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ABSTRACT

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THE IMPACT OF STUDENT THINKING JOURNALS AND GENERIC PROBLEM SOLVING SOFTWARE ON PROBLEM SOLVING PERFORMANCE

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ABSTRACT

This study examined the effects of specially designed *thinking journal* activities that have been attributed with encouraging reflective thinking, on instruction using *generic*, or *content-free* problem solving software. Sixty-three fourth grade students participated in four instructional sessions using a software package called *Moptown Hotel*. Students completed separate posttests that measured (1) performance on problems of the same kind as those used in instruction, and (2) transfer of skills to other kinds of problems. Scores of students who wrote thinking journals prior to testing were compared with scores of students who did not.

Results indicate that students who wrote thinking journals performed the same as students who did not when tested on problems similar to those practiced in class. Tests in which students transferred their skills to word problems, however, produced significant differences. There was no significant difference between scores when averaged over all four weekly occasions. However, for the final session alone, students who wrote thinking journals scored higher on tests of problem solving transfer than students who did not ($p < .01$).

The study also examined the relationship between the degree of metacognitive thought displayed in students' journal entries, and their measured problem solving ability.

Results indicate that students who had higher *average* reflectivity scores also had higher average problem solving performance and transfer scores ($p < .05$). It was also noted that the significant relationship between reflectivity and scores of problem solving ability was only observed in male students.

It was concluded that under the right conditions, and for the right kinds of problems, thinking journal writing can help students understand their own thinking processes, resulting in improved problem solving behavior. The study also raises the question of whether there are differences between the ways that male and female students apply metacognitive awareness gained through journal writing experiences.

Computer software to teach problem solving has been popular almost as long as microcomputers have been used in the classroom. Programs like *Gertrude's Secrets*, *Moptown Hotel*, and *Gears* were developed in the early 1980's, and are still widely used today. It is often assumed that the skills learned with these *generic*, or *content-free* problem solving software packages are useful in other problem situations faced by students, but researchers seldom report that skills learned with such software *transfer* to other kinds of problems or to performance on tests of general problem solving ability.

In general, transfer is difficult to attain, difficult to measure, and is seldom reported in the literature (Frederiksen, 1984; Yates & Moursund, 1988; Palumbo & Reed, 1991); this is also true of studies of problem solving software. For instance, students in a study by Malojkovich learned to operate the logic gates in *Rocky's Boots* and to solve problems, but they did not transfer skills to similar logic software (Lieberman & Linn, 1991). Pea, Kurland, and Hawkins (1985) also failed to show transfer from a computer-based microworld that modeled a problem similar to a classroom planning task. There are exceptions; Swan (1989) reported that fourth through sixth grade students transferred skills from a computer environment to paper-and-pencil exercises, and Melnik (1986) reported that students using computer software made significantly greater gains on a problem-solving portion of the Stanford Achievement Test

than students in a control group. Although problem-solving games can be highly motivating and can provide opportunities for students to practice "lower-level" thinking skills, the skills learned in a computer simulation or game are worthless if they cannot be transferred to other academic or real-world problems.

There are two general kinds of problem-solving *strategies*. One kind of strategy involves specific, multiple-step procedures that guide learners in planning and organizing problem-solving tasks, such as the well-known four-step process suggested by Polya. The other type of strategy is referred to as a *heuristic*. Heuristics are simple, "unordered" strategies (Marzano, et. al., 1988, p.46-47), usually consisting of general rules-of-thumb like *working backwards from the goal statement* or *breaking down a complex problem into one or more simple problems* (Andre, 1986; Gagné et. al., 1988; Frederiksen, 1984; Cyert, 1980). Teaching heuristic strategies is considered a very effective method for improving problem solving performance, and problem solving software packages do, in fact, require students to solve problems and to use heuristic strategies. Why, then, do studies of problem solving software seldom report improvement in general problem solving ability?

Researchers sometimes attribute failure to find significant gains in problem solving skills to inadequate research design, i.e., studies not grounded in problem solving theory, subjects who are too young for the

instruction provided, inadequate quality, length, or intensity of treatment, and lack of sensitivity of measurement (Palumbo and Reed, 1991; Langholz and Smaldino, 1989, p. 274; Burton & Magliero, 1988). Computers themselves are often considered a treatment, with the selection of software and instructional methods left to chance, or not fully described.

However, researchers also report that problem solving software is ineffective unless supported by classroom activities or instruction. Generic problem solving software does not teach students how to solve problems; it relies on the classroom teacher to provide the guidance and instruction needed (Lieberman and Linn, 1991). For example, students who received no problem solving instruction in a study of *The King's Rule* and *Safari Search* (Duffield, 1990), and students who were self-directed in the use of *Rocky's Boots* (Burbules and Reese, 1984), made little or no gains in the use of problem-solving strategies. Stein & Linn (1985) reported that even gifted students did not master *Rocky's Boots* during free exploration, but a brief instructional intervention had dramatic results.

What kinds of instructional intervention might be effective, particularly when teaching for transfer? It is believed that students cannot effectively learn problem solving skills, and therefore cannot apply them to other problems, unless they openly think about, communicate, and in the process, become aware of their own problem solving

behavior. Such *metacognitive* activity is believed to play an important role in effective problem solving (Flavell, 1981; Flavell, 1979; Lockhead, 1981; Sherman, 1988; Blakey & Spence, 1990; Lieberman & Linn, 1991). Some state that teaching for metacognition is *essential* if thinking skills are expected to transfer (Belmont & Butterfield, 1977; Meichenbaum, 1985).

Of particular interest in this study is a kind of metacognitive activity called *reflection*, one that involves *evaluative* thinking about problem solving or other intellectual processes. There is consensus that "reflection plays an integral part in independent problem-solving and self-regulated learning, and reflective activities have improved learning with instructional problem solving software" (Higgins, et al., 1991). For instance, researchers concluded that student reflection of problem solving resulted in clearer development of problem-solving procedures in a problem-solving game called *Zapworld* (Levin, et al., 1986). It has also been suggested that problem solving software might be more effective if it were modified to include reflective activities (Yates and Moursund, 1988; Levin, et al., 1986). Therefore, instruction in problem solving should include activities that require students to reflect on their own problem solving, asking questions like "how well did I do?", "how well did my strategies work?", and "what should I do differently next time?" (Barell, 1991, p. 153).

Recently, teachers of even very young children have engaged them in writing activities intended to improve self-awareness, self-esteem, and communication skills. This kind of writing is called *journal writing*, and special purpose journals have been designed to support cognitive processes like problem solving. Barell (1991) describes journals that encourage metacognitive awareness and reflection of problem-solving activities. Students keep *thinking journals*, in which they identify problems and record how they solved them. They also record what they learn about their own thinking abilities and attitudes. Problem solving journals were used to foster goal setting for sixth grade students and in-depth understanding of second-grade math problems, as well as for discussing general problem-solving strategies, and for visualizing problems (p. 72-76, 145, 225, 228). Perhaps, then, instruction that combines thinking journal activities with problem solving software experiences will lead to better problem solving performance, and greater transfer of problem solving skills.

Research Questions

This investigation examined the impact of software instruction supported by student thinking journal activities on student problem solving behavior. Two types of behavior were observed. Problem solving *performance* was defined as the student's ability to solve problems of the same kind and content as those used for instruction and practice, while

transfer was defined as the ability to solve problems of the same kind but different content than those used for instruction and practice. The study asked the following primary questions:

1. Will students who write thinking journal entries after each instructional session score significantly higher on tests of problem solving *performance* than students who do not write thinking journals?
2. Will students who write thinking journal entries after each instructional session score significantly higher on tests of *transfer* of problem solving skills than students who do not write thinking journals?

Secondarily, the study examined the relationship between the degree of metacognitive thought displayed in students' journal entries, and subsequent problem solving *performance* and *transfer*. Metacognitive thinking (the "higher order" mental processes an individual uses to regulate thinking) can be described as following a continuum, ranging from complete lack of awareness of decision making processes, through various degrees of awareness, to the point that individuals can *reflect* upon their own thinking, evaluating and comparing specific thinking processes (Barell, 1990, p.211). For this study, the *degree of metacognitive and reflective thought* was defined as the degree to which the problem solver has progressed along this continuum, and two secondary research questions were posed:

3. Will there be a positive relationship between the *degree of metacognitive and reflective thought* evident in student journal entries, and scores on tests of problem solving *performance*?
4. Will there be a positive relationship between the *degree of metacognitive and reflective thought* evident in student journal entries, and scores on tests of problem solving *transfer*?

This study was intended as an exploratory study. Since selection of participating classes was at the discretion of the school administration, and there was no attempt to randomly select classes from a larger population, no claim of generalizability to a larger population is made.

DESIGN AND METHODOLOGY

Sixty-three fourth-grade students, from three classes, served as subjects in this experiment. Class sizes for instruction were twenty, nineteen, and twenty-four. Each class was scheduled for four weekly 1 1/2 hour sessions. Classroom instruction was provided by the researcher. Post-tests were administered by a classroom teacher for the first half of the experiment; subsequent post-testing was administered by the researcher, with assistance from classroom teachers, allowing descriptive data to be collected regarding student behavior during testing.

This experiment examined the relationship between two levels of an independent variable (*Method*), and two dependent variables, problem solving performance *(Performance)*, and transfer of problem solving skills *(Transfer)*. Students assigned to *Method A* (*Journals*) participated in instruction and computer practice, followed by a thinking journal exercise, while those assigned to *Method B* (*Control*) participated in the same instruction and computer practice, but were given an alternate, non-reflective writing exercise.

The study utilized a "Simple Randomized Subjects" design (Kerlinger, 1986, p. 307, 319). Within each class, students were randomly assigned to two treatment groups, *Journals* and *Control*. Since each class contained members of both treatment groups, and since the two groups within each class received simultaneous instruction, the design controlled for inadvertent differences or biases in instruction among classes.

Testing Hypotheses

To test the primary hypotheses that thinking journal activity would improve problem solving *performance* (hypothesis 1) and *transfer* (hypotheses 2), separate comparisons of group means were performed for each independent variable (*Performance* and *Transfer*). At the end of the experiment, the mean of all observations of *Performance* associated with *Journal* treatments was compared

with the mean of all observations of *Performance* associated with *Control* treatments. The same procedure was followed for measures of the other independent variable, *Transfer*. Separate comparison of means for each test occasion were also performed, to test hypotheses 1 and 2 independently for each of four testing occasions.

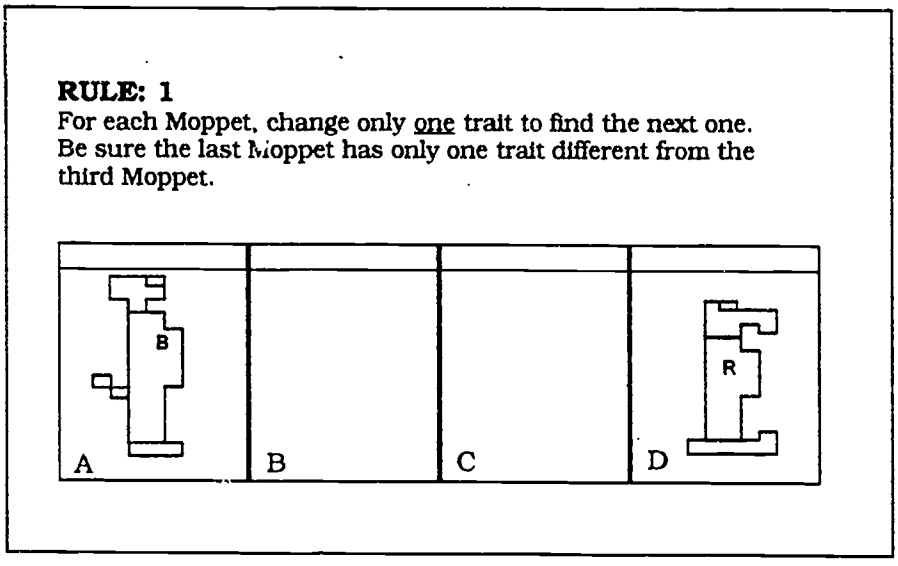
The study also examined a second, mediating variable, degree of metacognitive and reflective thought *(Reflectivity)*. An instrument was designed with which journal responses could be rated in terms of progressive degrees of metacognitive awareness. Degree of metacognitive and reflective thought *(Reflectivity)* was measured by analyzing students' thinking journal entries, and assigning a numeric rating (0, 1, 2, or 3) to each individual response, according to the following scale: 0 = unaware, 1 = aware / mentioning; 2 = descriptive; 3 = reflective. The rating scale is defined such that the endpoints match those of a model suggested by Swartz and Perkins, in which there is a continuum of "levels of thought that are increasingly metacognitive" (Barell, 1990, p.211). Journals for all thirty *Method A* students were analyzed and ratings recorded. Each student received a mean *reflectivity* rating for each of the four journal writing sessions, and a grand mean *reflectivity* rating was calculated for each student by averaging the four individual means. To test the hypotheses that positive relationships exist between the *degree of metacognitive and reflective thought* and both problem

solving *performance* and *transfer*, associations between measured *reflectivity* and *performance*, and between *reflectivity* and *transfer* were tested using multiple linear regression analysis.

Instructional Design

Problem solving practice involved interaction with a computer game titled *Moptown Hotel*. *Moptown Hotel* provides a progressive series of puzzles in which students discriminate properties, use analogies, process negative clues, control variables, make inferences, and develop organized problem solving strategies (Perl, 1984B). *Moptown Hotel* lessons one, two, three, and five were selected for study. An example problem from lesson two is shown in figure 1.

Figure 1. The problem for *Moptown Hotel* lesson two



An unsuccessful attempt to teach lesson five to the first class resulted in withdrawing it from the study. An analysis of classroom observations and test data for all lessons indicated that students were having difficulty with subskills practiced in lesson two, so lesson five was replaced with a second, modified treatment of lesson two, which was subsequently taught to all three classes. Instructional materials were changed for the second treatment, and the focus of instruction was adjusted to address the difficulties that had been observed. Improved post-tests were also developed, to minimize the reactive effects of previous testing, and to improve reliability.

Lesson activities included direct instruction and "group discovery" of both specific rules for *Moptown Hotel* and general "unordered" heuristic problem solving strategies. Each computer activity was preceded by an introductory lesson, followed by guided practice with the software, a follow-up discussion, and then journal writing activities.

All students in the experimental group wrote responses to questions in a thinking journal. The journal was composed of four sets of questions, one for each *Moptown Hotel* lesson taught. Thinking journal questions for this study focused on *procedural* knowledge, and encouraged reflection of problem solving activities (figure 2). The format and questions were adapted from a thinking journal format proposed by John Barell (1990, p. 225).

Figure 2. Sample Thinking Journal Questions

Journal 3 - *Spot Me*

1. What was the **problem** you had to solve?
2. What is the **rule** for spotting the Moppet with the greatest difference? **Explain.**
3. **How** did you discover this rule - in other words, what was your **strategy**? Describe your thinking.
4. What **other strategies** could you use next time? **Why** would this be better?
5. How did you feel working through the problem? **Why?**

Students in the control group followed identical procedures, but they received alternate journal questions that focused on *declarative*, rather than procedural knowledge. Students received "content" questions, not designed to foster reflective thought.

The researcher observed and interacted with children in both treatment groups as they wrote. Each student received a personal, written response from the researcher, in order to encourage and support children in both treatment groups. Responses included encouraging comments, probing questions, reflecting and rewording the student's comments, clarification for students who misunderstood questions or concepts, and requests for more complete answers. Students were given an opportunity to read the responses prior to the following writing session.

Instruments

Students completed eight written problem solving worksheets adapted from worksheets included with *Moptown Hotel*. Four worksheets have the same kinds of problems as *Moptown Hotel* computer activities, and were used to assess problem solving *performance*. Four worksheets have different content (typically word puzzles), but they require the same skills; they were used to assess the student's ability to *transfer* skills to other kinds of problems. Validity of the post-tests was determined by analyzing the degree to which the written form is equivalent to the computer exercise, or in the case of *transfer* tests, the degree to which the written test requires the same strategies and rules used to solve the computer problem, using a learning task analysis described by Gagné (1988). Reliability of post-tests was established by calculating a *coefficient of internal consistency*, using the Spearman-Brown prophecy formula (Kerlinger, 1986, p. 412-413).

Analysis of Student Journals

Degree of metacognitive and reflective thought (Reflectivity) was operationally defined as a numeric rating from zero to three, based on an analysis of student writing in thinking journals. All experimental group journal responses were typed, and spelling and grammatical errors were corrected, to reduce evaluator bias. Each of the 660

student responses received a rating according to the following scale:

Level

0 *Unaware* - the response contains *no indication of awareness* of thinking or problem solving processes, rules, problem definitions, or feelings.

1 *Aware / Mentioning* - the response indicates that the child is *aware* of thinking or problem solving processes, but the descriptions rely solely on reference to labels, or obvious or non-informative surface characteristics.

2 *Descriptive* - the response provides *explicit descriptions* of thinking or problem solving processes, rules, problem definitions, or feelings.

3 *Reflective* - the response provides explicit *evaluation, reasoning*, or *justification* of problem solving processes or rules, or explicit *comparison* or consideration of alternatives.

Reliability of the analysis was established by calculating inter-rater reliability between these scores and those of an independent observer who scored a subset of student responses ($r = .7811$).

RESULTS

The Effects of Journal Writing on Problem Solving *Performance*

First, it was hypothesized that students who wrote thinking journals would perform better on tests of problem solving *performance* than students who did not write thinking journals. A 2 by 2 factor Multivariate Analysis of Variance (MANOVA) was performed to determine whether significant differences exist between overall mean *Performance* scores for the two groups. For all MANOVAs in this study, gender was factored to control for observed differences in performance between male and female students. The results of comparisons of group means for *Performance* are summarized in Table 1.

Table 1. Results of MANOVA for Mean Problem Solving *Performance*

MANOVA * * ANALYSIS OF VARIANCE * *

Tests of Significance for Mean Performance

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	11606.69	46	252.32		
GENDER	1654.39	1	1654.39	6.56	.014
METHOD	109.30	1	109.30	.43	.514
GENDER BY METHOD	11.94	1	11.94	.05	.829

Results indicate that there were no significant differences in scores on tests of problem solving

performance between students who wrote thinking journals, and students who did not ($p > .05$). Because of the expectation that early journal sessions might be less effective than later ones, the hypothesis was also tested individually for each of the four testing occasions, using four separate MANOVAs. Analysis of main effects for *Method* indicates that there were also no significant differences at the .05 level between *Journal* and *Control* group scores for any single weekly treatment. Whether measured overall, or separately for each session, journal writing was not observed to improve problem solving *performance*.

The Effects of Journal Writing on *Transfer* of Problem Solving Skills

It was also hypothesized that students who wrote thinking journals would perform better on tests of problem solving *transfer* than students who did not write thinking journals. A 2 by 2 factor MANOVA was performed to determine whether significant differences exist between *grand mean Transfer* scores for the two groups. The results of comparisons of group means are summarized in Table 2.

Table 2. Results of MANOVA for Mean Problem Solving *Transfer*

MANOVA * * ANALYSIS OF VARIANCE * *

Tests of Significance for Mean Transfer

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	12402.38	44	281.87		
GENDER	2375.44	1	2375.44	8.43	.006
METHOD	375.67	1	375.67	1.33	.255
GENDER BY METHOD	183.84	1	183.84	.65	.424

Results indicate that there was no significant difference between the *average* transfer scores of students who wrote thinking journals, and students who did not ($p > .05$). As in the case of *Performance*, the hypothesis was also tested individually for each of the four testing occasions, using four separate MANOVAs. While there were no significant differences for the first three testing occasions when analyzed separately ($p > .05$), in the final session, students who wrote thinking journals scored significantly *higher* on tests of problem solving transfer than students who did not write thinking journals ($p < .01$); transfer scores were higher for both male and female journal-writing students (Table 3).

Table 3. Results of MANOVA for *Transfer*, final session

MANOVA * * ANALYSIS OF VARIANCE * *

Tests of Significance for Transfer

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	41442.68	53	781.94		
GENDER	3386.43	1	3386.43	4.33	.042
METHOD	5725.36	1	5725.36	7.32	.009
GENDER BY METHOD	680.62	1	680.62	.87	.355

Metacognitive and Reflective Thinking

It was hypothesized that there would be a positive, significant relationship between the degree of metacognitive and reflective thinking in student journal responses, and scores on tests of problem solving *performance* and *transfer*. Lack of such a relationship would have questioned the influence of reflective thinking journal writing upon the outcome of the experiments. Associations between *individual mean Reflectivity ratings* and *individual mean Performance ratings*, and between *individual mean Reflectivity ratings* and *individual mean Transfer ratings* were tested using multiple linear regression analysis; values were entered for both *Reflectivity* and *Gender* as predictors.

The results indicate that both *Reflectivity* and *Gender* are significant predictors of problem solving *Performance* (*Reflectivity*, $\beta = .413$, $p < .05$; *Gender*, $\beta = .384$, $p < .05$), and that both are also significant predictors of *Transfer* (*Reflectivity*, $\beta = .455$, $p < .05$; *Gender*, $\beta = .456$, $p < .05$). In other words, students who had higher *average*

reflectivity scores also had higher average problem solving performance and transfer scores. It was found, however, through post hoc analyses of correlation coefficients, separated by gender, that this relationship existed *only* with male students, and not females (Tables 4 and 5). Why a strong relationship between *Reflectivity* and problem solving ability never existed for female students is a question that cannot be answered from the data in this study.

Table 4. Correlations, *Reflectivity* with *Performance*

Correlations (r) - Journal ratings with Performance

Week:	1	2	3	5	Mean
All group A	0.1712	*0.3497	0.2303	0.0234	*0.3818
Female only	0.1325	0.1105	-0.3359	-0.0053	0.1058
Male only	0.2754	**0.8737	*0.6338	0.5160	**0.8676

* p < .05
** p < .01

Table 5. Correlations, *Reflectivity* with *Transfer*

Correlations (r) - Journal ratings with Transfer

Week:	1	2	3	5	
All group A	0.2996	-0.0602	0.2527	‡0.3475	*0.4034
Female only	0.2367	-0.3758	0.2722	0.2740	0.3064
Male only	0.5437	0.5601	0.2634	**0.8225	**0.8351

* p < .05
** p < .01
‡ p = .052

Other statistics indicate that during the course of the four week treatment, students who wrote thinking journals

progressed in their journal writing abilities. The average number of words per journal increased, and the length of individual responses increased by almost fifty percent, from 12.5 words per response in week 1, to 18.6 words per response in week 5. Also, student reflectivity ratings increased significantly during each of the first three weeks ($p < .01$), ranging from .94 in week one, to 1.25 in week 5. Reflectivity ratings for males and females were almost identical for all four weekly measures.

CONCLUSIONS

This study produced no results that would indicate that, generally, journal writing helps students learn to solve problems. This is inconsistent with several studies that reported that children demonstrate higher levels of thinking and problem solving ability when they verbalize their activities and their thinking (Dickson, 1982; Olson & Ives, 1983, cited in Dickson, 1985; Metwali, 1979, cited in Silver & Thompson, 1984).

However, the study did find a substantial advantage for journal writing students in the final test of problem solving *transfer*, in which students applied skills learned with one problem representation to a problem set using another representation. This provides evidence that *under some conditions*, writing in thinking journals can improve transfer. This supports results of a study in which written reflection of problem solving activities following practice

with a computer problem resulted in clearer development of problem-solving procedures (Levin, et al., 1986).

The "conditional" effectiveness of journal writing could mean several things. First, a common sense assumption is that some students need specific instruction and practice in writing thinking journals before any benefits occur. The experimental evidence from this study supports this "practice effect" assumption to some extent; a significant difference occurred in only one of the four measures of *Transfer* - the *last* one. Unfortunately, no clear trend can be documented to further support this hypothesis, since a uniformly increasing advantage for journal-writing students did not develop (or did not have time to develop). However, descriptive data gathered while observing students working in journals suggests that substantial practice was *required*, that early journal formats were ineffective, and that students were still progressing at the end of the study.

It is also possible that ongoing improvements in journal formats and instructional design contributed to a greater effect of the *treatment*. There were several differences in the final weekly treatment. First, the posttests for the final lesson had been improved, based on prior concerns of reliability and observed difficulties with the instruments. In fact, the measured reliability (internal consistency) of the posttests improved substantially over the course of the treatments. It is possible, then, that the significant results for the final lesson were influenced by more

reliable measurement. Also, the journal format for the final lesson was much more direct and explicit in its questions than previous journals. It had become apparent that to be effective, the questions must be focused toward the specific thinking desired. Therefore, it is possible that the journals were more effective because they had been improved.

Reflectivity and Problem Solving Ability

The results that showed a greater correlation between *reflectivity* and performance indicate that while the journal writing experience had the same effect on problem solving behavior for both gender groups, it is possible that males apply metacognitive awareness gained through journal writing differently than females. Males who wrote more reflective comments in their journals also performed better on both kinds of problem solving tests, while for females, the metacognitive thinking displayed in journals (which was as high as for males) was unrelated to their performance. Rather than providing an answer, this poses two important questions. First, since female problem solving behavior also improved due to journal writing activities, what features of journal writing, other than the kind of reflective thought measured in this study, produced the effect? Secondly, should practitioners and researchers view journal writing activities differently for male and female elementary school children? If so, how?

Both descriptive and quantitative data collected for this study suggest that journal writing can be used to provide instruction at a personal and individualized level that both increases the child's metacognitive awareness and increases the child's ability to verbalize procedural matters. Individualized instruction is an important facet of thinking skills instruction, especially for younger students who are more easily distracted by irrelevant factors, more likely to exhibit problems with cognitive load, and who some researchers believe are not at a sufficient level of cognitive development to warrant thinking skills instruction at all. Individualized instruction is difficult to manage within the realities of public school instruction. Journal writing, therefore, can be an important tool for educators who must somehow teach children to "learn how to learn."

Implications for Classroom Instruction

Journal writing can be a very important tool for supporting the development of children's problem solving skills, because it is very difficult to teach thinking and problem solving skills to large groups of young students. Several specific recommendations for the use of journal writing in problem solving instruction can be made on the basis of both quantitative and descriptive information gathered through this study.

1. Since journal writing produced significant results in only a single lesson, and since there were other indicators that students reacted differently to different kinds of problems, teachers should be aware that journal writing might be helpful in some problem situations, and not in others. Teachers should be watchful for situations in which journal writing is unproductive, and students' journals responses themselves might be a source of the information needed to make this decision.

2. It is apparent that young students need instruction and extended practice before journal writing becomes productive, and before any benefits of journal writing can accrue. Therefore, it is essential that the concepts and terminology needed to understand thinking journal questions be explicitly discussed with students before the journals are used in instruction.

3. The process of familiarizing students with the problem solving concepts needed for effective thinking journal writing can be made more efficient through the design of journal questions that include scaffolding devices or cues. In this study, the journal format for the final lesson was much more direct and explicit in its questions than prior journals, and this might have contributed to higher scores for journal writing students.

4. It was repeatedly observed that classroom instruction must be constantly refined due to the demands of thinking skills instruction, and that even when this is done, most

students needed additional individual guidance in order to begin to assimilate and apply the information discussed.

Suggestions for Further Research

1. Future studies should address the question of what aspects of journal writing, other than the kinds of reflective thinking measured in this study, contribute to more successful problem solving behavior. Are other thinking skills used in journal writing, unidentified in this study, also helpful in problem-solving activities?

2. Prior research had produced several metrics of reflective thought, however, these were found ineffective because they had been designed for older and more experienced students. Future studies of young children should continue to develop, adapt and refine formal measures of written and spoken metacognitive and reflective thinking, so that knowledge of *why* and *how* verbalization helps clarify thought can be examined for younger populations.

3. Most importantly, the results of this study suggest *possible* benefits of journal writing in problem solving activities other than generic problem solving software. Although generic problem solving software can still be an important feature of a well-rounded instructional technology program, and even though it lends itself well to an experimental study because of the ease with which skills can be isolated, there are other, more current trends in teaching thinking skills with computers. The effect of

journal writing on other kinds of problem solving activities should be studied as well, particularly those involving less structured, more "authentic" kinds of problems.

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