Use of Physical Education Classes as a Didactic Laboratory for Teaching Mathematics: An Example with a Quadratic Function

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Abstract

The research objective of this study was to evaluate the use of Physical Education classes as didactic laboratory for lessons in Mathematics, presenting an alternative way to conduct classes, mainly of quadratic functions, illustrating basic concepts such as graphs plotting and determination coefficients, analyze if such use achieves some of the goals of using a Didactic Laboratory in addition to research ways to interdisciplinary with Physics. Discusses an action in which students work in groups to solve problems proposed based on empirical data obtained through play activities and measures of athletics values practiced by the students allowing may have the opportunity to produce arguments and more meaningful answers, which would improve the overall learning. The athletics and recreational activities are then used as problematic objects both empirically and qualitatively. As a result, it was observed that some of the objectives of a Didactic Laboratory are achieved when using the Physical Education classes and it appears that this feature is much more available in public schools than they are equipped with a science laboratory.

Keywords: Teaching of Mathematics, Physics Education, Didactic Laboratory, Physical Education, Interdisciplinary.

1. Introduction

Many teachers in Brazil have experienced difficulties in teaching mathematics and as a result seek alternative methods in order to present new teaching resources aimed at stimulate the student and show the concepts in a way that has less difficulties in the teaching and learning process. Thus, the need for innovation and the use of methods alternatives has become a trend in recent years (BORGES, 2002).

One of these trends is mathematical modeling that uses empirical data. So the teacher provides an environment in which students can problematize and investigate, through exercises mathematical, more real and concrete situations, making it possible to analyze the dimension discourse of science teaching and learning processes in real situations in the classroom (VILLANI AND NASCIMENTO, 2003). The traditional Didactic Laboratory seeks to identify within routine activities, such as athletics exercises and other recreational activities, the concepts mathematicians involved in them.

The use of the traditional Didactic Laboratory is a subject that has been widely studied by researchers in science education in Brazil, even without a specific space for such (GRANDINI AND GRANDINI, 2008). For a country where a considerable fraction of students have never had the opportunity to entering a science laboratory, it may seem absurd to question the validity of classes practices, especially as in most schools they simply do not exist (BORGES, 2002). One should try to offer students an alternative to the traditional didactic laboratory through routine activities, such as physical education classes. Like this, this proposal aims to identify within athletics and other activities playful concepts of quadratic function (IEZZI AND MARAKAMI, 1993; LIMA, 2013) involved in them and analyze not only quantitatively, but also in a conceptual way the exercises of Physical Education through Mathematical concepts.

2. Methodology

The research was carried out in stages at a Public School in the city of Belém – State of Pará - Brazil. In the first, we tried to determine the objectives of the didactic laboratory, which according to GRANDINI and GRANDINI (2008) are: 1) illustrate content taught in theoretical classes; 2) use experimental data to solve specific problems; 3) stimulate and maintain the student's interest in the study of mathematics and 4) help to bridge the gap between theory and practice. Such search consisted of a research based on materials involved by other researchers in the use of the Didactic Laboratory and the use of recreational activities (VILLATORRE et al., 2008), seeking to establish modeling processes in Mathematics classes. This research showed the importance of the Didactic Laboratory in the training of high school students (GRANDINI, GRANDINI, 2008).

In the second part of the work, a discussion was developed about the space and time quantities and their units of measurement, an initially theoretical view. Then a series of measurements is made, which were performed with tape measure and measuring tape to determine the size of the objects and some sizes of linear trajectories. It was interesting to note how the size perception of measurement units such as the meter and centimeter was flawed. During the measurements taken by the students, the concept of significant algharisms without the use of annotations was discussed and it was later verified that this resource seen in practice, even without it have been noticed by the students, was better absorbed than those taught in the classroom, since the students gave it greater meaning.

To paraphrase the comment of one of the students in the class seems to me to be very relevant to the situation. "As I was holding the measuring tape and making the size measurements it was easier for me to learn". This shows that the use of the senses is very important in learning scientific concepts.

Then, competition groups were formed, dividing 38 students into four groups, two groups containing 9 students and two groups containing 10 students. These groups were engaged in two kind of competition.

The first competition was related to the athletics dispute and the second competition was related to the precision of the measurements of the times and distances referring to the athletics dispute. Each team would then have to choose their athletes who would participate in the activity athletics, in this case, the shot put was chosen.

Each team chosen an athlete to compete in shot put and the other team members were tasked with measuring the distance of the shot from all groups. There was no computerized equipment to measure the distance of the pitches, so students' measurements were compared between themselves. Table 1 shows the measurements recorded by each team.

Table 1 – The distance measurements recorded by each team in the shot-put activity.

Athlete	**Distance measurements recorded by each team (m)**			
	Team 1	Team 2	Team 3	Team 4
Team 4	13,04	13,05	13,04	13,02
Team 2	12,68	12,68	12,67	12,67
Team 3	11,53	11,54	11,54	11,53
Team 1	10,40	10,42	10,41	10,42

In each shot put, it was assumed that there was an angle of about 45 degrees to the vertical axis. Thus, the following question was asked: With an angle of 45 degrees at the launch and considering the height of the athlete as initial height of the object (weight), what was the initial velocity of shot put?

This situation created several inquiries by the students who questioned the way the launch angle was chosen, but as we did not have the equipment to carry out this measure, the value was accepted (with reservations).

In this case, it was observed that even one or two "assigned" parameters without taking the necessary measures creates a lot of doubt and, therefore, difficulty in assimilating the concepts involved.

A playful activity was also carried out with the ball tossing among the students. To analyze the movement of the thrown ball, each team selects three students to be the experimenters and the rest of the team to be for data collection and analysis. While two students throw a handball ball from one to the other, a third student performs motion filming. In this activity, each team produced several videos. With the videos in hand, the students responsible for analyzing the movements chose one of the videos made. The data collected from the chosen video was used to assemble Table 2 with information relevant to the description of the movement, such as time of movement and maximum height. The reach of the movement remained fixed between the teams since the position of the students who were making the shots were previously established. The heights were determined using the equation:

$$h = \frac{g.t^2}{2}$$

where t is the ascent time obtained by the timing given by the videos made by the students and g is the gravity acceleration.

Table 2 - Time measurements collected in ball launch activity

	Collected data			
	Team 1	Team 2	Team 3	Team 4
Total time (s)	1,83	2,08	1,96	1,92
Ascent time(s)	0,92	1,04	0,98	0,96
Maximum height(m)	4,2	5,4	4,8	4,6

3. Questioning the collected data Problems developed from the recorded data

The following is a collection of some of the problems proposed to students in the classroom regarding the empirical data collected during physical education classes. The obtained tables were organized in small handouts and distributed to students before each series of exercises. The construction of the graphs by the students was done with a more modern tool, in this case, GeoGebra (dynamic mathematics software).

3.1. Shot put problems

The following problems will use the data in Table 1. The resolutions will be show for the data collected by Team 1.

3.1.1. Problem 1

Considering the shop put made by the students from an angle of $\alpha = 45º$, determine the velocity of the launch using the reach value measured by your team. Considere: $g = 10\ m/s^2$ and $A = \frac{V_0^{\ 2}\sin(2\alpha)}{g}$ (reach).

Resolution:

It will be shown the resolution for the data recorded by team 1. Since $\alpha = 45º$, then $sin(2\alpha) = 1$, so the launching velocity can be determined by:

$$V_0 = \sqrt{gA}\ .$$

Hence the velocities per team will be: Team 1: $V_0 = 10{,}20 m/s$; Team 2: $V_0 = 11{,}26 m/s$; Team 3: $V_0 = 10{,}74 m/s$; Team 4: $V_0 = 11{,}42 m/s$.

3.1.2. Problem 2

Using the trajectory equation:

$$f(x) = \tan(\alpha)x - \frac{gx^2}{2(V_0\cos(\alpha))^2}\ ,$$

write the function that represents the trajectory of the weight thrown by your team, considering $\alpha = 45º$ and the velocity value determined in the previous question. $(g = 10 m/s^2)$.

Resolution:

The winning team launching velocity, that is the Team 4, will be presented in this solution, but every team made your resolution. With $V_0 = 11{,}42 m/s$ and $\alpha = 45º$, we will have $cos^2(\alpha) = (cos45)^2 = (0{,}71)^2 = 0{,}5$ and $tan(45) = 1$, we get

$$f(x) = x - 0{,}076x^2$$

3.1.3. Problem 3

Determine the roots of the equation obtained in the previous question.

Resolution:

We get

$$x - 0{,}0767x^2 = 0$$
$$x(1 - 0{,}0767x) = 0$$

Therefore, $x_1 = 0 \; and \; x_2 = \frac{1}{0{,}0767} = 13{,}04$. Note that the value of x_2 is equal to the launch reach.

3.1.4. Problem 4

Determine the vertex of the parabola given by the equation obtained in the Problem 2.

Resolution:

We have

$$V = \left(\frac{-b}{2a}, \frac{-\Delta}{4a} \right),$$

with $a = -0{,}0767$, $b = 1$ and $\Delta = 1$. Thus,

$$x_v = \frac{-b}{2a} = 6{,}52 \text{ and } y_v = \frac{-\Delta}{4a} = 3{,}26$$

Note that the value of x_v is the midpoint of the roots obtained, and that the value of y_v corresponds to the maximum height of the weight's trajectory.

3.1.5. Problem 5

Sketch graph the function obtained in the Problem 2.

Resolution:

The function being given by:

$$f(x) = -0{,}0767x^2 + x,$$

the roots are $x_1 = 0 \; and \; x_2 = 13{,}04$ and the vertex the point (6.52; 3.26), we can Sketch the graph as shown in Figure 1.

3.2 Problems with ball launch

The following problems use the data in Table 2.

3.2.1. Problem 1

Considering the launches made by students under an angle of $\alpha = 60º$, determine the launch velocity using the ascent time value measured by your team. Use $g = 10\ m/s^2$ $g = 10m/s^2$ and $t_s = \frac{V_0 \sin(\alpha)}{g}$.

Resolution:

Como $\alpha = 60º$, então $sen\alpha = 0{,}866$, then the launch velocity can be obtained by:

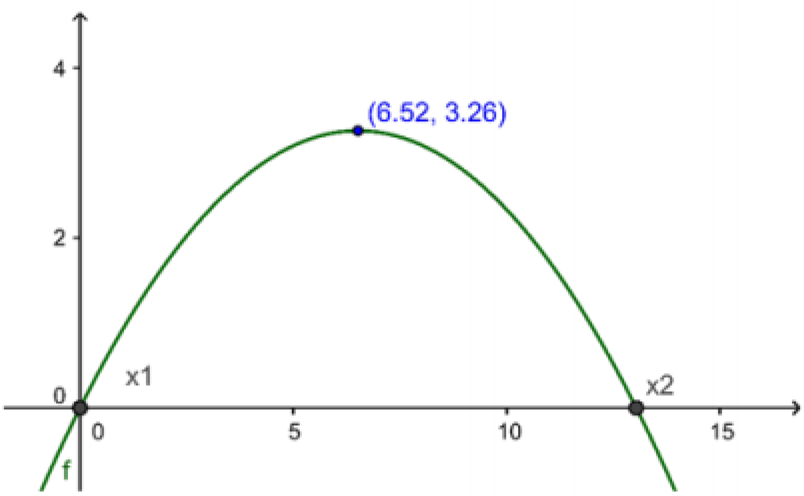
$$V_0 = \frac{g.t_s}{0{,}866}.$$

Hence the speeds per team will be: Team 1: $V_0 = 10{,}62m/s$, Team 2: $V_0 = 12{,}01m/s$, Team 3: $V_0 = 11{,}32m/s$, Team 4: $V_0 = 11{,}08m/s$.

Figure 1 - Graph of the quadratic function of the shot-put team 4 with data recorded by team 1.

3.2.2. Problem 2

Using the trajectory equation:



$$f(x) = \tan(\alpha)x - \frac{gx^2}{2(V_0\cos(\alpha))^2},$$

Write the function that represents the trajectory of the ball launch by your team, considere $\alpha = 60º$ and the speed value determined in the previous question, $(g = 10m/s^2)$.

Resolution:

We consider the launch velocity of team 2 with $V_0 = 12{,}01m/s$. With $\alpha = 60º$, we will have $cos^2(\alpha) = (cos60º)^2 = (0{,}5)^2 = 0{,}25$ and $tan(\alpha) = 1{,}73$, so

$$f(x) = 1{,}73x - \frac{10x^2}{2(12{,}01)^2 0{,}25}$$

$$f(x) = -0{,}139x^2 + 1{,}73x$$

3.2.3. Problem 3

Determine the roots of the equation obtained in Problem 2.

Resolution:

We have

$$x(1,73 - 0,139x) = 0 .$$

Therefore,

$$x_1 = 0 \ and \ x_2 = \frac{-1{,}73}{-0{,}139} = 12{,}45 \ .$$

3.2.4 Problem 4

Determine the vertex of the parabola given by the equation obtained in Problem 2.

Resolution:

We have

$$V = \left(\frac{-b}{2a}, \frac{-\Delta}{4a} \right),$$

with: $a = -0{,}139, b = 1{,}73$ $a = -0{,}139,\ b = 1{,}73$ and $\Delta = 2{,}99$. Thus,

$$x_v = \frac{-b}{2a} = 6,22 \text{ and } y_v = \frac{-\Delta}{4a} = 5,28 .$$

Note that the value of x_v, is the midpoint of the roots obtained, and that the value of y_v corresponds to the maximum height of the body's trajectory.

3.2.5. Sketch graph the function obtained in the Problem 2.

Resolution:

The function being given by:

$$f(x) = -0{,}139x^2 + 1{,}73x,$$

the roots are $x_1 = 0$ and $x_2 = 12{,}45$ and the vertex the point $(6{,}22;\ 5{,}38)$, we can Sketch the graph as shown in Figure 2.

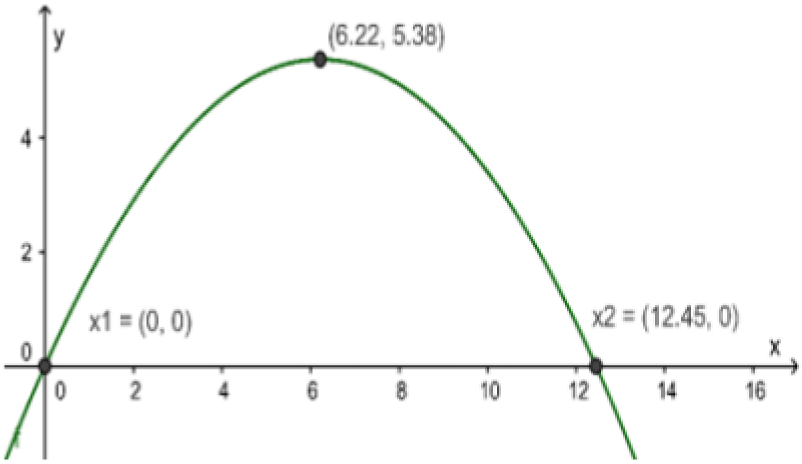


Figure 2 - Graph of the quadratic function of the launch ball with data recorded by team 2.

4. Considerações finais

It was possible to observe with this research that Physical Education classes work with a great tool, including reaching the objectives of a Didactic Laboratory and also serving to arouse the interest of students in learning.

At the end of the process, students in the class where the research was carried out were asked to complete a short questionnaire related to the activities and students' opinions regarding the validity of the proposed process. The questionnaires used, shown in Table 3, were based on previous research on the subject. (GRANDINI, GRANDINI, 2008). In question 1 the student could choose only one of the two options while in questions 2 and 3 he could choose more than one option.

Table 3 – Student Point of view

Questionnaire	%
1. What is a Didactic Laboratory for you?	
1.1. It is a place where activities are developed to illustrate the content taught in theoretical classes;	42%
1.2. It is a set of practical activities incorporated into Science Education.	58%
2. For which reasons should practical activities be part of high school math classes?	
2.1. They encourage the student to know, understand and apply the theory in practice;	92%
2.2. They teach content not included in theoretical classes;	62%
2.3. They train students in the interpretation of experimental data;	81%
2.4. They teach principles and attitudes in experimental work;	86%
3. Among the objectives below, check the one that you believe is most important for the use of Didactic Laboratory.	
3.1. Helping to bridge the gap between theory and practice;	88%

3.2. Stimulate and maintain interest in the study of Mathematics;	96%
3.3. Solve math exercises;	64%
3.4. Develop basic practical skills.	78%

When analyzing the answers to the first question, where 42% of the students still consider the Didactic Laboratory just a place where practical activities can be carried out, we noticed that even for a class that had activities carried out in several places, the notion of "reserved" space the activities experimental is very firm.

In the second question, students could choose more than one option and it became evident that the use of the didactic laboratory greatly encourages learning, showing ways for the student to experience situations where the theory is applied. The answers given to question 3 only reinforce this notion of stimulating students' interest in the learning process.

The activities proposed to students in the classroom, after the practical classes, served to illustrate in a more interesting way to the student the concepts of quadratic functions worked in the first year of high school. It is also noteworthy that the practical classes directly influenced the students' arguments, which allowed them to make a more concrete analogy of the contents taught with phenomena observed and performed by themselves.

Finally, it is possible to observe the need for prior planning of the classes taught, to provide attractive tools in order to provide students with more instruments that they can use to form a solid argument based on athletics and other recreational activities.

In addition to the first questionnaire, which aims mainly to get an idea of the students 'motivations, a second questionnaire, shown in Figure 6, was proposed, in which it seeks to verify the extent to which the objectives of the didactic laboratory were achieved in the students' view.

We note that most students agree that the objectives of the Didactic laboratory were achieved satisfactorily when using Physical Education classes, being important to provide experimental data for the solution of problems and mainly to stimulate students in the study of Mathematics.

Even though the students' opinion about the process is important, but it is still the verification of the results obtained by the students of the class that participated in the process. While the average grades of students in other classes of the first year of the school was 5.7; the average grades of students in the class where the survey was conducted was 6.8; an average grade 19.3% above the average of other classes.

Mathematics taboos regarding their learning difficulties can be countered with activities that encourage students to think for themselves by developing more solid forms of argument through routine experiments.

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