Strategies in Maximizing the Use of Existing Technology in Philippine Schools

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Abstract: One of the challenges that continue to confront teachers in Philippine schools is the accessibility of technology for the study and learning of mathematics. In this paper, we will look at several situations and actual experiences happening in Philippine schools. Strategies on how existing technological tools are to be maximized will be discussed, including the creation of lesson plans and classroom activities. The use of technology-based manipulatives in mathematics learning as alternatives to unavailable technology will also be looked at.

1. Introduction

There is an increasing importance of using technology in the teaching and learning of mathematics. It allows students to explore and discover concepts and it has the potential of extending the mathematics that can be taught. However, Philippine schools do not have access to some of these technologies. We classify these situations into four constraints. The first one is having Internet access. The second is having a computer without Internet. Third, there are also situations where computers are not available at all. Finally, we discuss the scenario where technology is available, but in very limited numbers. For each situation, we provide suggestions to use the available technology efficiently and to devise materials that could be alternatives to unavailable technology.

2. Using the Internet

Some schools have computers with internet access but some use it primarily for obtaining data or using email. However, the internet also provides several ways to enhance mathematics teaching and learning. It allows both teachers and students to access interactive resources, curriculum materials, and real-world data [3]. One important way by which the Internet can enhance mathematics learning is through interactive applications. A good example of this is the Mathsnet website (www.mathsnet.net). Created by Bryan Dye of Norfolk, England, this project is a source of free interactive math resources aimed at providing an enjoyable learning environment. Further, the applications require the user to fully participate, and not just be a passive viewer. The website includes an Interactive Construction Course where students use interactive figures to do geometric constructions (See Figure 1.1). Students may use their tools incorrectly in doing actual compass and straightedge constructions. The interactive course, however, allows students to do precise constructions. There are different levels of difficulty to cater to individual needs. Another advantage is that the applet allows the students to move the original figure and view their own constructions in a dynamic environment. Students can see more clearly the role of these constructions in their own geometric proofs.

Another way by which the internet could be used is through the curriculum materials that it provides [3]. Materials could be found on the teaching and learning of mathematics for all levels. Lesson plans, as well as teaching strategies are available and could be revised to adapt to the Philippine setting. One example would be the lesson plans developed by through the Rational Number Project (http://education.umn.edu/rationalnumberproject/). It is widely recognized that children in Philippine schools have difficulty in learning fractions. The course materials produced

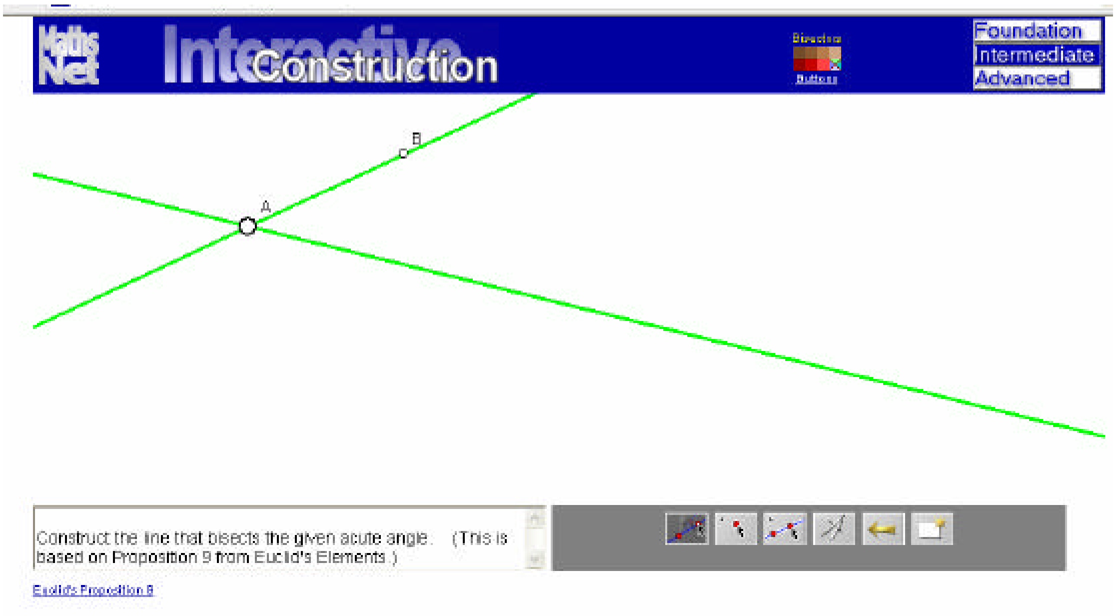


Figure 2.1 Doing Geometric Constructions on the Internet
(http://www.mathsnet.net/campus/construction/ibb4.html)

by this project are the result of a long-term research on how children learn fractions, decimals, and proportionality, and were made accessible over the internet.

3. Using Free Software Packages

Another problem faced by teachers in Philippine schools is the unavailability of some software packages. Fortunately, the internet provides access to a number of shareware applications. Some of these programs are executable files and can be copied directly from one computer to another. Sharing them becomes even more convenient since no installation is required. Thus, even computers without internet access could have copies of these programs. One such resource is Wingeom (795 Kb), which can be downloaded for free from the Peanut Software Homepage (http://math.exeter.edu/rparris/). The program was developed by Rick Parris of Phillips Exeter Academy in New Hampshire. One example of how the program can be used is through investigating the analytic geometry of the parabola (See Figure 3.1). Another possibility is the

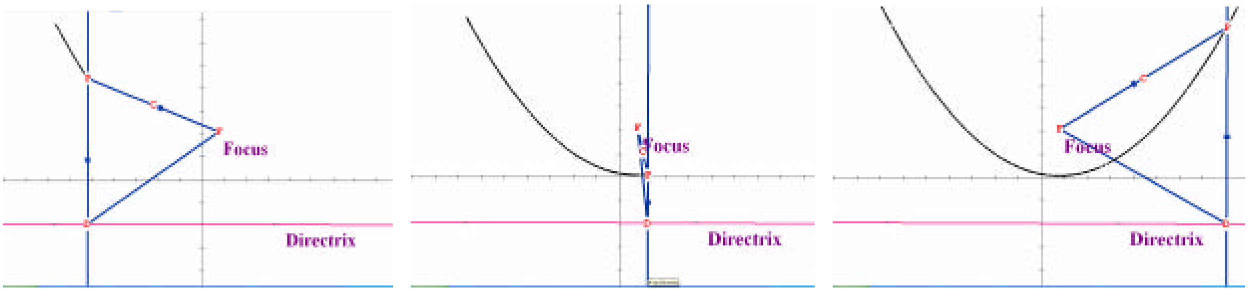


Figure 3.1 An Animation of the Locus of All Points Equidistant from a fixed point and a fixed line.

exploration of geometric art (See Figure 3.2). This is a Geometer's Sketchpad (GSP) project suggested in [8]. However, Wingeom could be used to perform this GSP project. Concepts related to the construction of such designs could then be analyzed. The same website by Parris is also a source of programs catered to Algebra, Discrete Mathematics, Linear Algebra, and Statistics.

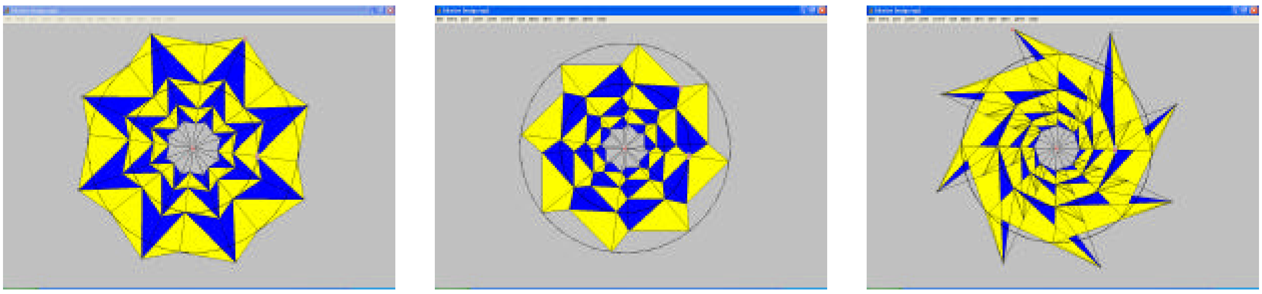


Figure 3.2 An Animation of Different Possible Designs Obtained by Dragging Vertices.

Another free software package is GRAPES, which was developed by Japanese mathematics teachers (http://www.criced.tsukuba.ac.jp/grapes/). This program has already been translated to English and Spanish. The program could be used to analyze how the derivative of a function is related to the function itself (See Figure 3.3).

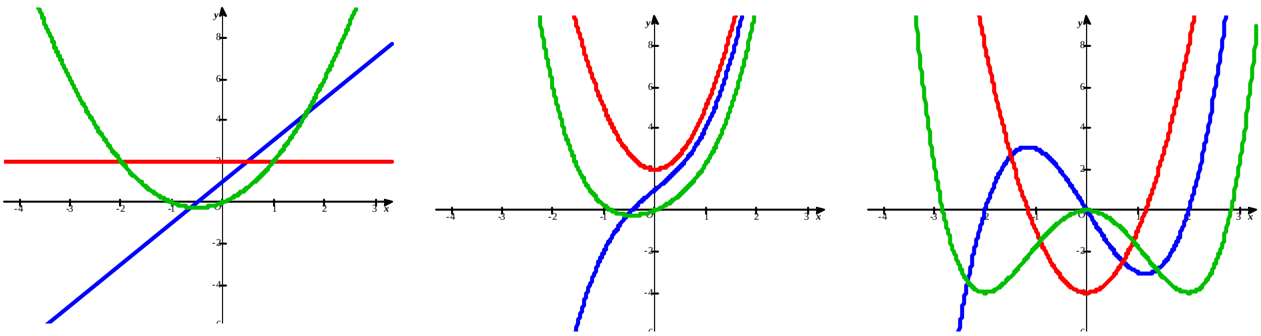


Figure 3.3 An Animation of a Function and its First and Second Derivatives

These free software packages are not exactly the same as commercial ones, though. For instance, some features in Geometer's Sketchpad, such as creating buttons, are not in Wingeom. The user interface of Wingeom is also simpler and less eye-catching than a commercial package. GRAPES, meanwhile is mostly a tool for graphing, and it cannot show ideas in geometry. However, by learning what a free software package can and cannot do helps the teacher come up with suitable activities for the classroom. It is also advised that teachers try to find free software packages which have features which are not present in the free software currently used. Thus, even if a free software package lacks certain features, it is still possible that some other program would carry that missing feature.

4. Using Technology-Based Manipulatives and Non-Graphic Calculators

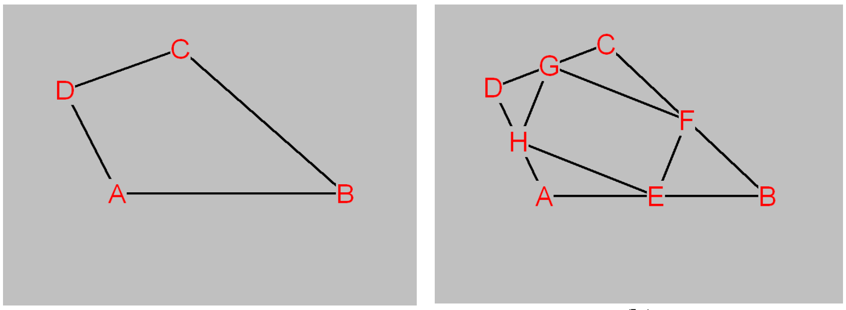
With the advent of newer and more advanced tools and software, one may not see much importance in the ordinary four-function and the scientific calculator. However, it these are still tools which further mathematical thinking and learning. Even though it cannot show a graphical representation, it still has numeric capabilities which could facilitate discussions and group work. These capabilities can be used to the fullest if the teacher has a good grasp of how the tool works.

One activity that utilizes the scientific calculator would be an analysis of real-world data using regression analysis. Students could be asked to make a survey on a relevant and interesting topic. Data gathered could be studied using regression analysis. There are also times when solutions to equations cannot be obtained feasibly by hand. Scientific calculators which can compute roots can then be used. Students get a feel for real-world problems which almost certainly would not result in equations with "clean" solutions. Another topic which can be discussed with the aid of a scientific calculators would be series. For instance, one can see numerically that an infinite series could yield a finite sum while an approximation for the number *e* using Taylor's Formula, gives the expected, yet amazing, result.

In fact, several studies, such as [7] illustrate the many benefits of a non-graphic calculator, even in primary school. Rather than spending a considerable amount of time drilling students on adding numbers, students may use calculators to explore patterns, and to develop skills such as estimation and analysis. Students then have more time to comprehend the problem, allowing them to be more involved in the problem-solving process. Whereas students sometimes answer questions by just guessing the arithmetic operation needed, calculators would give the teacher and the students more time to discuss the ideas and concepts behind the problem-solving task. Calculators would also allow students to explore patterns since students save a lot of time doing computational work and could thus focus more on recognizing existing patterns. Needless to say, appropriate changes must be made in the curriculum to implement the use of calculators even in lower elementary grades. The important thing is to realize that the calculators can be used not only to provide instant results, but they can be used to learn mathematical concepts. It is just a matter of learning how to make lesson plans which give students this opportunity. Traditionally, students may use pencil-and-paper computations to solve percents. Now, they may use calculators to investigate underlying concepts, such as, what happens if a number is repeatedly reduced to 75%. These investigations introduces more elaborate mathematics, such as exponential decay and limits, even though the topic involves elementary arithmetic.

If there is no accessible computer at all, some activities performed using dynamic geometry software could still be replicated using concrete models which can easily made at home. In particular, we construct manipulatives out of ordinary cardboard and pins.

Let us consider the following example, performed using dynamic geometry software. Construct a kite *ABCD* (See Figure 4.1(a)). Connect the midpoints of each side to construct a new quadrilateral, which we call the Midpoint Quadrilateral (See Figure 4.1(b)).



(a) (b)

Figure 4.1 A Kite and the Quadrilateral Formed
by Joining the Midpoints of its Four Sides.

Using the drag mode, students are able to see properties of that for any kite, the midpoint quadrilateral is always a rectangle (See Figure 4.2).

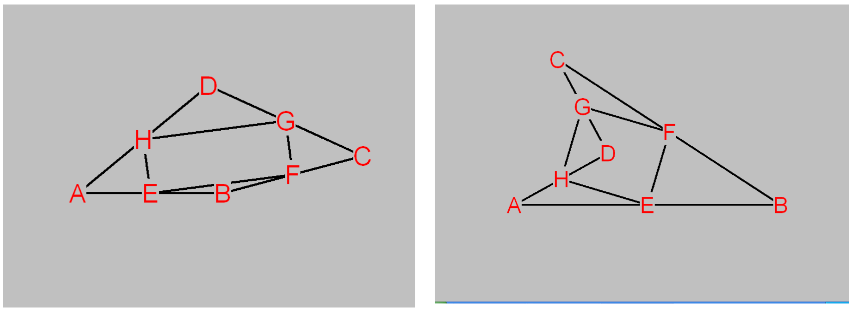


Figure 4.2 The Midpoint Quadrilateral is a Rectangle
for any orientation, and even if the kite is convex.

The same property could be exhibited using easily available materials. Strips of cardboard are used for the sides, while cardboards with a slit in the middle could serve as sliders, used to connect the midpoints. These sliders are created to allow the lengths they represent to vary, as the kite's orientation varies itself. By alternatively pushing and pulling on the kite's vertices, one can see that the midpoint quadrilateral remains rectangular (See Figure 4.3)

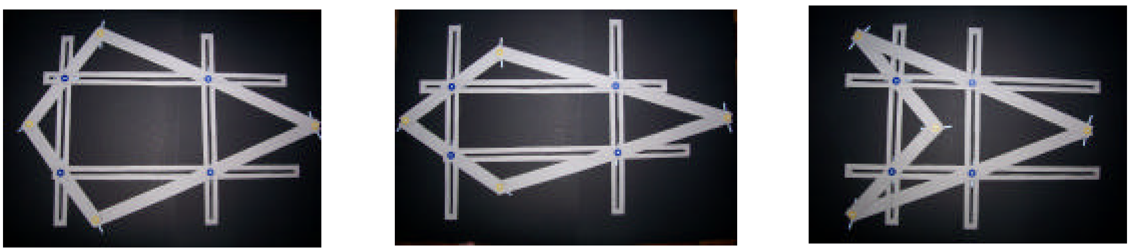
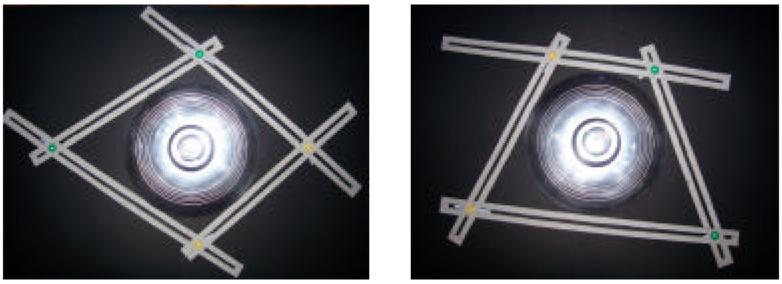


Figure 4.3 The Midpoint Quadrilateral as Seen Using
a Concrete Manipulative.

The sliders themselves could be used to demonstrate some mathematical results. For instance, as suggested by [1], the sliders could be used to lead students to discover some properties of cyclic quadrilaterals. Use the sliders to construct an apparatus similar to Figure 4.4(a). Fit a circular object inside so that the circle is inscribed in the quadrilateral formed by the apparatus (See Figure 4.4(b). Groups of students may perform the activity using different circle sizes. The students should also be instructed to make different quadrilaterals which circumscribe their circles. This experiment would then allow students to form conjectures about cyclic quadrilaterals.



(a) (b)

Figure 4.4 Different Quadrilaterals Circumscribing a Circular Object

It is a challenge, therefore, to think of new instruments to help students visualize geometric concepts. Many more concepts could be shown using some variations on the above tools. It is up to the teacher to come up with inexpensive manipulatives which can show these geometric concepts.

5. Maximizing the Influence of a Limited Number of Computers

We now discuss the case where there are not enough technological tools for each individual student. This subject is treated last since it may be applicable to any of the situations described in Sections 2 to 4. For instance, several suggestions in these sections could be used easily if each student has his own computer or if not, then at least there should be one computer equipped with a video display. However, this is not always the case. Very often, not all students could use the tools simultaneously, while some schools do not have an LCD or even an overhead projector. In this section, we suggest ways by which to work out the problem.

For simplicity, let us consider the case where there are only five graphing calculators in a classroom of 50 students. It has been recommended by Alejandre [2], that the calculators could be used as one of the stations within a menu of stations. This is a technique wherein several areas are set up in the classroom, with each area having its own set of tasks or instructions to be completed by a group of students. Thus, in a class of 50 students, the chairs could be arranged facing each other in 11 groups of four, and two groups of three. Alejandre also suggested having one or two more areas than there are groups of students so that students could move around once they complete the activity in their station. In our scenario, since there are only five graphing calculators, then only 5 of the stations would be equipped with one. The activities for the rest of the station should be answerable by hand or by some other method.

As an illustration, consider the following activity where students use graphing calculators to learn graphing transformations such as translations and reflections. Some papers exploring the possibility of teaching this topic through art designs are shown in [5] and [6]. Sample designs are shown in Figure 5.1. In these papers, students are tasked to create designs by graphing equations or inequalities. Ideally, each student should have his own graphing calculator so that he can do a design of his own. How can a teacher perform these activities in a classroom with only five graphing calculators?

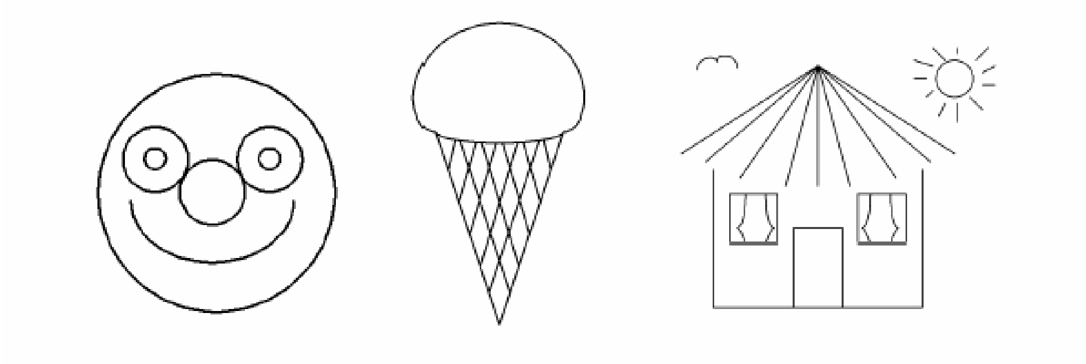


Figure 5.1 Some Designs that Could be Reproduced by Graphing Equations

One option is to divide students into groups of five, and organize several stations within the classroom. All the five calculators should be located on one station. The group assigned to this station would make their own design by graphing equations or inequalities. The other groups could be to assigned to all the other stations, where they would answer some paper-and-pencil tasks regarding transformations. They could also be asked to answer questions about previous topics, for review. One station could also be a recreational math station where students may answer any absorbing math problem. After a pre-specified amount of time, students would be asked to change stations, so that everyone may have a chance to use the graphing calculators.

Another option is to simply divide the class into five groups, with each group having one calculator. Each group would then be asked to create a design, such as a playground. Each member would then divide tasks among themselves. One person could create a slide, another could graph a sandbox, and so on. Collectively, their equations would be used to create a single playground scene. These activities are suitable for primary and secondary school students, depending on which type of graphs are to be used in the designs. Even college-level students could perform these activities when they study polar or parametric equations.

In the previous suggestion, the activity was primarily meant to serve as a way to reinforce a concept. It is also possible that these are used to facilitate mathematical discovery among students. The websites, computer activities, and even the concrete apparatus mentioned above could serve as one of the stations, while the rest of the class are involved in paper-and-pencil work. For instance, if the topic is about quadrilaterals, and there are only five computers (without internet access), then the teacher could load the free software packages beforehand. Each computer station would include tasks related to quadrilaterals that can be easily seen using dynamic geometry software. Each station would also provide students with questions that would lead them to discovering new properties about quadrilaterals. A number of other stations could have concrete models that could show other concepts on quadrilaterals. If a graphing calculator is available, then it could also be included as one of the stations. A good starting point in organizing these types of activities would be the Multicultural Math Fair website (http://.mathforum.org/alejandre/mathfair/index.html), again suggested in [2].

Back to the original scenario where there are five graphing calculators, it is also possible to use these to help students check their work. For instance, groups of students may be asked to solve limits on their seats and verify their answers using the graphing calculator. In this case, students make use of the graphing calculator only after solving each question. Since they need only a few minutes to check their solution, the five calculators would be enough for the needs of the entire class. If the lesson were on derivatives, each group of students could be given a graph on paper. Then, as a group, they help each other compute the slopes of the tangent lines at several points, and estimate how the graph of the derivative function would look like. They then verify their answers using the graphing calculators. They may then be asked follow-up questions related to points where a function attains an extreme value, and points where a function becomes non-differentiable.

In fact, a class can benefit from having just one graphing calculator especially if it comes with a projection screen. In this case, the calculator could be used by the teacher to illustrate an example, to help students visualize mathematical concepts, or to facilitate problem-solving which involve non-integer solutions. This also provides an opportunity where a disadvantage could be turned into a benefit. A large student-to-class ratio, primarily thought of as a drawback, would actually take less time to perform simulation experiments. A large number of students would make data-gathering more efficient since several students could perform simultaneous experiments. The activity suggested by Alejandre [2] is to use the computer or graphing calculator to store data gathered by the entire class. For instance, each student could perform experiments on the Monty Hall dilemma, while a pre-specified student could be tasked to encode all data into the available technological tool. Moreover, the data and the interpolated function could easily be displayed by the spreadsheet as students interpret and analyze their results. This is one way of turning a disadvantage into something that benefits the entire group.

6. Concluding Remarks

While it is true not all technological tools may be available in Philippine schools, it is also true that teachers could still manage ways to come up with creative and ingenious solutions to such circumstances. This paper could serve as a springboard from which Filipino teachers could build a base on. The important thing is not to focus on what is lacking, but to concentrate on what is available and on what can be done. Students themselves learn to be more resourceful, and to make the most of what they have.

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