this moment, another expressed himself saying: - There is that form that only needs to know the roots **and a,** here in the notebook. (P) - It is another possibility, the factored form, who remembers? Again they went to get information in the notebook and got the formula to find the function. Most found and followed without major problems, others it was necessary to explain the relationships between the coefficients and roots. This fact demonstrates that these students were building their knowledge. Some chose to choose the roots and place the coefficient value **a = - 1 for** the two initial parables. Knowing that when **a = - 1**, they could think of two numbers whose sum is **the value of b/a with exchanged** signal and the product is **the value of c/a**, **they made the** McDonald's m using this strategy. As the parabola had to have the concavity facing down, it placed the **a= -1.** Thus, they obtained the result below in Figure 6 and 7:

FIGURE 6 - Results obtained

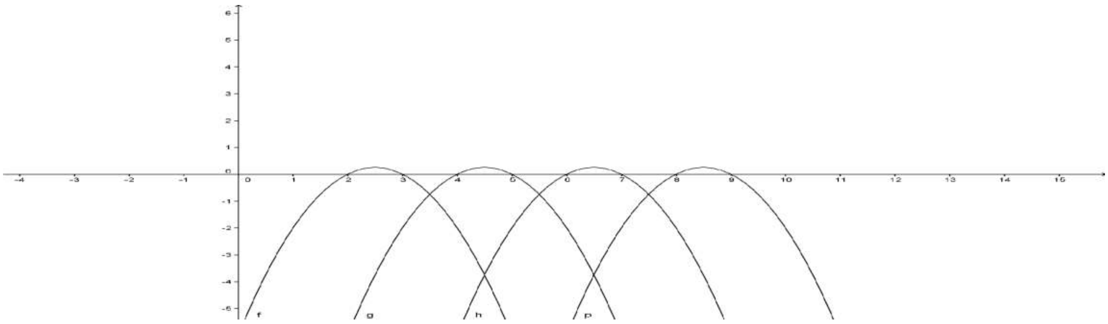
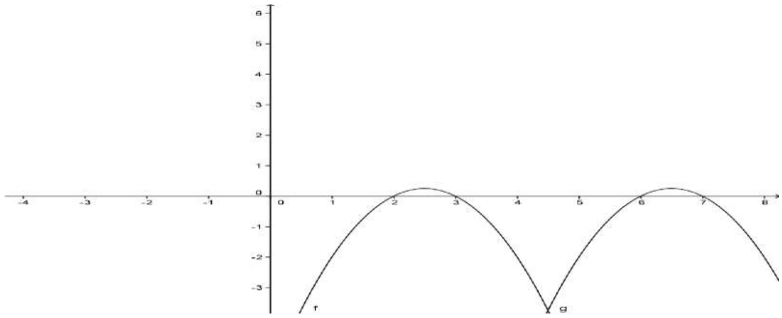


FIGURE 7 - Chosen functions

$F(x) = - x^2 +5. x - 6$	$F(x) = - x^2 + 9.x - 20$
$F(x) = - x^2 +13. x - 42$	$F(x) = - x^2 + 17.x - 72$

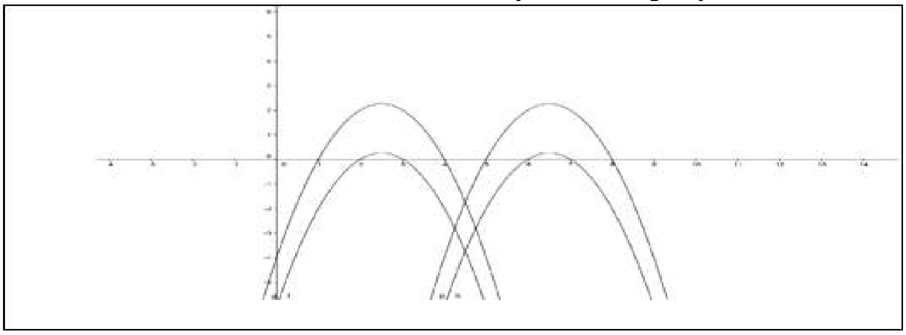
When they plotd, they were asked to improve the design so that the two parables were chosen to **represent m.** Some chose the **roots 2 and 3** and those of roots **6 and 7**, as shown in the drawing below in Figure 8.

FIGURE 8 - Results obtained



The functions worked were: $\mathbf{F(x) = - x^2 + 5.x - 6}$ and, $\mathbf{G(x) = - x^2 +13.x - 42}$. At this moment, emphasis was once again placed on the importance of algebraic representation and the factored form, a choice made by another group where $f(\mathbf{x}) = \mathbf{a.(x-x')(x-x'')}$. This representation was worked and the students only used it when the **coefficient a** was equal to **– 1** or **+1**, to facilitate the calculation; this, by the way, was the path chosen by some and after they succeeded, socialized with the other. One of the examples in Figure 9.

FIGURE 9 - Results obtained by one of the groups



The functions worked were:

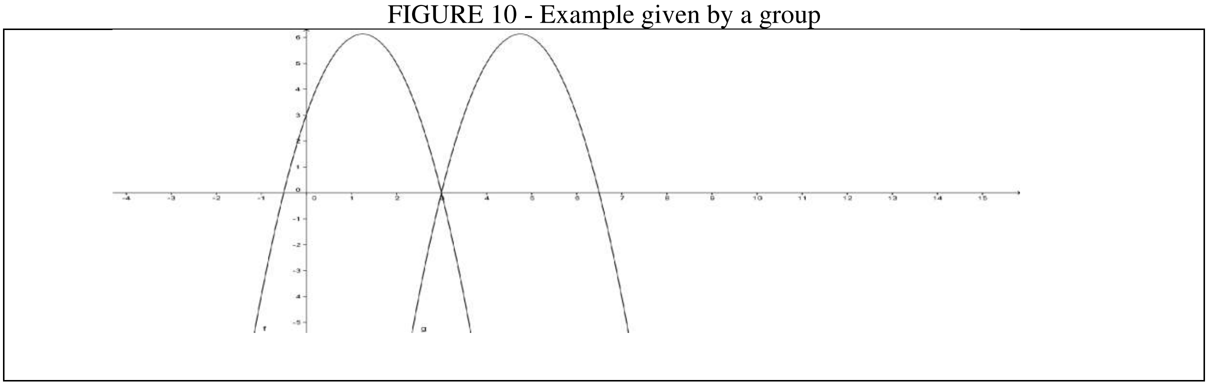
$F(x) = - x^2 + 5.x - 6$

$G(x) = - x^2 +5.x - 4$

$H(x) = - x^2 + 13.x - 42$ and $J(x) = - x^2 +13.x -40$.

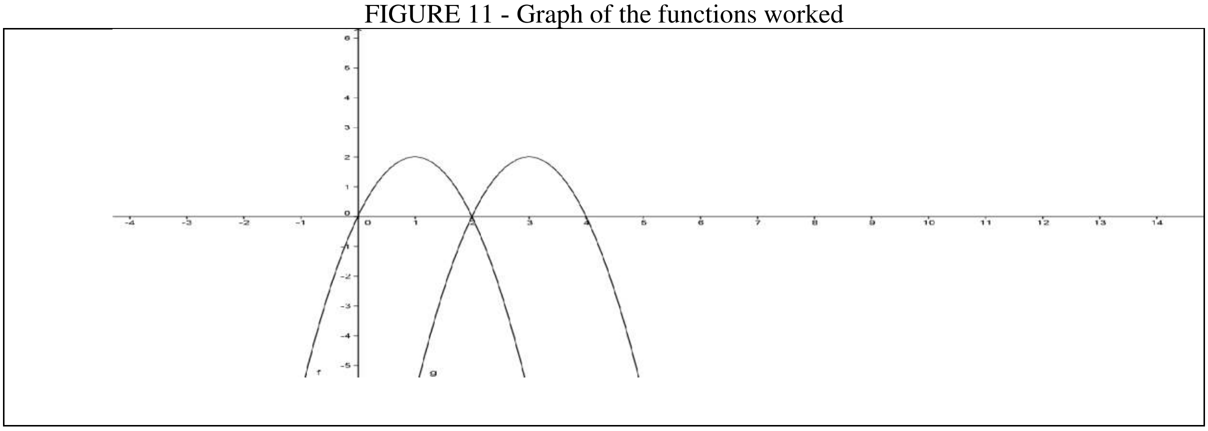
To obtain the above functions, the students, after many discussions, came to the conclusion that they would always choose the roots and work with the factored form **where $f(x) = a (x - x'). (x - x'')$**, and put the coefficient value **to = -1**. At this point a student asked if there was no other way. The teacher asked them to think about other possibilities. These conclusions and the questioning of new situations demonstrate that the institutionalization of knowledge was (re)constructed. Many other examples arose when they were asked to vary the value of coefficient **a**, as exemplified in Figure 10:

FIGURE 10 - Example given by a group



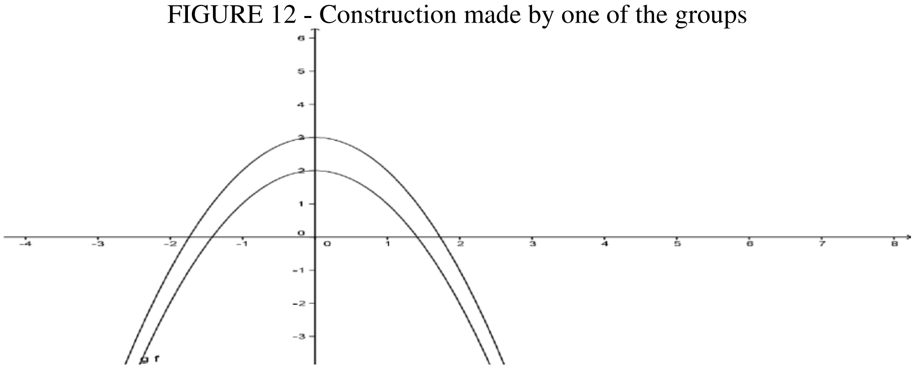
The functions worked were; $F(x) = - 2. x^2 + 5.x +3$ and $G(x) = - 2. x^2 +19.x - 39$. Your charts are in figure 10

FIGURE 11 - Graph of the functions worked



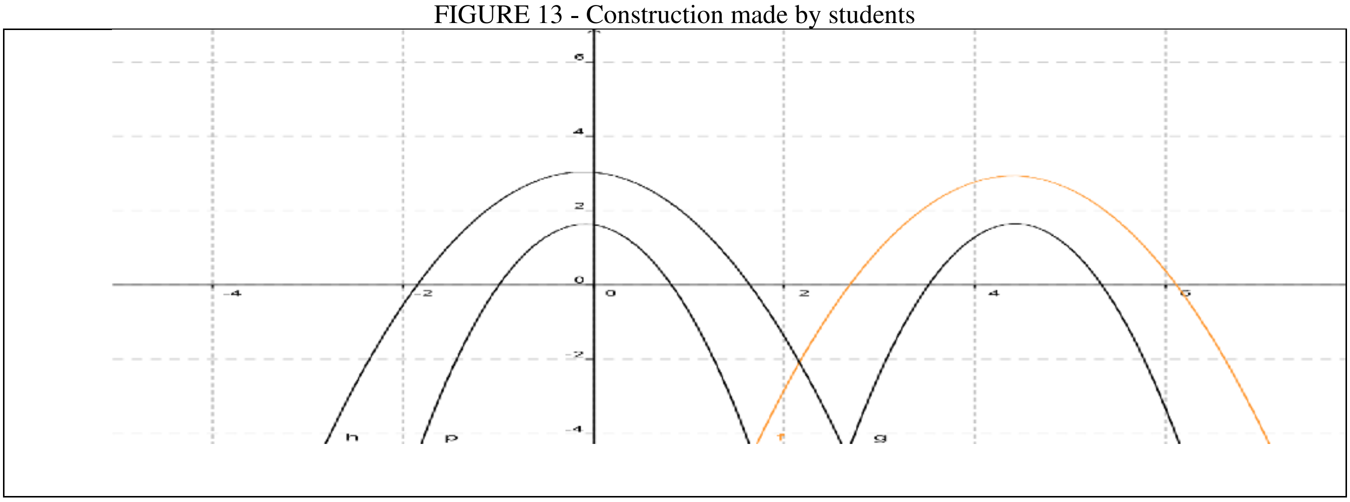
The functions worked were:$F(x) = - 2. x^2 +4.x$ and $G(x) = - 2.x^2 + 12.x - 16$. The students were involved and one asked: (A) - Why didn't we make the logo using the dots that we found important like the vertex?. (P) - We use important points, the roots. As the teacher realized that he was restless and asked if he had any doubts. He answered with a question. (A) - Why was the parable we found in the room from the vertex coordinates?. (P) – All these points are very important, but the use of each of them will depend on what is being requested and the information contained in each of the situations given. We realized that the proposed activities placed the student in a process of imbalance where he can reorganize his thinking in the reconstruction of his knowledge, that is, knowledge resulted from the adaptation of the student, which gives new answers to a situation that previously did not dominate. The dialogue continued (it was observed that the others also paid attention). (Q) - Let's think about other construction possibilities? (A) - Teacher, I have an idea!. (Q) - Are we going to hear the colleague's idea? (A) – I can put the **b=0 and** it will be easy. (P) - Why? . (A) - Because I put **c=3** and then **c=4** and will stand one on top of the other as in figure 12

FIGURE 12 - Construction made by one of the groups



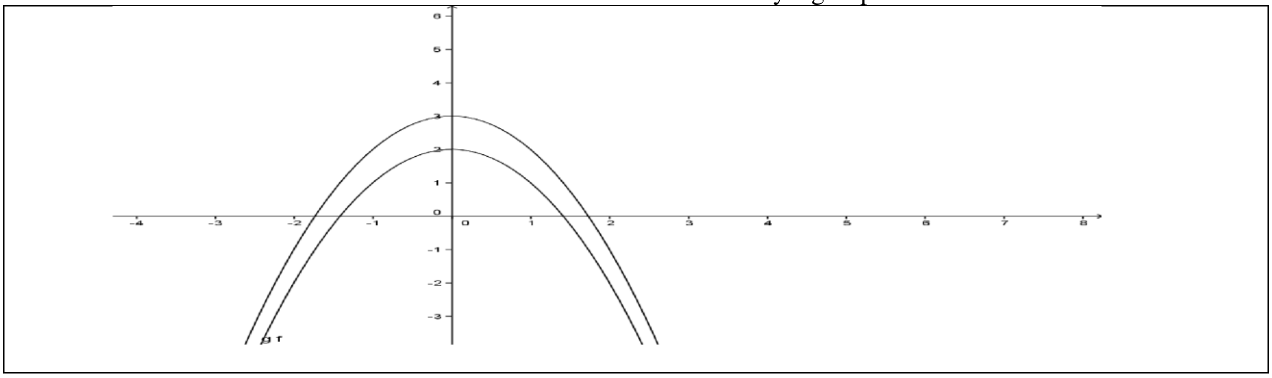
(Q) - How would you do with the other two parables? (A) - I've found that I can drag teacher, can I? Look how it turned out!

FIGURE 13 - Construction made by students



(P)- Great! The program offers this feature, but if the program did not offer? (Q) - If I want to find it, what should I do?. (A) - I can think of the roots I want to have and put the **same as** the top leg, can I? (P) - Of course you can, let's try?. (A) – Teacher, I did choosing the value of **a,** xv **and yv**, can I finish? Is it going to work? (Q) - Are we going to build using this path? What values have you chosen? (A) - I put in the first leg roots **- 1** and **+ 1** with **c = 2** and **c = 3** and it gets $f(x) = - x^2 + 2$ and $g(x) = - x^2 + 3$ (P) - How did it look? Construction in figure 14

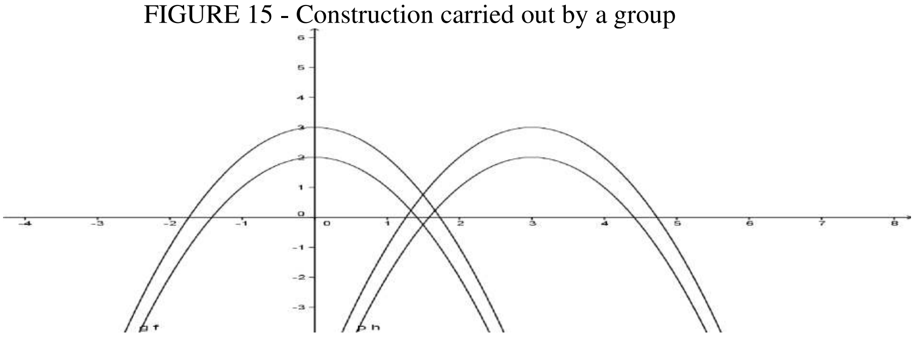
FIGURE 14 - Construction made by a group



(Q) - What then? (A) – I put **the = -1**, equal to the first leg and looked at the **yv** for each leg. Then I thought that value of **x** is in the middle that is **the xv,** because the vertex is in the middle. **xv = 3** and **xv = 3**, then **yv = 2** and **yv = 3** and lastly **a = - 1 and a = -1**

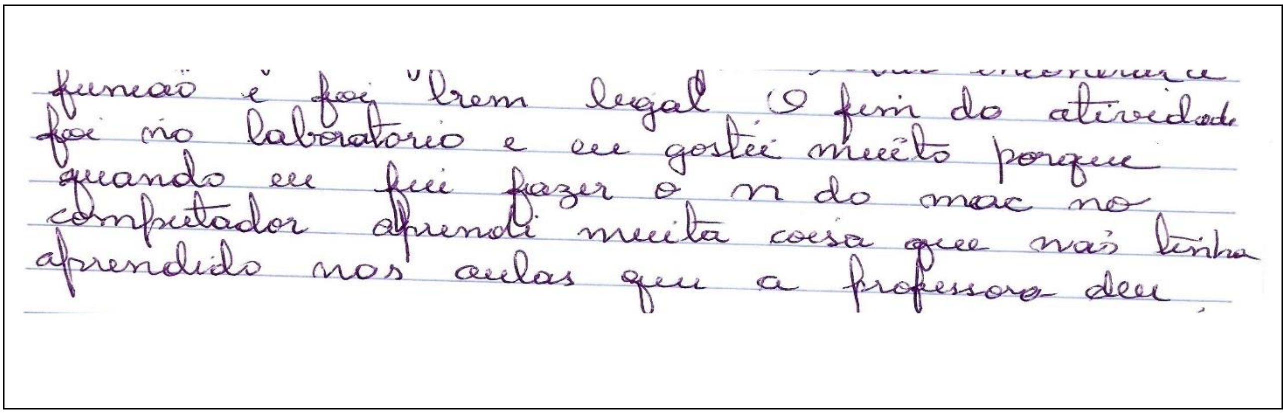
I was left with $f'(x) = - x^2 + 6 . x - 7$ and $g' (x) = - x^2 + 6.x - 6$, as shown in figure 15

FIGURE 15 - Construction carried out by a group



(P) - Wonder! Shall we explain to the class how you thought? The interest was general and all participated as we can see below.

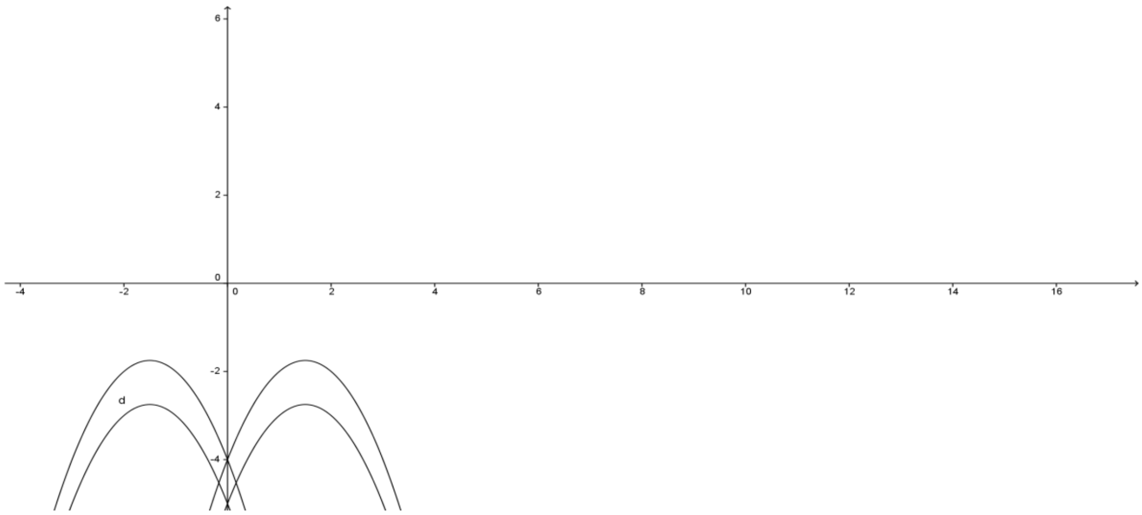
FIGURE 16 - Comments of a student


função e foi bem legal O fim da atividade foi no laboratório e eu gostei muito porque quando eu fui fazer o n do mac no computador aprendi muita coisa que não tinha aprendido nas aulas que a professora deu.

3 FINAL CONSIDERATIONS

As the objective of this study, we report how the teacher's activities and provocations can contribute to the reconstruction of concepts and definitions already studied. Working mathematics content with technological support, drawing, was a well accepted proposal by all involved. We emphasize the importance of choosing an object that is part of the student's context. We realized in the course of the process that the proposed activities placed the student in a process of imbalance where he can reorganize his thinking in the reconstruction of knowledge, that is, knowledge resulted from the adaptation of the student when he gave new answers to a situation that previously did not dominate. Due to the degree of involvement of the students, we hope that this work can motivate mathematics teachers to develop activities in their classes using the teaching proposal described in this report, in addition to the use of the resources offered by the GeoGebra software, stimulating their students in reconstruction, with understanding of the concepts addressed. We believe that this proposal can contribute to a learning with more meaning, since it places the student as the center of the educational process, emphasizing it as being active in the process of knowledge construction and making connections with pre-existing knowledge in its cognitive structure. This can be seen by observing the model that the teacher had in mind when elaborating the activity, result of the conclusions obtained through the study of the coefficients: coefficient **a** (concavity of the parabola and opening), **coefficient c** (coordinate **y of** the point where the parabola cuts the axis of the ordered), coefficients **a** and **b** (equal and different signals so that the desired displacement of the parabola occurs, horizontally) and coefficients **a**, **b** and **c** (preserving coefficients **a and b** so that the axis of symmetry remained and **increased from 1** unit to **coordinate C**, obtaining the displacement of the parabola vertically) . The students were able to observe the horizontal displacement of the parabola, when they made connections with the rules previously memorized in relation to the **sign of coefficient b,** when they analyzed the formulas to **obtain xv** (observing the signs of coefficients a and b); thus, they understood the **displacement of the xv** and identified the symmetry axis of the parabola. The students walked several paths and encouraged by the teacher, through dialogue, it can be seen that the objective of involving students in the process of construction of knowledge about the graph of the polynomial function of the 2nd degree making think, analyze, conjecture, experiment, conclude, building the M of McDonald's in GeoGebra, it was met, because the proposal was to make the path chosen by the students, resulting from the reflections, questions, dialogues and conclusions that arose during the process, necessary to understand and design the McDonald's logo, meeting the main objective of this work.

Path initially conceived by the teacher described above and exemplified in the figure below:



$$Y = -x^2 + 3x - 4$$
$$Y = -x^2 - 3x - 4$$
$$Y = -x^2 + 3x - 5$$
$$Y = -x^2 - 3x - 5$$

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