An Action Research Approach to Examining the Metacognition of Middle School Mathematics Students

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Abstract

Building off an earlier preliminary study done in 2008, an action research project was conducted to examine the metacognition of sixth and seventh grade mathematics students. This research project was a component of the partnership between Benedictine University and Saint Ethelreda School, an elementary school on the south side of Chicago. In this study students were asked their perceptions of two cooperative learning activities and mental math activities. Students rated the effectiveness of each activity, and also ranked the three in terms of effectiveness. A mixed-methods approach was used. Results provided insight into student perception of the effectiveness of these activities; this in turn, resulted in a shift in pedagogical practices.

Introduction

Wishing to more fully understand the art and science of teaching mathematics to middle school students, a university professor, as part of a university/school partnership, co-taught on a weekly basis with a middle school math teacher. An earlier but unpublished study during the 2008-2009 school year conducted by these two educators indicated that students believed that cooperative learning activities and authentic problems were beneficial, but that writing activities were not as effective. An interesting phenomenon did occur during that study. During one of the study's cycles, the researcher included the daily mental math activities that had always been used into the mix. While not initially considered a constructivist activity, mental math received very high scores. A very important finding of this initial study was with student explanations of why they like liked a particular activity; many student responses did <u>not</u> use "cognitive learning words." These are words that describe what one does during the learning process or what goes on in one's mind when he or she is learning. Following are phrases that are examples of cognitive learning words.

- I get ideas from other people
- I learn when I put math knowledge with English knowledge
- When I find patterns, I learn
- I compare my ideas with my partner, and then we see if they are the same.
- When I put my words into diagrams I learn
- When my partner and I have the same result, we try to figure out why

Both teachers continued to use cooperative learning and mental math in their co-teaching during subsequent years, blending cooperative learning, mental math, and Problem-Based Learning.

Rationale

Since both researchers had continued the use of different cooperative learning activities and mental math activities, they were interested in student perceptions of these practices. Additionally, the researchers wanted to see if their direct discussion of metacognitive processes resulted in more student use of cognitive learning words. In the spring semester of 2011 these two teacher/ researchers decided to again examine the metacognition of students, with the primary purpose of examining what activities students perceive as effective, and to determine the extent to which students use cognitive learning words. It must be noted that both teachers/researchers implemented direct class discussions focusing on how one learns.

The researchers based their research on the literature regarding metacognition and metacognitive training. This includes an examination of 1) the nature of metacognition, 2) the relationship between metacognition and cognitive development, 3) the relationship between metacognition and academic achievement, and 4) research on the effectiveness of metacognitive training.

The Nature of Metacognition

Metacognition can be analyzed in terms of its very nature, including its purpose and the behaviors by which it manifests itself. Zimmerman (2002) defines metacognition as "knowledge about one's own thinking" (p.65). Costa (1984) views metacognition as one's ability to know what we know and what we don't know.

Hall (2001) lists specific aspects of metacognition; included in this list were knowing the limits of one's own ability to learn and remember, knowing what learning strategies are effective, creating a plan for approaching learning tasks, and knowing at what point a learning goal has been accomplished.

Metacognition and Cognitive Development

In general, research has shown that metacognition develops in complexity as people age, not only in the school-age years but also in the adult years. According to Kegan (1994), reflecting on one's thinking and feelings is not merely making a distinction between already existing things, "but a matter of fostering a qualitative evolution of mind that actually creates the distinction" (p. 275). [Emphasis added] Grossman (2009) recognized the maturation aspect of metacognition: "Only more mature problem solvers have developed a mental place that allows their inner experience to be the object of their observation" (p.17). Flavell (1979), in discussing a model of metacognition says, "it will naturally be very important to try to discover the early competencies that serve as building blocks for subsequent acquisitions rather than merely cataloging the young child's metacognitive lacks and inadequacies" (p.909).

In a study involving four age groups (13-15, 23-25, 33-35, and 43-45), Demetriou and Bakracevic (2009) examined the performance, self-evaluation, and self-representation of Slovenian participants. The study used quantitative tools, with the results indicating that self-evaluation improved throughout each age span that was studied. However, the studies of Vukman and Licardo (2010) and Mok, Fan, and Sun-Keung (2007) had some surprising results—self regulation/metacognition decreased with age.

Metacognition and Academic Achievement

In an exploratory study of 35 students at the University of Namur, Romainville (1994) conducted semi-structured interviews; the findings included the conclusion that high achieving students demonstrated a more frequent use of metacognitive knowledge of cognitive processes and cognitive results. In a similar vein, Hwang and Vrongistinos (2009) studied the metacognition of high and low achieving elementary teacher education students; the study concluded that higher achieving students were more likely to use self-regulated strategies (SRL) and metacognition.

Teaching Metacognitive Skills to Students

Michalsky, Mevarech, and Haibi (2009) investigated how metacognitive training implemented at different phases of reading can influence scientific literacy of fourth grade students. Statistical analysis indicated that the group receiving metacognition training outperformed the other treatments. Boulware-Gooden, Carreker, Thornhill, and Joshi (2007) examined the effects of direct instruction of metacognitive strategies designed to improve reading comprehension of third grade students; it was found that the instruction was effective. Camahalan (2006) studied the effects of the Metacognitive Reading Program on the reading achievement of two students diagnosed as having dyslexia. The findings suggested that metacognitive strategies improved reading achievement. A study examining the effectiveness of cooperative learning with or without metacognitive instruction was done by Kramarski, Mevarech, and Arami (2002); they concluded that cooperative learning with metacognition training had positive effects on both lower and higher achievers.

The results of a study examining the effects of metacognitive training on conditional university students (Rezvan, Ahmadi, and Abedi 2006), suggested that the academic achievement average of the experimental group had increased.

Summary of Literature

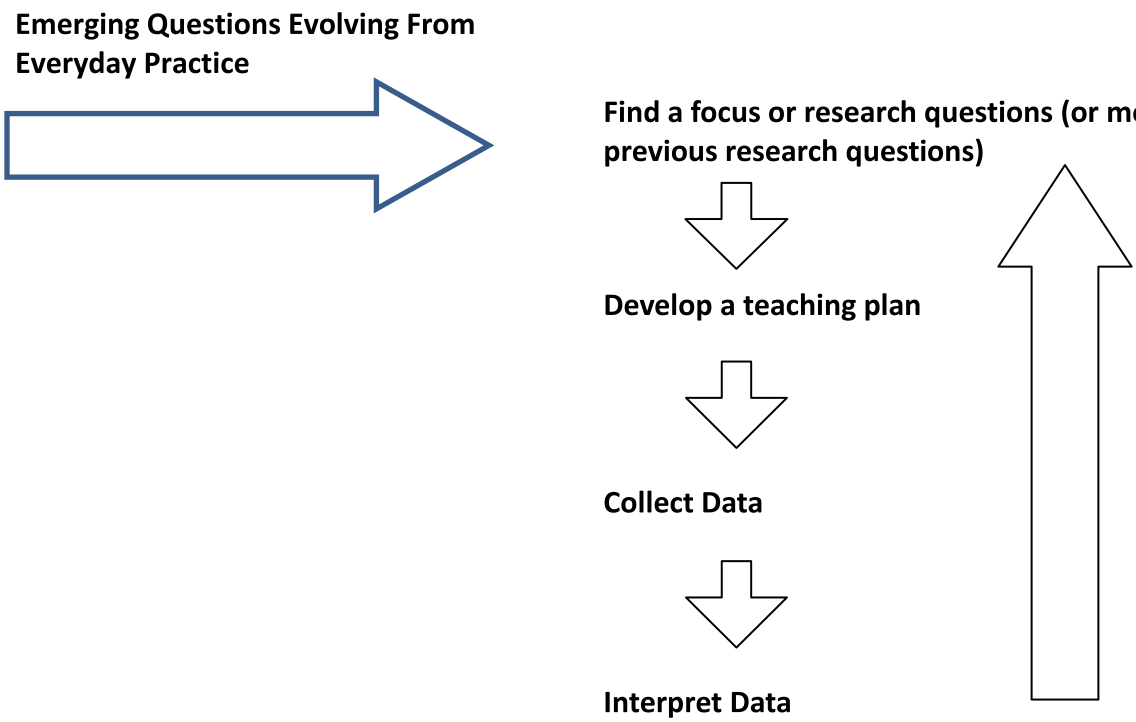
The research indicates that metacognition is a multi-dimensional construct that is can be influenced by and aligns with development. The reviewed studies also showed that direct instruction on metacognition was effective, including instruction embedded within the context of content area instruction. Studies on metacognition used instruments such as questionnaires and student achievement scores. Other measurement tools such as student voice and the use of cognitive words were not predominantly used. Additionally, studies were not conducted within a naturalistic environment, thus not providing data generated within context and representing student perceptions within context.

Method

The examination of these research studies indicated the effectiveness of direct instruction on metacognition. Focusing on their mission to improve student learning and to improve teaching, the authors decided to provide direct instruction on metacognition which was blended with cooperative learning; this was done in the context of everyday classes.

The purpose of this research was to add meaningful data on metacognition to the existing research. While the literature provides much insight into metacognition, it does not do this through a naturalistic environment. This research planned to extend the findings of previous literature by examining student metacognition of middle school students in a naturalistic setting by using student voice and the types of words used in describing their understanding of their metacognition. An action research platform using a qualitative data approach was used in order to drive this naturalistic study.
Action research is a cohesive, systematic inquiry approach in which the teacher/researcher collects data in order to determine how to examine student outcomes (Mills, 2003). Calhoun (2002) views action research as a continual process of formal inquiry in which educators examine their practices, and examine resulting changes. Tomal (2010) views the action research platform as a “systematic process of solving educational problems and making improvements” (p.10). The model of action research used in this study contains elements of all three models, and is shown in Figure 1.

Figure 1.
The Action Research Cycle



Action research is a research staple for the constructivist teacher. The acts of developing and modifying a research question and interpreting data are autonomous acts of knowledge construction. Hendricks (2009), in discussing action research states that “all results feed back into the action research cycle so that the study is continuous, flexible, and constantly evolving” (p.3).

Research Questions

Based on the review of the literature and on their own prior observations of students, the following research questions guided the study:

1. In the view of middle school math students, what teaching strategies are most effective?

2. In the view of middle school math students, what are the reasons for the effectiveness of these strategies?

3. Do students use cognitive learning words in their written and spoken explanations?

4. How can student metacognition guide and improve teaching?

Participants

Students participating in this research were sixth and seventh grade middle school students at a Catholic elementary school in Chicago. There were seventeen sixth grade students, and twelve seventh grade students. It must be noted that while all these students participated in the study, not all were present on the day that the surveys were completed.

Procedures

The study took place at the school once a week for approximately ten weeks. Each week the researchers co-taught a math class in both sixth and seventh grade; this entailed using cooperative learning activities, or as will be explained later, mental math activities. An activity would be embedded into class activities for approximately two weeks (this would be considered a cycle), and at the end of the cycle students were asked to complete a survey. The survey consisted of two questions: the first question asked students to rank the effectiveness of the activity from “Strongly disagree” to “Strongly agree,” and the second question asked students to explain their ranking. This was done in order to have students reflect on their metacognition and to make their metacognition more visible by having them write out the words. (See Appendix 1). Both educators would then meet to analyze results and plan for the next cycle.

Each new cycle would begin with a new activity being emphasized. At the end of the third cycle, students were also expected to rank the activities from the previous three cycles and to also have them explain their reasoning. The survey for this is shown in Appendix 2. It must be noted that during the time between the professor’s visits, the middle school math teacher embedded the chosen activity as much as possible. The surveys were relatively short in order to minimize the time spent on the survey, thus ensuring the naturalistic environment of the study. The activity for Cycle 1 was a cooperative learning activity, the activity for Cycle 2 was a Mental Math activity, and the final Cycle used a second cooperative learning activity. These activities are explained in the following sections.

Results and Discussion of Cycle 1

In the first cycle students participated in a “Think/Pair/Share/Tell What Your Partner Said” activity. This was a traditional cooperative learning activity with the “twist” that students were called on to explain what their partner had said. Since both co-researchers were concerned with the listening skills of the students, it was decided to add the requirement of actively listening to their partner. From this point on, the activity will be referred to as “Think/Pair/Share.” Table 1 displays the results. The coding system was designed such that a “1” indicated a “Strongly disagree” rating, and a “6” indicated a “Strongly agree” statement.

Table 1.
Student Ratings for Think/Pair/Share

Response	Frequency	Percent	Cumulative Percent
1	2	8.3	8.3
2	0	0	8.3
3	3	12.5	20.8
4	3	12.5	33.3
5	7	29.2	62.5
6	9	37.5	100

The results indicate that approximately 67% of respondents rated this activity a 5 or 6, with 8 out of 13 sixth graders and 8 out of 11 seventh graders rating this way. While the descriptive data tells us their perspectives, the narrative responses provide insights into the reasons for these ratings. Table 2 provides a sample coding of student narratives.

Table 2.
Sample Student Narrative Responses on the Think/Pair/Share

<u>One Learns from their Partner</u>

- It helped me learn because I can hear what my partner had to say about the lesson.
- I responded this way because I didn't know how to do it, but when my partner explained it to me in some order, I understood it.
- You get to share things with your partner.
- I chose 5 because you get to learn what other people learned.
- I agree because I might not know how to do the problem, but my partner would know.
- I learned about improper fractions from my partner.
- Because some people have different answers and we talk about them.

<u>A Partner Provides a Different Perspective</u>

- It tells me how other people think and the different ways to say or explain things.
- It helps me out because there was more than one answer so I learned how to do the problem in other ways.

While some responses were just a description of the activity, how students felt, or what they learned (not shown), the responses from Table 2 provide insight into how students perceived their learning. The responses in Table 2 indicate that students are beginning to comprehend how one learns and are also using cognitive learning words. These types of responses indicate the effectiveness of the instructors directly discussing with students the benefits of working with a partner; this provided concrete evidence for considering the formal creation of a program for teaching thinking and other cognitive skills.

In order to create a working premise to improve student learning, the descriptive and qualitative data were connected to each other. Table 3 contains this data, which was derived by relating student perception (descriptive data) of effectiveness to the type of narrative response (qualitative data); all categories of narratives are represented; Table 3 also compares 6th grad data with 7th grade data.

Table 3.
Student Ratings and Narrative Responses by Grade Level

Sixth Grade		
Type of Narrative Response	**Rating**	**Number of students**
One Learns from Their Partner (or provides help)		3
A Partner Provides a Different Perspective	5 or 6	3
Learning as a Metaphor	6	1
Negative response ("I already know how to do the problem")	1	1
Irrelevant (Describes an algorithm or discusses irrelevant information)	4 or lower	4
Seventh Grade		
Type of Narrative Response	**Rating**	**Number of students**
One Learns from Their Partner (or provides help)	5 or 6	3
A Partner Provides a Different	5 or 6	3
Helps with Standardized Tests	4	1
Negative response ("I already know how to do the problem")	Between 3 and 6	3
Irrelevant (Describes an algorithm or discusses irrelevant information)	Between 3 and 5	2

The results from Table 3 indicated that students ranking Think/Pair/Share a “4” or higher may have benefited from the direct instruction on the advantages of cooperative learning. The results also indicated that students are starting to view effective activities as ones which provide either help from a partner or a new perspective from a partner; this is seen through the students’ use of cognitive learning words. It must be noted that since the teacher/researchers never discussed how cooperative learning could help with standardized tests and never discussed using metaphors to evaluate cooperative learning, these responses by students indicated that some middle-level students are beginning to create their own framework for evaluating effectiveness.

One difference that emerged from the data was that more seventh grade students voiced negative comments than sixth grade students. The negative comments follow:

- I already know how to do the problem (6th grade).
- It is hard to understand what your partner or teacher said (7th grade).
- I might not want that person to know that I think some things are hard, but I cannot be afraid (7th grade).
- My partner didn't know it himself very well. I learned math more than my partner (7th grade).

While the comment from the 6th grade student indicated that this student did not understand that another person can expand what one already knows, the other three comments expose potential mis-assumptions for cooperative learning: 1) cooperative learning activities make the assumption that students are already emotionally comfortable with expressing their honest opinions to peers, 2) students must know that working with a partner may provide the opportunity to be a "cognitive coach," and one learns when assuming this role, and 3) cooperative learning assumes that students have some level of proficiency for listening and processing what others say.

Action Plan following Cycle 1

Both teacher /researchers individually and collaboratively reviewed the themes and concepts presented by the data. They used these to develop an action plan which included the continuation of cooperative learning activities and the continuation of class discussions on the advantages of cooperative learning; additionally, the researcher and teacher agreed to consider developing a plan for implementing activities creating the prerequisite skills for cooperative learning.

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Results and Discussion of Cycle 2

While students indicated that they viewed cooperative learning as effective, it was decided to do more mental math activities. The previous study indicated that students thought that mental math was the most effective activity. In that class and in the present class, students really enjoyed these activities; after engaging in these activities students seemed to be more engaged in class and more confident in their abilities. In one of the classes students made it very clear that they wanted to do mental math. The following portion of the professor's journal relates this.

> Their response in class surprised and disappointed me. They said that pair/share was boring! Wow! Then, immediately, they wanted to know if we could do some mental math… While I was excited, I wondered about this. I wondered if I could design mental math exercises that would align with the (standardized tests).

Thus, it was decided to examine student perceptions of mental math. Appendix 3 provides examples of these activities. Additionally, both teacher/researchers wished to see if students used cognitive learning words. Table 4, Table 5, and Table 6 show the results of the surveys for Cycle 2.

Table 4.
Student Ratings for Mental Math

Response	Frequency	Percent	Cumulative Percent
2	1	4	4
3	1	4	8
5	7	29	37
6	15	63	100

The data from Table 4 indicates that Mental Math was considered more effective than the Think/Pair/Share activity. The narrative comments provided more insight into how students were thinking. Tables 5 and 6 provide this data.

Table 5.
Student Narrative Responses for Mental Math-Efficiency

- I learned to how to do math in my head quickly.
- Because it helps me do math in quick time.
- It is easy and stops you from counting on your fingers and guessing.
- It is faster and easier.

Table 6.
Student Narrative Responses for Mental Math-A Different Strategy

- It helped me because it showed me a different way to add.
- I learned a different way to do math
- I agree because it helps you learn good strategies.

The data from Tables 5 and 6 show that mental math was being evaluated in terms of its efficiency, and in terms of being a second way of doing math; this later theme may indicate that students are now realizing that there is more than one way to do mathematics, and this represents growth in metacognitive ability.

Action Plan following Cycle 2

It was decided to continue to do mental math during the next cycle, as well as introducing a new cooperative learning activity, a "Partner Share Worksheet." Appendix 4 provides an example of this activity. Student reaction to mental math was so enthusiastic that both instructors wished to keep student enthusiasm going. Also, by keeping mental math "fresh in student minds," students may be able to articulate more clearly the reasons for their rankings. Additionally, it was decided to interview students in order to gain more insight into their perspectives. The specific goals and guidelines for Cycle Three were as follows:

- To examine if students responses for a new cooperative learning activity (Partner Share Worksheet) would differ from the first cycle.
- To examine how students rank the three activities.
- To examine if students use more “cognitive processing’ terms when explaining their ranking than in the first cycle.
- To determine if students view mental math as a tool for efficiency or as a tool for thinking.

Cycle 3 Results and Discussion

During this cycle students engaged in the Partner Share Worksheet activity, evaluated it as in the other two cycles, and then ranked the three activities. Table 7 displays the results of students ranking The Partner Share Worksheet.

Table 7.
Student Ratings for Partner Share Worksheet

Response	Frequency	Percent	Cumulative Percent
4	5	22	22
5	7	30	52
6	11	48	100

Students rating this activity a 5 or 6 totaled 78 percent, placing the “Partner Share Worksheet” second to Mental Math. Students then ranked the three activities by most effective of the three to least effective of the three (See Appendix 2). The cumulative rankings of the three activities were interpreted by weighting the rankings. Mental Math ranked first, followed by Partner Share Worksheet, and then by Think/Pair/Share.

Table 8.
Cycle ratings and cumulative ratings

Activity	Cycle Rating of 5 or 6	Weighted Score of 3-week Cycle
Mental Math	92%	1st
Partner Worksheet	78%	2nd
Think/Pair/Share	67%	3rd

The cycle ratings and the weighted cumulative ratings align with each other. Mental Math had the highest percentage of students rating it with a 5 or 6, and it had the highest weighted average when students ranked their favorite of three activities. Partner Share Worksheet had the second highest percentage of students rating it a 5 or 6, and it ranked second in the three-week cycle ratings. Think/Pair/Share was third in both ratings.

In order to gain a deeper understanding of student perceptions, students were interviewed. Three major themes emerged from the interviews: 1) Activities as tools for thinking; 2) The mechanics of thinking (cognitive learning words); 3) The disadvantages of cooperative learning activities. Table 9 provides a sampling of these themes.

Table 9.
Sampling of Themes from Student Interviews

Tool for thinking

- It helps me think more (Mental math).
- See how your brain works (Mental Math).
- You think faster (Mental Math).
- It helps me think about what I am doing (Mental Math).
- Helps me know something (Partner Share Worksheet).
- You find the weaknesses between you and your partner (partner Share Worksheet).
- When I write it out I won't forget (Partner Share Worksheet).
- How I worked out the problem (Think/Pair /Share).
- What I was thinking about the problem (Think/Pair/Share)

Mechanics of thinking (Cognitive Thinking Words)

- You learn different things from your partner (Partner Share Worksheet).
- My partner helps if I get stuck (Partner Share Worksheet).
- My partner will help me understand it (Partner Share Worksheet).
- Show what we both know, try to make it better (Partner Share Worksheet).
- When I put it in my own language I understand (Think/Pair/Share).
- It helps me know what I do not understand about the problem (Think/Pair/Share).
- We paired together to see both of our ideas were the same or had the same comments about it (Think/Pair/Share).
- Two can help in a way teachers don't really understand (Think/Pair Share).
- Everybody get to hear different answers (Think/Pair/Share).

Disadvantages of Cooperative Learning Activities

- If you have a bad partner, it may not go well (Partner Worksheet).
- You feel like you don't need to explain, it's like something the teacher already explained (Partner Share Worksheet).
- If you do something wrong, they will get all mad (Partner Share Worksheet).
- Couldn't get to understand what partner said (Think/Pair/Share).
- When it gets time for me to ask them to repeat, it will be time for me to speak to my partner (Think/Pair/Share).
- Sometimes I don't like working with partners (Think/Pair/
- Share).

The data from this table display two important phenomena. One phenomenon is that students are more consistently referring to the mechanics of thinking by using cognitive learning words. These responses suggest that the direct discussion of these behaviors in class may be effective in student development of these traits. The other phenomenon was that students were still describing the activities in general terms such as “thinking,” “knowing,” or “using your brain.” After approximately one-half of the students were interviewed, both teacher/researchers decided to address this issue by directly asking the last group of interviewees to discuss what is meant by the term “thinking.” This was done deliberately to see if participants would use cognitive thinking words. Table 10 displays responses some typical student responses.

Table 10
Sampling of Themes from Student Interviews - What is Thinking?

- Show what we both know.
- I have to think about it first.
- Use your brain.
- To think means to use your brain to help you out.
- You think before you answer. You think before you talk, or you might say the wrong thing.
- Thinking is like…when you think of how to do the problem…think of the numbers.

The results from Table 10 indicate that students have created the construct of cognitive thinking words, but have not constructed a mental space that connects these words to the concept of thinking. Both teacher/researchers agreed that it was mandatory to address this situation.

Action Plan following Cycle 3

Examining the interpretation of Cycle 3 surveys and interviews, the teacher/researchers decided to implement the following action plan:

- Long-term: 1) To start a formal process to examine how to address the weaknesses of cooperative learning; 2) to examine how to integrate metacognition throughout the curriculum; 3) to examine the constructivist nature of mental math and the cognitive activities involved in doing mental math.

- *Short-term/Immediate:* To conduct formal discussions in the two classes concerning what one does when they think. These discussions were held in both the sixth and seventh grade. The final result was a student-produced product, a "Thinking Skills Sheet" found in Figure 2.

Figure 2.
Thinking Skills Sheet

Saint Ethelreda/Benedictine University Partnership

THINKING SKILLS

1. Check answer. Was it correct? Why or why not?
2. Check answer with partner. Did your partner do it differently?
3. What procedures should be followed?
4. Are there other ways to do the problem?
5. What do I know?
6. What do I need to do?
7. What do I still need to do?
8. Connect this problem to other ideas
9. Use different words to describe your thinking

Results of Action Plan following Cycle 3

This sheet was used during the last days of the semester; and the results were very encouraging. Students readily and enthusiastically used the sheet, while teacher observations indicated that these sheets were instrumental in guiding student thinking. Teachers would directly model their thinking out loud as they used the sheet to solve math problems. Next, teachers would guide students in their use of the thinking sheets. This guiding process aligns with the ideas of Paris and Paris (2001).

> The developmental metaphor recognizes the Piagetian tenet that behavior is organized and that self-regulation is an adaptive expression of that organization. Self-regulation in this view is not “acquired” as much as it is shaped and elaborated through participation in “zones of proximal development” according to tenets of socio-cultural theories (p. 96).

Additionally, it was decided to use these sheets during the upcoming school year, with the possibility of using them in classes other than mathematics. Early indications signaled that these sheets were effective in helping students learn problems and solve problems. In turn, this led to another unexpected outcome. The following fall the classroom teacher was now teaching English Language Arts, and modified the Thinking Skills Sheet so it can be used in an English Language class. This is shown by Figure 3.

Figure 3.
Thinking For Writing

Saint Ethelreda/Benedictine University Partnership

THINKING FOR WRITING

1. What procedures should be followed?
2. What do I know about what should be written?
3. What don’t I know about the topic? What must I do to learn this?
4. What other ideas can I connect to the topic? Can I connect personal experiences to the topic? Can I connect other subject areas to this topic?
5. What other strategies or perspectives can I use?
6. What have I written that has surprised me? Should I expand on this?
7. Did my partner write it differently? Can I incorporate any of my partner’s ideas into my writing?
8. What other words can I use in this essay?
9. Are there other ways to write this essay?
10. After the revision, what can I still do? What do I still need to do?

The modification of the Thinking Skills Sheet for a Math class for use in an English Language Arts class brings up an unexpected result of this research. This phenomenon addresses the question, "Can metacognition be transferred across domains?" This initiative correlates with the views expressed by Veenman, Van Hout-Wolters, and Afflerbach (2006): "General metacognition may be instructed concurrently in different learning situations and may be expected to transfer to new ones, whereas specific metacognition has to be taught for each task or domain separately" (p.7).

Conclusion and Summary

This action research study sought to use student perspectives to not only analyze student metacognitive awareness and levels, but to use these perspectives to drive instruction and curriculum. The results align with the research questions driving this study and also resulted in unexpected results. These results drove the curriculum in unexpected directions.

In terms of the first two research questions, students differentiated between the different types of learning activities, including the two types of cooperative learning activities. While students viewed cooperative learning as effective, the process of using their voice resulted in data which influenced our teaching. We found out that amongst other things, students believed that they learn from their partners, that their partners provided another perspective, that writing down or explaining their ideas is effective, and that two students can explain a concept as well or better than a teacher. What was not expected were the negative comments concerning cooperative learning. These comments enabled the researcher and teacher to make changes in their teaching and the entire school curriculum. This included examining the prerequisites for cooperative learning and a development of a school-wide plan for this. This aligns with question four which asks how student metacognition can be used to guide and improve teaching.

Results of the qualitative data align directly with research questions three and four. The coding of student responses showed that students do use cognitive words, and that formal and informal class discussions helped to improve student metacognition through the use of cognitive words, and this aligns with the literature. The results also demonstrated that analyzing student words can be used as an effective assessment instrument. These comments, as well as anecdotal comments, showed however, that students, while using cognitive words, did not connect these phrases/words to the word "thinking." This resulted in a plan for formally discussing with students what it means "to think." The result of this formal class activity was the "Thinking Skills" sheet, which was then modified across domains to be used in an English Language Arts Class.

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Appendix 1

SAINT ETHELREDA/BENEDICITNE PARTNERSHIP

SURVEY FORMS

*Name*_____________________________ *Date* _____________________________

Grade ___________________________ *Activity* ___________________________

1. *Look at the following statement. "This week's activity helped me learn mathematics." Please circle the response that describes how you feel.*

○	○	○	○	○	○
1 **Strongly disagree**	**2**	**3**	**4**	**5**	**6** **Strongly agree**

2. *Look at your response from above. Write a few sentences to explain why you feel the way you do about the activity.*

Appendix 2

SAINT ETHELREDA/BENEDICITNE PARTNERSHIP

CYCLE SURVEY FORMS

SPRING 2011

Name______________________________ Date ______________________________

Grade ____________________________

Dr. Pelech has just reviewed the learning activities from the last three weeks. He has written their names on the board. Please rank these by writing the name of the activity in each blank. The first blank is for the activity that is the most effective for you. The second blank is for the second most effective activity. The third blank is for the activity that was the third most effective activity. Please feel free to explain your response in the space provided.

1. *Most Effective Activity for you. ____*
2. *Second Most Effective Activity for you.__________________________________*
3. *Third Most Effective Activity for you.____________________________________*

Appendix 3

SAINT ETHELREDA/BENEDICITNE PARTNERSHIP

MENTAL MATH PROBLEMS

1. Finding the answer to a string of numbers that are added, subtracted, multiplied, or divided.
2. Put in Multiply by 11
   - *Ex: Multiply 17 X 11.*
   - *This "trick uses the distributive law.*
   - *N(10+ 1) =- 10N + 1X N*
   - *To multiply a number by 10, you add a zero. To multiply a number by 1 results in the number.*
   - *17 X 11 = 170 + 11= 187*
   - *It must be noted that we made sure that the students understood the mathematics behind the "trick" before they were allowed to use the trick exclusively.*
3. Multiply by 25
   - *25= 100 X ½ X ½*
   - *Thus, one adds two zeros, "splits in ½" twice*
   - *Ex: 44 X 25 =4400, split in ½ =2200, split in ½ = 1100*
   - *It must be noted that we made sure that the students understood the mathematics behind the "trick" before they were allowed to use the trick exclusively.*
4. Add left to right vs. adding right to left

   This "maneuver" does not use the often-used algorithm of "carrying." Additionally it uses the concept that a number is actually the result of relating other numbers; as an example, 10 is two more than eight, and twelve is two more than ten.

   Ex: 37

   <u>+ 45</u>

   30 + 40 = 70 and 7 + 5. Then, 7 + 3 = 10, and two more is twelve.

   So, 70 + 10 = 80, and two more is 82.

Appendix 4

SAINT ETHELREDA/BENEDICITNE PARTNERSHIP

PARTNER SHARE WORKSHEET

Name______________________ Name ______________________

1) Solve for x and show all work

   $3x - 5 = 22$

2) Solve for x and show all work

   $5x + 11 = 49$

3) Solve for x and show all work

   $4x + 6 = 26$

4) Solve for x and show all work

   $9x - 5 = 67$

EXPLANATION: For this activity, there are two partners. They both put their names on the sheet. Partner A does problem 1 and explains his reasoning to Partner B as he writes it down his work. If Partner A gets stuck, Partner B then coaches him. The teacher then discusses the work with the entire class. Partner A then gives the paper to Partner B, and roles are reversed.

