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USING WRITING AS A MODE OF LEARNING MATHEMATICS

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Reading, writing, and arithmetic constitute what is known as the 3 R's in the basic skills that every child has to master in school. In this article, we shall present some strategies in using writing, one of the basic skills, in the learning of mathematics. Writing is a powerful tool for students in learning how to learn and for teachers of different content areas in teaching how to learn. Learning how to learn is a desirable educational goal in that the acquisition of learning skills will enable students to obtain knowledge for themselves. Once successfully acquired in school, learning skills become firmly imbedded into the students' cognitive structure which, when required, can be retrieved for application in solving practical problems in their daily lives. An inevitable experience for students who are learning how to learn is the process of inquiry which involves observation, manipulation for deeper understanding, analysis for clarification, collection and synthesis of related information, reorganization of new knowledge with the old, and discovery of a new principle, concept, or the solution of a problem. **Mayher**, Lester, and Pradl (1983) consider writing as an active approach to learning involving a complex process of exploration and discovery enabling the learners to achieve a rich and versatile vocabulary of the subject at the same time. Writing about a problem causes one to gain a new awareness of how the fragments of information about that problem relate to one another. Emig (1981) maintains that writing has a unique value for learning because it has the characteristics of successful learning strategies. The assumption that writing is an effective mode of learning mathematics is therefore not without any theoretical basis.

Writing In Mathematics

Based on 37 Mathematics lessons observed in two American high schools, **Applebee** (1981) reported a mean of 64.2% of

lesson time involved in writing, consisting of 47.6% mechanical uses of writing involving mainly calculations and 16.6% informational use of writing involving mainly **note-taking**. From the data of a national questionnaire survey on writing, he also reported that calculations were the most frequent writing activity (reported by 99.3% of the 143 mathematics teachers surveyed), followed by note-taking (**49.0%**), and proofs (38.5%). Only 1.4% of the teachers reported the use of writing tasks involving more than a paragraph. To bring about more situations in which writing can serve as a tool for learning, **Applebee** suggests further work be done to describe specific practical techniques and activities that can be successfully incorporated into the various content areas and to investigate systematically the benefits of such activities in terms of student writing skills and subject area knowledge.

In his study of student writing on relationships between pairs of probability concepts, Geeslin (1977) found that many students performed poorly on the writing tasks and had important misconceptions of mathematical concepts not revealed by achievement tests. By examining their writings, teachers can diagnose students' weaknesses. As good writing is a part of the **problem-solving** process, "students need the opportunity to use and refine writing skills in a mathematical context" (Johnson, 1983, p. 117). Gillespie (1981) identified eight writing skills as most important for students in every subject area. In order of importance, these were: (a) write an acceptable answer to an essay question; (b) set forth facts and opinions to explain a main idea or belief as in expository writing; (c) take notes, as in outlining or synthesizing from a class lecture or presentation; (d) defend or attack a position or opinion as in argumentation; (e) write a summary of the main points of a chapter or article; (f) write a report of an experiment, process, or problem solved, using a logical, developmental sequence; (g) write legibly; and (h) write a summary of what has been covered in class.

Although writing across the curriculum has been advocated in Britain and U.S.A. for some time now, there is still room for improvement in using it in the classroom. Some teachers feel that teaching students to write should be the English teachers'

responsibility. In the U.S. survey, **Applebee (1981)** reported 32% of mathematics teachers felt it to be so. However, in view of what writing can do for the students, the teaching of writing should be done by teachers in all courses. Another reason is the lack of proper orientation of teachers utilizing writing as a possible teaching strategy to improve student learning across the curriculum. To introduce writing in **mathematics** to teachers, an appropriate step to take is to incorporate writing as a component in the mathematics and mathematics methods courses and workshops offered to student teachers and in-service teachers at all levels in teacher-training institutions. School-based workshops can be held to introduce writing to mathematics teachers who may use writing to enhance the mathematics lessons that they teach.

Writing Strategies For Learning Mathematics

The strategies presented here have been classified into three categories: (a) student journals, (b) classroom strategies, and (c) inservice training in writing for mathematics teachers.

Student Journals

Aims

1. To motivate students to learn mathematics.
2. To improve students' ability to master mathematics content.
3. To enable students to use their own words to make connections between new material and what have been learned previously.
4. To encourage students to apply the mathematical ideas learned in class to real-life situations.

5. To provide an opportunity for students to react and interpret materials written in mathematics texts.
6. To provide an additional avenue for students, especially shy ones, to ask questions.
7. To help students delve deeply into the process of a difficult mathematical operation or sequence.
8. To involve students to write in a personal way about mathematical facts and information they have learned and how they feel and think about them.
9. To enable teachers to diagnose their students' weaknesses and find ways to help them improve their learning.

Activities

Table 1 lists 10 writing activities which can be carried out in conjunction with student journals.

Table 1

Writing Activities in the Use of Student Journals

No.	Situation	Students' Activities	Writing Points
1	Before starting a new topic	write down expectations & predictions of what the topic may involve	<ol style="list-style-type: none"> a. What general ideas b. Is it interesting c. Any field work
2	After introducing each concept, principle, or theorem	write down their understanding in own words	<ol style="list-style-type: none"> a. Key points b. Method of proof c. Uses

Table 1 (continued)

No.	Situation	Students' Activities	Writing Points
3	Teacher writes 4 or 5 key words on the board	free-write about them for several minutes	<ul style="list-style-type: none"> a. Explanation b. What importance c. Your impressions
4	During the last five minutes of class	summarize concepts & write questions about things confusing	<ul style="list-style-type: none"> a. New terms b. Examples c. Relationships
5	In class or at home	construct word or story problems to challenge or share with others	<ul style="list-style-type: none"> a. Concepts involved b. Significance c. Applications
6	After reading about topic in text	write in response a short paragraph showing reactions	<ul style="list-style-type: none"> a. Ideas in text b. Difficult concepts c. Like it?
7	After selecting a topic in mathematics	write a short report for presentation to class	<ul style="list-style-type: none"> a. Real-life uses b. Biographies c. Prejudices
8	After attempting homework problems	write questions about specific problems which seem mystifying	<ul style="list-style-type: none"> a. What mystifies b. Why not that way c. Any other expression
9	After learning a topic in class	write how they go about learning the topic	<ul style="list-style-type: none"> a. How things make sense b. Frustrated c. Steps in learning
10	After reading a book related to mathematics	write a report related to content or their reactions	<ul style="list-style-type: none"> a. Math anxiety b. Why learn math c. Why Johnny can't add

Classroom Strategies

The classroom situations of mathematics lessons in which language plays a significant role consist mainly of five types: (a) defining new terms, (b) solving word problems, (c) finding procedures for solving problems, (d) proving theorems, and (e) knowing about mathematics issues,

(a) Defining New Terms

Aim To enable students to have a clear understanding of new terms.

Strategy

1. After introducing a new term, teacher asks students to say what it means.
2. Teacher explains if not acceptable answers are given.
3. Students try again.
4. Repeat steps 2 and 3 until acceptable answers are obtained.
5. At the end of the lesson, students write in their own words what each new term means.

(b) Solving Word Problems

Aim To enable students to learn about writing solutions and understand what a good solution is.

Strategy 1 (For class)

1. Teacher selects a simple word problem.
2. Students are divided into small groups of 3 or 4 and given 10 minutes to write down solution.
3. Group leaders present solution.
4. Teacher comments.
5. Students offer alternatives.
6. Repeat steps 4 & 5 until solutions are acceptable by class.
7. Strategy is used again with a harder word problem.

Strategy 2 (For take-home)

1. Teacher selects a word problem.
2. Students hand in their solutions for the next class meeting.
3. Teacher writes comments on solution (e.g., structure, omissions).
4. Teacher returns comments with a request that students consider the comments and revise their write-up.
5. Repeat steps 2 through 4 till solution is found acceptable.
6. Teacher gives positive reinforcement in the form of brief comments about what in particular in students' work is acceptable.
7. Strategy is used again with a harder word problem.

(c) Finding Procedures for Solving Problems

Aim To enable students to learn to write procedures for solving problems.

Strategy

1. Teacher gives problem for students to solve.
2. Students construct an algorithm and describe the procedure.
3. Teacher comments on algorithm design.
4. Students revise based on comments.
5. Repeat steps 3 and 4 **till** procedure is correct.
6. Students solve the problem and report results to teacher.
7. In the case of short procedures, strategy can be used in class. Otherwise, use in the form of personal dialogue between teacher and individual students.

(d) Proving Theorems

Aim To help students to develop their own unique standards of conciseness and clarity.

Strategy

1. Teacher presents and explains the statement of the theorem.
2. Students are given 10 minutes to devise their own proofs.
3. Students present proofs to class.
4. Discussions follow.
5. Teacher plays the role of an intelligent observer who wants to understand fully all that is being presented. Teacher asks questions when obscure assertions are made. Teacher does not supply answers.

(e) Knowing about Mathematics Issues

Aim To arouse the interest of students in current mathematics issues and call for their concern for possible implications affecting them.

Strategy 1 (For pairs)

1. Each student chooses a topic of his interest (e.g., dislike **Math**).
2. Students write about it at home.
3. Students are divided into pairs in the following class.
4. Students read own essays and make changes.
5. Students read partners' essays and provide feedback.
6. Individual students revise and students jointly proofread and edit.

Strategy 2 (For small groups)

1. Each group selects a general topic.
2. Members brainstorm in class.
3. Students write about it at home.
4. In the following class, students listen to writings within the group and **provide** feedback.
5. Individual members revise and the group proofreads and edits.

Conclusion

In order to enhance learning of students in mathematics, we, as teachers, have the obligation and responsibility to choose and apply the teaching techniques that have been found to work in making students understand mathematical concepts and principles. Not only this, we have to constantly enrich our own knowledge of pedagogy by reading relevant literature and devise innovations which, we think, will benefit our students in learning. Using writing as a learning mode in mathematics is a worthwhile strategy for teachers to try. We are certain that when applied regularly in class, it will enable students to reach a higher level of mathematical achievement than what they are now able to.

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