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Learning Mathematics From Procedural Instruction: Externally Imposed Goals Influence What Is Learned

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Do externally imposed achievement goals influence what children learn from procedural instruction? Third- and 4th-grade children's goals were manipulated toward either learning or performance. All children were then taught a procedure for solving mathematical equivalence problems (e.g., $a + b + c = a + _$). Children who were given learning goals were initially more likely to gain conceptual knowledge from the procedural lesson than were children who were given performance goals. After a 2-week period, however, children who were given performance goals exhibited the same conceptual gains as children who were given learning goals. Both initially and after the 2-week period, children who were given either goal were more likely to extend their knowledge beyond the taught procedure than were children who were not given goals. External sources such as teachers and parents may have the potential to foster children's learning by shaping children's goals.

When children learn a problem-solving procedure, they may not necessarily gain the corresponding conceptual knowledge. Further, children may not be able to transfer their procedural skills to novel problems. Both of these learning processes, gaining conceptual knowledge from procedural instruction and transferring newly acquired knowledge to novel problems, challenge children to go beyond an instructed procedure. The purpose of the present study is to examine whether externally imposed achievement goals influence children's ability to extend their knowledge beyond an instructed mathematical procedure.

Extending knowledge beyond a mathematical procedure can be difficult. In domains such as fraction multiplication and multidigit subtraction, many children learn correct procedures but never seem to learn the principles that underlie them (Byrnes & Wasik, 1991; Fuson, 1990; Hiebert & Wearne, 1996). Children who learn a procedure for solving mathematical equivalence problems such as

$3 + 6 + 5 = _ + 5$ sometimes show improvements in conceptual knowledge, but gains are typically modest and do not hold for all children (Rittle-Johnson & Alibali, 1999). Similarly, children often fail to transfer newly acquired procedural skills to novel problems (see Singley & Anderson, 1989). For example, children who learn a procedure for solving mathematical equivalence problems such as $3 + 6 + 5 = _ + 5$ are sometimes unable to transfer that procedure to problems without a repeated addend, such as $3 + 6 + 5 = _ + 4$ (Perry, 1991).

Why is it so difficult for children to extend their knowledge beyond an instructed procedure? To answer this question, it is important to understand what is involved when children learn a problem-solving procedure. Consider the example of learning a procedure for solving repeated-addend mathematical equivalence problems. In this situation, children are presented with a problem such as $3 + 4 + 5 = 3 + _$, and they are taught a procedure for solving it, such as "cancel the two 3s, and add the 4 and 5." To get the problems correct, children do not need to understand the procedure but rather need only to apply the procedure exactly as instructed. However, a dilemma arises when children are required to transfer their knowledge to other types of problems. If children do not derive underlying principles from a particular procedure, then they may not be able to adapt the procedure for use on different types of problems. Because it is usually not necessary for children to understand procedures to apply them, it is not surprising that many children do not gain conceptual knowledge from procedural instruction and they consequently have difficulty transferring learned procedures to novel problems.

We hypothesize that children's achievement goals have the potential to influence children's ability to extend their knowledge beyond a mathematical procedure by affecting how incoming information about mathematics problems is processed (see Elliot & Dweck, 1988, for a similar argument). We base this hypothesis on past research that has indicated a relationship between achievement goals and behaviors related to learning (e.g., Barron & Harackiewicz, 2000; Diener & Dweck, 1978; Schunk, 1996). An *achievement goal* can be defined as "the purpose or reason for an

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individual's achievement pursuits in a particular situation" (Barron & Harackiewicz, 2000). A body of literature by Dweck and colleagues has identified two important types of achievement goals: *learning* goals and *performance* goals (see Dweck & Elliot, 1983; Dweck & Leggett, 1988, for reviews). Children with learning goals are characterized by their focus on mastery, or understanding answers, and children with performance goals are characterized by their focus on ability evaluation, or getting answers right.

There is clear evidence that children's achievement goals influence their motivation and behavior during challenging tasks (Dweck & Elliot, 1983; Dweck & Leggett, 1988). Children who have learning goals tend to display behavior characterized by challenge seeking and persistence, whereas children who have performance goals tend to display behavior characterized by challenge avoidance and lack of persistence. These two achievement goals and the associated behaviors influence problem-solving performance, task involvement, and persistence after failure (e.g., Diener & Dweck, 1978; Smiley & Dweck, 1994). Nonetheless, relatively few studies have examined the effects of goals on learning itself. One of these studies has reported that children with different achievement goals showed differential mastery of a text that was presented after an experimental manipulation intended to cause confusion (Licht & Dweck, 1984). Another study (Farrell & Dweck [1985], as cited in Dweck, 1986) has suggested that children with learning goals were more likely than children with performance goals to transfer their knowledge of a science principle to a novel task. However, no research to date has addressed whether children's goals influence their ability to learn from and extend their knowledge beyond procedural instruction.

The aforementioned research involving children's achievement goals has focused on the relationship between goals and learning behaviors during challenging tasks. This research has focused on the goals children possess when they enter a learning experience, but it has not examined the causal relationship between goals and learning behaviors. Experiments conducted in business and work settings have demonstrated causal links between goals set for workers and subsequent work performance (e.g., Locke & Latham, 1990). However, there has been surprisingly little research investigating the causal relationship between goals and learning behaviors in educational contexts.

One of the few educational studies of this issue examined the effects of externally imposed goals and self-evaluation on children's motivation and achievement outcomes after a lesson about fractions (Schunk, 1996). Children were given either the goal of learning the problems or the goal of solving the problems. This manipulation was factorially combined with the presence or absence of self-evaluation. Children had higher motivation and solved more problems when they were given the goal of learning the problems than when they were given the goal of simply solving the problems. Also, children who were given the goal of solving the problems in the absence of self-evaluation demonstrated less learning than did children in the other conditions. In the experiment's posttest, 70% of the problems were similar to the problems on which children were instructed, and the other 30% were more complex. Yet, results were not broken down so that the effects of the manipulation on transfer to the more complex problems could be evaluated. Further, the study did not address the influence of goals on conceptual knowledge gain.

The purpose of the present study is to assess the causal impact of externally imposed goals on children's ability to extend their knowledge beyond an instructed procedure. To address this issue, we manipulate children's goals and examine the effects on conceptual gain and transfer. We propose that externally imposed goals influence conceptual knowledge gain and transfer because they affect how children process incoming information about problems. Specifically, we hypothesize that externally imposed goals facilitate children's ability to represent and interpret problem features. This proposal is based on the notion that externally imposed goals help direct attention and action toward goal-relevant behaviors and away from behaviors that prevent goal achievement (Locke & Latham, 1990).

Let us consider the information that children must process to understand and solve a mathematics problem. We argue that in solving problems, children construct a mental representation of the problem and operate on that representation (Newell & Simon, 1972; Siegler, 1976). We further propose that children's problem representations involve two components: (a) mental representation of the perceptual features of the problem and (b) interpretation of those perceptual features. For example, when children are presented with a problem such as $3 + 4 + 5 = 3 + _$, they must mentally represent the positions of the numbers, the operators, and the equal sign. Further, children must understand that the plus sign means that numbers should be added and that the equal sign expresses an equivalence relation.

We argue that problem representation is a dynamic process, so that a new representation is constructed for each new problem that is presented (Alibali & McNeil, 2000). An inherent result of this dynamic process is variability in problem representation, both across and within problems. According to this view, a child may construct multiple representations for a single problem. For example, for the problem $3 + 4 + 5 = 3 + _$, a child may represent it as $3 + 4 + 5 = 3 + _$, as $3 + 4 + 5 = _$, as $3 + 4 + 5 + 3 = _$, and so on. Some of the representations may be robust, in that they are easily interpreted or are linked to particular problem-solving strategies (e.g., $3 + 4 + 5 + 3 = _$). Conversely, some of the representations may be impoverished, in that they are not easily interpreted or are not linked to particular problem-solving strategies (e.g., $3 + 4 + 5 = + 3 _$).

In some cases, a problem solver may construct a robust problem representation that derives from a *mental set*, which is a familiar, well-practiced approach to solving a problem. Luchins (1942) illustrated the mental set phenomenon in his famous water jar experiments. Problem solvers solved a number of problems using a particular multistep strategy, which subsequently led them to use the same multistep strategy on similar problems that required only a single step. A problem solver's propensity to apply a mental set was influenced by the number of problems in the initial problem set, so that the more problems solved with the multistep strategy, the more likely it was that the strategy would be applied to the single-step problems. We postulate that a mental set is constructed not only within a particular problem-solving experience, as in Luchins' experiments, but also over time. For example, children are very familiar with simple addition problems (e.g., $3 + 4 + 5 + 3 = _$), and the strategy of adding all the numbers is highly practiced. Thus, when children are presented with novel problems that superficially resemble simple addition problems (e.g., $3 + 4 + 5 = 3 + _$), they may be likely to activate the simple addition

problem mental set and represent the problems as simple addition problems (Alibali & McNeil, 2000). In this situation, children's inappropriate mental set interferes with their ability to process the incoming problem information accurately; consequently, children represent and solve the problem incorrectly.

Given that mental sets interfere with problem solvers' ability to process novel problem information accurately, it is likely that they prevent problem solvers from gaining conceptual knowledge. Mental sets rely solely on existing, well-practiced knowledge, so children who represent and solve novel problems based on a mental set do not concentrate on features of the problem that deviate from that mental set. If children do not consider all of a problem's important features, then it is unlikely that they will gain conceptual knowledge from working on the problem. We argue that externally imposed achievement goals encourage conceptual knowledge gain, in that they discourage mental sets. If a teacher helps children identify an important goal (e.g., "The goal is to understand the problem," or "The goal is to get the problem right"), then that specific goal will be especially salient for the children. When children have a specific, salient goal, they will not use a problem representation that prevents goal achievement, such as one that is based on an inappropriate mental set. Instead, they will shift their attention toward alternative problem representations that are likely to help them achieve their goal. Thus, we hypothesized that children who were given a goal would be more likely to gain conceptual knowledge from procedural instruction than would children who were not given a goal.

We further expected that the type of goal given to children (i.e., learning or performance) would influence their ability to gain conceptual knowledge from a problem-solving procedure. Because learning goals stress understanding, children who are given them may be more likely to try to interpret the meaning of all components of their active problem representations so that they can better understand the problem. Conversely, because performance goals stress getting problems right, children who are given performance goals may be more likely to try to memorize the instructed problem-solving procedure exactly as taught in hopes that they will be good at applying it later. They may focus solely on the problem representation that corresponds with the instructed procedure. As a result, they may successfully represent the problem features that go with the instructed procedure, but they may not accurately interpret those features, or they may fail to represent other features. Thus, we hypothesized that children who were given learning goals would be more likely than children who were given performance goals to gain conceptual knowledge from the instructed problem-solving procedure.

We also were interested in examining the influence of externally imposed goals on children's ability to transfer their knowledge to novel problems. To achieve this end, we administered a transfer test that included some problems on which the instructed problem-solving procedure could not be directly applied. Children could produce three possible *difficult transfer responses* on these problems. They could (a) revert back to the initial, incorrect procedure that they used before instruction, (b) incorrectly apply the procedure they were taught, or (c) generate a new problem-solving procedure (one that they did not use on the pretest or learn in the instruction). We interpreted the meaning of each difficult transfer response in terms of children's learning. When children reverted back to initial, incorrect procedures, we took this as evidence that

they were applying their original mental set and giving up on the challenge without trying to apply the instructed procedure at all. This transfer response suggested resistant learning and little knowledge change from pretest. When children incorrectly applied the procedure, we took this as evidence that they focused on applying the procedure itself, instead of trying to understand why it worked. This transfer response suggested narrow learning and superficial knowledge change from pretest. When children generated new problem-solving procedures, we took this as evidence that they were thinking about the problems and trying to adapt the instructed procedure to the problems. This transfer response suggested resourceful learning and substantial knowledge change from pretest.

Because children who are given goals may be less likely to apply a mental set, we hypothesized that they would be less likely than children who were not given goals to revert back to their initial, incorrect procedures on the transfer problems. Further, we expected different externally imposed goals to influence transfer in different ways. Because children who are given learning goals may try to interpret all of their problem representations, we hypothesized that children who were given a learning goal would be likely to generate new problem-solving procedures. Because children who are given performance goals may be good at representing, but not interpreting, the problem features that go with the instructed procedure, we hypothesized that they would be likely to incorrectly apply the instructed problem-solving procedure.

As our experimental task for investigating these issues, we chose mathematical equivalence problems such as $3 + 6 + 8 = 3 + _$. Such problems are rarely presented in the standard elementary curriculum, and they are solved incorrectly by approximately 75% of American third- and fourth-grade students (Alibali, 1999; Perry, Church, & Goldin-Meadow, 1988). However, students can readily learn to solve such problems from a procedural lesson (e.g., Perry, 1991). We were interested in whether externally imposed goals discouraged inappropriate mental sets, so we needed to use problems on which children would be likely to initially apply a mental set. Therefore, we used equivalence problems of the type $a + b + c = a + _$, as opposed to ones of the type $a + b + c = _ + c$. Problems of the type $a + b + c = a + _$ superficially resemble simple addition problems (e.g., $a + b + c + a = _$), with which third- and fourth-grade children are very familiar, and past work has suggested that children are likely to apply mental sets when solving this type of equivalence problem (Alibali & McNeil, 2000).

Before the start of the experiment, we measured children's achievement goals to get a sense of the goals children possessed when they entered the learning context. However, the main goal of our study was to investigate whether externally imposed achievement goals influenced children's ability to extend their knowledge beyond an instructed procedure. We were interested in externally imposed goals both because they allow us to examine the causal impact of goals and because they assign a specific, salient goal to children for the particular learning experience. Thus, we manipulated children's goals, gave children instruction about a problem-solving procedure, and subsequently assessed their conceptual knowledge gain and transfer performance.

Method

Participants

Seventy-seven third- and fourth-grade children (41 boys and 36 girls; mean age = 9 years 8 months) from one urban, one suburban, and two exurban parochial elementary schools were screened to participate. Because we wished to examine the process of learning a correct problem-solving procedure, children who already knew a correct procedure were excluded from the sample ($n = 24$; mean age = 9 years 7 months). The final sample consisted of 53 children (23 boys and 30 girls; mean age = 9 years 8 months) who solved the pretest problems incorrectly. Experimental sessions took place in a quiet room at the schools during school hours.

Measures

Children's achievement goals were measured at the outset of the study using a questionnaire developed by Stipek and Gralinski (1996). Children were asked to rate each of 10 possible reasons for why they did their math work. Five of the reasons were *learning* reasons (e.g., "I do my math work because I want to learn as much as possible"), and 5 of the reasons were *performance* reasons (e.g., "I do my math work because it is important for me to do better than the other students"). Children could rate each reason from 1 to 5. Ratings for the 5 learning reasons were summed for each child's learning goal score, and ratings for the 5 performance reasons were summed for each child's performance goal score.

Children's conceptual knowledge about equations was measured at three points during the study, using a measure that was adapted from Rittle-Johnson and Alibali (1999). During the conceptual knowledge assessment, children were asked to complete three tasks: (a) tell what the equal sign means, (b) reconstruct three equivalence problems after viewing each for a brief period of time, and (c) identify 12 nonstandard equations (e.g., $8 = 2 + 6$) and 3 standard equations (e.g., $7 - 4 = 3$) as either correct or incorrect. These tasks were used to assess three aspects of conceptual knowledge respectively: (a) understanding of the equal sign, (b) representation of equivalence problems, and (c) understanding of the structure of equations.

Procedure

Children participated in two experimental sessions that were videotaped. Sessions were videotaped in their entirety with a camcorder that was in full view of the participants. In the first session, children first completed the conceptual knowledge assessment, which included the equal sign definition, the problem reconstruction, and the equation identification tasks. Next, children completed a problem-solving pretest in which they solved and explained three mathematical equivalence problems of the form $a + b + c = a + \underline{\quad}$. For each problem, the experimenter placed the problem on an easel and said, "Try to solve the problem as best as you can, and then put your answer in the blank." After children wrote their solution, the experimenter asked, "Can you tell me how you got x ?" (The experimenter stated the child's solution rather than the variable x .) All children were able to explain their solutions.

After the pretest, children were randomly assigned to one of three experimental conditions: (a) control, in which children were not given a goal ($n = 17$); (b) performance goal, in which children were given a performance goal ($n = 17$); or (c) learning goal, in which children were given a learning goal ($n = 19$). Only the introductions of the instruction differed among experimental conditions. The introductions focused on key dimensions of performance and learning goals, as described in Elliot and Dweck (1988). Performance goals provoke individuals to avoid negative evaluations by proving their ability on easy tasks, whereas learning goals provoke individuals to master new skills by seeking challenges. Further, performance goals lead individuals to focus on getting answers correct, whereas learning goals lead individuals to focus on understanding answers.

The introductions were adapted from Elliot and Dweck (1988). They were as follows:

[For control condition] Now I am going to teach you a way to do the problems.

[For performance goal condition] Now I am going to teach you a way to do the problems. After I teach it to you, you will be tested on more problems, so I can see how well you can do. You will only learn one new thing, so it probably won't be very hard, but you will really be able to show me how well you can do. The most important thing will be for you to try to solve the problems correctly. These problems are important because if you try your best to get them correct, you will be able to show me how well you do on the problems compared to other children your age.

[For learning goal condition] Now I am going to teach you a way to do the problems. After I teach it to you, you will do some more problems, so you can see how much you've learned. You will learn a lot of new things, but it won't be easy, so you will probably make some mistakes. The most important thing will be for you to think about the problems and try to understand them. These problems are important because if you try your best to understand the problems, you will know more about math, and you will be one step closer to learning algebra.

After the introduction, a manipulation check was done for children in the performance and learning conditions to assess whether children had adopted the goal. Children were asked the following question: "So, what are you going to be trying really hard to do?"

After the manipulation check, a female instructor taught all of the children the grouping procedure on two problems. The instruction was as follows: "See this problem? Because there is an a here and an a here, you can just cancel them and add the b plus c ; that gives x ." The numbers in the particular problem, rather than the variables a , b , c , and x , were used during instruction. The instructor wrote the correct answer in the blank for each problem. On the rare occasion that a child had a question about the procedure, the instructor said, "I'm sorry, but I'm not going to answer that right now; you can ask me later." After being instructed on two problems, children completed a problem-solving posttest in which they solved and explained three equivalence problems similar to the ones on the pretest ($a + b + c = a + \underline{\quad}$). Children also completed a transfer test in which they solved and explained six equivalence problems that differed from the original ones in either the position of the blank, the position of the repeated addend, or the presence of the repeated addend (i.e., $a + b + c = b + \underline{\quad}$; $a + b + c = \underline{\quad} + c$; and $a + b + c = d + \underline{\quad}$). Children could not directly apply the instructed problem-solving procedure on the equivalence problems of type $a + b + c = d + \underline{\quad}$; these were defined as the difficult transfer problems. After the transfer test, children completed the conceptual knowledge assessment for the second time.

Approximately 2 weeks after the first experimental session (the time period used by Alibali & Goldin-Meadow, 1993), children participated in a second experimental session. The purpose of the follow-up experimental session was to assess whether the effects observed in the first experimental session endured over time. Thus, there was no further experimental manipulation between the first and second sessions. Seven children were not available to be tested in the second session, and 1 additional child was excluded from the problem-solving portion of the follow-up because of a videotaping error. Thus, the sample at the second-session conceptual knowledge assessment consisted of 46 children, and the sample at the second-session problem-solving assessment consisted of 45 children.

In the second session, children first completed the conceptual knowledge assessment. Next, children participated in a problem-solving follow-up test in which they solved and explained equivalence problems similar to the ones on the pretest and posttest ($a + b + c = a + \underline{\quad}$). Children also

completed a transfer test that was similar to the one in the first experimental session. At the end of the study, all children who still had trouble solving the equivalence problems correctly received an individualized lesson. Children received a brightly colored pencil for participating in the study, and each classroom received a book for participating.

Coding the goals that children had when they came into the learning experience. Children's scores on the goal questionnaire were tallied. Questions were grouped by goal, and two separate scores were recorded for each child: a learning goal score and a performance goal score. The possible range for each goal score was 5–25. The distribution of learning goal scores was positively skewed. Very few children had low learning goal scores (none scored below 12; the median was 22). Transformations were used to reduce skewness. However, neither a square root transformation nor a logarithmic transformation remedied the skewness. We suspect that children may be inclined to say that they do things for learning reasons because they think that adults value learning, so children's learning goal scores may be confounded with social desirability. As a result, we used only children's performance goal scores in our analyses. Performance goal scores were normally distributed, and they spanned the entire range from 5 to 25, with a median of 15.

Coding conceptual knowledge. Children's conceptual knowledge was coded using a system adapted from Rittle-Johnson and Alibali (1999). First, children's definitions of the equal sign were transcribed and coded. Children were given a score of 1 if their equal sign definition conveyed a relational understanding of the equal sign (e.g., "It means the same as") and a score of 0 if it did not (e.g., "It means the answer"). Next, children's problem reconstructions were coded. Children were given a score of 1 if all three of their reconstructions had the equal sign and the right plus in the correct positions (e.g., $a + b + c = a + _$) and a score of 0 if any of their three reconstructions did not (e.g., $a + b + c + a =$). Then, children's identifications of equations as correct or incorrect were coded. Children were given a score of 1 if they identified 9 out of the 12 nonstandard equations correctly and a score of 0 if they did not (the criterion used by Rittle-Johnson & Alibali, 1999). Finally, children's scores on each of the three measures of conceptual knowledge were summed to give their conceptual knowledge score. In the overall sample, scores ranged from 0 to 3; however, none of the children who solved the problems incorrectly were at ceiling on pretest. The proportion of children who scored a 0 on the pretest did not differ across conditions, $\chi^2(2, N = 53) = 1.89, p > .25$.

To validate the conceptual knowledge measure, we compared the scores of children who solved the problems correctly at pretest ($n = 24$) with those of children who solved the problems incorrectly at pretest ($n = 53$). Children who solved the problems correctly scored higher on the conceptual knowledge measure, on average, than children who solved the problems incorrectly (children who solved the problems correctly, $M = 1.5$, $SD = 0.92$; children who solved the problems incorrectly, $M = 0.77$, $SD = 0.72$), $F(1, 69) = 11.71, p < .001$.

Coding problem-solving strategies. Children's problem-solving strategies were coded using a system adapted from Perry et al. (1988). Children's problem solutions and verbal explanations were transcribed, and strategy categories were assigned on the basis of children's problem solutions. When a child's solution was ambiguous, the strategy category was determined from the child's verbal explanation. Four incorrect strategies and three correct strategies were identified. Examples are presented in Table 1.

Coding transfer performance. We first calculated an overall transfer score by calculating the number of correct solutions for each child on the six transfer problems. We then examined children's strategies on the two difficult transfer problems of type $a + b + c = d + _$. On the basis of their strategies, children were placed into one of three difficult transfer categories: (a) revert back to initial, incorrect strategy, (b) incorrectly apply the taught procedure, or (c) generate new problem-solving procedure. Children were placed in only one category so that a chi-square test could be used to analyze the data. If children used different strategies on the two

Table 1
Incorrect and Correct Strategies for Solving the Problem
 $3 + 4 + 5 = 3 + _$

Strategy	Solution	Verbal explanation
Incorrect strategies		
Add all the numbers	15	"I added them all up."
Add to equal sign	12	"I added 3 plus 4 plus 5, and that equals 12."
Carry	4	"I saw 3 plus 4 over there, so I just made 3 plus 4 over here."
Add two numbers	7	"I added 3 plus 4 equals 7."
Correct strategies		
Grouping	9	"I saw the two 3s, so I just added the 4 and the 5, and that's 9."
Make both sides equal	9	"3 plus 4 plus 5 equals 12, and 3 plus 9 equals 12."
Add-subtract	9	"I added 3 plus 4 plus 5, and then I took 3 away from that."

difficult problems, they were placed into the category that assumed the most change (i.e., generate > incorrectly apply > revert back).

Reliability of coding procedures. A coder who was unaware of children's condition assignment established reliability on a subset of the children ($n = 12$). Percentage agreement between the original coder and the reliability coder was 89% for equal sign definitions, 95% for problem reconstructions, 97% for problem-solving strategies, and 92% for difficult transfer categories.

Results

First, we examined whether the goals that children had when they came into the learning experience influenced learning. Simple regressions were performed between children's scores on the dependent measures of learning and children's performance goal scores on the questionnaire administered at the outset of the study. Children's performance goal scores were not associated with the learning outcomes: For conceptual gain from pretest to posttest, $R = .10$, $F(1, 51) = .518, p = .47$; for number of transfer problems solved correctly at posttest, $R = .09$, $F(1, 51) = .430, p = .51$; for conceptual gain from pretest to follow-up, $R = .01$, $F(1, 44) = .005, p = .94$; and for number of transfer problems solved correctly at follow-up, $R = .11$, $F(1, 44) = .492, p = .49$. Because the goals that children possessed when they came into the learning experience were unadulterated in the control condition, separate simple regressions were performed for children in the control condition. The performance goal scores of children in the control condition were not associated with the learning outcomes: for conceptual gain from pretest to posttest, $R = .16$, $F(1, 15) = .411, p = .53$; for number of transfer problems solved correctly at posttest, $R = .33$, $F(1, 15) = 1.85, p = .19$; for conceptual gain from pretest to follow-up, $R = .22$, $F(1, 12) = .597, p = .45$; and for number of transfer problems solved correctly at follow-up, $R = .15$, $F(1, 12) = .252, p = .63$. Thus, the goals children had when they came into the learning experience did not influence conceptual gain or transfer.

At first glance, this finding seems inconsistent with the model of goals introduced by Dweck and her colleagues (e.g., Dweck & Elliot, 1983; Dweck & Leggett, 1988). However, there are at least two possible explanations. First, the questionnaire we used may not provide a valid index of children's goals during procedural

instruction. Second, most research has focused on how children with learning and performance goals respond to failure, and in the present study, all children could solve the problems in one way or another, and no feedback was given to children concerning their performance. Because the goals that children had when they came into the learning experience yielded null results, the remainder of the analyses focuses on the effects of the experimental variable of interest, externally imposed goals, on conceptual gain and transfer.

Manipulation Check

Before proceeding with the data analyses, we investigated whether children in the experimental groups adopted the externally imposed goals that were given to them in the experimental manipulation. To do so, we examined children's responses to the manipulation check question ("So what are you going to be trying really hard to do?"). We coded children's responses as conveying a learning goal (e.g., "to learn"), a performance goal (e.g., "to get the problems right"), or a neutral goal (e.g., "to solve the problems"). All responses fit into one of these categories. The distribution of responses differed across the two conditions, $\chi^2(2, N = 32) = 15.43, p < .005$. Children in the learning goal condition were more likely to adopt a learning goal than were children in the performance goal condition (93% vs. 21% of children). Children in the performance goal condition were more likely to adopt a performance goal than were children in the learning goal condition (79% vs. 7% of children). Four children were inadvertently not given the manipulation check.

Did Children Apply a Mental Set at Pretest?

We chose problems of type $a + b + c = a + _$ because they resemble simple addition problems with which third- and fourth-grade children are very familiar and because we expected them to cause children to apply an inappropriate mental set (Alibali & McNeil, 2000). Therefore, we examined whether children applied the simple addition mental set when solving the problems. Seventy-five percent of the children used the "add all the numbers" strategy on the pretest problems (see Table 2). Thus, as expected, children tended to apply a mental set to the problems at pretest. However, it is possible that children did not actually apply a mental set that interfered with their ability to accurately represent the problems as equivalence problems, but rather they may have represented the problems correctly and then chosen to apply a more familiar strategy. To address this issue, we examined chil-

dren's performance on the reconstruction component of the conceptual measure. We found that 83% of the children reconstructed at least one problem incorrectly at pretest. Thus, most children did not represent the problems correctly at pretest.

Change in Conceptual Knowledge From Pretest to Posttest

We first examined whether any of the children made conceptual gains after learning the problem-solving procedure. Overall, 47% of the children increased their conceptual score after learning the problem-solving procedure. However, the average conceptual gain from pretest to posttest was quite small ($M = 0.40, SD = 0.86$). Because of potential floor effects, we analyzed the data using nonparametric statistics.

Figure 1 displays the proportion of children in each condition whose conceptual knowledge score increased, stayed the same, or decreased from pretest to posttest. The manner in which children's score changed was contingent on the external goal manipulation, $\chi^2(4, N = 53) = 10.47, p < .05$. We used chi-square partitioning (Bresnahan & Shapiro, 1966) to pinpoint the source of the difference. Fifty-three percent of children in the experimental conditions increased their score from pretest to posttest, and 29% of children in the control condition did, $\chi^2(1, N = 53) = 2.54, p = .11$. Sixty-eight percent of children in the learning goal condition increased their score from pretest to posttest, whereas only 35% of children in the performance goal condition did, $\chi^2(1, N = 36) = 3.97, p < .05$. Considering only the children whose score did not increase, 42% of the remaining children in the control condition decreased their score from pretest to posttest, whereas only 12% of the remaining children in the experimental conditions did, $\chi^2(1, N = 29) = 3.82, p < .06$. Also, 18% of the remaining children in the performance goal condition decreased their score from pretest to posttest, and none of the remaining children in the learning goal condition did, $\chi^2(1, N = 17) = 0.13, p > .20$. Table 3 displays the proportion of children in each condition whose performance increased, stayed the same, or decreased from pretest to posttest on each component of the conceptual knowledge measure.

Thus, children's conceptual score change from pretest to posttest depended on the goals they received. Children who were given learning goals were the most likely to gain conceptual knowledge from pretest to posttest, and children who were not given a goal were the most likely to lose conceptual knowledge from pretest to posttest.

Ability to Transfer Newly Acquired Knowledge to Novel Problems

Table 2 displays the proportion of children who used each strategy on at least one problem for the pretest, posttest, overall transfer test, and difficult transfer problems. As shown in the table, all of the children used the instructed procedure on the posttest problems. Thus, all children learned the instructed procedure, regardless of the goal manipulation.

Children's performance on the transfer test was not as good. Overall, the average number of transfer problems solved correctly (out of 6) was 2.83 ($SD = 2.04$). Because of potential floor effects (particularly in the control condition), we used nonparametric

Table 2
Percentage of Children Who Used Each Strategy on at Least One Problem During the Pretest, Posttest, Overall Transfer Test, and Difficult Transfer Problems

Strategy	Pretest	Posttest	Transfer	Difficult transfer
Add all the numbers	75	0	45	42
Add to equal sign	11	0	38	19
Carry	15	0	15	6
Add two numbers	0	0	42	32
Grouping	0	100	56	0
Other correct	0	0	21	17

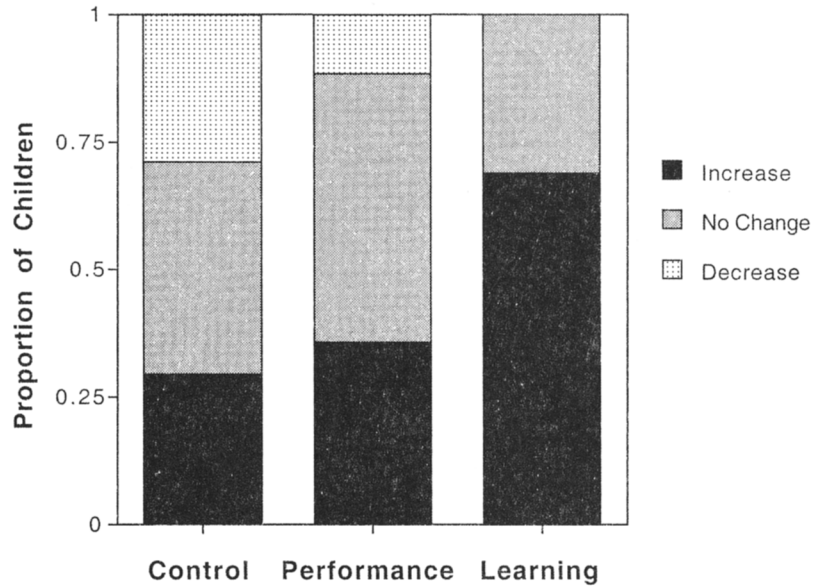


Figure 1. Proportion of children whose score on the conceptual knowledge measure increased, stayed the same, or decreased from pretest to posttest.

statistics to analyze the data. Figure 2 displays the proportion of children in each of the goal conditions who solved more than half of the transfer problems correctly. Whether children solved more than half of the transfer problems correctly was contingent on the external goal manipulation, $\chi^2(2, N = 53) = 6.85, p < .05$. Fifty-six percent of children in the experimental conditions solved more than half of the transfer problems correctly, whereas only 18% of children in the control condition did, $\chi^2(1, N = 53) = 6.76, p < .01$. Fifty-eight percent of children in the learning goal condition solved more than half of the transfer problems correctly, and 53% of children in the performance goal condition did, $\chi^2(1, N = 36) = 0.09, p > .70$.

We next examined children's strategies on the difficult transfer problems ($a + b + c = d + _$). Relatively few children solved the difficult transfer problems correctly (only 17% of children overall, see Table 2). Thus, the difficult transfer problems were

indeed difficult. Children could solve the difficult transfer problems in one of three ways: (a) they could apply their initial mental set by reverting back to the incorrect procedures that they had used on the pretest, (b) they could incorrectly apply the taught procedure, or (c) they could generate new problem-solving procedures. Each child's performance on the difficult transfer problems was classified into one of these three categories. Figure 3 contains the distribution of children across categories for each condition. Children's difficult transfer response was contingent on the external goal manipulation, $\chi^2(4, N = 53) = 12.54, p < .02$. Again, we used chi-square partitioning to pinpoint the source of the differ-

Table 3
Proportion of Children Who Increased, Stayed the Same, or Decreased From Pretest to Posttest on Each Component of the Conceptual Knowledge Measure

Condition	Increase	Stay the same	Decrease
Equal sign definition			
Control	.00	.94	.06
Performance goal	.06	.94	.00
Learning goal	.11	.89	.00
Problem reconstruction			
Control	.24	.59	.18
Performance goal	.41	.53	.06
Learning goal	.53	.32	.16
Identifying equations			
Control	.59	.29	.12
Performance goal	.53	.29	.18
Learning goal	.74	.21	.05

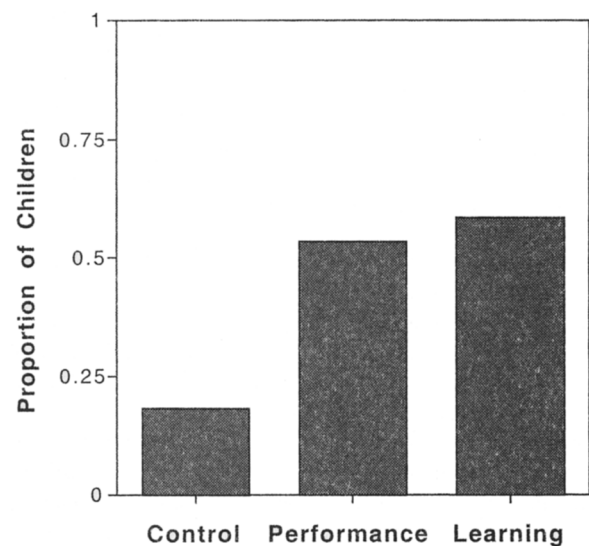


Figure 2. Proportion of children who solved more than three transfer problems correctly at posttest.

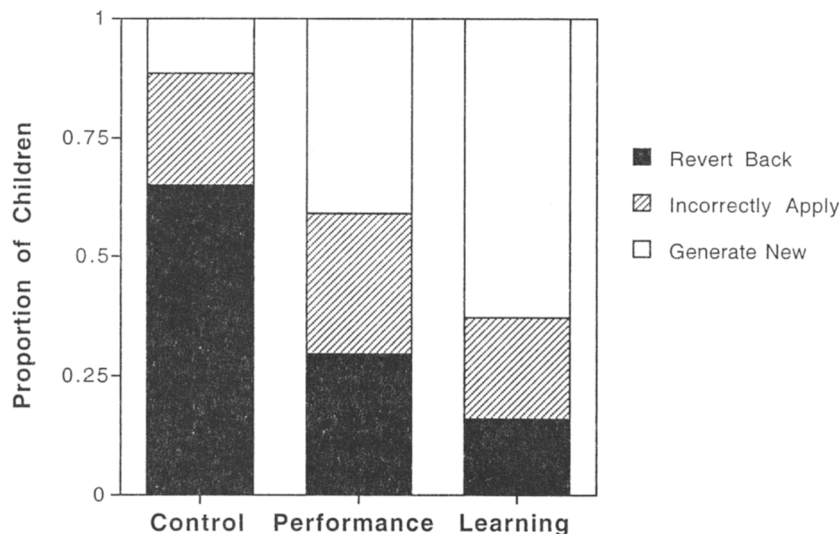


Figure 3. Proportion of children who reverted back to their initial incorrect procedure, incorrectly applied the taught procedure, or generated a new procedure on the difficult transfer problems.

ence. As predicted, the difference was in children's tendency to apply their initial mental set by reverting back to their initial, incorrect procedure. Sixty-five percent of children in the control condition applied their initial mental set, whereas only 22% of children in the experimental conditions did, $\chi^2(1, N = 53) = 9.06, p < .005$. Twenty-nine percent of children in the performance goal condition applied their initial mental set, and 16% of children in the learning goal condition did, $\chi^2(1, N = 36) = 0.72, p > .50$. Considering only the children who did not apply their initial mental set on the difficult transfer problems, 33% of the remaining children in the control condition generated a new strategy, and 68% of the remaining children in the experimental conditions did, $\chi^2(1, N = 34) = 1.66, p > .10$. Also, fifty-eight percent of the remaining children in the performance goal condition generated a new strategy, and 75% of the remaining children in the learning goal condition did, $\chi^2(1, N = 28) = 1.09, p > .50$.

In sum, children who were given goals were more likely to solve more than half of the transfer problems correctly than were children who were not given goals. Furthermore, on the difficult transfer problems, children who were not given goals were most likely to apply their original mental set by reverting back to their initial, incorrect strategies.

Results indicated that children in the control condition were more likely to apply their original mental set than were children who were given goals. An alternative possibility would be that children in the control condition actually represented the problems correctly but then chose to apply a more familiar strategy. To address this issue, we examined children's performance on the reconstruction component of the conceptual measure at posttest. At posttest, 94% of children in the control condition reconstructed at least one problem incorrectly, whereas only 64% of children in the experimental conditions did, $\chi^2(1, N = 53) = 5.43, p < .03$. Thus, at posttest, children in the control condition were more likely to incorrectly represent the problems than were children who were given goals.

Do Effects Endure Over Time?

Do the effects of externally imposed goals endure over time? To address this question, we assessed children's conceptual score change from pretest to follow-up. Overall, 56% of the children increased their conceptual score from pretest to follow-up, and the average conceptual score change from pretest to follow-up for the group of children as a whole was 0.80 ($SD = 1.11$). Because of potential floor effects, we analyzed the data using nonparametric statistics.

Figure 4 displays the proportion of children whose conceptual knowledge score increased, stayed the same, or decreased from pretest to follow-up for each condition. How children's score changed from pretest to follow-up was contingent on the external goal manipulation, $\chi^2(4, N = 46) = 12.17, p < .05$. Again, we used chi-square partitioning to pinpoint the source of the difference. Seventy-six percent of children in the experimental conditions increased their score from pretest to follow-up, whereas only 29% of children in the control condition did, $\chi^2(1, N = 46) = 8.81, p < .01$. Seventy-five percent of children in the learning goal condition increased their score, and 76% of children in the performance goal condition did, $\chi^2(1, N = 32) = 0.00, p > .90$. Considering only children who did not increase their score from pretest to follow-up, none of the remaining children in the experimental conditions decreased their score, whereas 30% of the remaining children in the control condition did, $\chi^2(1, N = 18) = 3.35, p < .08$. Table 4 displays the proportion of children in each condition whose performance increased, stayed the same, or decreased from pretest to follow-up on each component of the conceptual knowledge measure.

Thus, at follow-up, children who were given goals were more likely to gain conceptual knowledge from pretest to follow-up than were children who were not given goals, and there were no longer differences between children who were given learning goals and children who were given performance goals. Children who were

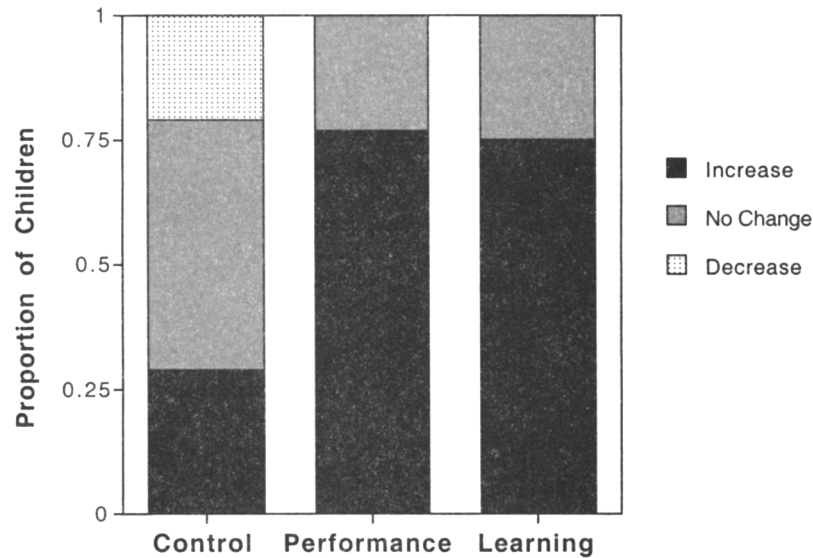


Figure 4. Proportion of children whose score on the conceptual knowledge measure increased, stayed the same, or decreased from pretest to follow-up.

not given goals were still more likely to lose conceptual knowledge from pretest to follow-up.

We next examined children's performance on the problem-solving follow-up test. Recall that the problems on the follow-up test were comparable to those on the posttest. Also recall, as seen in Table 3, that 100% of the children used a correct strategy on the three posttest problems. This was not the case on the follow-up test. On the follow-up test, only 73% of children used a correct strategy on all three of the problems. Whether children solved all three of the follow-up test problems correctly was not contingent on the external goal manipulation, $\chi^2(1, N = 45) = 1.46, p > .20$.

To gain a deeper understanding of children's performance on the follow-up test, we investigated whether children tended to apply their initial mental set by reverting back to their initial, incorrect pretest strategies. Thirty-eight percent of children in the control condition applied their initial mental set on the follow-up test, whereas only 9% of children in the experimental conditions

did, $\chi^2(1, N = 45) = 5.35, p < .03$. In keeping with the previous results, children in the control condition were more likely to apply their initial mental set by reverting to their initial, incorrect strategies on the follow-up than were children in the experimental conditions. To address the possibility that children in the control group actually represented the problems correctly but then chose to apply a more familiar strategy, we examined children's performance on the reconstruction component of the conceptual measure at follow-up. At follow-up, 71% of children in the control condition reconstructed at least one problem incorrectly, while only 39% of children in the experimental conditions did, $\chi^2(1, N = 46) = 5.62, p < .05$. Thus, at follow-up, children in the control condition were more likely to have incorrect representations than were children who were given goals.

Finally, we examined children's performance on the follow-up transfer test. Whether children solved more than half of the follow-up transfer problems correctly depended on the external goal manipulation, although the effect was only marginally significant, $\chi^2(2, N = 45) = 4.80, p < .10$. Fifty percent of children in the experimental conditions solved more than half of the follow-up transfer problems correctly, whereas only 23% of children in the control condition did, $\chi^2(1, N = 45) = 2.75, p < .10$. Thirty-eight percent of children in the learning goal condition solved more than half of the follow-up transfer problems correctly, and 63% of children in the performance goal condition did, $\chi^2(1, N = 32) = 2.05, p > .10$. Note that from posttest to follow-up, the percentage of children who solved more than half of the transfer problems correctly in the learning goal condition decreased from 58% to 38%, whereas the percentage of children in the performance goal condition increased from 53% to 63%.

In sum, after a 2-week period, effects of the learning goal manipulation on conceptual knowledge gain endured, and new effects of the performance goal manipulation on conceptual knowledge gain emerged. Moreover, children who were not given a goal were more likely to apply their initial mental set on the

Table 4

Proportion of Children Who Increased, Stayed the Same, or Decreased on Each Component of the Conceptual Knowledge Measure From Pretest to Follow-Up

Condition	Increase	Stay the same	Decrease
Equal sign definition			
Control	.07	.86	.07
Performance goal	.06	.88	.06
Learning goal	.13	.87	.00
Problem reconstruction			
Control	.20	.73	.07
Performance goal	.44	.56	.00
Learning goal	.25	.75	.00
Identifying equations			
Control	.43	.50	.07
Performance goal	.50	.44	.06
Learning goal	.69	.31	.00

follow-up test problems than were children who were given goals. The effects of the learning goal manipulations on transfer performance weakened, and the effects of the performance goal manipulation on transfer performance endured.

Discussion

The present study focused on how externally imposed goals influence children's ability to learn from procedural instruction. There were two main findings. First, children who were given goals outperformed children who were not given goals on both measures of learning (conceptual gain and transfer). Second, children who were not given goals were more likely to apply their initial mental set than were children who were given goals.

We have argued that externally imposed goals influence how children process problem information. Specifically, we suggest that externally imposed goals facilitate children's ability to represent problems accurately. In the case of mathematical equivalence problems used in the present study, children sometimes impose a mental set that interferes with their ability to represent the problems accurately. Because children have long been exposed to simple addition problems, they tend to apply an incorrect, simple addition approach to such problems. This idea of a mental set is supported by the fact that 75% of children used the "add all the numbers" strategy on the pretest. Children applied the more familiar strategy of adding all the numbers to the novel equivalence problems, suggesting that children applied a mental set that interfered with their ability to represent the problems accurately. Importantly, the proposed mechanism that externally imposed goals discourage mental sets was supported by the results both on the difficult transfer problems, and on the follow-up problems. Children who were not given a goal were more likely to apply their initial mental set by reverting to their initial, incorrect procedures.

The proposed mechanism also was supported by children's performance on the reconstruction component of the conceptual measure. At both posttest and follow-up, children who were not given goals were more likely to have incorrect problem representations than were children who were given goals. This is not to say that these children did not have the correct representation in their repertoire. Indeed, we assert that children often have multiple representations of a given problem (Alibali & McNeil, 2000; Goldin-Meadow, Alibali, & Church, 1993). Some of the representations may be robust, and some of them may be impoverished. The mental set of adding all of the numbers relies on a particularly robust representation that is linked to a well-practiced strategy. Most children are exposed to simple addition before they enter school, and in school, mathematics instruction tends to reinforce the operational schema (Baroody & Ginsburg, 1983). Because the mental set of adding all the numbers is so pervasive, it is not surprising that children apply it when they are unsure about a problem. However, both learning and performance goals have the potential to dissuade children from applying a mental set. Goals help direct attention and action toward goal-relevant behaviors and away from behaviors that prevent goal achievement (Locke & Latham, 1990). If children are told that their goal is to get the problems right or to learn new things, then applying a mental set will prevent them from achieving their goal. In this circumstance, children's attention may be directed toward some of their other representations, especially the correct representation, be-

cause those representations are more likely to facilitate goal achievement.

The goal manipulations in this study included three main components that may have helped children represent the problems more accurately. This was true of both the learning and the performance goal manipulations. First, each goal statement stressed an important goal of the instruction (e.g., "The most important thing will be for you to try to solve the problems correctly"). Second, each goal statement provided children with information that discouraged mental sets by helping children realize that the problem was different from other more familiar problems (e.g., "You will learn a lot of new things"). Third, each goal statement provided children with information about why the problems are important (e.g., "These problems are important because if you try your best to get them correct, you will be able to show me how well you do on the problems compared to other children your age"). Each of these three components may have influenced children's problem representations in the present study.

We have shown that externally imposed goals have the potential to influence children's learning. Indeed, it seems likely that differences in externally imposed goals may be one factor responsible for individual differences in learning. At the least, differences in externally imposed goals have the potential to help explain individual differences in learning mathematical procedures. Teachers may give goals to some students but not to others. Moreover, different teachers may give different goals to students, or the same teacher may give different goals to different students. Although every teacher may not provide explicit goals for students, teachers' behaviors and practices may implicitly highlight particular goals. Fortunately, this is a factor that teachers and parents have the ability to control so that learning can be optimized. When teaching students new procedures, teachers and parents should make an effort to provide students with goals.

This view of goals may provide a possible explanation for some of the findings in the teacher expectation literature. For example, in a well-known study by Rosenthal and Jacobson (1968), teachers were told at the beginning of the school year that a random group of children were likely to show a spurt in intellectual growth, and by the end of the year, those children's IQ scores were raised significantly. One explanation that has been suggested is that the teachers had different expectations for those children, and those expectations were communicated to the students, either directly or indirectly. One possible way in which these expectations may be communicated is through the goals that teachers give to children. Teachers in the Rosenthal and Jacobson study may have given the experimental children, but not the other children, goals to meet. The externally imposed goals may have been responsible for the actual learning behavior of the children. Although this is only speculation, it seems likely that externally imposed goals could be one means by which teachers' expectations are communicated. To test this hypothesis, future studies could examine the relationship between teachers' expectations and the goals they give their students.

Another important educational implication of the present study has to do with the relationship between conceptual gain and transfer. Although both of these processes require children to extend their knowledge beyond an instructed procedure, they may not do so in an analogous fashion. At posttest, children who were given learning goals were more likely to gain conceptual knowl-

edge than were children who were given performance goals; at the same time, the two goal manipulations had similar effects on transfer performance. By follow-up, the two goal manipulations had similar effects on conceptual gain; at the same time, children who were given learning goals declined in their transfer performance, whereas children who were given performance goals did not. We suspect that the incongruent relationship between conceptual gain and transfer may be due, at least in part, to differences in how these processes relate to problem representation. According to our view, problem representation has both a perceptual component and an interpretation component. We speculate that transfer performance may be closely associated with the perceptual component. The results of the present study provide some correlational support for this speculation. The transfer performance of children who were given learning goals declined from the first session to the second session, and their problem reconstruction performance also declined. The transfer performance of children who were given performance goals showed a small increase from the first to the second session, and their problem reconstruction performance also increased. Our future research will address this hypothesis directly by manipulating either children's interpretation of a feature of a problem or their perceptual representation of that feature and then examining the effects on conceptual gain and transfer.

In sum, the present study investigated how goals influence learning from procedural instruction. Externally imposed goals predicted children's conceptual gains and transfer performance. We have proposed a mechanism by which externally imposed goals influence learning. Specifically, we suggest that externally imposed goals influence how problem information is processed by discouraging mental sets and helping problem solvers represent problems accurately. To explore this mechanism, our future research will focus directly on the relationships among externally imposed goals, mental sets, and problem solvers' ability to represent problems accurately.

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