A MATH TRAIL EXPERIENCE: CONNECTING MATHEMATICS AND HISTORY

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Abstract

Many view mathematics as an uninteresting and an abstract subject; unable to see connections between mathematics and the real world. This presentation shows the experience of the author and some in-service teachers examining how mathematics can be made interesting and relevant by exploring the relationship between mathematics and history. A field trip was conducted with the teachers to Penang Fort Cornwallis and many interesting mathematical and historical events evolved through this excursion.

Keywords: math trail; trigonometry; history

Introduction

Math Trail: What? Why?

The Math Trail concept used in schools for the teaching and learning of mathematics can be traced back to the late Eighties and early Nineties. The Math Trail activities involve students carrying out an expedition to explore certain situations and attempt to find the relevance of mathematics concepts to real-life activities. Thus, math trails provide opportunities for students to apply mathematics concepts they learn through creation of problems based on what they have learned and at the same time provide solutions the problems created. Through the activities, they extend their learning from books to real life situations and which enabled them to see connections between mathematical concepts and nature.

According to Toliver (2011), the responsibility of teachers is not just to develop mathematical skills but also to prepare them to be able to use these skills in life. The math trail is an exciting way to achieve this objective. Educationists and theorists always remark that passive learning always dulls the child whereas active learning helps the child construct mathematical ideas. Math trail is an interesting way to help the child construct mathematical ideas through a fun way and the activities encourage them to apply mathematics in real life situations.

In-Service Teachers from Acheh, Indonesia

A customised course, "Professional Development Programme for Indonesian (Acheh) Secondary Mathematics Educators" was conducted at the Regional Centre for Education in Science and Mathematics (RECSAM). There were 21 participants at the beginning of the course but due to some personal reasons 3 of them left for home earlier. In the end, 19 participants completed this course. All teachers who attended the course were secondary in-service teachers who had a wide range of experience in teaching secondary mathematics.

In view of some development in theory, research and practice in the teaching and learning of Mathematics at secondary level, the course was intended to enhance the skills and concepts of teaching secondary mathematics and to provide various thinking skills, motivation and

interest to secondary mathematics teachers from Acheh. One of the pedagogical topics, which was selected for this course, is the Math Trail, which has relevance to the current trend to enable students see connections between mathematics and real life situations. The discussion on learning through real life has been on for many decades. It is still being emphasised in the 21st century. One of the objectives of the programme was to enable participants to recall and realise the importance of the application of knowledge learned to real life situations. This was achieved by introducing to the teachers a Math Trail excursion where they experienced mathematics in a real life situation.

Methods

A field trip was organized to give participants an opportunity to relate mathematics and history. For decades, most educators talked about connection between Maths and the Sciences but there was very little on History connected to Maths. The purpose of this field trip was to provide some insight in developing some links between Maths and History. The site at Penang Fort Cornwallis was chosen because of its historical past. Before the trip, workshops were conducted to a group of in-service teachers (a) to help them realise the objective of the field trip and (b) to prepare some instruments which they may require to take measurements in carrying out their tasks.

Pre Math Trail Activities

A workshop was conducted at RECSAM to help the group of 21 participants to develop a low cost measuring instrument, a clinometer. Before the construction of the instrument, teachers were briefed on the general purpose of the instrument. A more detailed discussion on the use of the instrument was carried out after the instrument was made by each group of the participants.

Some class activities are shown below:

Testing a Clinometer

Cutting out a Clinometer

Cooperative Working

Ready for Use

After they have completed making the clinometers, the author posted two questions to the participants: (1) if a tree is very tall, how would you find its height?
(2) How would you find the width of a river?

The participants broke into groups and attempted to measure the height of the tree and the width of the river in a simulated situation.

Data Collection at Penang Fort Cornwallis

The following is an example of how participants collected some measurements at the site and related history with mathematics.

Example 1
A group of participants attempted to measure the height of the fort wall and the width of the moat that surrounded the fort. Historically, the defender would have planned to build the wall and the moat as a defence against his enemies. This is the connection between history and mathematics in this context.

Entrance to
Fort Cornwallis, Penang

Wall of the Fort Cornwallis

How high is this wall?
Why should we want to find the height?

Moat of the Fort Cornwallis
Acheh Group 2 is examining the width of the moat.
What do you think they are doing?

Example 2

The author also walked round the fort to inspect if any structures of the fort could be related to mathematics. These are some pictures taken of different structures in the fort and insight derived in relation to mathematics learning.

Inner view of the Fort

What is the width of the field?

What is the ratio of the height to the width of the building?

Inner Fort Field

How large is this area?

A group member is estimating the area.

Slope to the top of the defending wall
What is the slope length?
How much soil is needed to fill up this tiny hill?

Chapel
How high is the door?
From this we can predict how tall Corn Wallis is.
How high is the chapel?

Reports of Participants' Work

There were four groups of participants taking part in the activity. They were briefed after the math trail on the format of their reports. The following is what was required from them: (a) introducing the problem, (b) objectives, (c) planning, (d) preparation for try-out, (e) data collection and solution to the problem. One example of their work is attached as an Appendix.

Conclusion

The objective of this paper is to describe an activity that was carried out in an in-service course to provide participants with ideas of connecting mathematics concept with real life environment. The author paved the way for participants to understand the concept of a math trail followed by activities carried out in a historical site. Students always conceptualised

connections between Maths and the Sciences but this paper attempts to explore beyond the expectations of students who have this misconception. The activities carried out at Penang Fort Cornwallis showed that Mathematics is closely linked to History in certain aspect. The report by one of the four groups linked very well Mathematics with History on the building of the wall, bridge and moat of the castle. The objective of the activity is achieved in the sense that the participants have taken action to investigate mathematics and history through this expedition and manage to link mathematics and historical event. The link between the activity and the report by the participants shows the achievement of the participants and the objective of the programme. This paper may invoke further interest in this area of teaching and learning mathematics.

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Appendix

A Brief Math Trail Report by Abdul Razak, Darmawati Kaoy, Intan Illyani, Mami Hastuli Sulano and Riewan from Acheh

Introducing the Problems

Fort Cornwallis was a fort built by the British Empire in 1786 in Penang. The goal of building this fort was to provide protection of the English government against enemy attack. The fort was surrounded by thick and tall walls. A moat was built all around the fort and filled with water and mines to keep enemy attacks against the fortress. In addition to the moat, there were several mines built some distance away from the moat.

Assuming a group of enemy soldiers was trying to occupy the fort at that time, what were the obstacles that were likely to happen to inhibit them from attacking? If the group of enemy soldiers decided to attack the fort, what preparations did they need beforehand? The likely preparations were to make some ladders tall enough to climb the walls and a bridge long enough to cross the river. In order to build the ladders and bridge, they need to take some measurements followed by calculations to make the ladders and bridge.

The Tasks

It appears that in order to reach the inner part of the fort, the immediate tasks were to calculate

1. the width of the moat that surrounds the fort
2. the height of the fort wall
3. the minimum length of bridge

Planning for the Activity

(a) Discussion was made among the group members to determine the calculations required to complete the tasks identified above. Mathematical concepts and skills required for the tasks identified were as follows:

- Trigonometry: Comparison of trigonometry ratios in Right Triangle (Sine, Cosine and Tangent).

  $\sin C = \frac{AB}{AC}$ $\cos C = \frac{BC}{AC}$ $\tan C = \frac{AB}{BC}$
- Pythagoras Theorem.

  $AC^2 = AB^2 + BC^2$

(b) During the class workshops, an instrument was prepared for measuring angles and a simulation procedure was used to work out the problems.

1. Preparation of tools:

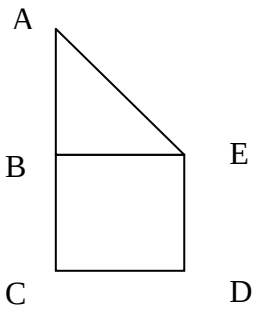
Created a simple clinometer from thick cardboard and paper with a picture of a protractor;

Used a ready-made meter rule;

Used a calculator;

Some stationery;

2. Identifying measurements to be taken:
   Specifying the object to be measured (the pole).
3. Measuring the distance between the eye and the top of the pole in meter (595 cm).
4. Measuring the height of the pole in meter (100 cm).
5. Measuring the angle of elevation angle of the top of the door using a clinometer (14^0)
6. Calculating the height of the door.



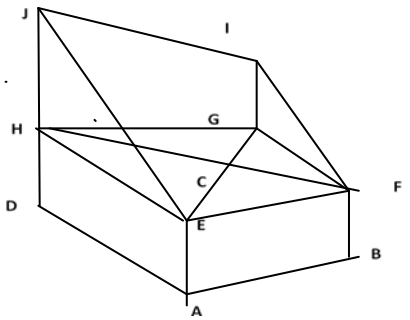
$$CA = DE + BE \cdot \tan BEA$$
$$CA = 100 + 595 \cdot \tan 14^0$$
$$CA = 248.2719$$

7. Measuring the height of the door in meter (232 cm).
8. Calculating error.

$$error = \frac{|Measured - Calculated|}{Measured} \cdot 100\%$$
$$error = \frac{|232 - 248.2719|}{232} \cdot 100\%$$
$$error = 7.01\%$$

Actual Calculation at Field Trip

Problem solving involved 3 phases:
1. Planning to solve the problem (Polya's Phase 1)
   - Making a sketch and decide what to measure



   - Measure the length AB (612 cm).
   - Measure the length AE and BF (should be the same length) (120 cm).

- Measure the angle EFH (60^0) .
- Measure the angle HEJ (12^0).

2. Carrying It Out (Polya's Phase 2)
   - Calculated EH used tangent definition.
     $EH = EF \cdot \tan EFH$
     $EH = 612 \cdot \tan 60^0$
     $EH = 1065.2122\ cm$
   - Calculate HJ used tangent definition.
     $HJ = EH \cdot \tan HEJ$
     $HJ = 1065.2122 \cdot \tan 12^0$
     $HJ = 226.4176\ cm$
   - Calculate DJ used addition.
     $DJ = DH + HJ$
     $DJ = 120 + 226.4176$
     $DJ = 346.4176$
   - Calculate AJ used Phytagoras theorem.
     $AJ = \sqrt{AD^2 + DJ^2}$
     $AJ = \sqrt{(1065.2122)^2 + (346.4176)^2}$
     $AJ = 1120.1250\ cm$

3. Interpret the results
   - The width of the area around the fort, which avoided (the location of mines and moat), is 1065.2122 cm.
   - The height of the wall fort is 346.4176 cm.
   - The minimum length of bridge is 1120.1250 cm.
   - Significance level is 92.99 %.