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ABSTRACT

Teachers today are faced not only with oversized classes, but with students of varying abilities who differ in the ways they process information. The fostering of diverse styles of learning has been neglected in the teaching of mathematics. The use of journal writing as a vehicle for assessing students' understanding of material provides an opportunity for the graphic expression of thought and the utilization of a spatial communication mode. This is accomplished when students can keep linguistic, numeric, and even pictorial records of what they have learned in either journals or diaries. There is a strong relationship between visualization and mathematical problem solving ability. In a comparison between 2 groups of students enrolled in a mathematics methods course required for teaching at the elementary level, the experimental (trimodal) group reported a better sense of task and a more focused introduction to their journal than the control (bimodal) group. Both groups agreed that their math anxiety decreased and their self-confidence increased as a result of the journal assignments. A multi-modal approach to instruction is both a logical and viable alternative to the traditional methods that have limited students and teachers alike. (Contains 25 references.) (CR)

Andi Stix

THE NEED FOR PICTORIAL JOURNAL WRITING

We all know that teachers today are faced not only with oversized classes, but with students of varying abilities, differing in the ways they process information. We also know that teaching to a group of twenty-eight students individually can be frustrating for everyone. What is possible, however, is adapting instruction to reach a larger percentage of students. When we use our students' different styles for receiving information to develop our instructional procedures, we can help them receive information with greater ease and confidence. Students need to be encouraged to express their ideas to themselves, to their peers, and to their teachers.

Language arts has traditionally been the domain of a multimodal approach to instruction and expression (Baum, 1990; Galyean, 1981; Good and Brophy, 1987). Pictures, music, and rhythm have accompanied students' expressive writing with impressive results. Unfortunately, the fostering of diverse styles of learning has been neglected in the teaching of mathematics.

If we acknowledge that in addition to different learning processes, students also have varying abilities to integrate verbal, spatial, and numerical information, then we can reach a larger audience in the field of mathematics. Not only must we acknowledge students' abilities to be receptive and to integrate information, but we must recognize their abilities to

express a conceptual understanding of the newly presented material.

The use of journal writing as a vehicle for assessing students' understanding of material provides an opportunity for the graphic expression of thought and the utilization of a spatial communication mode. This is accomplished when students can keep linguistic, numeric, and even pictorial records of what they have learned in either journals or diaries. Therefore, as we examine the relationship between spatial

visualization and journal writing in mathematics, it becomes apparent that the use of pictorial journal writing in expressing the understanding of mathematical concepts has much to offer.

The Link Between Art and Mathematics

Ferguson's (1977) historical review, linking art and technology, indicates that inventors and art are closely aligned. Ferguson cites many examples of how inventors have relied on art. In 1588, Ramelli sought a way to bring to the public's attention the notion that all mechanical arts depend on mathematics. He devoted eight large folio pages in the preface of his machine book to this controversial notion. Benjamin Henry Latrobe, a renowned architect and engineer, was an accomplished watercolorist. Samuel Morse, inventor of the Morse Code and the telegraph, as well as Robert Fulton, inventor of the steamboat frame, were both artists before they turned to careers in technology. Ferguson's evidence of artists-turned-technologists and vice-versa is comprehensive and convincing. The relationship between technology and art does, indeed, exist. When the preliminary proposals of these "inventors" are studied, we can see that their work is spatially based and, in fact, the mathematics component is introduced later. This relationship also supports the need for understanding how visualization can "demystify" mathematics for those students who have become "mathemaitcs phobics" as a result of poor instruction.

Testimonies of Experts

The testimonies of historically significant individuals provides insight into the relationship between visualization and thought. In 1888, Francis Galton, the founder of the science eugenics, stated that he thought in pictorial images (Galton, 1907). Albert Einstein claimed that his ability to think visually was so strong it was actually laborious for him to translate his thinking into conventional language (Holton, 1972). William

James considered the role that visual or tactile imagery might play in human cognition (Wilshire, 1971) and engaged his colleagues in a dialogue over whether thought was possible without language. Galton reported that Sir Flinder Petrie, Egyptologist, used a sliding rulers in his mind to calculate addition. He placed one ruler against the other and used his "mind's eye" to read off the sum (Galton, 1907).

How can we use these accounts of diverse approaches to teach mathematics with better success? Arnheim (1969) claimed that internal speech is not the only type of thought process that exists. Visual imagery is just one type of cognitive operation that exists without language. Visual imagery can use an inner design that relies on spatial thinking. Arnheim led the way for many other theorists to confirm the need for approaching the teaching of mathematics with a new and better understanding of available possibilites.

Visualization and Mathematics

The challenege to find alternate ways to enhance a student's ability to conceptualize new information in mathematics continues. Presmeg (1989) believes that information will be more meaningful if it is presented within the student's frame of reference. Then, visual imagery is more likely to lead to greater understanding of mathematical concepts at both the primary and secondary levels.

Many researchers agree that there is a strong relationship between visualization and mathematical problem solving ability. Visualization often provides students with additional strategies to solve the problems so they have more to draw upon within their repertoire (Ben-Chaim, Lappan, and Houang, 1989).

Journal Writing in Mathematics

Expressive vs. Receptive Tasks

When children appear to understand mathematical ideas that have been communicated to them, they are showing evidence of receptive ability. A purely mathematical task that tests a student's ability to recall an addition fact with rational numbers provides an example of pure recall and is a poor way to determine how well a student understands the concept.

On the other hand, when a student is required to express this understanding in a more expanded procedure, such as adding rational numbers whose sum is greater than one, there is often difficulty in expressing the concept. While children often seem to understand the mathematical ideas presented to them, they frequently cannot communicate these ideas to others or even to themselves (Clements and Del Campo, 1989). Consequently, it is critical that teachers encourage students to write expressively. Not only will students then have the opportunity to open up to communicate with themselves, but their teachers will recognize that students have something worthwhile to say about how and what they are learning (Graves, 1978).

Exploration and Discovery

The most effective method of using writing to aid students in their learning of mathematics is through journal writing (Vacca and Vacca, 1986). Individualized learning and discovery is an important feature attributed to the journal writing process.

In their studies of journal writing, Selfe, Petersen, and Nahrgang (1986) concluded that the entries demonstrated a catalytic process in which the expository writing of thoughts sparked the act of discovery. They observed that while the beginning section of entry forms frequently lacked focus, an understanding of how to arrive at the solution began to emerge as students had the opportunity to examine their thoughts and to make them more concrete.

Personalizing Information

Writing facilitates a group lesson or a cooperative learning group to become more personal and also connects group work and individualized instruction. Not only does journal writing encourage students to explore and discover, it also gives them the opportunity to translate and connect their personal experiences to the lesson (BeMiller, 1987). Journal writing allows the students to sort out, construct, and make meaning of concepts for themselves in a logical direction. At first, students sort the information for themselves; then later they are able to communicate these ideas to others (Smith, 1982). Journal writing gives students the opening they need to become active participants in their own learning.

Assessment

As educators, we understand that before we can help a student, we need to understand the probelm. It is often almost impossible to determine what is creating confusion for a student. If we could get a picture of exactly what is happening as each student attempts to critically organize the information in the problem, we could find the obstacle in the way of his understanding and, consequently, in the way of his success.

Misunderstandings may not be clear-cut in a typical homework assignment or in a purely numerical examination. We know that because students can rely on a purely memorized process for calculating equations, misconceptions often do not become obvious (Davison and Pearce, 1988).

Journal writing creates an opportunity for students to express their understanding of what they have learned and, as important, allows teachers to see where there is confusion. Evan (1984) reacted to using journal writing in the classroom by stating, "I could immediately see who understood the concepts I was teaching and, more importantly, who didn't" (p. 834). Burton (1985) added that when a student is encouraged to write, the misconceptions come into focus. In this way, the student is able to be extremely specific about the precise aspect causing a problem.

Retention

Evans (1984) found that after information was discussed in a journal entry, students were better able to remember and retain information. Because students had personal ownership of the information, the tendency to recall standard text definitions became easier. Evans' class of fourth grade journal writing students outperformed a control group on a multiplication unit, even though the control group had high CTBS (California Test of Basic Skills) scores at the beginning of the year.

Tierney (1986) strongly recommends that students become "owners" rather than "renters" of information. In his study, fifth grade students who used writing as a tool for personalizing information had a higher retention rate than did the control group. Schubert (1987) tested children's ability to recall information a year later. On the post-test for the fraction chapter in grade five, children who previously used the journal format had a range of 71 percent to 100 percent, with an average of 94 percent. Students who did not use the journals had a range of 35 percent to 100 percent, with an average score of 81 percent. While there will always be students who learn mathematics easily and can score 100 percent, the lower scores of 35 and 71 how the significance of the use of journal writing.

Pictorial Journal Writing

Non-verbal thought has shaped much that is creative and innovative in the world. The most complicated inventions frequently begin with a hastily drawn sketch. Often nothing more than a sudden realization of a visual image that flashed through the mind is needed to create something both tangible and extraordinary. Ferguson's (1977) research documents early evidence of using pictures in manuscripts, or diaries. What he reveals helps us to better understand how pictorial journal writing can be the key we need to unlock mathematical potential.

History

Traces of pictorial journal writing have been found as early as the sixteenth century. Ferguson (1977) examined various areas to prove how essential the influence of drawing has been to the development of mankind. Creative pictorial representations have been traced to technology, graphic design, art, and perspective. Ferguson's research supports the concept of pictorial journal writing. Furthermore, it supports the need to nurture potential talents as a vehicle for developing mathematical skill.

Technology

Ferguson's survey takes us to the middle of the fifteenth century. Here we can see Leonardo da Vinci completing one of his many technical drawings in the pages of his personal notebook. In Leonardo da Vinci's day, it was standard practice for engineers to draw illustrations of their visual images in technical notebooks of this kind to circulate among other engineers.

Francesco di Giorgio Marini's "Trattato di Architettura," drafted around 1475 (Ferguson, 1977, p. 828) is an extraordinary example of how technical information can be transmitted through illustrations. However, it is the accompanying text that is truly unique. In isolation from the illustrations, the words are meaningless. Marini's notebook reveals that language does, in fact, enhance the expression of the illustration.

Graphic Drawing

Graphic drawings or illustrations have customarily been used to clarify pictorial representations. Many techniques, such as perspective drawing, exploded view, orthographic projection, isometric view, or the ordinary graph of a curve, have initiated the unlimited ways in which artists, mathematicians, and inventors communicate their

innovations. In fact, a recurring theme in the literature is the relevance of pictorial perspective in easing the ability to communicate. As long as the visual image in one mind can be shared, then the facility for peers to exchange ideas is enhanced.

Current Findings

When students are the given the opportunity to express themselves in the area of mathematics, teachers witness the willingness to explore areas that have been untouched. Clements and Del Campo (1989) recommend that students should "be free to express themselves...by speaking, writing, drawing, performing, and imagining mathematics" (p. 27). As we nurture this freedom in students and encourage them to utilize many modes of expression in journal writing, we "encourage awareness of individual strengths and weaknesses" (Baum, 1990, p.2). Similarly, BeMiller (1987) suggests that as students interact with different modes of expressions, they "consequently visualize more relationships and [they have] better exposition of these ideas" (p.365).

It is unfortunate that systems of multi-modal writing appear to break down after the third grade. Teachers find it difficult to encourage an approach that feels untraditional and might be regarded as a childish game. We are suspicious of "game playing" past what has been acknowledged as the appropriate time to stop. Nevertheless, research supports the fact that concrete, semi-concrete, and pictorial writing are just as important in the middle and upper grades as in lower, primary grades.

Ben-Chaim, et al., (1989) recommend that adolescent students build with cubes, represent three dimensional objects in two dimensional drawings, and read from each other's drawings. Unless students are exposed to multi-modal instruction and pictorial drawing, most of them will have difficulties visualizing hidden parts or realizing the correct elements of dimensionality.

Recent researchers share a commitment to the importance of including pictorial representations as a component of journal writing. Dirkes (1991) is even more specific

about how pictures should be used when students write. She urges that students be encouraged to refer to their own drawings as a source of information. Furthermore, she suggests that numbers be placed as close as possible to the illustration they represent. Dirkes also recommends the use of reading and drawing assignments. She provides an overall structure for solving a mathematical problem. For instance, students are encouraged to read the example more than once, then expected to draw something to illustrate the facts. Finally, the pupil is required to list more ideas than he thinks he needs.

In 1992, I compared two groups of students enrolled in a mathematics methods course required for teaching at the elementary level. The control group, labeled as bimodal, was only allowed to use words and numbers in their assignments. The experimental group, labeled as trimodal, was allowed to use words, numbers, and pictures in their journal writing assignment.

The following areas were significant between the two groups: The trimodal group reported a better sense of task and a more focused introduction to their journal than the bimodal group. The trimodal group felt that the pictures helped clarify ideas, offered better evidence to prove their points, aided in determining a logical order, and improved their ability to express themselves more succinctly. Both groups agreed that their math anxiety decreased and their self-confidence increased as a result of the journal assignments.

Activities that incorporate drawings help prolong the time spent during the thinking process. Understanding and retention are two goals of teaching because retaining information is a reflection of understanding the material offered. If instructors teach for understanding, then they are teaching for retention (Phillips, 1987).

If students begin to show an increase in their achievement scores, it is only logical that feelings of self-confidence and success will be enhanced. One study with low achieving students indicates that exercises used in visual spatial activities not only

improved their understanding of the material, but greatly increased their self-concept (Lord, 1987). My own findings support increased self-confidence when approaching and solving math problems when pictures in journal writing are used (Stix, 1992).

Conclusion

We are familiar with the many ways (tactile, auditory, spatial, visual imagery, reading symbols) students have of integrating information. Their approaches are as diverse as their ideas. As educators and parents, we need to view their strengths and weaknesses as tools that can be effectively used to help them express these ideas. When we recognize that their differences in learning styles are an asset in helping them to communicate their needs, then we can truly teach for understanding and retention.

A multi-modal approach to instruction is both a logical and viable alternative to the traditional methods that have limited students and teachers alike. An integrated approach to teaching mathematics that includes pictorial journal writing or note taking nurtures the best in our students and in ourselves.

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