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ABSTRACT

This report investigated to what extent a curriculum designed to actively teach critical thinking skills resulted in students utilizing higher-order thinking skills (e.g., analysis, synthesis and evaluation). An intervention strategy was designed for a sixth grade class located in a diverse suburban community in northern Illinois. The intervention targeted the mathematics curriculum and was designed to incorporate the teaching of critical thinking skills. Students were administered a pretest to determine baseline data. The intervention included the daily use of a variety of thinking skill enhancers and guided assessment of problem-solving strategies for a twenty-week period. Results indicated success on many levels. Students displayed increased self-esteem and confidence in their abilities to problem-solve. Self-reflection of their work was also observed. Students were able to verbalize their thought processes in analyzing problems. As an indicator of success, however, it was hoped that there would have been a higher number of students displaying an increase in posttest results. Nevertheless, with over fifty percent of the students involved in the intervention showing increased scores, the time and energy expended in this project were affirmed. (Contains 13 references.) (Author/YDS)

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INCREASING CRITICAL THINKING SKILLS TO IMPROVE PROBLEM-SOLVING ABILITY IN MATHEMATICS

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Results indicated success on many levels. Students displayed increased self-esteem and confidence in their abilities to problem-solve. Self-reflection of their work was also observed. Students were able to verbalize their thought processes in analyzing problems. As an indicator of success, however, it was hoped that there would have been a higher number of students displaying an increase in posttest results. Nevertheless, with over fifty percent of the students involved in the intervention showing increased scores, the time and energy expended in this project were affirmed.

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CHAPTER ONE

PROBLEM AND CONTEXT

The sixth grade class in question exhibits an inability to relate and apply facts and concepts to tasks requiring them to utilize critical thinking skills, a deficiency which mirrors student ability throughout our educational system. This difficulty manifests across all core curriculum subjects, but most markedly in the subject of mathematics. Informal teacher observations indicate that students perform poorly on tasks when they must apply critical thinking skills to reach a solution or an answer. In addition, Stanford Achievement Test scores over recent years show that students do not utilize higher-order thinking skills such as analysis, synthesis and evaluation nor do they transfer these strategies to problems they encounter outside the classroom.

National Context

As stated, enhancing students' critical thinking through the use of higher-order thinking skills is a problem faced by educators nationally. Research on developmental education has repeatedly found that programs based on a cognitive model that encourages students to become strategic and self-regulated learners are more successful than those based on remediation of discrete skills (Stahl, et al., 1992). Students are taught from a very early age to be unquestioningly obedient to adult directives. Usually students continue this pattern of behavior in school. It is more common than uncommon for students not to question reasons for performing a particular task. Metacognition is virtually an unknown in students' school experiences; it is neither sought after by students nor encouraged through instruction (Sternberg and Wagner, 1982). Findings corroborate theories that emphasize the integration of cognitive, metacognitive, and affective components in learning. Education that targets only content or rote learning is limited in its power to enable students to link school instruction with real-world behaviors and to retain and transfer knowledge to new situations (Hartman and Sternerg, 1992-93). This theory is substantiated by the research data of Dossey, et al:

> The mathematical performance of students at ages 9, 13, and 17 has improved somewhat over the past eight years, yet a closer look at levels of proficiency indicates that most of the progress has occurred in the domain of lower-order skills. This picture reflects classrooms more concerned with students' rote use of procedures than with their understanding of concepts and the development of higher-order thinking skills
> (1988, p. 12).

In the current movement toward emphasis on thinking skills as a primary goal of education, special instruction is being instituted in colleges, secondary and elementary schools. The implication of theory and research of critical thinking is that it is an integral part of teaching basic skills in the content areas. Teaching students thinking processes enables them to use critical thinking strategies efficiently in a variety of situations.

Research and Solutions

"The proportion of college graduates who demonstrate an advanced ability to think critically, communicate effectively, and solve problems will increase substantially" (U.S. Department of Education, 1991). This goal was included in the Goals 2000 Act passed by Congress in 1990. However, five years later Robert Ennis, a major figure in the critical thinking movement, wrote: "Although critical thinking has often been urged as a goal of education throughout most of this century, not a great deal has been done about it" (1993, p. 179). Ennis, among others (e.g., Halpern, 1993; Paul and Nosich, 1991; and Facione, 1990) believes teaching students to become critical thinkers can be accomplished if educators begin with a comprehensive definition of critical thinking, are clear about the purpose of teaching critical thinking skill, and use multiple measures of critical thinking.

Although there are dozens of definitions of critical thinking, there is significant overlap in most of them (Halpern, 1993). The definition that is most comprehensive can be found in Facione's Critical Thinking: A Statement of Expert Consensus for the Purpose of Educational Assessment and Instruction, which states:

> We understand critical thinking to be purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference...The ideal critical thinker is habitually inquisitive, well-informed, trustful of reason, open-minded, flexible, fair-minded in evaluation, honest in facing personal biases, prudent in making judgments, willing to reconsider, clear about issues, orderly in complex matters, diligent in seeking relevant information, reasonable in the selection of results... Thus, educating good critical thinkers means working toward this ideal
>
> (1990, p. 2).

Gourgey and Earisman (1997) applied the theory of the above definition to create a developmental course called "Precise Thinking" that integrated reading, writing and mathematical skills with underlying metacognitive processes. The term "precise thinking" reflected the program's goal that students learn to think carefully about language and numerical concepts, that students reflect on the meaning of what they read, that they explain their reasoning clearly both orally and in writing, and that they learn to use language and mathematics explicitly and accurately as a "map" of events and relationships in the real world. Students worked independently (at their own pace) and in groups to complete packets or tasks. All packets required students to apply basic verbal and/or quantitative skills in a manner requiring precise thought and analysis. From the beginning, the following principles guided the development of the program:

- The truly basic skill is thinking, whether manifested in reading, writing or mathematical problem solving; thinking underlies all academic work and most productive life activity.

- Skill development requires that students be constantly working at the edges of their abilities; hence the work must be challenging.

- Thinking skills, which facilitate the acquisition of knowledge cannot be acquired in a content-free environment

- Students, in thinking skills courses, should be trained to monitor their thinking processes—that is , to acquire metacognitive skills.

- Educators should not function as "expert" but as generalists, comfortable with both mathematics and verbal skills and keenly aware of their own thinking processes as learns and as teachers (p. 50).

The results of their program indicated that Precise Thinking "graduates" acquired more perseverance and more strategies for self-directed learning than students receiving traditional instruction.

Summary

Critical thinking is a skill. Like any other skill, it can be taught, it can be learned, and it can be improved with practice and daily use. The purpose of this study will be to identify a specific critical thinking skill, provide direct instruction and practice of that skill, report findings, and evaluate student development.

CHAPTER TWO

PROBLEM CAUSES

Evidence of Problem

Administration of a pre-test that identified students' strengths and weaknesses in deductive and inductive reasoning skills indicated that the targeted class performed lower than the national norms. Students often exhibited frustration when confronted with problems or situations for which they were expected to draw conclusions. Students were consistently unable to infer and draw logical, well-founded conclusions. These observations and assessments indicated the need to strengthen their use of deductive and inductive reasoning.

Probable Cause

Based upon informal observations of teaching strategies utilized in the school in question, the major focus of instruction is still on traditional subject areas: Reading, written expression, Math, Social Studies, and Science. Teachers often complain about their inability to cover all the material in the content curriculum, lending credence to the belief that there is more concern with covering material than teaching students how to think and evaluate ideas and concepts critically. Teachers may often assume that students have developed higher-order thinking skills through the use of traditional approaches to instruction, relying heavily upon classroom presentations, textbooks, and workbook or teacher-prepared exercises. These strategies serve to assist student attainment of basic levels of proficiency; however, based upon students' performances on formal and informal assessments, they have not proved to help students achieve higher levels of critical thinking.

Teacher accountability for student learning and growth has become a salient issue in the district. Teachers have been informed that they may be held liable for student progress and learning. This has heightened many educators' anxiety to push through the curriculum, with little or no regard for fostering student thinking skills and creativity.

The district has also taken an aggressive initiative to end social promotion, recognizing that working to give students the opportunity to reach high standards of learning is the responsibility of educators and state and local leadership. Students who are allowed to continue to pass through school with their peers without meting academic standards are placed at risk for becoming successful and productive members of a technologically-demanding society. This initiative as well has produced an environment in which teachers are more concerned with the quantitative measures of education as opposed to the quality of instruction.

It is clear that a strategy is needed which emphasizes developing the lifelong learning and thinking skills necessary to acquire and process information within an ever-expanding field of knowledge. The accumulation of facts to recall, recite and describe has become obsolete in educating students for their life and work (Costa, 1981). The work force of the future will demand that workers use high skill levels and creative thinking. Educators must recognize the need to teach critical thinking skills if students are to become successful. Robert Ornstein (1980) stated, "We need a break-through in the quality of thinking employed both by decision-makers at all levels of society and by each of us in our daily affairs" (p.1).

Demographics

The population of the target school consists of 335 students as reported in the 1998 School Report Card. It is part of a seven school district that has a total enrollment of 3,059 students. The grades in the target school are Kindergarten through sixth grade. After sixth grade, students feed into the district junior high school to complete seventh and eighth grades.

The racial/ethnic make-up of students enrolled in the target school as compared to district enrollment is indicated in Figure 1.

	White	Black	Hispanic	Asian/Pacific Islander	Total Enrollment
School	51.60%	43.60%	2.70%	2.10%	335
District	10.40%	87.10%	1.80%	0.07%	3,059

Figure 1: Racial/ethnic background and total enrollment

There is a significant disparity in the number of low-income families when the state figures are compared to the district and target school (see figure 2).

	Low-Income
School	59.70%
District	63.60%
State	36.30%

Figure 2: Low-income students

Low-income students are defined as students from families receiving public aid, living in institutions for neglected or delinquent children being supported in foster homes with public funds, or eligible to receive free or reduced-price lunches.

The attendance rate of 93.8% is comparable with state figures; however, the target school's mobility rate is 13.5% higher than the state's mobility rate of 18.2%.

School staffing includes one principal, fifteen grade level teachers, two cross-categorical teachers, one reading remedial/resource teachers, one special education resource teacher, one full-time physical education teacher, one full-time music teacher, one part-time nurse, one part-time speech and language specialist, one part-time school psychologist, and two classroom full-time teachers' aides. Auxiliary personnel include one secretary, four lunchroom aides, and two janitors. The school personnel are 69% white and 31% black.

CHAPTER THREE

METHODOLOGY

The business of education is never static. Teaching strategies designed for student success must continually be analyzed, reviewed, reformed, and re-analyzed. Where deficiencies are observed, intervention must be designed and instituted. It was upon this premise that this research project was based.

This report investigated to what extent a curriculum designed to actively teach critical thinking skills resulted in students utilizing higher-order thinking skills. A strategy that emphasized development of lifelong learning and thinking skills was implemented in an effort to acquire and process information within an ever-expanding field of knowledge.

Historical Description of the Intervention

Identification of Study Participants

An intervention strategy was designed for a sixth-grade class located in a diverse suburban community in northern Illinois. The class of seventeen students that comprised this study was part of a sixty-two member sixth grade population: fifty-eight students were divided into three regular education classrooms and four students were grouped into a self-contained special education classroom. The regular education teaching team was responsible for teaching team was responsible for teaching Reading, Math and Spelling. In addition, the sixth grade teachers decided to departmentalize the remaining subjects of Science, Social Studies and Language Arts. Each regular education teacher was therefore responsible for teaching one of the departmentalized classes.

Per an administrative directive, all regular education students from second thru sixth grades were ability-grouped for Math and Reading, based upon their skill level and performance on the previous year's standardized tests. Students were grouped into three math groups and four reading groups. (The reading program had an extra staff member because the district qualified for the services of a Title I reading improvement teacher.) The rationale for ability groups was based on research that suggested students are more successful when they are grouped with students who are functioning at a similar skill level.

The math groups were determined based upon the 1999 Stanford Achievement Test results. The test was administered in May of 1999 and tests the following math skills:

Problem Solving:	Measurement, Estimation, Problem-solving Strategies, Number and Number Relationships, Number Systems and Number Theory Patterns and Functions, Algebra, Statistics, Probability and Geometry
Procedures:	Computations/Symbolic Notation, Computation in Context, and Rounding.

Student total math scores were ranked from high to low. The scores ranged from PHS (post high school) to 3.4 (see Figure 3).

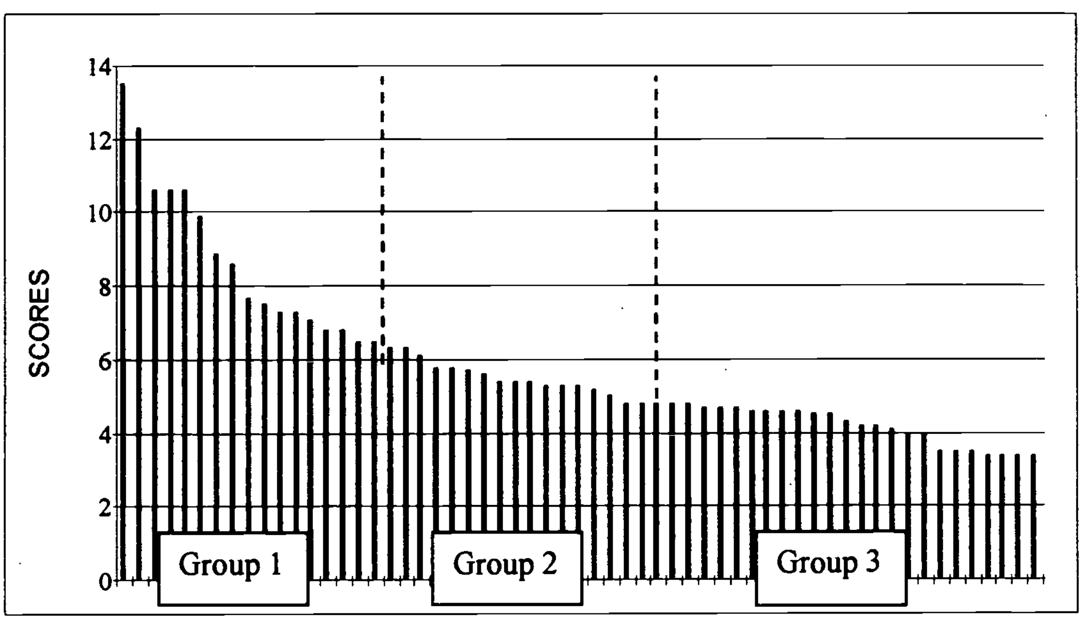

Figure 3: Ranked list of student mathematics scores

Student ability groups were formed as follows: twenty-two students in Group One (PHS to 6.2); seventeen students in Group Two (6.1 to 4.5); and nineteen students in Group Three (4.5 to 3.4). Of the twenty-two students in Group One, twelve of the students were girls and ten were boys. The ethnic make-up of Group One was nine black students, ten white students, two Hispanic students and one Philipino student. Group Two's composition was similar to Group One. There were nine girls and eight boys. Ethnically, Group Two consisted of ten black students and seven white students. Group Three had nine girls and ten boys. The ethnic make-up was nine black students, eight white students and two Hispanic students.

Description of Problem Assessment

All regular education students in sixth grade were administered a pre-test to determine baseline data regarding their ability to problem-solve using inductive reasoning. The test administered, Part One of the Cornell Critical Thinking Test, Level X, 1985, was designed for students grades four through fourteen (see Appendix A). This assessment instrument provided a method of measuring the thinking ability of the test taker. The test is designed to detect the differences in critical thinking ability between groups. Specifically, the twenty-two item test questions were designed to measure the test taker's ability to discern support for a hypothesis. The questions indicate ability to explain fact, determine facts that may be inconsistent with the hypothesis and identify information that is in conflict with information that might weaken the support for a hypothesis.

The purpose for using the Cornell Critical Thinking Test, Level X was to determine whether a particular instructional approach was effective in increasing critical thinking skills. The same Cornell Critical Test was used as both a pretest and a posttest. The pretest assessment was administered to the students during the week of September 13, 1999. Particular caution was taken not to divulge to the students that the assessment was a pretest. Students were informed only that they were taking a test that would indicate how well they employed critical thinking skills. In addition, there was no discussion of pretest results that would have compromised posttest results.

Action Plan

Intervention Strategy

The intervention began the week of September 20, 1999 and concluded the week of February 14, 2000. It was determined that students in Group Two would be the group to receive the intervention. This decision was based upon the fact that students were being ability grouped and the research data that provided the premise for grouping. Because the same math curriculum was used for all three groups, research on ability grouping indicated that the higher-level group would tend to benefit from their association. According to research (Loveless, 1998), homogenous higher-level ability groups have a propensity to excel, whereas for lower ability groups to excel, curriculum must be adjusted to secure their success. Therefore, by adjusting the curriculum to actively teach critical thinking skills, if a lower level group receiving intervention were able to show growth in problem-solving skills, this would be an indicator that the intervention strategies applied had been successful.

Intervention Components

The major elements of the approach used to increase the higher-order thinking skills of the subjects fell into three categories: those strategies designed to infuse thinking skills into the curriculum; those strategies designed to empower students with their own thinking approaches; and , strategies designed to increase teacher emphasis on teaching for thinking. These elements related to the objective in that they attempted to bring about change in thinking skills.

The intervention strategy was administered for twenty consecutive weeks and consisted of four phases as outlined in the ensuing discussion and Figure 4.

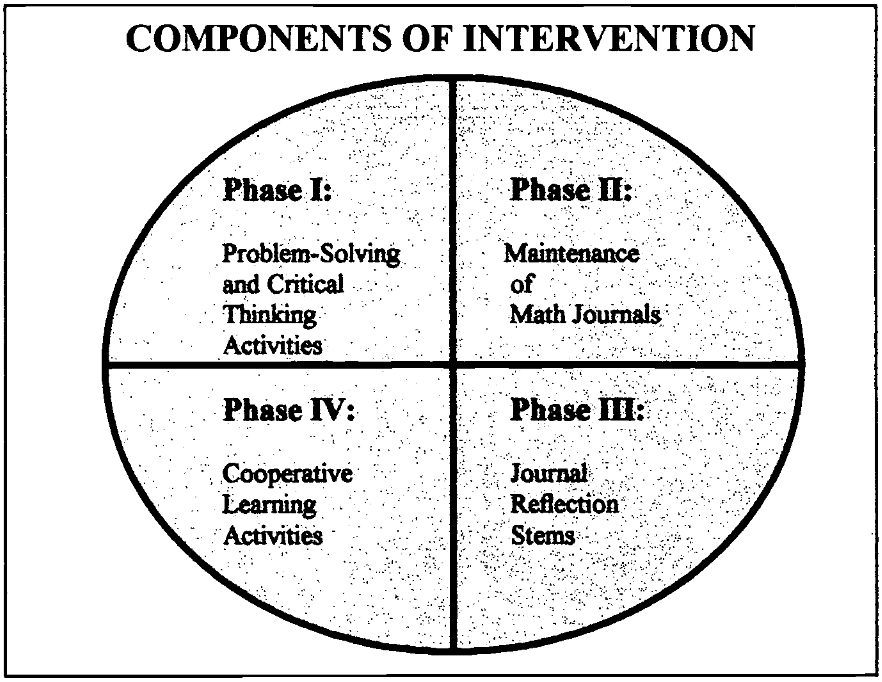

Figure 4: Four phases of intervention

Phase I: Problem Solving and Critical Thinking Activities. During the period of intervention, daily practice in problem-solving and instruction in developing problem-solving skills were implemented. Math class began with students independently solving two to four word problems (see Appendix B). Through class discussion, students conducted a self-check of their work. The teacher-led discussion consisted of three steps: questioning, strategizing and computing.

The class discussion, facilitated by the teacher, used guiding and leading questions to reveal and clarify the substance of the activity. Students were guided to think through the problem by analyzing its components.

The next step, strategizing, involved students discussing alternative approaches to solving the designated problem. Students were encouraged to think of creative and different ways to reach a solution by employing routine and nonroutine strategies (see Figure 5).

Routine Strategies	**Nonroutine Strategies**
Choose an Operation	Make a graph
Write an Equation/Number Sentence	Draw a Picture/Draw a Diagram
Use a Formula	Solve a Simpler Problem
	Try and Check
	Work Backward
	Make a Table
	Find a Pattern
	Use Logical Reasoning

Figure 5: List of problem-solving strategies

The final step of Phase I, solving the problem, involved the student applying computational skills to arrive at a solution. This step also included discussion of operational signal words and phrases. This step served as an opportunity for the student to extend and practice acquired problem-solving skills, applying problem-solving skills to new and different problems.

Phase II: Maintenance of a Math Journal. The math journal was used solely for student self-assessment of problem-solving skills. This evaluative tool encouraged students to "look back" at their work. Students were challenged to recall why they selected the strategy (ies) they used, why it did or did not work and how would they approach a similar problem in the future. The focus of the math journal was to guide students in analyzing their methodology and selection of operation rather than the mechanics of computation. The math journal provided an opportunity for students to self-criticize and evaluate their solutions and decision. The goal of maintaining a math journal was to promote student ownership of their learning (see Appendix C).

Phase III: Journal Reflection Stems. Four times during the period of intervention, reflective stems were completed by students (see Appendix D). The purpose of the stems was to lead students' metacognition of their problem-solving skills. Students reflected upon their strengths and weaknesses as problem solvers. The journal reflections were used as a measurement of how each child increased in higher-order thinking skills, looking at strategies used by the students, and articulation of thoughts by the students.

Phase IV: Cooperative Learning Activities. Cooperative learning activities provided opportunities for student encouragement and support of each other in their quest for the development of higher-order thinking skills. As an instructional strategy, cooperative learning naturally complements other instructional approaches for developing student-thinking skills. Students are given "think time" before the group began a task. Students were instructed to individually think about how they would approach the task or problem for one minute before group discussion began. Groups were instructed to develop a strategy; to discuss the importance of the content; talk about when, why, and how the information contained in the task is to be used and identified; and, what is to be learned before beginning a task. Following a cooperative or individual task, students reflected on the processing that occurred while completing the task. The reflections were discussed in cooperative groups, whole-class discussions and/or in their writing journals.

CHAPTER FOUR

EVALUATION OF RESULTS

Presentation and Analysis of Project Results

A variety of data collection methods were used to assess the effects of this intervention. Evidence of student higher-order thinking was measured by comparing beginning and ending data of the Cornell Critical Thinking Test, Level X, journal reflective stems, and teacher observations of cooperative learning groups. Abilities to relate and apply facts, reason, conceptualize, analyze, synthesize, and metacognate was evidenced in these assessments.

The pretest and posttest data of the Cornell Critical Thinking Test, Level X are represented in Figure 6.

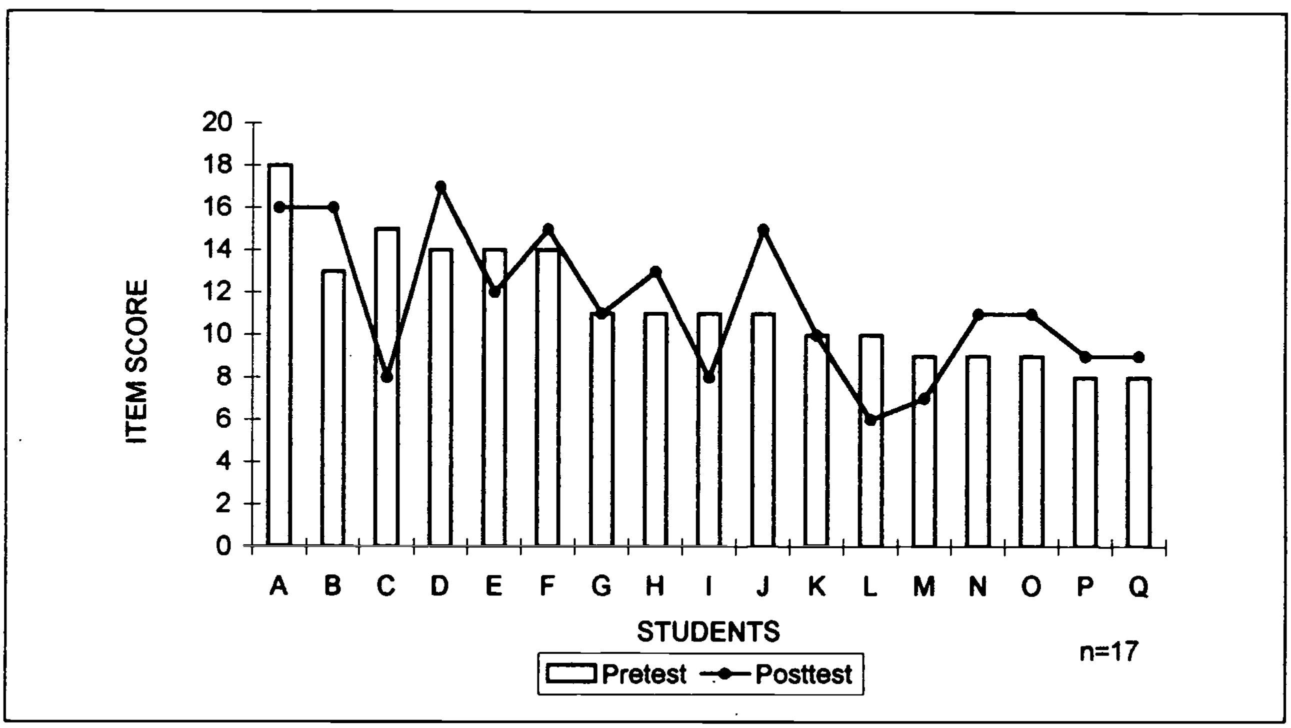

Figure 6: Cornell Critical Thinking Test, Level X, pretest and posttest comparison

The data displayed above indicates that of the seventeen students in Group Two, to whom the Cornell Critical Thinking Test, Level X was administered, gains were seen between both pretest and posttest scores in fifty-three percent of students. An additional twelve percent of student scores remained the same for both pretest and posttest. Thirty-five percent of the students involved in the intervention did not improve scores when pretest and posttest results were compared. Student C showed the most significant decrease in scores. Because the range of scores for this student deviated by twice the averaged deviation of the other students, Student C's scores suggested that perhaps extenuating circumstances needed to be evaluated. An informal interview revealed that on test date, the student was indisposed. This was accepted as a viable explanation for the student's poor performance on the posttest.

Beginning and ending comparison results from student journal reflective stems indicated an increased use of higher-order thinking skills by students. Student responses evidenced a more organized and systematic approach to problem solving. Initially when asked to respond to the stem, "What are your strengths in math?", student responses indicated that students felt competent in mathematical computation (i.e., addition, subtraction, multiplication and division, see Figure 7.)

	Pre-Intervention Reflective Stem Response	Post-Intervention Reflective Stem Response
Addition	14	16
Subtraction	10	14
Multiplication	11	15
Division	6	12
Decimals	3	8
Word Problems	0	6

Figure 7: Pre and post intervention reflective stem response

At the time of pre-intervention, no student identified that solving word problems was a strength. In fact, three students identified solving word problems as a weakness. However, when the question was asked again at post-intervention, six students included solving word problems as a strength. The implication of this data was that student competence increased as a result of the instructional strategy applied.

Reflections and Conclusions

The intervention strategy to improve student ability to think critically was successful on many levels. Increased student self-esteem and confidence were the most outward affective indications of success. Comments noted by students in their journals were quite often self-affirming. Students used phrases like: "Good job", "Way to go", "OK", or "All Right". These comments were written after daily self-assessments of word problems as evidence that students were pleased with their ability to problem-solve. Self-corrections of incorrect problems indicated that students were reflecting upon their errors in an attempt to improve.

As an indicator of success, it was hoped that the number of students who showed an increase in scores would have been higher. However, the nine students whose scores did increase were deemed substantial enough to validate the success of the intervention. The point can be argued that the time and energy expended was not wasted on the students who scored higher, nor has the long-term impact upon all the students involved been addressed.

During class discussions, students verbalized problem-solving processes, offering creative and imaginative solutions. Quite often several solutions were conveyed as evidence that students were exploring various pathways of thinking and making accurate predictions.

The cooperative learning skills continually improved throughout the intervention. These skills served to enhance the effectiveness of students focused on being successful as individuals as well as members of a team. Brainstorming solutions was facilitated because students applied cooperative learning skills, such as:

- accepting the ideas of others;

- listening attentively;
- taking turns speaking; and
- respecting the contributions of each group member.

The benefits of developing critical thinkers have been well documented. Our ever-increasing technological society demands that problem-solving skills be utilized. However, research and achievement test scores indicate that students are quite often not prepared to meet the challenge. The skill to think critically must be taught and reinforced through intervention such as the one discussed. Students must be given the necessary tools and time to practice using those tools in order for the skill to be assimilated into the student's life-long ability to solve problems. The teaching of critical thinking skills to problem solve may be fairly superficial without consistent reinforcement and use.

Minds must not be shaped and molded, because this determines boundaries and sets limits upon the student. Rather, minds must be exposed and encouraged to explore the endless possibilities and solutions to problems. This intervention provided a firm foundation for students to engage more skillful problem-solving techniques. The impact upon the students is immediate and crucial to future learning.

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Appendices

Appendix A

Cornell Critical Thinking Test, Level X, Section One

EXPLORING IN NICOMA

The year is 2001. It is the middle of June. Imagine yourself to be in the second group from Earth to land on the newly discovered planet Nicoma. Nothing has been heard from the first group, which landed on Nicoma two years earlier. Your group has been sent to make a report about what happened to the first group.

In this booklet, you will be told about some things learned on Nicoma by your group. Then you will be given problems that call for clear thinking. Answer these problems as if the things you are told are true.

Do not guess wildly at any answer. If you have no idea what the answer is, leave a blank. If you have a good idea, even though you are not positive, answer the problem.

The test has four parts. In the first two parts you must not go back to a problem once you have passed it.

Now wait until you are asked to begin.

SECTION I
WHAT HAPPENED TO THE FIRST GROUP?

The first job of your group is to find out what happened to the first group of explorers. Your group has landed on Nicoma and has just discovered the metal huts put up by the first group. From the outside, the huts appear to be in good condition. It is a warm day, and the sun is shining. The trees, rocks, grass, and birds make Nicoma appear like much of North America.

You and the health officer are the first to arrive at the group of huts. You call out, but get no answer.

The health officer suggests, *"Maybe they're all dead."* You try to find out if he is right.

Listed below are some facts you learn. You must decide whether each fact supports the health officer's idea, *or* suggests that the health officer's idea is mistaken—*or* neither.

For each fact, mark one of the following on your answer sheet:

- **A.** This fact **supports** the health officer's idea that everyone in the first group is dead.
- **B.** This fact **goes against** the health officer's idea.
- **C.** **Neither:** this fact does not help us decide.

Here is an example of the kind of problem in this part of the test:

1. You go into the first hut. Everything is covered by a thick layer of dust.

Is this fact **for** or **against** the health officer's idea, or **neither?** It certainly isn't enough to prove him right, but it does give some support. If a fact supports the health officer's idea, you should mark **A** on your answer sheet. Mark **A** for Number 1.

Mark your answer for this next example:

2. Other members of your group discover the first group's rocket ship nearby.

The answer is **C**. Knowing that the first group's rocket ship has been discovered doesn't help you decide one way or the other. Since this fact doesn't help you decide whether the health officer is right, **C** is correct.

GO ON TO THE NEXT PAGE.

Here is a list of facts. For each one mark **A, B,** or **C.** If you have no idea which to mark, leave a blank and go on to the next one. **Consider each fact in the order in which it is numbered.** Work carefully, and **do not return to a problem once you have passed it.**

Reminder—mark as follows:

- **A.** This fact **supports** the health officer's idea that they are all dead.
- **B.** This fact **goes against** the health officer's idea.
- **C. Neither:** this fact does not help us decide.

3. There are ten huts. You go into the second hut and again find that everything is covered by a thick layer of dust.
4. You go into the third hut. There is no dust on the cookstove.
5. You find a can opener by the cookstove in the third hut.
6. In the third hut you find the daily record of a member of the first group. It is written by a man named John Stilltron. The date of the last entry, July 2, 1999, is one month after the arrival of the first group.
7. You find that the two beds in the third hut are covered with a thick layer of dust.
8. You read the first entry in Stilltron's record: "June 2, 1999. We arrived today after a tiring trip. We put up the huts near our landing place."
9. You read the second entry in Stilltron's record: "June 3, 1999. There is a plentiful supply of food. Ducks, squirrels, and deer are here and are easily caught."
10. You read the third entry in Stilltron's record: "June 4, 1999. The water in the nearby stream has been tested by our health official. He says it is safe to drink. We are not drinking it yet. We're going to try it with some guinea pigs we brought from earth."
11. You read the last entry in the book: "July 2, 1999. I am getting weaker and can't hold out much longer."
12. In different but shaky handwriting below the last entry, you read, "John Stilltron died the same day."
13. The health officer has now looked in each of the ten huts. He reports that there is a thick layer of dust in each of them.
14. You examine the beds in each of the first three huts. You find that in each case the blankets and sheets are stripped from the beds and folded neatly in the closets.

Appendix A, cont.

Reminder—mark as follows:

A. This fact **supports** the health officer's idea that they are all dead.
B. This fact **goes against** the health officer's idea.
C. **Neither:** this fact does not help us decide.

15. The health officer reports that the beds in all the other huts are in the same condition. The blankets and sheets are neatly folded in the closets.

16. You notice a mound of earth behind Stilltron's hut. You examine it and find a stone with these words on it: "John Stilltron. July 2, 1999. He died as he lived—with honor."

17. The first group's truck is missing.

18. In the tenth hut you find a note dated March 15, 2001:

    If anyone should come looking for us, we have all gone exploring in the truck. We plan to head in the direction of the sunrise. (Signed) Captain Sardus, Leader of the Nicoma Explorers.

19. You see a note added at the bottom:

    P.S. We plan to be back within a week.

20. Eight members of your group get in one of your group's trucks and head in the direction of the sunrise. You follow a rough broad valley for 20 miles and find the first group's truck by a stream. The truck looks abandoned.

21. You find a note in the driver's seat:

    Engine breakdown. We plan to hike downstream. Perhaps there's a large body of water in that direction. (Signed) Captain Sardus.

22. One of the eight, who is a mechanic, examines the truck's engine. He says that it is in bad condition.

23. You notice that the truck's front tires are flat.

24. You start to drive downstream, since the land is level and clear. After 10 miles of driving, you see smoke rising in the distance. As far as you know, there are no volcanoes on Nicoma.

25. You soon come to a cliff too steep for the truck. So all eight of you get out and walk toward the smoke.

Appendix B

Sample Word Problems

Multiplication of Mixed Numbers

6. Marty rode his skateboard $2\frac{1}{9}$ blocks today. Dean rode his skateboard $2\frac{1}{2}$ times as far as Marty. How many blocks did Dean ride his skateboard today?

7. Craig joined his dad in riding around in their canoe on the lake. They traveled $2\frac{3}{4}$ miles in all. Doug rode in his canoe $1\frac{5}{6}$ times as far as Craig! How many miles in all did Doug ride around the lake in his canoe?

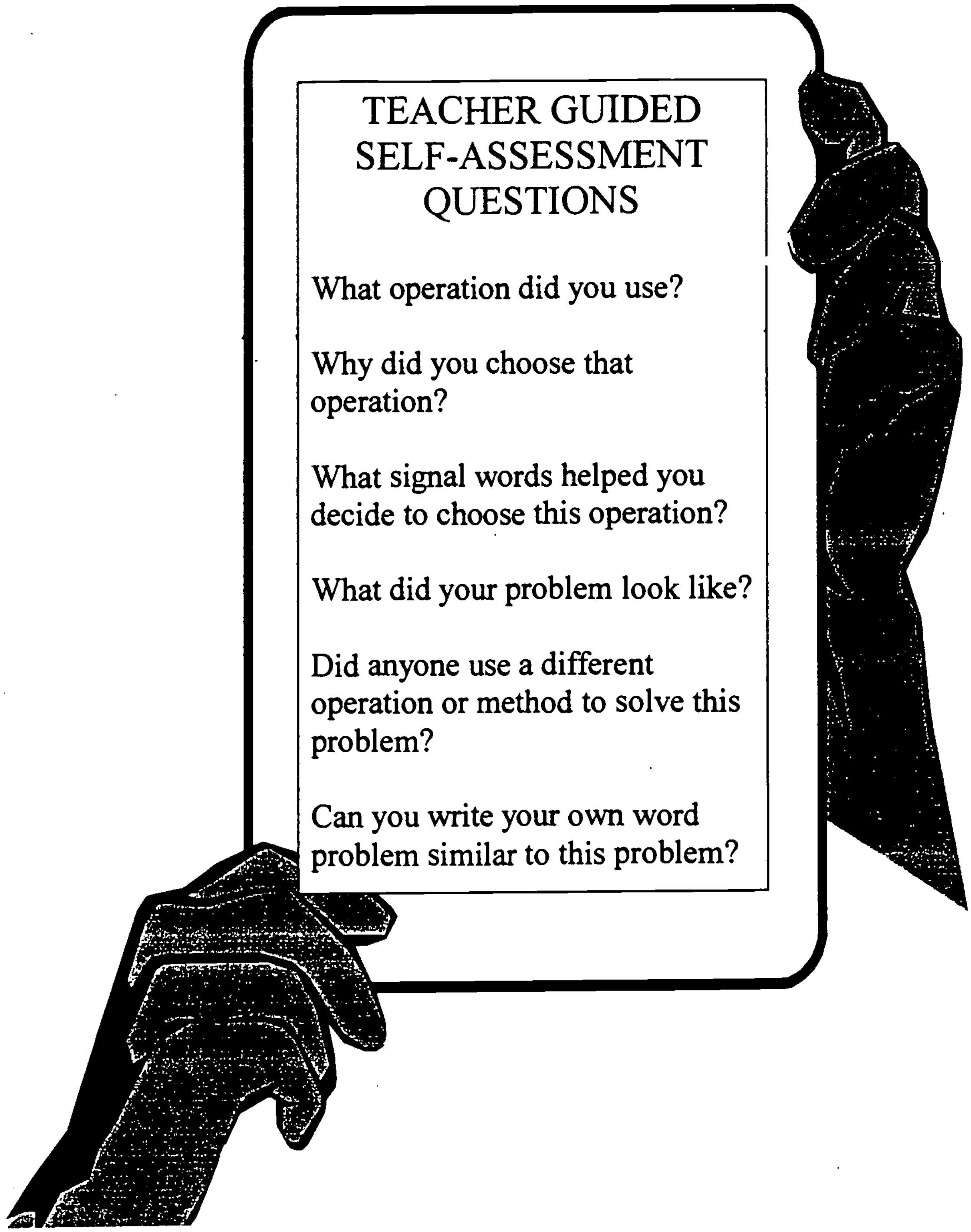
8. Dale found out that all the times he was gliding around the roller-skating rink was the equivalent of $2\frac{1}{8}$ miles! His friend Alex, who didn't take any breaks, actually rode around the rink $1\frac{1}{2}$ times farther than Dale. How many miles did Alex actually zoom around the roller rink?

9. Natalie took her cat for a walk. They went around the block $2\frac{3}{6}$ times! When her brother Tom walked their dog, they went $1\frac{2}{9}$ times farther. Great Danes need much more exercise! How many times did her brother go around the block?

10. Clinton and his classmates spent $3\frac{1}{2}$ hours on Saturday helping clean up their school. Through the rest of the month, the students spent an additional $2\frac{1}{4}$ times as many hours making their school environment beautiful. How many hours in all did they spend cleaning up their school?

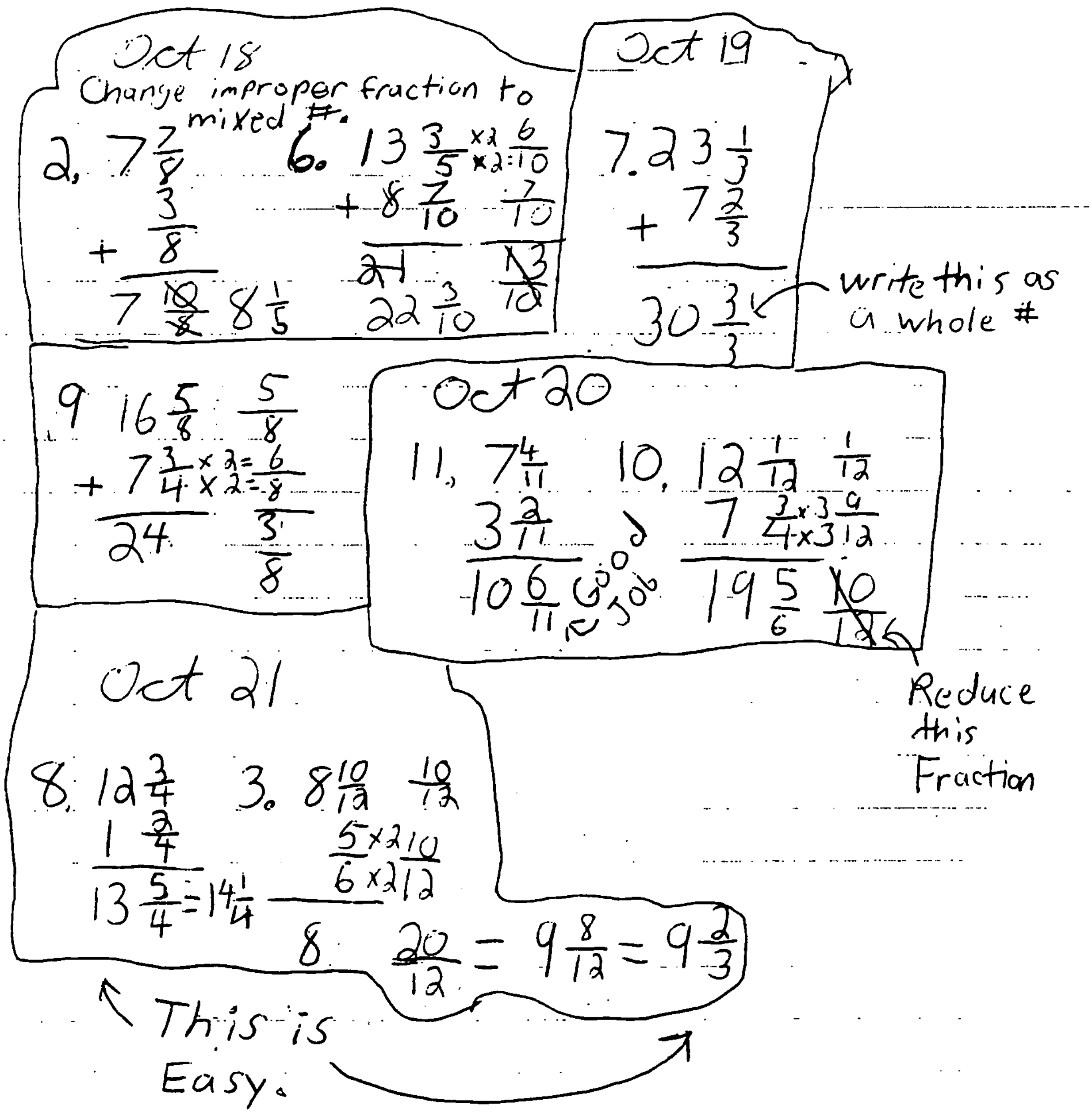
Appendix C

Teacher Guided Self-Assessment Questions



Appendix D

Sample Student Math Journal



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Appendix E

Sample Student Journal Reflection Stems

MATH LOG

A SELF-EVALUATION JOURNAL

My strengths are I have been doing good on Daily oral math. and I have been understanding word problems.

My weaknesses are I had a hard time on the work book page with reading numbers.

My math goal is to get all my homework in next week.

SE064300

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