Teaching and Learning Mathematics: Student Reflection Adds a New Dimension

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Abstract
The aim of this paper is to share ideas on how to improve students' mathematics learning through the use of Student Reflection Process (SRP). The process helps students improve their study habits and participation in mathematics classes. Guidelines for implementing SRP in any mathematics class are shared.

Introduction
Does it indicate understanding when students are able to answer conceptual questions correctly only by looking through their notes? Is it possible that students' difficulties in mathematics may not be as connected with the subject matter as with lack of certain study habits? The above situation provided the motivation for this project. The American Mathematical Association of Two Year Colleges (AMATYC), the National Council of Teachers of Mathematics (NCTM) and other groups have advocated that the ways mathematics is taught and learned need to change. The vision for change is discussed in such documents as the *Beyond Crossroads :Implementing Mathematics Standards in the First Two Years of College* (AMATYC 2006) *Principles and Standards for School Mathematics* (NCTM 2000), and *Professional Standards for Teaching Mathematics* (NCTM 1991). Many studies have been emphasizing the need for the teachers to reflect on their teaching practices (for example, Newborn 1999). While this is good and necessary, it will not by itself alone lead to the realization of the new vision for mathematics teaching and learning.

An area that has been neglected to some extent is an emphasis on student reflection. Literature has discussed student's self-assessment, which is an aspect of student reflection as used in this paper. The new vision for the teaching and learning of mathematics can be more realistically and fully realized if students are encouraged (or possibly required) to reflect on their learning.

There has been a proliferation of ideas on the topic of reflective thinking. As a result, there is little agreement on its content or in the nature of the contexts that promote it (Grimmett 1988). For the purpose of this discussion, student reflection is defined as the process of thinking about learning by a student. It involves thoughts that the student has before, during, and after a particular lesson or lessons. This process requires the student to do a self-assessment of his or her study habits, classroom involvements and interactions, as well as make an oral presentation to peers and teachers on what was covered in a previous lesson or lessons. The presentation requirement forces students to reflect in order to present effectively. And this will undoubtedly lead to improved learning. Hence, student reflection is a proactive way of supporting students' mathematical development in ways that are compatible with reform recommendations.

The presenter will share his experiences implementing student reflection in his mathematics class. Information that will aid other teachers to try this strategy in their classes will be shared. Finally, this practice can be implemented in every environment, and at all levels of mathematics learning.

Framework
The following constructs, are significant in the development of activities and experiences in the Student Reflection Process (SRP): *metacognition, modeling, communication* (*oral and written), and sharing of responsibilities.* .

Metacognition is a theory about how we think. This has several definitions, but one that seems to captures the essence of it is by Flavell, 1979. It describes metacognition as one's ability to think about one's thinking, and to monitor and regulate what one is doing and thinking as one has an experience (for example, solving a problem).

Modeling by the instructor provides students with ideas of concepts, skills, and knowledge that they should acquire and share with peers as they make their own presentations. That is, modeling provides students with useful images.

Communication according to NCTM (2000) "Communication is an essential part of mathematics and mathematics education. It is a way of sharing ideas and clarifying understanding"(p.60). Hence, in order to communicate (orally or in writing) effectively, students must reflect and clarify their ideas and thoughts from previous experiences.

Sharing Responsibilities refers to the fact that both instructor and students should see themselves as learners and teachers. The instructor learns what the students know and are able to do and uses this in making instructional decisions. Students on the other hand assume the instructor's role and try to share what they know and are able to do with both the instructor and classmates. This situation, while empowering the students, promotes the building of a learning community as envisaged by the reform vision for mathematics education.

Activities in the Student Reflection Process (SRP)

Student reflection can be implemented in any math class. For this project, the setting was a Calculus and Analytic Geometry I class (Math 131). There were twelve (12) students, some of whom were still in high school, but enrolled in a Post Secondary Education Option Program (PSEOP) at a branch campus of a large state university in the Midwest, USA. This was a one semester class that met for one hour a day, five days a week. The project itself lasted for six weeks. Students completed a Reflection Survey on Day 1 and on the next six Mondays of the project. The goal here was to compare the information gathered on Day 1 to that of the following next six Mondays. Students answered the open question: *How do you study mathematics*? on both Day 1 and the Last Day of the project. Their responses provided an insight into their study habits both before and after the reflection experience.

Following the students' responses to both the Reflection Survey and the open question, they received reflection guidelines and study hints. The reflection guidelines contained information on what they should be doing in the next six weeks of reflection while the study hints contained information on general and specific mathematics study habits.

Daily Oral Presentation and Other Activities

Student reflection included daily presentations (or oral reports) by students. The presenter's name was randomly picked from a bag that contained both the students' and the instructor's names. The presenter was expected to briefly explain the major concepts, definitions, theorems and procedures that were discussed in the previous class without referring to his or her books. I usually interjected with some probing questions. When the presenter was unable to answer a question correctly, it was directed to other students in the class and they were not allowed the use of their books either. I took note and rated students' performances numerically from 1 – 10 points. On each of the next six (6) Mondays, less than ten minutes of class times, were used by students to complete the Reflection Survey. In it, students were to describe briefly the main ideas, concepts, or procedures that they learned during the past one week. In addition, they were to describe their contributions to the course learning activities, as well as indicate their areas of difficulties. The survey included a provision for them to indicate if they needed help or not with the course. Students were further required to suggest what they thought would help improve learning in the course. In order to have an idea of the impact (if any) of student reflection on test

performance, I looked at three (3) student test scores (before, during, and after stopping daily reflection presentations).

Results

For this discussion, I will share a sample of the results of the First Day (Day 1) and randomly selected weeks (Weeks 1, 4, 5, 6) Reflection Survey (Items #3 and #6). These items were deliberately chosen for discussion because of their high instructional relevance.

Item #3: How have you contributed to the learning environment in the class this week? (For example, asking and answering questions, helping other students, solving a problem on the board, etc)?

Item #6: a. Is it time for you to ask the instructor for help? YES---- NO----. If YES, contact me at (phone #) or at (e-mail)

b. Provide suggestions for improving learning in this course

Students' contributions to the class learning environment increased as the weeks went by and included the following:

DAY 1 : Discussed problems with partner, answered teacher and student questions, and helped other students.

WEEKS 1, 4, 5, and 6: Received help, explained definitions to classmates, walked around the class helping other students, encouraged others to get tutored, and discussed problems in and outside of the math class with classmates.

Students' suggestions for instructional improvement included the following:

DAY 1 : Group activities, slower pace, breaking concepts into smaller pieces, doing more class examples, and giving individual practice/group practice problems in class, and providing review worksheets before tests.

WEEKS 1, 4, 5, and 6: In addition to the above, students' suggestions included : shortening the theorems, giving take-home tests, breaking tests/quizzes into smaller pieces, doing all test problems in class, as well as including bonus questions on tests.

The percent of respondents answering YES/NO to Item 6a were as follows:

DAY1 (45/55), and (62/38), (38/62), (44/56), and (44/56) for WEEKS 1, 4, 5, and 6 respectively.

The mean (standard deviation) percent scores of students on three tests that were given prior, during, and after the daily presentations were 65.7 (16.3), 83.7 (9.8), and 71.2 (10.9) respectively.

Analyses and Discussions

Results indicate that in Weeks 1, 4, 5, 6 of the project, students became more actively involved in their learning. They did things that they did not indicate on Day 1. These include, but not limited to listening to others, talking about and explaining theorems and definitions to classmates, asking and receiving help from other students, walking around to help others, and encouraging others to get help. These are actions that contributed positively to the learning environment. It was gratifying to walk into the classroom and the class was already 'on' before your arrival. Everybody came on time to "quiz" each other on the previous day's lesson.

Results indicate that before the reflection experience, only 45 % of the respondents to the Reflection Survey claimed that they needed help from the instructor. By the end of the first week reflection, 62 % of the respondents needed help from the instructor. This might be indicative of the impact of the reflective experience. By the last two weeks of this project, only 44 % needed help from the instructor. This might be because students are now reflective learners who can learn better on their own.

One suggestion that came up from Day 1, and Weeks 1, 4, 5, 6 of student suggestions for instructional improvement is the need for more class examples. Students may be saying here that they learn better when shown lots of examples. I believe that students will benefit more if they are involved (by offering suggestions) in the development of solutions to example problems. Hence, it is not beneficial for students to simply copy a solution that was solely worked out by the instructor. There should be provisions for 3-5 minutes of small group discussions when some

examples are being worked out. The multitude of student suggestions for improving learning in the course suggests that they have become very interested in the ideas that would make them more successful in mathematics.

A study of student Study Habit categories indicate that the reflection experience provided the students with more ways to study and succeed in mathematics. On Day 1, doing homework and taking and reading notes were the most frequently used habits to study mathematics. An instructional implication here is that instructors need to pay more attention to the notes and homework that they give to students.

The results of the Study Habit Survey on the last day of the reflection project seem to indicate that all students were doing what they should be doing to succeed in their learning of mathematics.

Results of the average performance of the students on three tests---before, during, and after reflection do indicate that students on the average performed better during reflection than prior to reflection and after daily presentations were stopped. The mean (std. dev.) scores for the three tests were 65.67 % (16.39), 83.67 % (9.84), and 71.17 % (10.91) respectively. It is my belief that the reflection experience might have contributed to the better performance during the project. When the presentations were stopped, the average test scores dropped, but not to a level that was equal to or below what it was before the reflection experience. Continuing the daily presentations beyond six weeks might have made a difference.

Use of Findings

Daily Oral Presentations

Identified misconceptions and areas of difficulties revealed students' weaknesses and these were addressed immediately. The oral presentation served as an assessment tool that benefited both students and instructor.

Study Habit Categories

Information obtained from the Study Habit Survey motivated me to encourage the students to ask questions and help others in class, as well as ask for help for themselves. I equally paid more attention to my class notes and homework.

Reflection Survey

Some of the students' suggestions for improving learning in the course guided my classroom instruction as the course progressed. For example, more group work was utilized and a wider variety of examples was used in class as well.

Teacher Guidelines for Implementing Student Reflection

The following guidelines will help any teacher of mathematics implement the use of student reflection in his or her mathematics class.

General Guidelines:

1. Explain the meaning and rationale for SRP.
2. Constantly check to ensure that the daily reflection is not neglected by continuing to randomly have students selected to present.
3. Collect the weekly reflections on say the Mondays following the week under consideration. Provide students with materials to write on to prevent cheating.
4. Ensure that all essential topics in a previous lesson were touched upon. It might be necessary to prepare a checklist of such topics for a particular lesson. A student who has difficulties remembering most of the topics definitely needs some help.
5. Incomplete reflections (oral presentations and written surveys) should be commented upon and if necessary, in a written reflection, a student should be asked to rewrite in an acceptable form.
6. Teach students how to study and how to improve their habits of studying mathematics by providing them with the information, as well as through modeling good habits in the class and constantly reminding them of what to do.

7. During an oral presentation, other students should be discouraged from looking into their books for responses to questions as this is not in line with the goals of the project.

Specific Guidelines:

Before Oral Presentation

1. Provide students with an orientation on how to work. Decide on the topics that will be covered by student reflection
2. Decide on what you want to learn about students' mathematical knowledge of the topics.
3. Decide on how you want to record and grade students' oral presentations.

During Oral Presentation

1. Remind students that they are to communicate (orally or in writing) their ideas clearly.
2. Point out that you will be taking notes on what they say or do.
3. Observe and listen as students make their presentations.
4. When the student completes his or her presentation, ask probing questions for clarifications as well as to check for understanding.
5. Throughout the presentation, record students' statements and actions. Take note of the use of diagrams and graphs, as well as student's apparent level of confidence.
6. Ensure that students' misconceptions are addressed by you or the class by the end of the presentation.

After Oral Presentation:

1. Quickly record any additional comments about specific events from the presentation.
2. Make decisions about scores after considering comments and notes.
3. Make an instructional decision based on your findings.

Challenges to the use of Student Reflection

1. Students did not take the SRP seriously until grades were assigned to it.
2. Some students could be nervous during presentation.
3. Lack of enough time for direct instruction due to time (5-10 minutes) that was spent on presentation and completion of reflection survey.

Conclusion

Mathematics classes that are conducted in an environment that encourages students to share (orally and in writing) with both instructor and fellow students what they learned in previous lessons hold promise in assisting students in becoming reflective learners. Reflection teaches students to be more reflective of their learning process and it provides the instructor with information on what each student has learned and what each student has difficulties learning. Because several of the students were experiencing the same difficulties, there was much to be gained by observing the daily presentations. This observation served each student as a powerful technique for reflecting on his or her study habits and learning process as well. Reflection provided an opportunity for the students to realize when to ask and receive help, contribute to the teaching-learning environment, and as a result, learn the materials of the course.

On the basis of the data and other information provided above, I suggest that students can be reflective of their learning. The process is both an individual and a shared experience that results in improved student learning in an environment where they are partners in the mathematics teaching and learning process.

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