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USING ORIGAMI TO TEACH ENGINEERING CURVES

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ABSTRACT

Folding paper and creating different shapes is an art known as Origami. Certain paper models contain hundreds of folds and a few complex models in fact require two or three differently folded shapes to be attached together. Math through Origami is an adventure to see as it literally 'unfolds' before the eyes of the student. This exploration helps to clarify abstract concepts in Math in an enjoyable way. Engineering curriculum specifically of first year Engineering Graphics contains some basic mathematical, geometrical curves such as Ellipse, Parabola, Hyperbola, Cycloids etc. These curves are included in the curriculum of engineering by the objective of introduction to mathematical curves. Students coming to engineering from Non-English schools and colleges find it difficult to understand the geometrical concepts especially mathematical curves mentioned above. Our study specifically highlights the learning dis-ability of the students for the curves and aids the teaching by using origami, paper folding techniques. Also a couple of examples illustrated showing the use of origami to teach Engineering Curves.

KEYWORDS: - Origami, Crease, DGS

INTRODUCTION

Origami is an ancient Chinese and Japanese art of paper folding. From the brief history of the ancient art of paper folding it is evident that Origami gained acceptance in the West in the early 1950s. Very comprehensive bibliographies are available online. Unexpectedly, information available online proved to be scarce. If mathematics & graphics educators and teachers had to choose the single most important principle for the learning of mathematics & graphics, they would probably allude to the importance of “active mathematical experiences.” One intriguing way of adding an element of active experience to a mathematics & graphics class is to fold paper. Forming straight lines by folding creases in a piece of paper is an interesting way of discovering and demonstrating relation- ships among lines and angles.

Once a relationship has been shown by folding paper, formal work on it later does not seem so foreign. Paper folding not only simplifies the learning of mathematics & graphics—it also builds an experiential base necessary for further learning. The concepts and ideas of motion, or transformation, geometry are becoming standard fare for the mathematics & graphics curriculum.

Paper folding offers many opportunities for illustrating these ideas. Folding a paper in half and making the halves coincident is an excellent physical model for a line reflection. The only materials needed for paper-folding is paper, felt pen, straightedge, and scissors. Although any type of paper may be used, waxed paper has a number of advantages: a crease becomes a distinct white line, and the transparency helps students “see” that in folding, lines and points are made coincident by placing one on the other. Although paper folding is easy, it is not always easy to give clear instructions to students either orally or in writing. It is helpful to supplement demonstrations with directions and diagrams.

In mathematics & graphics we always make certain basic assumptions on which we build a structure. In paper folding we assume the following postulates:

-Paper can he folded so that tile crease formed is a straight line.

-Paper can be folded so that the crease passes through one or two given points.

-Paper can be folded so that a point can be made coincident with another point on the same sheet.

-Paper can be folded so that straight lines on the same sheet can be made coincident.

-Line and angles are said to be congruent when they can be made to coincide by folding the Paper.

If these assumptions are accepted, then it is possible to perform all the constructions of plane geometry by folding and creasing.

In the geometry of paper folding, a straight line becomes a crease or a fold. Instead of drawing straight lines, one folds a piece of paper and flattens the crease. Folding paper is analogous to mirroring one half of a plane in a crease. Thus folding means both drawing a crease and mapping one half of a plane onto another. As in the usual Geometry, the distinction is being made between experimentation with the physical paper and the abstract theory of "paper folding". "Abstract paper" may be folded indefinitely although in practice the number of folds is by necessity limited. In the Paper Folding Geometry, a straight line - a fold - is clearly a primary object; a point is defined as the intersection of two folds.

EDUCATIONAL BENEFITS OF ORIGAMI

- Behavioral Skills
- Cooperative Learning
- A Link to Math
- Cognitive Development
- Multi-cultural Awareness
- Community Building

BEHAVIORAL SKILLS:

Origami is an example of "schematic learning through repeatable actions". To be successful, the student must watch closely and listen carefully to specific instructions and then carry them out with neatness and accuracy. Here is a case where a student's success is imposed by the activity rather than the teacher. Like group singing, hand games, and dancing, the pleasure comes in recreating the result and sharing it with others. For many students, it engenders a patience that leads pride in one's work, the ability to focus energy, and increased self-esteem.

COOPERATIVE LEARNING:

Origami is well-suited to working with a classroom of 30 or more students. In a multi-age setting, paper-folding tends to eliminate the status associated with IQ differences; the sharp students are often in a position to teach the not so smart, and it provides an activity that works well when teaming different grade levels. Many teachers report that students, who do no "star" in other places, are often quick to learn origami and help their classmates master the steps.

A LINK TO MATH:

Transforming a flat piece of paper into a three dimensional origami figure is a unique exercise in spatial reasoning. Origami is also important in teaching symmetry; for many of the folds, whatever is done to one side is done to the other. This is, of course, a fundamental algebraic rule that can be shown outside the framework of a formal "math lesson". In addition, paper-folding allows students to create and manipulate basic geometric shapes such as squares, rectangles, and triangles. Also complex shapes such as curves.

COGNITIVE DEVELOPMENT:

Through the actual folding, students use their hands to follow a specific set of steps in sequence, producing a visible result that is at once clever and pleasing. The steps must be performed in a prescribed order to yield a successful outcome - an important lesson not only in math, but in life. Piaget, the renowned student development psychologist, held that "motor activity in the form of skilled movements is vital to the development of intuitive thought and the mental representation of space.

MULTI-CULTURAL AWARENESS:

Rooted in Asia, origami reflects the ingenuity and aesthetics of Japanese culture. By participating, students gain appreciation of a different culture, perhaps opening a doorway to further exploration and increased tolerance.

ADDITIONAL BENEFITS OF ORIGAMI:

Educational Value
a positive learning experience
Stimulation for students
Suitable for people with a learning disability
Develops hand eye co-ordination
a form of communication without language

THERAPEUTIC VALUE:

Promotes a feeling of achievement and well being
Positive social interaction
Can be a bridging therapy
Team building exercise
One can be a participant or observer

SOCIAL VALUE:

A goal setting experience
Share feelings and knowledge
Promotes co-operation and well being
Breaks down barriers
Can be developed as a hobby

PAPER FOLDING VS DGS

Various software's are also available to learn geometry and mathematical curves. Such as Dynamic Geometry Software's (DGS). Paper folding is accessible to students in a way that DGS might not be. While evidence for the use of manipulative is mixed (Sowell, 1989, &Raphael and Ahlstrom, 1989), we might ask whether students introduced to geometric ideas via paper folding will generate better cognitive models than those who commence work on a computer. The engagement of the hands in the process of completing folds (and of the mind in the process of deciding what folds to pursue) possibly raises the cognitive models above those that might have been developed had pen and paper only been employed. This is, however, speculative. The act of selecting appropriate folds might be seen as an aid to developing the kinds of heuristics that are useful in establishing more formal proofs.

The affective aspects of paper folding are significant. Students enjoy paper folding. Paramount among the positive emotions appears to be a sense of pleasure brought on simply by understanding what is being done. Schlöglmann (2002) refers to the implicit emotional memory system that can be activated by the problem solving process; leading in some cases to negative reactions beyond cognitive control that effectively block learning. The value of positive experiences in the mathematics & graphics classroom should not be understated. We know that a sense of belief and worth is important for success in mathematics & graphics, so any mathematically sound process that encourages self belief is worthy of serious consideration.

Paper folding is certainly cheaper than equipping students with access to DGS. It relies less on knowledge of special procedures and is, in that sense, relatively transparent. Healy and Hoyles (2001) discuss issues related to tool selection. They report that in work with "less successful students, learners can… find themselves in a position where they are unable to use the tools they have in mind, even if they are convinced that their use would make sense mathematically, and they are familiar with how the tools should work".

In using a paper folding approach, nevertheless, the time will come when it is determined that students will benefit from progressing to DGS in order to make conjectures more clear or to amplify the signals that paper folding is providing.

This timing is likely to vary between students and so it is advantageous to have a structure in place that enables Students to operate in a differentiated fashion. Indeed, the suggestion is that the nature of the teacher mediated interplay between paper folding, pencil and paper and DGS will influence student achievement, and this interplay is likely to vary between students. In general, Paper folding provides a useful exploratory introduction to geometry and proof after which DGS can be utilized to extend investigations and foster a deeper understanding of proof. That said, paper folding has hidden layers of depth that invite further investigation.

HOW TO FOLD THE DIFFERENT CURVES

FOLDING A PARABOLA

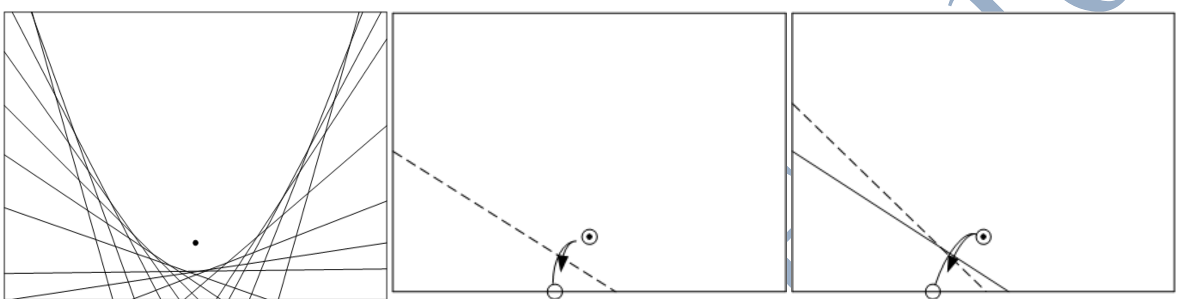

Fig no.1 folding a ParabolaFig no.2 step no. 1Fig no.3 step no.2

STEPS

Draw a dot on a piece of paper in "landscape" orientation half way across and about 5 cm up from the bottom edge. The dot can be anywhere on the paper, but this placement will yield a parabola that looks like the image above.
Fold the bottom edge of the paper up so that it touches the point. Make a crease and open the paper again.
Fold repeatedly so that the bottom edge touches the point you drew at many different spots along the edge. Creaseand open the paper each time of fold. The many creases will form a parabola.
The point drawn is the focus of the parabola and the bottom edge of the paper is the directrix.

FOLDINGAN ELLIPSE

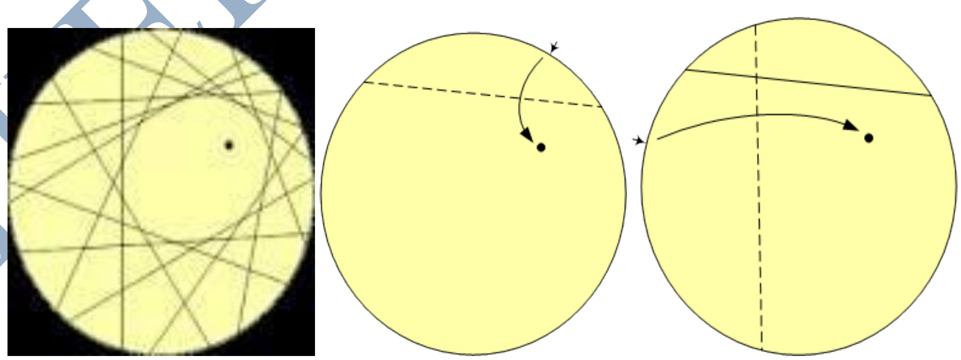

Fig no.4 folding an ellipse Fig no.5 step no.1Fig no.6 step 2

STEPS

Draw a circle and place a dot anywhere inside the circle.
Fold the circle so a point on the edge touches the dot. It doesn't matter which point on the edge picked.
Fold many different points along the edge of the circle to the dot. The creases define an ellipse with one focus at the dot and the other at the center of the circle. If the dot is inside the circle, folds produce an ellipse as above. The ellipse seems to turn inside out to form the hyperbola as the dot moves outside the circle.

FOLDING A HYPERBOLA

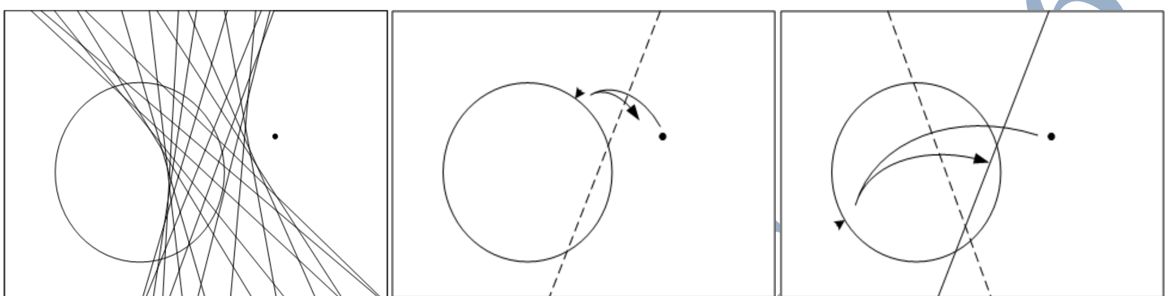

Fig no.7 folding a hyperbola   Fig no.8 step no.1Fig no.9 step no.2

STEPS

Draw a circle on a light piece of paper and place a dot somewhere outside the circle. Draw the circle with a dark line. Place the dot on the edge of the paper.
Fold the paper so the dot lands on the circle.
Fold the paper again so the dot lands on another spot on the circle.
Repeat several more times. Each time the dot should land somewhere else on the circle. A hyperbola emerges from the envelope of lines.

TESTS & EXPERIMENTS

A test was conducted on a group of 30 students with following procedure:

i. First a problem was taught to the group with traditional blackboard and chalk method.
ii. They are tested with 25 marks tests.
iii. Again they taught the same topics with using origami methods.
iv. Results were improved by 8% which was an encouraging thing for further tests.
v. Table no.1 shows test results.

Table no.1 Test results

	Regular Method	Origami Method
Students app.	25	25
Students passed	19	21
Students failed	9	4
% of passing	76	84

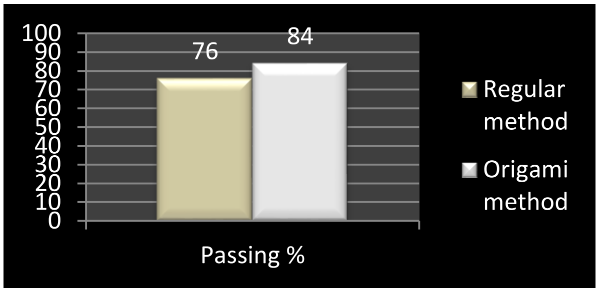

Chart No.1 for Table No.1

CONCLUSION

Results of the tests carried out shown an encouraging number of increases in the percentage of passing i.e. about 8%. Hence it is found that teaching engineering or mathematical curves using folding paper approach might help the students.

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Square pegs in round holes Ravindra Keskar Vigyan Prasar.2000
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5) Sowell, 1989, & Raphael and Ahlstrom, 1989
6) Schlöglmann (2002)

WEBSITES

http://chestofbooks.com/crafts/children/Paper-Folding/index.html

APPENDICES

1. Table No.1- Passing percentage analysis.
3. Figure No.1- folding a parabola.
4. Figure No.2- step no.1
5. Figure No.3- step no.2.
6. Figure No.4- folding an ellipse
7. Figure No.5- step no.1
8. Figure No.6- step no.2
9. Figure No.7- folding a hyperbola
10. Figure No.8- step no.1
11. Figure No.9-step no.2
12. Chart No.1-graphical representation of test data.