The contributions of the topography for the teaching of mathematics

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Abstract

Topography is a science that requires reasoning for problem solving, so it is understood that students, when familiarizing themselves with their studies and solving problems situations offered by daily life, will build competences that enable training for the exercise of citizenship. In this sense, the objective of this work was to investigate the contributions of topography teaching through the manufacture of alternative topographic equipment in the learning of the mathematics of the students of the Education of Young and Adults of the Field of High School of two communities belonging to the municipality of Serra Talhada - PE. For this, the methodology proposed by Paulo Freire’s pedagogical conceptions and the constructivism of Piaget, Vygotsky and Ausubel were used. Before and after the work, we applied tests with objective questions of mathematics in order to identify the previous knowledge and to verify if there was a contribution in the performance of the students from the intervention. Records were made of oral reports of the students to know their opinion about the contributions of the project in learning mathematics and rural work. For the statistical analysis of the applied tests, the completely randomized design was used. After the analysis, it was deduced that in the community of Conceição do Meio there was an increase in knowledge of 54.37% and in the Grotões community of 41.25%, thus observing that the methodology used in the communities had a positive effect. Based on the students’ reports about the contributions of the work, it was realized that it helped in the understanding of mathematics, approaching reality through the manufacture and use of the equipment, thus rebuilding the students’ point of view through the realization that Mathematics can actually be learned and useful in family farming.

Key-words: Alternatives Topographic Equipments, Field Education, Planning Maize Hybrid

Introduction

The knowledge of topographic studies in the agricultural sciences is fundamental to help students to operate with topographic equipment, to obtain information about the terrain, to apply area survey techniques, to build and interpret drawings and plans, with the objective of solving problematic situations offered by everyday life.

Nowadays, with the agricultural sector technoglobalized and in the process of adaptation to climate change, it is increasingly required of people who live in the countryside, creativity and ability to mobilize diverse knowledge to ensure a quality production that does not deplete natural resources and favors animal welfare. Thus, mathematics is a tool of great importance since this sector uses technologies from precision farming. However, the mathematical
content to be studied does not present itself as easy to assimilate, especially when it comes to students of Youth and Adult Education - EJA, who bring with them a history of dropout, low grades and repetition in their education, due to the fact that the school does not meet their real needs (Silva, et al., 2013).

The effect of a punitive education that treated teaching in an exclusive way, where students from the less privileged classes were labeled as incapable and destined to inhumane work. In this context, it is taught in a mechanical way, making the student memorize answers previously elaborated to simply superimpose in questions applied in periodic exams (Aranha, 1997).

In EJA's math classes, the inheritance of this method is noticeable, as it underestimates the students' ability and at the same time frustrates them by not being able to fit the ready-made, previously memorized procedures into new situations that require competence in solving them. According to Caldart (2012), Youth and Adult Education in the Field is a method of teaching Basic Education that aims to assist young people and adults of an age incompatible with regular education who for various reasons escaped during the period of their school education. However, it was found that a large part of the students enrolled did not complete the course due to the difficulty in connecting curricular contents to reality. Faced with this scenario, an alternative would be to offer practical activities making teaching closer to the students' lives, promoting moments in which students feel challenged to solve problems built from their reality. For this, they will have to build new knowledge and skills that will be acquired with different teaching activities, knowing what to study for and the application of the contents.

In this context, this study aimed to investigate the contributions of topography teaching, through the manufacture of alternative topographic equipment, in the learning of mathematics of EJA Campo.9 students. At the same time, it sought to propose a methodology for teaching mathematics, and thus analyze the performance of students with the insertion of the methodology, and know the opinion of students on the importance of knowledge acquired through the activities developed with this work.

**Material and methods**

The settlements of EJA Campo assessed students are located in the rural area of the municipality of Serra Talhada - PE. The settlement of Conceição do Meio is 47 km away and Grotões 10 km away from the city's landmark, both of which are part of the Pernambuco State Federation of Agricultural Workers (FETAPE).

The group of Grotões was composed of 14 students, 36% male and 64% female, with an average age of 33 years. In Conceição do Meio the class was formed by 20 students, 25% male and 75% female, with an average age of 34 years old. The activities were developed in the municipal school groups of these communities, during the night period from 6 pm to 9 pm, from July to November 2016, with field classes in the afternoon. The work took place every two weeks, alternating between the communities, during the math classes, totaling a workload of 40 hours. The Curricular Matrix of Youth and Adult Education for the population of the camp - High School was divided into four thematic axes, with each axis contemplating 500 hours/class. The same aimed to meet the reality of rural workers students according to Federal Law nº. 9,394/96.

As a starting point of the work, a test with ten objective multiple-choice questions was applied to identify EJA students' prior knowledge of mathematics in July 2016. At the end of the work in November 2016, another test with the same questions was applied to make the comparison and identify whether there was a contribution to improving student performance with the experience of the project. At the culmination of the topography project in November 2016, a panel interview was conducted according to Marconi and Lakatos (2007) where the interviewer gathered students from Grotões and Conceição do Meio in a circle, directing questions to the group of students about the project's contributions to math learning and agricultural work.

For the analysis of the results of the knowledge tests, the design was used entirely by chance with the help of the Computer Statistical Analysis System "SISVAR 5.6".

**Description of the methodology and equipment used in the classes**

The pedagogical conceptions that guided the classes were the Pedagogy of Paulo Freire (1996), and the learning according to Piaget, Vygotsky and Ausubel. The alternative equipments for simple
agricultural topographic surveys were built based on the material written by Miná and Neto (2008).

In this way it was possible to stimulate the students to build their own knowledge as they used topography to make the equipment and perform area surveys. The activities were structured in a sequence to facilitate learning. Figure 1 helps to better visualize the steps that occurred in practice, and all activities were described later.

I. Presentation of the project objectives and methodology to teachers, EJA Campo coordinators and FETAPE representatives.

II. Mobilization of the Grotões community and Conceição do Meio to present the project as follows:
- Opening of the project with the presentation of the community organized by the FETAPE coordinator and EJA Campo together with the teachers;
- Thematic mobilization with presentation of theoretical and practical contributions that would bring to each student and community, a moment when everyone was made aware of the importance of implantation, project objectives, schedule of activities, first referrals, round of conversation about the perspectives of students.

III. Delivery and orientation of Test 01 to be answered by EJA Campo students in order to understand the learning difficulties.

IV. Construction of knowledge about units of measurement and operations with straight and angles. Before the specific contents of topography, subjects concerning operations with units of measurement of angle and straight, similarity (similar figures, similar polygons and similar triangles), and the metric relations in the right triangle were reviewed.

V. Work with area and perimeter of flat figures, calculating the areas of some simpler geometric figures.

VI. Study of trigonometry including the contents of: rectangle; index of ascent; idea of tangent, laws of cosenos and ofenos, semiperimeter, resolution of any triangle, and basic trigonometric concepts.

VII. Discussion about the concept and importance of topography through students' previous knowledge about measurements of rural areas, activity on straight and angle, aiming to better understand the concept and the use of topography in rural areas.

VIII. Presentation of the instruments and accessories used to perform topographic surveys.

IX. Conducting workshops for the manufacture of simple alternative equipment agricultural topographical works: general guidelines for the construction of equipment alternative topography; dividing students into teams, each team developed your own topographic equipment; extra guidance for the content of the series regulate the incentive to develop the ability to use topographic devices; presentation of the team of each device made by them, as well as the demonstrations necessary for the use of each equipment and its agricultural importance.

X. Field class for surveying with the use of the constructed equipment. The teams worked in the field performing measurements and calculations to obtain data for agricultural planning.

XI. Delivery of Test 02 composed of the same questions as the first test in order to compare both to verify the contributions of the project.

![Flowchart: performed activities.](image-url)
XII. Students’ report on the experience of the project, where they had the opportunity to expose the contributions of the project in the learning of mathematics and other curricular components, as well as in the daily life of each peasant.

XIII. Return of the project to the community, where the results obtained were exposed and all the students showed how the devices were made and used in the field.

**Alternative equipment**

All the alternative equipment for simple agricultural topographic surveys built by the students of EJA campo, were made based on the study of Prof. Dr. Alexandre José Soares Miná and Jacob Soares Pereira Neto (2008), Scholar of the Federal University of Paraíba, of the Agriculture Sector, Topography Laboratory in the city of Bananeiras - PB. However, no calculations were found in the literature to determine the area from the dimensions and angles obtained with the alternative theodolite. Therefore, we tried to fit trigonometric equations studied in elementary and high school to enable and facilitate the understanding of the calculations by the students of EJA campo. Some adaptations were also made in the manufacturing of the equipment produced by Miná and Neto (2008) to facilitate their construction and use.

**Cross-Staff**

- Materials and Tools

**Table 1. Materials and tools used in the making of the surveyor's square**

| Items | Quantity | Materials and tools                                      |
|-------|----------|----------------------------------------------------------|
| 1     | 04       | Nylon Clamp 2,5 cm or flat wire                           |
| 2     | 06       | Wooden broom sticks                                       |
| 3     | 01       | Glue stick                                                |
| 4     | 01       | Knife                                                     |
| 5     | 01       | Protractor photocopy proportional to the diameter of the "pet" bottle |
| 6     | 01       | 2L green “pet” bottle                                     |
| 7     | 01       | Hammer                                                    |
| 8     | 02       | Spirit level                                              |
| 9     | 01       | Piece of styrofoam10 cm x 10 cm                          |
| 10    | 01       | Piece of transparent adesive plastic 15 x 15 cm           |
| 11    | 02       | Pieces of broom sticks of 9 cm                            |
| 12    | 04       | Thumbtacks                                                |
| 13    | 01       | Permanent marker brush                                    |
| 14    | 01       | Wire nail                                                  |
| 15    | 01       | 30 cm rule                                                |
| 16    | 01       | Handsaw                                                   |
| 17    | 01       | Sewing scissors                                           |
| 18    | 01       | Protractor                                                 |

Source: elaborated by the author

- Manufacturing

1st Step: Remove the bottom of the bottle with the scissors.

2nd Step: The photocopy of the protractor was glued in the Styrofoam circle so that it could be inserted in the bottom of the bottle and determine the angle markings.

3rd Step: The permanent marker brush and the ruler were used to mark the sides of the bottle with two vertical lines forming 180°. With the scissors a cut was made to the right and left of each scratch, leaving a space between one cut and another of 2 cm. The length of each "antenna" was 5 cm, used as supports to fix the pieces of broom cable with the bedbugs.

4th Step: Using the protractor xerox and the ruler, the vertical lines of the targets were marked at 0°, 45°, 90°, 135°, 180°, 225°, 270° and 315° angles, and then, with the knife heated, made the cuts on these marked parts.
Step 5: With the clamp the two levels of bubble were fixed on each piece of broom handle.

Step 6: Using the knife, a pencil point was made at one end of the broom handle and at the other end the mouth of the bottle was fitted to the other handles.

- Operation

Step 1: From the simultaneous levelling with the aid of the bubble levels, the surveyor's square was fixed.

Step 2: The target was aligned at the chosen point.

Table 2. Materials and tools used in the can pantometer manufacture

| Items     | Quantity | Materials and Tools                                         |
|-----------|----------|-------------------------------------------------------------|
| 1         | 01       | Wooden broom stick                                          |
| 2         | 01       | Glue stick                                                  |
| 3         | 01       | Knife                                                       |
| 4         | 01       | 20 cm x 20 cm plywood sheet                                  |
| 5         | 01       | Protractor photocopy 5 cm more than the can diameter         |
| 6         | 01       | Sandpaper                                                   |
| 7         | 01       | Hammer                                                      |
| 8         | 01       | Spirit level                                                |
| 9         | 01       | Piece of transparent adesive plastic 25 x 25 cm             |
| 10        | 01       | Permanent marker brush                                      |
| 11        | 01       | Wire nail                                                   |
| 12        | 01       | Bicycle spoke                                               |
| 13        | 01       | 30 cm rule                                                  |
| 14        | 01       | Handsaw                                                     |
| 15        | 01       | Sewing scissors                                             |
| 16        | 01       | Protractor                                                  |

Source: elaborated by the author

- Manufacturing

1st Step: The permanent marker and the ruler were used to mark the sides of the bottle with two vertical lines forming 180°. With the knife and hammer a vertical cut was made on each marker.

Table 3. Materials and tools used to make the level curve set-square in the shape of a beam

| Items | Quantity | Materials and Tools                                      |
|-------|----------|----------------------------------------------------------|
| 1     | 02       | Nylon Clamp 2.5cm or flat wire                            |
| 2     | 01       | School square                                             |
| 3     | 01       | Drilling machine                                          |
| 4     | 01       | Sandpaper                                                 |
| 5     | 01       | Spirit level                                              |
| 6     | 08       | bolt with butterfly nut                                   |
| 7     | 02       | 0.5 m slats                                               |
| 8     | 02       | 1.5 m slats                                               |
| 9     | 02       | Slats of 2 m or proportional to the ground                |
| 10    | 01       | Handsaw                                                   |

Source: elaborated by the author
2nd Step: With the nail and the hammer a hole was made at the end of each mark to cross the can with the bicycle spoke.

3rd Step: The photocopy of the transferred one was glued exactly in the center of the plywood, then the adhesive plastic was inserted over the gluing.

4th Step: The can was placed on the base made and nailed in the center of the protractor the broom handle.

- Operation

1st: From the levelling of the table with bubble level on each side, the can pantometer was fixed.

2nd Step: The target and the 0º of the protractor were aligned in the desired goal or point.

3rd Step: The angle for the other alignment was determined.

4th Step: The other points were marked by always hiding one goal behind the other so as not to form curves until the marking with the pickets was finished.

- Manufacturing

1st Step: Using the square (Figure 2), the laths are pre-assembled so that all internal angles measure 90º with a distance of 1 m between the horizontal laths, while the corner laths are sawn and adjusted so that the instrument maintains the right angles.

2nd Step: Drill holes have been made in each corner to fit the screws with a washer on each side pressed by the butterfly nut.

3rd Step: At the base above the square in the center the bubble level was fixed with two clamps.

- Operation

1st Step - The pickets that served as level reference for the contour lines were fixed.

2nd Step - One of the legs of the equipment was placed in the reference picket to level the equipment.

3rd Step - After levelling, another picket was placed on the other leg of the equipment that served as a reference for the other levelling of the equipment.

![Fig. 2. Level curve set-square in shape of beam.](image)

*Level curve set-square in shape of “A”*

- Materials and Tools
Table 4. Materials and tools used in making the "A" shape contour line

| Items | Quantity | Materials e Tools |
|-------|----------|-------------------|
| 1     | -        | Cimento 100 g ou gesso 200 g |
| 2     | 01       | Set-square |
| 3     | 01       | 1,5 m Nylon wire |
| 4     | 01       | Drilling machine |
| 5     | 01       | 200g tin |
| 6     | 01       | Papersand |
| 7     | 03       | bolt with butterfly nut |
| 8     | 03       | 1,4 m slats |
| 9     | 01       | Handsaw |

Source: elaborated by the author

- Manufacturing

1st Step - The slats were pre-assembled where the two largest were on the sides and the smallest on the horizontal forming an "A" (Figure 3).

2nd Step: Three holes were made, using the drill, in each corner to fit the screws with a washer on each side pressed by the butterfly nut.

3rd Step: The nylon wire was tied to the nail and the screw fixed to the can with cement to then calibrate the instrument.

- Operation

1st Step - The pickets that served as level reference for the contour lines were fixed.

2nd Step - One of the legs of the equipment was placed on the reference picket to level the equipment.

3rd Step - After levelling, another picket was placed on the other leg of the equipment that served as a reference for the other levelling of the equipment.

1st Step - The pickets that served as level reference for the contour lines were fixed.

Fig. 3. Operation of the "A" shape set-square

Rubber level

- Materials and Tools
### Table 5. Materials and tools used in the making of the rubber level

| Items | Quantity | Materials and Tools                   |
|-------|----------|---------------------------------------|
| 1     | 01       | Funnel                                |
| 2     | 10       | Fence clamps                          |
| 3     | 01       | Papersand                              |
| 4     | 01       | 10 m Transparent hose                 |
| 5     | 01       | Permanent marker brush                |
| 6     | 02       | 2 m slats                             |
| 7     | 01       | Measuring tape                        |

Source: elaborated by the author

- **Manufacturing**

  1st Step - The center of the lath length was determined and marked with the brush. The hose was placed over the mark to staple it along the length of the piece, being the distance from one staple to another of 10 cm. The hose had to be about 3 to 5 cm passing in the top of each lath.

  2nd Step - With the help of the trena made marks to each long centimeter of the pieces, making the zero coincide with the inferior part of the piece.

  3rd Step - The hose was filled with water, with the help of the funnel.

- **Operation**

  1st Step - The picket was fixed as a level reference to draw the topographic profile.

  2nd Step - One of the legs of the equipment (Figure 4) was placed on the picket to draw the desired profile. The other leg of the equipment served as a reference for the other movement of the equipment.

  3rd Step - The heights of the hose were noted according to the position of the water and the horizontal distance between the slats was also recorded using the tape measure.

- **Calculation**

  To calculate the slope of the terrain the difference between the water level reading of the lowest part (Li) and the level of the highest part (Ls) was made, thus obtaining the distance travelled in the vertical plane (EV) dividing the vertical distance by the horizontal (EH) and multiplying by 100 the percentage of the slope of the terrain (D%) was found (Figure 5).
Fig. 5. Schematic representation of the Triangle formed with rubber level

![Diagram of a triangle with labels DH, DV, and D%]

Equation I - calculation of vertical distance
\[ DV = Li - Ls \] (I)

Equation II - Calculation of slope
\[ D\% = \frac{DV}{DH} \times 100 \] (II)

Homemade theodolite

- Materials and Tools

| Items | Quantity | Materials and Tools |
|-------|----------|---------------------|
| 1     | 01       | 20 mm diameter and 10 cm long pipe |
| 2     | 03       | 20 mm diameter and 1 m long pipe |
| 3     | 03       | 25 mm diameter and 1 m long pipe |
| 4     | 01       | 40 mm diameter and 11 cm long pipe |
| 5     | 02       | Plywood circle 15 cm diameter |
| 6     | 02       | Plywood circle 21 cm in diameter |
| 7     | 02       | Plywood circle 24 cm diameter |
| 8     | 01       | Wooden glue |
| 9     | 01       | Stick glue |
| 10    | 01       | super bonder glue |
| 11    | 01       | Set-square |
| 12    | 02       | 21 cm diameter protractor photocopy |
| 13    | 01       | Drilling machine |
| 14    | 02       | Type C clip for woodworkers |
| 15    | 01       | Papersand |
| 16    | 01       | Hammer |
| 17    | 02       | Spirit level |
| 18    | 01       | 7 mm long screw with butterfly nut and 4 washers |
| 19    | 03       | Hexagon bolts with nut |
| 20    | 02       | 25 x 25 cm Piece of transparent adhesive plastic |
| 21    | 01       | 30 cm Slat |
| 22    | 01       | Permanent marker bush |
| 23    | 03       | Headless nail |
| 24    | 01       | Bicycle spoke |
| 25    | 01       | 30 cm rule |
| 26    | 01       | Hole saw for drill 20 mm |
| 27    | 01       | Jigsaw |
| 28    | 01       | Handsaw |
| 29    | 01       | Sewing scissors |
| 30    | 01       | Protractor |

Source: elaborated by the author

- Manufacturing

1st Step: The photocopies of the protractors were glued on the plywood circles of 21 cm in diameter and then plasticised and drilled in the centre of both, with the 21 cm drill bit proportional to the screw diameter and the other circle with the cup saw.
2nd Step: With the help of the cup saw an opening was made crossing in the center the circle of 15 cm of diameter, to then glue in the other piece of the same size and to fit in the hole the pipe of 20 mm of diameter and 10 cm of length. The Type C Clamp was used to hold the pieces together until the glue dried.

3rd Step: The piece of lath 30 cm was nailed over the circle of 15 cm, so as not to be over the hole where the pipe was placed, and 1.5 cm below the upper edge of the lath a hole was made, the screw was fitted with a washer on both sides and the plywood circle of 21 cm in diameter was placed to finally fit the pipe of 11 cm in length.

Step four: The 40 mm diameter and 11 cm long pipe was precisely marked with four parallel longitudinal straight lines forming four right angles in the center, the center of the pipe was drilled to cross with the screw, and at the front end it was drilled to fit the bicycle spoke, at the top of the 40 mm pipe a level of bubble plastic was placed, and finally the 20 mm pipe was fitted into the hole of the 21 cm diameter circle.

5th Step: To support the theodolite, a tripod was made where each leg was built by introducing the 20 mm pipe of 1 m long, in the other 25 mm pipe of the same size. A hole was made in the extremities of the 25 mm pipes and in the inferior part, a nut was fixed with super bonder glue to screw in the screw that served to regulate the height of the legs.

6th Step: To fit the legs of the tripod in the plywood of 24 cm in diameter, three openings were made, where the nails without head were placed in each pipe at the top and then a plywood circle was glued in the other.

- Operation: Altimetric survey

1st Step - The equipment was centralized to then level it.

2nd Step - The determination of the points to be measured was made (Figure 6).

3rd Step - The distance of the equipment to the chosen point was measured.

4th Step - The angle was determined through the target on the equipment to the chosen point and then perform the calculations.

Fig. 6. Schematic representation of the Triangle formed with rubber level

- Calculation for determining the vertical distance

To find out the height of an installation, simply measure the distance between it and the theodolite, then zero the instrument at the bottom and run to the top to get the vertical angle.

Equation III - Calculating the height from a side and a known angle of the rectangle.

\[ \tan \alpha = \frac{h}{d} \]

- Calculation for determining the vertical distance

1st Step - The equipment was centralized to then level it.

2nd Step - The points of the terrain were determined through pickets to begin the survey of the
angles and distances of the terrain. The distances were obtained using the tape measure and the internal angles formed between the pickets were determined with the horizontal measurement of the homemade theodolite, making the alignment of the target and the 0° of the protractor in the desired goal or point.

3rd Step - After zeroing, the entire survey was carried out to then calculate the area (Figure 7).

![Image](image_url)

**Fig. 7.** Planimetry work with homemade theodolite rubber level

- Calculation for determining the vertical distance

To discover the area of the polygon (Figure 12) obtained through the planimetric survey, it was necessary to decompose the drawing into three triangles in order to calculate the area of each one in this way, the result of the sum of the areas of the triangles coincides with the area of the polygon.

![Image](image_url)

**Fig. 8.** Field sketch Planimetry
Fig. 9. Terrain decomposition into triangles

Step one: We used the equation to determine the triangle areas and the equation to determine the missing side.

Equation IV - Calculation of the area of triangles I and II

\[ A = \frac{a \times b \times (\sin \alpha)}{2} \]  \hspace{1cm} (IV)

Replacing the terms in equation IV one has:

\[ \text{ATI} = \frac{20 \times 25 \times (\sin 98^\circ)}{2} = 247.5 \text{m}^2 \]

\[ \text{ATII} = \frac{45 \times 50 \times (\sin 90^\circ)}{2} = 1225 \text{m}^2 \]

Equation V - Calculation of the missing side in triangles I and II

\[ c^2 = a^2 + b^2 - 2 \times a \times b \times (\cos \alpha) \]  \hspace{1cm} (V)

Replacing the terms in equation V you have:

\[ \text{Ic}^2 = 20^2 + 25^2 - 2 \times 20 \times 25 \times (\cos 98^\circ) = 784 \text{m} \]

\[ \text{IIc}^2 = 45^2 + 50^2 - 2 \times 45 \times 50 \times (\cos 90^\circ) = 67.2 \text{m} \]
Step two: The equation for determining the triangle III semiperimeter and the equation for determining the area were used

Equation VI - Calculation of the semiperimeter

\[ S = \frac{(a+b+c)}{2} \]  

\[(VI)\]

Therefore, replacing the terms in equation VI one has:

\[ S = \frac{(784+67.2+40)}{2} = 445.6 \text{m} \]

Equation VII - Calculating the area of triangle III

\[ \text{ATIII}^2 = S \times (S-a) \times (S-b) \times (S-c) \]  

\[(VII)\]

Replacing the terms in equation VII one has:

\[ \text{ATIII}^2 = 445.6 \times 445.2 \times 67.2 \times 40 = 152,129.1 \text{m}^2 \]

3rd Step: The areas of triangles I, II and III were added together to obtain the area of the land.

Equation VIII - Calculating the area of the polygon

(Figure 13)

\[ A = \text{ATI} + \text{ATII} + \text{ATIII} \]  

\[(VIII)\]

- Replacing the terms in equation VIII one has:

\[ A = 247.5 + 1,225 + 152,129.1 = 153,601.6 \text{m}^2 \text{ or } 15.3 \text{ha} \]

Results and Discussion

The data obtained with the analysis of variance point to significant differences in relation to the results obtained from the knowledge test applied at the beginning and end of the project in Conceição do Meio (Table 7) and Grotões (Table 8).

| Table 7. Analysis of variance in the learning tests of the students at Conceição do Meio |
|---|---|---|---|---|---|
| | FV | GL | SQ | QM | Fc |
| Pr > Fc | | | | | |
| TEST | 1 | 23653.125000 | 23653.125000 | 82.093000 |
| Mistake | 30 | 8643.750000 | 288.125000 |
| Corrected total | 31 | 32296.875000 |
| CV (%) | 34.16 |
| General average | 49.6875000 | Number of observations | 32 |

| Table 8. Analysis of variance in the learning tests of students at Grotões |
|---|---|---|---|---|---|
| | FV | GL | SQ | QM | Fc |
| Pr > Fc | | | | | |
| TEST | 1 | 6806.250000 | 6806.250000 | 21.000000 |
| Mistake | 14 | 4537.500000 | 324.107143 |
| Corrected total | 15 | 11343.750000 |
| CV (%) | 33.89 |
| General average | 53.1250000 | Number of observations | 16 |

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Tukey’s test proves that there was an improvement in student learning in the class of Conceição do Meio and Grotões when comparing the test scores applied at the beginning and after the activities developed, it can be seen that there was an increase in learning of 54.37% in Conceição do Meio (Figure 13) and 41.25% in Grotões (Figure 14).

Comparing this work with the one developed by Silva (2004) topography has a great potential to leverage the learning of trigonometry and other curricular components.

Due to its practical character (Miná and Neto, 2008) it mobilizes several areas of knowledge to have data about the field in order to use it in a sustainable way. By making and using the various alternative topographic equipment it is proven that students are in fact quite effective in using mathematics in everyday life, but have difficulty in dealing with more
abstract situations (Carraher, 2001; Carraher and Schilemann, 2001).

EJA Campo students’ opinion on the experience of the project. According to the panel interview conducted with students from EJA Campo de Grotões and Conceição do Meio, one can see their opinion on the contributions of the topography project to mathematics learning and rural work. According to the students, the experience of the project has contributed to "learning trigonometry and facilitating calculations, making math easier and more useful in practice.

Through the methodology used in the project, it is possible to break the paradigm that keeps the contents taught in school away from concrete reality, facilitating the construction of trigonometry concepts in the face of the challenges proposed by topography. The students were satisfied and demonstrated the need to work in a precise way, saving time and inputs by exposing that "you must make a straight fence and not a crooked one, because it spends more barbed wire”.

The area survey work, with the use of the equipment, awakened in the students the need to value and know their own land, the result of years of struggle for land reform. The students recognized the importance of making sustainable use of natural resources as they used scrap material to make topographic equipment. The equipment, in addition to measuring, is used to "conserve the soil, make better use of rainwater on plantations and make vegetable gardens.

**Conclusion**

From the data obtained from the experience of the project, it was realized that it was possible to contribute significantly to the learning of mathematics by EJA students, thus helping in the understanding of trigonometry, units of measurement and in the performance of calculations.

With this work it was possible to develop a new teaching methodology in mathematics, proving its effectiveness based on the results of the knowledge tests that measured the students’ performance.

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**References**

Aranha, M. L. de A. 1997. Filosofia da Educação. São Paulo Moderna
Caldart, R.S.; Pereira, I. B.; Alentejano, P.; Frigotto, G. 2012. Dicionário da educação do campo. 2.ed. São Paulo: Expressão Popular, 2012.
Carraher, T.; Carraher, D.; Schilemann, A. L. 2001. Na Vida Dez, na Escola Zero. 12. ed. São Paulo: Cortez Freire, P. 1996. Pedagogia da autonomia: saberes necessários a prática educativa. 25 ed. São Paulo: Paz e Terra
Marconi, M.de A; Lakatos, E.M.. 2007. Fundamentos da Metodologia científica. 6. ed. São Paulo: Atlas
Miná, A. J. S.; Neto, J. S. P. 2008. Manufatura de equipamentos topográficos alternativos para simples trabalhos topográficos agrícolas. Bananeiras
Silva, J. J. da. Topografia: Um incentivo para o estudo de trigonometria. 2004. 12 p. Projeto de Pesquisa (Análise e Avaliação do Rendimento Acadêmico) – Curso de Licenciatura Plena em Matemática das Faculdades Integradas de Vitória de Santo Antão do Estado de Pernambuco
Silva, B.B.; Campos, S.; Ribeiro, N.C. 2013. Identidades da EJA : Conquistas, Desafios e Estratégias de Lutas. Disponível em: <http://www.seduc.mt.gov.br/Paginas/Identidades-da-EJA-Desafios-e-Estrat%C3%A9gias-de-Lutas.aspx>. Acesso em: 1 de fevereiro de 2017.