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An experimental evaluation of four tutoring strategies implications for instruction, affect, and transfer of training

Katherine Marie Savoy
Wilfrid Laurier University

An Experimental Evaluation of Four Tutoring Strategies:

Implications for Instruction, Affect, and Transfer of Training

Katherine Marie Savoy

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Abstract

In the present study, the type of instruction to which children were exposed was manipulated in an attempt to determine the tutoring effectiveness, affective consequences, and impact on generalization of tutoring patterns based on Vygotsky's (1934/1978) and Wood's (1980) concept of the "region of sensitivity to instruction." Participants were forty fourth and fifth grade children from the Waterloo Separate School Board. Each child was randomly assigned to one of four experimental conditions, or to a no-training control, and individually tutored by the experimenter on difficult long division math problems. The tutoring interventions were classified by levels of instructional support following the work of Wood, Wood, and Middleton (1978). The high support tutoring condition involved consistently instructing the child at very supportive levels of experimenter regulation. The moderate support tutoring condition involved consistently instructing the child at intermediate levels of experimenter regulation. The contingent support tutoring condition involved instructing the child with the aid of Wood's (1980) shift rule, which maximizes intervention in the child's current region of sensitivity to instruction. The shift rule specifies providing more support on the next intervention if the child failed in following instruction, and less support if the child succeeded. The sequential support tutoring condition involved providing minimal support during the first intervention of every problem step and subsequently providing gradually increasing support until the child succeeded. The control condition involved only the administration of the pretest and post-tests. Children were subsequently post-tested on long division problems three

times: immediately after tutoring, after one week, and after one month. Attached to each post-test was a two-item transfer of training measure. A measure of affect toward the tutoring was administered to each child immediately following the final tutorial session.

Results revealed that on the immediate post-test, for both training items and novel transfer problems, contingently-tutored children outperformed children in all other conditions. Moreover, this superiority of performance by the contingent group was maintained over the two long term post-tests of same and novel problems, administered one week and one month after the final tutorial intervention. Further, significantly better performance was observed among children tutored at intermediate levels of experimenter regulation compared with children . the control, high, and sequential conditions at the immediate post-test across both similar and novel problems. This performance difference was transient, however, as there was no significant difference in performance among children in the control, moderate, high, or sequential conditions on the one week and one month post-tests of same and novel problems.

Results from the affective data indicated that children tutored with the sequential strategy reported significantly more negative feelings toward the tutorial session than children tutored with the moderate or contingent strategies. Furthermore, a significant difference in reported positive feelings was found among children in the control condition and children in the remaining four conditions. However, no significant difference existed on this positive affect index among children in the four experimental conditions. Finally, a significant difference in perceived performance existed among

children tutored with the contingent strategy and children tutored in the control or sequential support conditions only. Results are discussed relative to the findings of Wood (1980).

An Experimental Evaluation of Four Tutoring Strategies:

Implications for Instruction, Affect, and Transfer of Training

Recently, there has been growing interest regarding the role of social support in the acquisition of cognitive skills by children. The present study was designed to experimentally investigate this issue through the assessment of four distinct tutoring strategies as forms of instructional support, based on the theories of Vygotsky (1934/1978) and the work of Wood (1980).

A substantial amount of research in the area of tutoring strategies has been spurred by the work of the Soviet developmentalist, Lev Semyonovich Vygotsky. The present thesis opens with a review of Vygotsky's theory, emphasizing the notion of the zone of proximal development. Recent ideas analogous to Vygotsky's notion of the zone of proximal development are then discussed, concentrating on Wood's (1980) conception of scaffolding and the "region of sensitivity to instruction." A review of the recent empirical evidence will follow. Finally, a rationale and hypotheses are provided for the present study.

Vygotsky has figured prominently in American psychology since the publication of his monograph, "Mind in Society" (1934/1978). He attempted to formulate a theory of human intellectual functioning based on the foundations of Marxism. According to Marx, "historical changes in society and material life produce changes in human nature (conscious and unconscious)" (Marx, as cited in Vygotsky, 1934/1978, p. 7). Fundamental to Vygotsky's theory of human intellectual development was the notion that higher mental functions, such as thinking, voluntary attention, and memory, and human consciousness in general, have their origins in human social life, deriving from "internalized social relations that have become functions for the individual and forms of his/her structure" (Vygotsky, 1934/1978, p. 164). For Vygotsky, the internalization of social relations referred to the internal reconstruction of external operations. This process consisted of three transformations. First, an external operation is gradually reconstructed into an internal operation. Vygotsky thus proposed that what is of importance to the development of higher mental processes is the transformation of operations from external activity to internal activity, as evidenced in the development of intelligence, voluntary attention, and memory (Vygotsky, 1934/1978). Second, an interpersonal process is transformed into an intrapersonal process (Vygotsky, 1934/1978). The child's every function of cognitive development, including voluntary attention, memory, and the formation of concepts, appears twice. It first appears on a social level, that is, between people or on the interpsychological plane, and then on an individual level, that is, within the child or on the intrapsychological plane. Vygotsky argued that all higher functions originate as interpersonal processes. Finally, the transformation of an interpersonal process into an intrapersonal process is the result of a long series of developmental events (Vygotsky, 1934/1978). Many functions never become transformed or internalized. The stage of external signs is their final stage of development. Other functions develop further and eventually become internal functions. However, Vygotsky stated that they take on the character of inner processes only as a result of prolonged development.

The acquisition of language in children is an example of the process of internalization. Language arises initially as a means of communication between the child and the people in his/her environment. Only subsequently, upon conversion to internal speech, does it come to organize the child's thoughts, that is, become an internal mental function (Vygotsky, 1934/1978). Piaget concluded that "communication produces the need for checking and confirming thoughts, a process that is characteristic of adult thought" (Cole & Scribner, 1978, p. 86). In the same way that internal speech and reflective thought arise from the interactions between the child and persons in his/her environment, these interactions provide the source of development of a child's voluntary behavior.

Vygotsky dedicated much of his theoretical writings to the analyses of the psychological processes which may be operating during the activity of teaching. He believed that the problems encountered in teaching could not be resolved nor formulated without addressing the critical relation between learning and development in school-aged children (Vygotsky, 1934/1978).

During the time of Vygotsky's writings, there were three primary theoretical positions regarding the relation between learning and intellectual development in children. The first centered on the assumption that "the processes of child development are independent of learning" (Vygotsky, 1934/1978, p. 79). Learning, therefore, was considered to be a purely external activity uninvolved in children's development. Cole and Scribner (1978) concluded that, in many experimental investigations of the development of thinking in school children, it has been assumed that voluntary attention, memory, and abstract thought occur without influence from formal education.

An example of such a position is Piaget's theory. The questions Piaget would ask children during clinical observations clearly illustrated this approach. Piaget, for example, would ask a five year old, "Why doesn't the sun fall?" Although he was fully aware that the typical five year old does not possess the intellectual capabilities to answer such a question, it was asked to eliminate the influence of previous knowledge or experience. Piaget sought to obtain childrens' thinking in a "pure" form, entirely independent of learning.

The second major theoretical position held that learning was development (Cole & Scribner, 1978). One such theory is based on the concept of the reflex. Development, from this position, is viewed as the acquisition of conditioned reflexes. James (1898/1958) elaborated this notion by reducing the learning process to habit formation, and identifying it with development. This theoretical position holds that any acquired response is considered to be either a more complex form of, or a substitute for, the innate response.

The third major theoretical position on the relation between learning and development attempted to moderate the two extremes by simply combining them (Vygotsky, 1934/1978). An example of this approach is Koffka's theory, in which "development is based on two inherently different but related processes, each of which influences the other" (Vygotsky, 1934/1978, p. 81). According to Koffka, development is contingent upon maturation and learning. Koffka argued that the process of maturation acts as an impetus for the process of learning. Learning then stimulates and "pushes forward" the maturation process.

Vygotsky proposed that in order to attain a more adequate view of the relation between learning and development, it was necessary to analyze all three theoretical positions discussed above. Vygotsky believed that the solution to the problem consisted of both the general relation between learning and development, and the specific features of this relation when children reach school age (Vygotsky, 1934/1978).

Although Vygotsky recognized that children's learning begins long before they attend school, his primary theoretical emphasis focused on the dimensions of school learning. Vygotsky believed that the specific dimensions of school learning could only be elaborated with the aid of the concept of the zone of proximal development.

It has long been argued that learning and the child's development should be matched in some manner for the child to experience success in the learning situation (Vygotsky, 1934/1978). For example, teaching skills like reading, writing, and arithmetic should be initiated at a certain age. Vygotsky proposed, therefore, that it is necessary to determine at least two developmental levels. The first level can be called the actual developmental level, where the child's mental functioning is established through independent performance on a given task. The use of standardized tests in determining a child's mental functioning provides a measure of the child's actual developmental level. The second level of development can be called the potential developmental level, where the child's mental functioning is assessed by his/her performance while participating in instructional social interaction with an adult or more capable peer. The logic behind determining a child's potential developmental level is based on Vygotsky's argument that what a child can do while participating in instructional social interaction may, in some sense, be more indicative of future mental development than the child's independent performance on any given task.

To further illustrate Vygotsky's distinction between a child's actual and potential developmental level, consider the following example.

> Imagine that we have just examined two children to determine that the mental age of both is that of seven years. This means that both children can solve tasks accessible to seven year olds. However, when we attempt to push these children further there turns out to be an essential difference between them. With the help of leading questions, examples, and demonstrations, one of them can solve test items taken from two years above his actual level of development. The other can solve test items that are only a half year above his actual level of development (Rogoff & Werstch, 1984, pp. 2-3).

According to Vygotsky, in terms of their actual developmental level the two children are equivalent, but in terms of their potential level, the two are sharply different. The difference in the two children's potential developmental level suggested to Vygotsky that the children's subsequent learning will also be different. The difference between a child's actual and potential developmental level is what Vygotsky referred to as the zone of proximal development. Specifically, it is the distance between that level of performance determined by the child's independent problem solving and that level determined through problem solving under the guidance of, or in collaboration with, an adult or more capable peer.

Vygotsky further proposed that a child's actual developmental level referred to those functions which have already matured, whereas the potential level of development defined those functions which have not yet fully matured, but are in the process of maturation. Vygotsky referred to the later functions as the "buds" or "flowers" of development, rather than "fruits." It is not until the "buds" or "flowers" of development have become internalized that Vygotsky referred to them as the "fruits" of development. Mental development is therefore defined retrospectively through a child's actual developmental level, and prospectively through a child's potential developmental level (Cole & Scribner, 1978).

A further critical component of learning according to Vygotsky's theory is the process of instruction. Vygotsky hypothesized that it is through instruction that the zone of proximal development is created. One cannot, however, immediately assume that, because a child's performance is better while collaborating with an adult or more capable peer, the child's level of potential development is "arbitrarily high." Because a child can only operate within a particular range that is determined by the state of his/her intellectual development, the zone of proximal development is a joint product of both the developmental level of the child's functioning and the form of the instruction involved (Rogoff & Werstch, 1984). For Vygotsky, therefore, the process of instruction "rouses to life an entire series of internal processes of development" (Rogoff & Werstch, 1984, p. 4). These processes at that point in time are in such a stage of development that they can only be successful with the instruction of a more knowledgeable collaborator. Through the process of internalization, nese skills will eventually become an internal property of the child.

Concern with experimentally validating Vygotsky's notion of the zone of proximal development has characterized the work of several authors in the Soviet Union, and has begun to have an impact on North American investigators (Rogoff & Werstch, 1984). Several researchers (e.g., Brown & Campione, 1984; Brown & Ferrara, 1985; Brown & French, 1979) have conducted in-depth analyses of the relation between the child's actual and potential developmental levels. In studies such as these, problems presented to children are common IQ items, usually referred to as pattern matching or geometric design. The child is given a model (picture) of a silhouette and s/he must copy this model by combining a subset of wooden geometric forms. Unlike American intelligence tests, however, some of the requisite shapes are not included in the set of available wooden pieces but must be constructed by joining two pieces together. Children attempt to solve test items both independently and then in collaboration with an adult or more capable peer. The child's performance, therefore, is assessed both at an independent level as well as on a social level. The results of such research have generally revealed that, using a measure based on the child's independent functioning, success on a task could not be explained on the basis of a standardized assessment of the child's performance alone (i.e., an IQ test). Such results clearly suggest that in order to get an accurate assessment of the child's developmental level, performance should be assessed on both an interpsychological, as well as an intrapsychological plane.

In recent years, there has been a growing number of parallel formulations which incorporate notions similar to the zone of proximal development. Several American researchers (e.g., Hunt, 1961; Turiel, 1972) proposed that a child's intellectual development could be facilitated if the environment provided just the right discrepancy between prior achievements and present demands (Rogoff & Werstch, 1984). In these formulations, effective training, which focuses on the next step in a stage-sequential model, contrasts with ineffective training, which goes too far above or below the child's current level of functioning (Griffin & Cole, 1984). Support has been mixed for these ideas however (e.g., Walker, 1982).

The most widely accepted North American analogy to Vygotsky's notion of the zone of proximal development is Wood, Bruner, and Ross's (1976) concept of the "region of sensitivity to instruction." Wood et al. devised a procedure to locate the child's region of sensitivity to instruction. In a later article, Wood (1980) labeled this a "levels of scaffolding analysis." According to Wood (1980), the notion of scaffolding refers to a procedure wherein an adult's tutorial interventions are contingent upon the child's level of task competence. For example, the more difficult the task component, the more support and direction the tutor provides. Scaffolding involves providing children with goals or sub-tasks which they can at present master, though they cannot yet master the overall task on their own.

A review of recent studies on scaffolding instructional patterns with children reveals that much of the research has been observational in nature, concerned with parents' patterns of interventions in tutoring. The results consistently indicate that children of parents who scaffold while tutoring tend to learn more. Reeve (1987) found that maternal scaffolding on a simple math (addition) task with kindergarteners was positively correlated with post-test math performance. Reeve divided mothers' teaching strategies into one of three patterns: scaffolding, responsible, or inconsistent. Scaffolding mothers "were those who appeared very sensitive to their child's ability, offering instructions contingent upon the child's response to the previous directive" (Reeve, 1987, p. 5). Responsible mothers "frequently took charge cognitively of problem solving activity" (Reeve, 1987, p. 5). Finally, inconsistent mothers "did not exhibit an identifiable teaching pattern," at least in the coding scheme used in the study (Reeve, 1987, p. 5).

Reeve (1987) found that children of mothers who were labeled as scaffolders outperformed children of mothers who were labeled responsible or inconsistent. Reeve concluded that children of mothers who provided an appropriate problem solving scaffold were more likely to solve addition problems correctly than children of mothers who either took responsibility for joint problem solving or provided inconsistent problem solving support. A follow-up measure of tutoring style a few weeks later suggested that maternal teaching styles were consistent across short-term intervals.

Pratt, Kerig, Cowan, and Cowan (1988) studied mothers and fathers interacting with their three year old children on a block construction task, a matrix completion task, and a story-retelling task. They hypothesized that both mothers and fathers would demonstrate some ability to locate and operate within their child's region of sensitivity to instruction, following Wood et al. (1976), contingent upon the child's success or failure on the task. Pratt et al. further hypothesized that parents rated as authoritative in their general parenting style should show greater use of their child's region of sensitivity to instruction in their tutoring interactions, and should be more appropriately contingent in response to the child's performance, than parents rated as authoritarian or permissive. This hypothesis was based on Baumrind's (1973) typology of parenting style. Baumrind suggested that inherent in an authoritative parenting style is a tendency to support independence while at the same time providing an optimal amount of structure and guidance for the child. Thus, parents rated as authoritative exert firm control in a warm manner, explaining the reason for each rule and requiring obedience only because the child understands the purpose of the rule. Parents rated as authoritarian (i.e., those who exert a lot of control, expect strict conformity and unquestioning obedience, and tend to be detached and cold), or permissive (i.e., those who make few demands on the child, explain the rules they do have, and are generally warm and noncontrolling) do not generally exhibit these qualities.

Across three distinct tasks, Pratt et al. (1988) found that as children became more capable of independent performance, parental support declined. Likewise, parental scaffolding was consistently correlated with the child's successful participation and accomplishment on the tasks. Also consistent with Pratt et al.'s hypothesis, a correlation was found between an authoritative parenting style and the effective use of the child's region of sensitivity to instruction in tutoring. Specifically, more authoritative mothers were better in obtaining successful child participation on matrix and story-retelling tasks and more authoritative fathers were better in obtaining successful child participation on block construction and story-retelling tasks. Moreover, as part of the same investigation, Pratt (personal communication) observed parents' scaffolding success when tutoring children at three and one half years on a story-retelling task, and found that it was positively correlated with the children's independent story-telling performance, measured longitudinally at age five. These results are certainly consistent with the hypothesis that greater scaffolding effectiveness is associated with children's greater skill internalization.

Green (1987) also studied parental scaffolding of instructions to ten year old children on a long division math task. He observed the instructional interaction of mother-child dyads who were attempting to solve eight long division math problems. He hypothesized that all mothers should provide more support on the newer and more difficult components of the problems (long division, estimation) and less support on the easier components (multiplication and subtraction). Green also hypothesized that an authoritative parenting style should be associated with the most effective tutoring, as observed before (Pratt et al., 1988). Finally, Green predicted that a positive correlation should exist between maternal region of sensitivity use and the learning of the child as measured by an independent post-test of mathematics skill. Green developed an analysis of tutoring for the long division problem which differentiated maternal tutoring support into one of eight possible levels in a hierarchy (see Appendix A for Green's, 1987, categorization of levels and examples).

As predicted, the more difficult and novel the task component, the more support the mother provided. Green (1987) also found that, as predicted, maternal region of sensitivity use showed a positive correlation with the child's learning on an independent post-test of mathematics skill. The results did not, however, totally support the hypothesis that those mothers who were rated as authoritative (high on both warmth and structure) would be the most effective tutors. Rated maternal warmth, but not structure, was positively related to patterns of more effective scaffolding. However, maternal region of sensitivity use in tutoring was positively correlated with children's long division post-test performance, as predicted.

Rogoff, Ellis, and Gardner (1984) observed mother-child interactions in both a home and school context. They examined maternal tutoring with six and eight year old children on various recall tasks. They found that patterns of scaffolding varied significantly with the age of the child and the task employed. Specifically, on school-related tasks, mothers provided more support to the younger children than they did to the older children; on home-related tasks they did not differentiate use of support by age. Rogoff et al. explained these results in terms of mothers' perceptions of the ability of the child. Mothers expected school-related tasks to be more difficult than home-related tasks and subsequently provided more instruction to younger children on these tasks than to older children, in order to foster their performance.

Saxe, Guberman, and Gearhart (1987) investigated the relation between social and developmental processes in the numerical understanding of children in working and middle class families. Saxe et al. conducted interviews with two and one-half to four and one-half year old children to assess their understanding of numbers. Likewise, interviews were conducted with the mothers to determine the child's everyday number activities. Finally, Saxe at al. observed mother-child dyads in interaction during "prototypical" number activities. The researchers devised a game which required the child to reproduce the number of objects they saw on a model. Each parental response was coded in terms of the level of instructional support provided, very similar to the approaches of Wood (1980) and Green (1987).

Saxe et al. (1987) found that children in their investigation were regularly engaged with "social activities involving numbers." However, the nature of the children's "numerical understanding" and their "numerical environments" differed in several ways. Primarily, across several tasks, age was the most significant factor associated with a child's numerical understanding. Secondly, a relationship was found between parents' reports of children's "everyday" number activity and the social class of the child. Four year old middle-class children displayed better numerical competence than their working-class peers and engaged in more complex number activities. Finally, during mother-child instructional interactions, mothers "adjusted" their support on each task to reflect their children's present abilities to structure numerical goals. Likewise, children "adjusted" their goals to their mothers' efforts to organize the activity. Although a few working-class mothers simplified the goal structure activity to a greater extent than middle-class mothers, overall few differences in maternal tutoring existed between these social class groups with children of equivalent ability. Saxe et al. (1987) concluded that children's numerical understandings are a function of both their own understanding and the sociocultural context of development.

The utilization of the region of sensitivity to instruction as a method of tutoring is not limited to countries or cultures with formally organized educational systems.

Cross-cultural evidence for the effective use of a child's region of sensitivity to instruction has been provided by several investigators. Childs and Greenfield (1980), for example, clearly illustrated the role of scaffolding in informal instruction in weaving with the Zinacantecan tribe of south-central Mexico. Fourteen girls were videotaped at various levels of learning to weave. There was always at least one instructor present while the girls were weaving. Childs and Greenfield (1980) found that novice weavers were able to produce woven material that was indistinguishable from material of the expert weavers, as seen through the eyes of the researchers. This good performance on the part of the novice weavers was made possible through the sensitive efforts of the instructors. The instructors provided more support on the difficult components of the task and less support on the easier components of the task. Through this procedure, the instructor was able to locate and operate within the child's region of sensitivity to instruction.

Most of the research reviewed above has been observational in nature. Wood, Wood, and Middleton (1978) are among the few researchers in this paradigm who have studied instructional patterns from an experimental perspective. From observational data on mothers teaching a block model-copying task, Wood et al. identified four naturally-occurring tutoring strategies, labeled demonstration, verbal, swing, and contingent. Demonstration tutoring involved the mother constructing the entire task while the child looked on. Verbal tutoring involved telling the child each step of the procedure with no physical intervention from the mother. Swing tutoring involved the mother swinging from nonspecific verbal encouragement to demonstration and back again. Contingent tutoring involved the mother utilizing what Wood (1980) referred to as the "shift rule." The shift rule specifies providing more support on the next intervention if the child failed in following instruction, and less support if the child succeeded. According to Vygotskian theory, contingent tutoring should produce superior learning because the child is provided with the opportunity to eventually attain full control over the task, thereby experiencing the problem at several levels of instructional support and subsequently being lead to more frequent use of the region of sensitivity to instruction. Moreover, the child is not presented with a more difficult subtask until the supported, "less difficult" task components have been successfully mastered.

In Wood et al.'s (1978) experimental investigation, children between the ages of three and four years were instructed by the experimenter on a pyramid construction task with one of the above four tutoring strategies. Upon completion of the tutoring session, children were requested to construct the pyramid independent of experimenter intervention. Based on Vygotsky's ideas, Wood et al. predicted that children in the contingently-taught group would perform better than children in the other three groups, and that the demonstration-taught group would perform the poorest overall. The results of Wood et al.'s (1978) investigation revealed that the contingently-taught children were the most active and capable on the independent pyramid construction task. No other significant differences were found.

Analysis conducted on the tutor's activities revealed that the instructional rule was somewhat harder to follow in the contingently-taught group. Of the thirty percent error rate by the tutor in this condition, the majority included use of a repeated or paraphrased instruction following child failure, instead of the tutor taking over more control. A final analysis was conducted to test the possibility that the differences between the tutoring strategies might be correlated with the time given to instruction. Wood et al. (1978) performed a within-subjects analysis to test this possibility. They found, however, no relation between teaching time and performance of the child after instruction. Wood et al. concluded that effective tutoring was attained through the instructor's sensitivity to the successes and failures of the child and the appropriate amount of support thus required for each tutorial intervention.

The Wood et al. (1978) study might be criticized for not including suitable controls for the shift tutoring condition, however. In this condition, the average level of tutorial support provided is necessarily intermediate within the overall hierarchy of intervention levels. Savoy (1988) recently addressed this issue in a somewhat different tutoring paradigm. In her study, fifth and sixth grade children were randomly assigned to one of three tutoring conditions. Children completed a pretest of long division mathematics skill, consisting of four difficult problems (i.e., a two or more digit divisor into a three or more digit dividend). Upon completion of the pretest, children were subsequently tutored by the experimenter using one of three tutoring strategies: moderate support, high support (demonstration) or contingent support. In the moderate support condition, children were provided with a consistent and intermediate amount of experimenter regulation regardless of success or failure (levels three and four using Green's, 1987, eight level system; see Appendix A). In the contingent support condition, the experimenter utilized the shift rule, as did Wood et al. (1978). In the high support condition, the experimenter had almost full control over the tutorial session (level seven or nearly demonstration using Green's, 1987, eight level system; see Appendix A). The moderate support condition served as an average levels control for the contingent tutoring of the shift rule condition.

Upon completion of the tutorial intervention, each child was administered an immediate post-test. Two long-term post-tests, administered one week and one month after the tutorial intervention, were employed to establish the durability of the learning. The tutorial session and post-test problems were of a similar difficulty level to those of the pretest. The results revealed that all children, regardless of their condition, did equally poorly on the pretest (approximately 10% correct overall), indicating that these were difficult long division problems for them. Results on the immediate post-test revealed that both contingently-tutored children, as well as children tutored at moderate levels of experimenter regulation, showed equivalent large performance increments (85% correct solutions). However, on the one week post-test, performance began to decline in children tutored with moderate support. The contingently-tutored children's performance remained consistently high and the high support tutored children's performance remained low. By the one month post test, the durability of this learning was considerably greater in the contingently-taught children. This one month post-test indicated that the contingently-tutored children maintained their superior performance (80% of the problems were solved correctly), whereas children tutored at intermediate levels of experimenter regulation showed a large and significant decrement in performance (only 25% of the problems were solved correctly and indeed their performance was not reliably different from that of children in the high support condition on the one month post-test). The high support condition children showed no significant improvement from baseline on either the immediate, one week, or one month post-tests.

The results of Savoy's (1988) study appear congruent with Vygotsky's notion of internalization, as discussed previously. Shift rule-tutored children appeared to be more likely to internalize critical aspects of the skill being taught and were thus able to maintain performance over time. In contrast, the moderate level tutoring did not seem to lead to effective internalization, and performance deteriorated on later post-tests. Within a Vygotskian framework, internalization is presented as a process which develops over a considerable period of time. Savoy's (1988) results, however, appear to suggest that the transition from interpsychological functioning to intrapsychological functioning, may, in some cases, occur more rapidly than others. Presumably, however, these results are due to the fact that many elements of the long division task (e.g., subtraction components) are already under full control of the child and "internalized." Tutoring thus becomes primarily a matter of facilitating correct application of various subskills. Shift rule instruction appeared to provide the child with the opportunity to eventually attain full control over the task and its components, perhaps through practice of problem-solving with very little support (by the end of the tutoring session). Such low-support practice did not occur for the moderate group, however.

Savoy (1988) was also interested in the affective consequences associated with each of the tutoring strategies employed. Children's ratings of "how hard you found the math problems," "how confused you felt while working on the math problems," and "how frustrated you felt while working on the math problems" were obtained on five-point Likert-type scales and used as an index of negative feelings toward the tutorial session. The affect measure was administered prior to the immediate post-test to ensure that performance on the post-test did not influence the child's affective responses. The results revealed that children who were tutored at high levels of experimenter regulation were significantly more likely to report negative feelings than children in the remaining two conditions. No significant difference was found between the responses of those children in the moderate and contingent support conditions.

Ratings of "how well you felt you did" and "how much you felt you learned" were analyzed as an index of perceived performance. The results revealed that children's perceived performance varied significantly across the three tutoring conditions. Specifically, children in both the contingent condition and in the moderate support condition perceived their performance as better than did children in the high support condition. However, no differences were found on three positive rating items (i.e., "enjoyment of the tutoring session," "lack of boredom," and "willingness to participate in a similar tutorial session in the future") across the three conditions, though the contingently-tutored group tended to score higher.

The present research was designed to replicate and extend the findings of Savoy (1988). The replication will further clarify the instructional and affective results of previous work, and the extension will attempt to determine the effect of repeated tutorial interventions on children's learning and transfer of training. Such generalization of training is often difficult to achieve (e.g., Brown & Campione, 1984), but seems to be best fostered by training that focuses the child on self-regulative procedures for monitoring his or her own performance (termed metacognitive activities, Flavell, 1985).

Thus, several recent theories (e.g., Brown & Campione, 1984) suggest that the most effective instruction is that which facilitates the use of metacognitive processes. General skills of metacognition include checking the outcome of any attempt to solve a problem, planning one's next move, monitoring the effectiveness of any attempted action, and testing, revising, and evaluating one's strategies for learning (Campione, Brown, & Ferrara, 1982). It is reasonable to hypothesize that contingent tutoring of a child may facilitate the use of metacognitive processes in children, in that the tutor's presentation of all steps of the task at a variety of levels allows the child to internalize appropriate verbal self-regulative processes. Contingently tutoring a child may thus encourage next-step planning, monitoring, and verbally evaluating one's performance.

To briefly sum up the present study, fourth and fifth grade children were tutored on difficult long division math problems with one of four techniques: high support, moderate support, contingent support, or sequential support. In the high support condition, children were tutored at very supportive levels of experimenter regulation (level seven using Green's, 1987, eight level system; see Appendix A). In the moderate support condition, children were tutored at intermediate levels of experimenter regulation regardless of their performance on the task (levels three and four using

Green's, 1987, eight level system; see Appendix A). In the contingent support condition, children were tutored with the aid of Wood's (1980) shift rule. Tutorial interventions in this condition were contingent upon the child's performance, as before (Savoy, 1988).

The sequential support condition was designed to provide a control for use of minimal levels of tutor support (levels one or two using Green's, 1987, hierarchy). In the sequential support condition, children were initially and consistently provided with low levels of experimenter regulation (levels one or two) for the first intervention on each task subcomponent. However, subsequent "within-step" interventions were contingent upon the child's response. Each tutorial intervention increased in degree of experimenter regulation until success was experienced. Both the contingent and sequential support tutoring conditions were designed to provide interventions within the child's current region of sensitivity to instruction. The technique with which each condition located this optimal learning region was quite different, however. There are three primary differences between the contingent and sequential tutorial support conditions. The first involved the expected number of interventions provided before the child experienced task success. Specifically, it was expected that children in the sequential support condition would require more tutorial interventions, because with each new subcomponent, the experimenter always provided minimal support and then sequentially increased experimenter regulation. With the children in the contingent support condition, however, experimenter regulation on each intervention, including the initial intervention of each new subcomponent, was contingent upon the child's previous response to that subcomponent. Specifically, if the child succeeded at level four on one subcomponent, the initial experimenter intervention on the next instance of that subcomponent would be at level three for the contingent condition (as opposed to a constant level one for the first intervention in the sequential condition).

The variability within contingent and sequential tutoring in the number of interventions necessary for task success should produce a second difference between the two tutorial styles. Specifically, it was expected that children in the sequential support condition would experience a higher proportion of failures than children in the contingent support condition. This is because they experience a higher proportion of interventions focused at levels below their current region of sensitivity to instruction.

The third difference involved the contingency aspect of tutoring, fully present in the contingent condition but only partially present in the sequential condition. As noted previously, tutorial interventions during the contingent condition are fully dependent upon the child's response, both between and within each task subcomponent. In contrast, tutorial interventions during the sequential condition were only contingent within each task step, not across steps, as sequential tutoring required that each initial intervention for each new task subcomponent be of minimal support.

The purpose of the sequential tutoring condition was to assess the role of instructional interventions with minimal support even if the child is not yet able to successfully follow them. The sequential support condition thus exposed the child to as wide a variety of instructor support as does the contingent condition over the course of a session, but in a less than contingent fashion.

Based on Vygotsky's theory, it was hypothesized that those children tutored with the aid of Wood's (1980) shift rule would be most likely to internalize the skills being taught. Such internalization should be reflected in superior learning and retention of skills over time, as measured by immediate and delayed post-tests. Moreover, internalization was predicted to facilitate the ability to flexibly use these newly acquired skills, thus resulting in greater transfer to novel tasks for the contingent condition. Both moderate and sequential tutoring were also predicted to produce some learning. However, this was not expected to be as marked as the learning obtained in the contingent tutoring condition, nor to be so readily transferred to novel tasks.

The present study further attempted to determine the affective consequences associated with each of the tutoring strategies employed. Based on the informal observations of Wood et al. (1978) and Pratt et al. (1988), children tutored within their region of sensitivity to instruction appear to experience fewer feelings of confusion, frustration, and bewilderment than children tutored with alternative methods. From these data, it seemed possible that tutoring within a child's optimal learning region produces intrinsic motivation and interest in the child.

McReynolds (1971) proposed a theory of cognitive competence which supports the notion that intrinsic motivation is inherent to efficient information processing. According to McReynolds, new information is either assimilated or not assimilated. If new information is unassimilated it is subsequently ignored. However, if it becomes assimilated, it undergoes the process of "cognitive innovation." According to McReynolds' theory, optimal cognitive functioning requires both keeping the rate of unassimilated material to a minimum in order to minimize anxiety, and optimizing the rate of cognitive innovation to maximize the pleasure of cognitive motivation. It appears, therefore, that tutoring within one's region of sensitivity to instruction would satisfy both of these optimization rules and result in more positive feelings on the part of the child. When a tutor scaffolds a task, s/he regulates the amount of unassimilated information that a tutee is presented, thereby reducing the anxiety related to the learning task. At the same time, instruction is provided just above the child's current level of performance, which may optimize the amount of new information the child can assimilate into his or her current cognitive structure.

Based on McReynolds' (1971) theory of cognitive innovation, it was hypothesized that children taught with the aid of Wood's (1980) shift rule would be more likely to report positive feelings and less likely to report negative feelings about the tutorial session than children tutored with all other techniques.

Method

Subjects

Forty children (males = 11, females = 29) from the Waterloo Separate School Board participated in the investigation. The children were volunteers from the fourth and fifth grades at a local elementary school, whose parents had given permission for their participation (see Appendix B for letter to parents and consent form used).

Design

The design of the study was a 2x5x4 factorial. The three factors were gender (2), tutoring style (5), and time of testing (4). Gender and tutoring style were between-subjects factors, whereas time of testing was a within-subjects factor. The tutoring styles included high support, moderate support, contingent support, and sequential support. A no-train control condition was also employed. There were eight children in each of these groups. The four times of testing included a pretest, an immediate post-test, a one week post-test, and a one month post-test.

The high support condition involved instructing the child at very supportive levels of experimenter regulation, that is, level seven in the eight level system used by Green (1987; see Appendix A). The moderate support condition involved consistently instructing the child at intermediate levels of experimenter regulation, that is, levels three and four in the eight level system used by Green (1987; see Appendix A). The contingent support condition involved instruction with the aid of Wood's (1980) shift rule. The shift rule specifies providing more support on the next intervention within a subcomponent if the child failed in following instruction, or less support if the child succeeded. The sequential support condition involved providing minimal support on the first intervention of each problem-solving step of the task and subsequently providing more support until the child succeeded. The no-train control condition children were required to complete the pretest and the post-tests. They were not, however, exposed to the experimental tutoring sessions.

Tasks and Measures

Pretest Mathematics Measure. A pretest mathematics measure was administered to each child prior to the tutorial interventions to determine the child's present ability on long division math problems (see Appendix C for the pretest mathematics measure).

The pretest consisted of eight long division math problems which systematically increased in difficulty, based on the results of earlier work (Savoy, 1988). Each child was allotted one minute to complete each of the easy problems and four minutes to complete each of the more difficult problems. The four easy problems were designed to provide children with a reasonable degree of task success, thereby maintaining interest and motivation. The order of the four easy problems and the four difficult problems was randomized separately for each child. The number of problems a child could successfully complete was determined. The analysis of each problem was broken down into five subcomponents: estimation of dividend, multiplication of divisor and dividend, subtraction, bringing down the following digit, and correctly obtaining the remainder (see Appendix D for a complete example of this coding scheme). For purposes of determining a child's score on the division problems, only written responses were coded.

Tutorial Intervention. A total of three tutoring sessions was employed for each child. Each session utilized two difficult long division math problems and was administered approximately every third day over a period of one week (see Appendix E for the tutorial session problems). The order of the three sets of problems was counterbalanced across children.

Measure of Affect and Interest. A measure of the child's affective response to the tutoring (adapted from Savoy, 1988) was administered immediately following the final tutorial intervention. The measure consisted of ten Likert-type five point scales in which 1 represented "not at all" and 5 represented "very much" (see Appendix F for the affect and interest measure). This measure represented an attempt to determine the child's feelings about the tutorial sessions, including levels of enjoyment, distress, and willingness to participate in a similar tutorial session in the future. A total of fifteen possible points (across three items) could be obtained on the negative and positive affect index and a total of ten possible points (across two items) could be obtained on the perceived performance index.

Mathematics Post-tests. Upon completion of the third and final tutorial intervention, each child was required to complete three post-tests of long division skill consisting of four problems each (see Appendix G for the mathematics post-tests). The three post-tests were administered immediately after the affect measure, after one week, and after one month. These problems were of a similar level of difficulty to those used in the tutorial sessions and the later pretest items. The purpose of the immediate post-test was to observe any effects of tutoring on the performance of the child. The purpose of the one week and one month post-tests was to determine the level of maintenance of learning based on the tutorial interventions. The number of problems or partial solutions a child could successfully complete was determined according to the coding scheme (see Appendix D); a total of thirty-two possible points (across four problems) could be obtained on any post-test.

Transfer Measure. Attached to each of the mathematics post-tests was a two-item word problem measure, which required use of long division skills for correct solution. These were a type of problem on which children had not been trained. The purpose of this measure was to determine whether different tutoring styles produce varying degrees of transfer to these novel tasks (see Appendix H for the transfer measure). The order of the transfer measure sets by post-test was counterbalanced across children. A total of twenty possible points (across two problems) could be obtained on any transfer measure.

Procedure

The study was conducted by the author in a vacant room at the child's school. The long division pretest was administered to each child individually. The child was told to attempt to solve as many of the division problems as s/he could within a twenty minute interval. Children were randomly assigned to either one of the four experimental conditions or the no-train control condition. The high support tutoring condition involved instructing the child at very supportive levels of experimenter regulation, level seven using Green's (1987) eight level system (see Appendix A). The only responsibility of children in this condition was to record the correct value in the appropriate place as indicated by the experimenter for each step of the problem. The moderate support tutoring condition involved consistently instructing the child at intermediate levels of experimenter regulation. This involved instruction at levels three and four using Green's (1987) eight level system (see Appendix A). For example, a multiplication step would be cued by a statement such as, "multiply six by thirty-two." The contingent support tutoring condition involved instructing the child with the aid of Wood's (1980) shift rule. The shift rule specifies providing more support on the next intervention if the child failed in following instruction, or less support if the child succeeded. For example, if the child can successfully accomplish a task subcomponent at level four, when intervening next on this subcomponent the experimenter will provide support at level three. The sequential support tutoring condition involved initially providing very minimal support to the child on each subcomponent of the task and sequentially increasing support until the child succeeded. This entailed beginning support at level one using Green's (1987) eight level system (a general verbal prompt such as "Try this one"), and working downward step-by-step to more supportive levels of experimenter regulation until the child succeeded. The children in the no-train control condition were only required to complete the pretest and post-tests. Due to the structural nature of each tutorial session, if a child made an error or failed to respond in any of the "noncontingent" conditions, the tutor continued to adhere to the guidelines as closely as possible.

Each tutoring session was composed of two long division problems. The first session immediately followed the pretest. The remaining tutorial sessions were administered approximately every third day over a period of one week (see Appendix I for written transcripts of tutorial instruction for each condition).

Upon completion of the final tutorial session, children were administered an immediate post-test by the author. Children were first administered a ten-item affect measure. Immediately following the affect measure, children were required to complete a four-item post-test of long division and a two-item transfer measure. Two further four-item long division post-tests were administered to each child. As noted, the two long-term post-tests were administered approximately one week (seven to ten days following the pretest) and one month (twenty-eight days following the pretest) after the final tutoring session. These two long-term post-tests were administered in a group session by the classroom teacher. The teachers were blind to the hypotheses and the tutoring conditions of the children. The word problem transfer task was also administered by the teachers with each of the two long-term post-tests.

Each tutorial session was audio-taped to assess the experimenter's adherence to the guidelines of the tutorial intervention. Each tutoring session lasted approximately ten minutes. The pretest and post-tests each lasted approximately thirty minutes.

All participants' parents or guardians were forwarded a feedback letter which described the results of the present study (see Appendix J for the feedback letter).

Results

An analysis of variance on group revealed no condition by gender interaction. Likewise, no significant main effects for gender existed, so results were pooled over this factor for subsequent analysis.

Overall Analysis of Training Effects. A split-plot analysis of variance on group was performed, with condition (5) as the between-subjects factor and time of testing (4) as the within-subjects factor. As observed previously (Savoy, 1988), a significant main effect of condition was found, $F(4,35)=34.48$, $MSe=26.25$, $p<.001$, such that math performance varied across the five conditions. This was qualified, however, by a significant condition by time of testing interaction, $F(4,35)=28.78$, $MSe=31.67$, $p<.001$. Follow-up one-way ANOVAs were therefore conducted to determine the source of this interaction.

Training Data

Analysis of Pretest Math Performance. A one-way analysis of variance revealed no significant effect of condition on pretest math performance, $F(4,35)=0.16$, $MSe=3.31, p=.985$. The pretest means and standard deviations are presented in Table 1.

Table 1: Training Measure Means and Standard Deviations (in parentheses)

Condition	Pretest	Immediate	One Week	One Month
Control	3.62 (2.97)	3.75 (4.30)	5.50 (2.50)	3.87 (5.06)
High Support	4.25 (4.59)	3.62 (3.58)	4.00 (5.89)	3.87 (7.02)
Moderate Support	4.50 (4.78)	12.00 (8.96)	7.00 (5.32)	5.12 (4.91)
Contingent Support	3.50 (6.00)	25.50 (3.07)	27.62 (2.33)	29.00 (2.73)
Sequential Support	2.87 (4.05)	4.00 (7.05)	4.87 (6.75)	3.37 (5.34)

Note. Possible score = 32

Analysis of Immediate Post-test Math Performance. A one-way analysis of variance revealed a significant effect of condition on immediate post-test math performance, $F(4,35)=21.06$, $MSe=34.14$, $p<.001$, as observed previously (Savoy, 1988). The immediate post-test means and standard deviations are presented in Table 1. Fisher's Post-hoc Least Significant Difference Tests (LSD = 7.97; $p<.01$) revealed that performance of children in the contingent condition was significantly higher than performance of children in the remaining four conditions ($ps<.01$). Further, significant differences existed between the moderate condition and the sequential, high and control conditions ($ps<.01$).

Analysis of One Week Post-test Math Performance. A one-way analysis of variance revealed a significant main effect of condition on one week post-test math performance, $F(4,35)=33.47$, $MSe=24.02$, $p<.001$. The one week post-test means and standard deviations are presented in Table 1. Fisher's Post-hoc Least Significant Difference Tests (LSD = 6.68; $p<01$) revealed that performance of children in the contingent condition was significantly higher than performance of children in each of the remaining four conditions ($ps<.01$). There were no other significant differences.

Analysis of One Month Post-test Math Performance. A one-way analysis of variance revealed a significant effect of condition on one month post-test math performance, $F(4,35)=37.00$, $MSe=26.98$, $p<.001$, as observed previously (Savoy, 1988). The one month post-test means and standard deviations are presented in Table 1. Fisher's Post-hoc Least Significant Difference Tests (LSD = 7.08; $p<.01$) revealed that performance of children in the contingent condition was significantly higher than performance of children in each of the remaining four conditions ($p<.01$). There were no other significant differences.

Results from the training data thus revealed that on the immediate post-test, contingently-tutored children outperformed children in all other conditions. Moreover, this superiority of performance by the contingent group was maintained over the one week and one month post-tests. Significantly better performance was also observed between children tutored at intermediate levels of experimenter regulation and children in the control, high, or sequential conditions. This effect was transient, however, as there was no significant difference in performance among children in the control, moderate, high, or sequential conditions on the one week and one month post-tests.

Generalization Data

Analysis of the Immediate Transfer Measure. A one-way analysis of variance revealed a significant effect of condition on the immediate transfer measure, $F(4,35)=50.12$, $MSe=10.47$, $p<.001$. The immediate transfer measure means and standard deviations are presented in Table 2. Fisher's Post-hoc Least Significant Difference Tests (LSD = 4.41; $p<.01$) performed on the means of each tutoring condition revealed that performance of children in the contingent condition was significantly higher than performance of children in the remaining four conditions ($ps<.01$). Furthermore, a significant difference existed between performance of children in the moderate support condition and children in the sequential, demonstration and control conditions ($ps<.01$).

Table 2: Transfer Measure Means and Standard Deviations (in parentheses)

Condition	Immediate Transfer	One Week Transfer	One Month Transfer
Control	0.37 (1.06)	0.50 (0.93)	1.62 (3.11)
High Support	0.62 (1.06)	1.50 (2.83)	0.62 (1.19)
Moderate Support	7.87 (6.83)	3.25 (3.33)	2.50 (3.38)
Contingent Support	19.12 (1.25)	19.12 (2.12)	18.87 (2.10)
Sequential Support	0.87 (1.35)	1.25 (2.76)	0.87 (2.10)

Note. Possible score = 20

Analysis of the One Week Transfer Measure. A one-way analysis of variance revealed a significant effect of condition on the one week transfer measure, *F*(4,35)=78.75, *MSe*=6.41, *p*<.001. The one week transfer measure means and standard deviations are presented in Table 2. Fisher's Post-hoc Least Significant Difference Tests (LSD = 3.45; *p*<.01) performed on the means of each tutoring condition revealed that performance of children in the contingent condition was significantly higher than performance of children in the remaining four conditions (*p*s<.01). There were no other significant differences.

Analysis of the One Month Transfer Measure. A one-way analysis of variance revealed a significant effect on condition of the one month transfer measure, *F*(4,35)=78.53, *MSe*=6.27, *p*<.001. The one month transfer measure means and standard deviations are presented in Table 2. Fisher's Post-hoc Least Significant Difference Tests (LSD = 3.41; *p*<.01) performed on the means of each tutoring condition revealed that performance of children in the contingent condition was significantly higher than performance of children in each of the remaining four conditions (*p*<.01). There were no other significant differences.

Results from the generalization data thus revealed that on the immediate transfer measure, contingently-tutored children outperformed children in all other conditions. Moreover, this superiority of performance by the contingent group was maintained over the one week and one month transfer measures. Significantly better performance was further observed between children tutored at intermediate levels of experimenter regulation and children in the control, high, or sequential conditions. This performance difference was transient, however, as there was no significant difference in performance among children in the control, moderate, high, or sequential conditions on the one week and one month transfer measures.

Affective Analysis

Analysis of the Negative Affect Items. The items of "confusion," "frustration," and "difficulty" were summed together and analyzed as an index of negative feelings toward the tutorial interventions. Pearson correlation coefficients revealed that these three items were significantly intercorrelated (all $ps<.01$), as observed previously (Savoy, 1988). Specifically, intercorrelations for the above items were as follows: difficulty and frustration, $r(38)=+.65$; difficulty and confusion, $r(38)=+.63$; and confusion and frustration, $r(38)=+.88$. A significant effect of condition on this negative affect index was found, $F(4,35)=5.11$, $MSe=12.58$, $p<.002$. The negative affect index means and standard deviations are presented in Table 3. Fisher's Post-hoc Least Significant Difference Tests (LSD = 4.83; $p<.01$) performed on the means revealed a significant difference in reported negative feelings toward the tutorial sessions between children in the sequential condition and children in the moderate and contingent conditions. No other significant differences were found on this negative affect index. Results from this negative affect index generally replicate the results of our earlier work (Savoy, 1988).

Analysis of the Positive Affect Items. Th. items of "enjoyment," "willingness to participate in a similar tutorial session in the future," and "a lack of boredom" were summed together and analyzed as an index of positive feelings toward the tutorial interventions. Pearson correlation coefficients revealed that these three items were only inconsistently intercorrelated. Specifically, intercorrelations for the above items were as

Table 3: Affect Measure Means and Standard Deviations (in parentheses)

Condition	Negative Affect	Positive Affect	Perceived Performance
Control	10.0 (3.20)	9.0 (1.85)	5.25 (1.39)
High Support	8.87 (4.49)	10.63 (1.06)	7.37 (2.32)
Moderate Support	4.75 (2.31)	10.75 (0.46)	7.75 (1.75)
Contingent Support	6.0 (2.73)	10.87 (0.35)	8.62 (1.06)
Sequential Support	11.62 (4.43)	10.87 (1.25)	5.37 (3.16)

Note. Possible score of negative and positive affect items = 15.

Possible score of perceived performance items = 10.

follows: enjoyment and willingness to participate $r(38)=+.21, p=.099$; enjoyment and a lack of boredom $r(38)=+.06$, $p=.35$; and willingness to participate and a lack of boredom, $r(38)=+.68, p<.01$. Although only one of the three items was significant, this index was used previously and it was decided to composite it for analysis here also. A significant main effect on this positive affect index was found, $F(4,35)=4.00$, $MSe=1.29$, $p<.01$. The positive affect item means and standard deviations are presented in Table 3. Fisher's Post-hoc Least Significant Difference Tests (LSD = 1.55; $p<.01$) performed on the means revealed a significant difference in reported positive feelings between children in the no-train control condition and children in the remaining four conditions. No significant difference was found between children in the contingent, sequential, moderate, or high support conditions on this positive affect index.

Analysis of the Perceived Performance Items. The items of "how well you felt you did" and "how much you felt you learned" were summed together in an attempt to determine if the child's perception of performance varied across the five conditions.

Pearson correlation coefficients revealed that these two items were significantly intercorrelated, $r(38)=+.54$, $p<.01$. A significant main effect on this index was found, $F(4,35)=4.17$, $MSe=4.30$, $p<.01$. The perceived performance item means and standard deviations are presented in Table 3. Fisher's Post-hoc Least Significant Difference Tests (LSD = 2.83; $p<.01$) performed on the means revealed a significant difference in reported perceived performance between children in the contingent condition and children in the control and sequential conditions. No significant difference was found between children in the high and moderate support conditions and children in the contingent condition. This same general pattern of results replicates earlier findings (Savoy, 1988).

Results from the affective data thus indicated that children tutored with the sequential strategy reported significantly more negative feelings toward the tutorial session than children tutored with the moderate or contingent strategies. Furthermore, a significant difference in reported positive feelings was found between children in the control condition and children in the remaining four conditions. However, no significant difference existed on this positive affect index among children in the four experimental conditions. Finally, a significant difference in perceived performance existed between children in the contingent condition and children in the control or sequential support conditions only.

Analysis of the Tutor's Activity

Analyses of the tutorial sessions were conducted to establish the tutor's adherence to the guidelines for each of the tutoring conditions. A sample of audiotapes for each session was coded for each tutor intervention level and subsequent child compliance. Within the high, moderate, and sequential support conditions, integration of the tutor's interventions and the child's behavior was relatively straightforward. The author's adherence to the guidelines of these three conditions was virtually 100%. Not surprisingly, perhaps, the tutor was less able to follow the rules exactly in the contingent support condition, where more complex interactive instruction was necessary. During 75.5% of the interventions, tutorial level was accurate. The majority of errors (approximately 14%) involved providing a repeated or paraphrased instruction following child failure, instead of the tutor taking over more control as the rule specified. The remaining errors (approximately 10.5%) involved an inappropriate shift in intervention level. An inappropriate shift in tutor support involved providing an intervention at two or more levels above or below the child's current level of optimal instruction. This same general pattern of errors replicated earlier findings (Savoy, 1988).

Success Percentage by Child

Analysis of a sample of the tutoring sessions revealed that, not surprisingly, children tutored with high support (demonstration) reported very few errors in complying with direct instruction. These children were able to comply with direct instruction 84.47% of the time. The children tutored at intermediate levels of experimenter regulation support complied successfully with direct instruction 54.5% of the time. Children tutored in a contingent fashion complied with direct instruction 70.67% of the time. The children tutored with the sequential strategy successfully complied with direct instruction only 37.86% of the time. Thus failure rates, as expected, were considerably higher in this condition.

More careful analysis of the relatively high compliance with instruction from the children in the contingent support condition revealed that the overall average reflected a systematic increase in compliance from some of the children in this condition during the later tutorial interventions. Many of these children had evidently successfully internalized the long-division skills by the third intervention, and this was shown in an average increase in successful compliance with direct instruction over the three tutorial sessions, even though less support was provided by the tutor in the later sessions. Specifically, during the first tutorial intervention children in the contingent condition were complying with direct instruction 56.5% of the time. By the second intervention, children were complying with direct instruction 69% of the time. By the third and final tutorial intervention, children were complying with direct instruction 86.5% of the time. This general pattern of improvement was not observed in the other conditions.

Discussion

The majority of research in the area of effective tutoring strategies has been spurred by the work of the Soviet developmentalist, Vygotsky. Of central importance to Vygotsky's theory is the notion that higher mental functions have their origins in human social life. According to Vygotsky, therefore, when studying cognitive development in children, it is essential to investigate how the child interacts with more experienced members of society.

A great deal of variability exists in how parents and teachers provide instruction to children. A modest observational literature in developmental psychology suggests that a number of correlations exist between the type of instruction provided and children's problem solving abilities (e.g., Saxe et al., 1987). It is difficult to interpret such correlations, however, because the direction of causation is unclear (Wood et al., 1976). Yet to date, there have been few experimental studies of tutoring strategies conducted within this paradigm. The present study investigated the effects of adult-child interaction experimentally, through the use of various tutoring strategies which were analogous to those previously observed in parents (e.g., Wood, 1980).

Each of the four tutoring strategies used in the present study could be described and evaluated in terms of Wood et al.'s (1978) system of analysis, thereby enabling us to predict how well children taught by each of the strategies should do on post-tests of independent skill maintenance as well as transfer to a novel problem type. We had predicted that those children tutored with the aid of Wood's (1980) shift rule would be most likely to internalize the skills being taught. Such internalization would be reflected in superior learning and retention of skills over time, as measured by immediate and delayed post-tests. Moreover, we had predicted that successful internalization of the skill would facilitate the flexible use of this newly acquired knowledge, thus producing greater transfer to a novel task. Both moderate and sequential tutoring were expected to produce some learning, but this was not expected to be as marked as the learning obtained in the contingent tutoring condition. As well, the present study also investigated the affective consequences associated with each of the tutoring strategies employed.

Mathematics Training Results

The results of the tutorial manipulation provide support for our hypothesis about the nature of effective instruction. Specifically, the results strongly support the hypothesis that the most effective tutoring is that which utilizes Wood's (1980) shift rule. Marked gains on the immediate, one week and one month post-tests, compared with pretest scores, were shown in those children who were tutored using the shift rule. Other groups showed no effects, or very transient learning. Moreover, the fact that post-test scores for the contingent group showed no decrement over time, and instead were maintained at a high level of performance (approximately 80-90% correct performance at each post-test), indicates that these new long division skills were well "internalized" and capable of independent usage.

Although contingently-tutored children outperformed children in the remaining four conditions across all three post-tests, children tutored at intermediate levels of experimenter regulation also outperformed children in the control, high support and sequential conditions on the immediate post-test. However, on the one week and one month post-tests, no significant performance differences existed among the moderate, high, sequential, or control conditions. Thus, the learning apparent in the moderate support condition on the immediate post-test was very transient, as observed in a previous study (Savoy, 1988), indicating little evidence of skill "internalization" or independent functioning for this moderate support group.

The superior performance of the children in the contingent condition is consistent with the results of Wood et al. (1978) who found that children taught in a contingent manner outperformed children taught with the aid of demonstration, swing or verbal techniques. Wood et al. argued that this contingency tutoring resulted in superior performance because the child was continually presented with problems of "controlled complexity." This strategy "demands that the instructor increases control immediately the child starts to fail to the point where the child starts to find him/herself successful, and that then, the instructor attempts to progressively relinquish control to the child, leaving him/her with a limited scope for error" (Wood et al., 1978, p. 144). The shift rule utilized this strategy, thereby consistently presenting the child with problems of controlled complexity. It seems reasonable to conclude therefore, based on the results of the long division post-tests, that instruction which utilizes the shift rule yields durable results.

Such a finding is consistent with Vygotsky's theory. Moreover, the type of learning which occurs when a child is instructed with the shift rule appears to be superior to the learning which occurred with all alternative techniques of instruction used in the present study. The slight increment in performance observed in children tutored at intermediate levels of experimental regulation is not incompatible with this conclusion. Tutoring at levels three and four using Green's (1987) eight level system does produce some learning as measured by the immediate post-test. This learning, however, is transient, as measured by the long-term post-tests. Instruction which provides a consistent and moderate amount of support probably does not permit the child to attain full control over the problem or to fully internalize solution skills, since the child is never presented with tutor interventions at the least supportive levels. Thus, the child is always, to some extent, dependent upon the tutor for support. Instruction with the aid of Wood's (1980) shift rule must, however, permit the child to attain increasing control over the problem, by definition. The results of the post-tests on the training task thus support Vygotsky's notion that effective instruction involves continually challenging the child to perform the task, with aid, at more advanced and independent levels.

Results from our earlier work (Savoy, 1988), however, did not show a significant difference in the performance of those children tutored at intermediate levels of experimenter regulation and children tutored in a contingent fashion on the immediate post-test. There are several plausible explanations for the discrepancy between the present findings and those of our earlier work. One hypothesis might be that the difference in the findings across the two studies for children in the moderate support condition is related to the notion of the child's region of sensitivity to instruction. It may be that the region of sensitivity to instruction of children in our earlier study was at or about levels three and four, using Green's (1987) eight level system, whereas the region of sensitivity to instruction of children in the present study was somewhat lower in the hierarchy. Results from the children's success rates across the two studies lend support to this hypothesis. In the earlier study, the moderate support tutored children were correct approximately 70% of the time, whereas results from the success percentage analysis for the moderate support condition of the present study indicated that children were experiencing success only 56.5% of the time. Perhaps then, children in the moderate condition in the present study were not being instructed as often within their region of sensitivity, and thus failed to acquire as much in the way of usable skills during training.

A related explanation for why this performance difference existed across the two studies among the moderately-tutored children focuses on the difference between the samples. Children in our earlier study were in the fifth and sixth grade, whereas the children in the present study were in the fourth and fifth grade. Further, the earlier data were collected during the second half of second semester, whereas the present data were collected during the middle of first semester. Moreover, it is the opinion of the author that the problems of the present thesis were more difficult than the problems used in the earlier study. This was a conscious attempt on the author's part because the present study utilized repeated tutorial interventions and it was expected that more learning would occur in three tutorial sessions than one session. Thus, a number of factors may have contributed to greater learning difficulty for the children in the present study. In turn, it appears that the moderate condition provided too little support in the present experiment.

Generalization Results

The second hypothesis of this study concerned generalization of the skills taught to novel word-problem tasks which also required use of long division skill. The results from these transfer measures parallel the findings for the long division training itself. As predicted, children tutored with contingent support, that is, the shift rule, showed a significant increment in generalization performance over children in the remaining four conditions on all post-tests. Moreover, results of the immediate transfer measure revealed that moderate support-tutored children showed a significant increment in performance over children in the high support, sequential support, or control conditions. However, consistent with the findings of the long division post-tests, the learning of the moderate-support condition children was found to be transient. That is, no significant performance difference was found among children tutored in high support, moderate support, sequential support, or control conditions on the long-term transfer measure post-tests. It appears, therefore, based on the post-test results for both same and novel problems, that the most effective tutoring strategy is that which is contingent upon the child's previous response. Reeve (1987) also found that "scaffolding" training of preschoolers' simple math skills (addition) showed evidence of generalization to similar problem types, though not to problems in a rather different format.

Several recent theories (e.g., Brown & Campione, 1984) suggest that the most effective instruction is that which facilitates use of metacognitive processes. As noted previously, general skills of metacognition include checking the outcome of any attempt to solve a problem, planning one's next move, monitoring the effectiveness of any attempted action, and testing, revising, and evaluating one's strategies for learning (Campione et al., 1982). Brown (1978) argued that these metacognitive skills do not necessarily follow a stage-like pattern in development in the sense that, although they are more often used by older children and adults, quite often younger children may monitor their activities on a simple problem.

According to Campione et al. (1982), learners at any age are more likely to take active control of their own cognitive endeavors if they are faced with tasks of intermediate difficulty (if the task is too easy, they need not bother; if the task is too hard, they give up). It is reasonable to speculate then that contingent tutoring of a child may facilitate the use of metacognitive processes in children. Contingently tutoring a child may encourage next-step planning, monitoring, and verbal evaluation of one's performance. Bringing problem solving strategies and the entire range of subcomponent steps to the conscious awareness of the child may facilitate the child's learning. The results of the present study are consistent with this hypothesis. Instruction at high levels of experimenter regulation may have been perceived as simplistic and restricting, and hence the child may not have bothered to attempt to actively learn the material. In contrast, instruction commencing at very low levels of experimenter regulation, as in the case of sequential tutoring, may have been perceived by the children as too difficult, and subsequently not even attempted.

However, it is necessary to acknowledge at this point that these high levels of transfer suggest that children already had some knowledge of word problems, as both the contingent and moderate support conditions showed evidence of immediate transfer. Because no other group except the contingent condition showed clear evidence of learning, it is difficult to focus specifically on variations in transfer of training differences across these conditions. In some respects then, the second hypothesis was only incompletely tested.

Affective Results

A further variable investigated in the present thesis was that of children's affect toward the tutorial interventions. It was hypothesized that children taught with the aid of Wood's (1980) shift rule, that is, in a contingent manner, would be more likely to report positive feelings, and less likely to report negative feelings about the tutorial session compared with children tutored with other techniques. A child's affect may help explain the benefits of tutoring with the aid of Wood's (1980) shift rule. It could also be expected to influence children's responsiveness to further instruction.

An analysis of variance conducted on the negative affect items revealed that children tutored with the sequential strategy were significantly more likely to report negative feelings toward the tutorial interventions than either children tutored at intermediate levels of experimental regulation or children tutored in a contingent manner with the aid of Wood's (1980) shift rule. However, significant differences were not found on this negative affect index between children in the control, demonstration, or sequential conditions. In addition, no significant difference was found between children in the moderate and contingent conditions. This pattern generally replicates the findings of Savoy (1988), in which both contingent and moderate support conditions showed equivalent low levels of negative affect compared to the high support condition. Apparently the tailoring of instruction in these two conditions is sufficient to allow children to master most feelings of confusion and difficulty. Clearly the sequential condition in the present study is associated with high levels of such negative feelings, however. One factor which may have contributed to these negative feelings could be the level of failure experienced by children in this condition.

Analysis of variance conducted on the positive affect items revealed that children in the study control condition were significantly less likely to report positive feelings about the tutorial sessions than children in the remaining four conditions, which did not differ. The positive affect results of the present study generally replicate the findings of our earlier work (Savoy, 1988); all children reported enjoying the tutorial sessions across all instructional strategies. Although our earlier work found the same general pattern of results, we had predicted in the present study that we would have more of a differential impact on children's positive affective responses through the addition of repeated tutorial interventions. It appears however, based on our present findings in conjunction with the findings of our earlier work, that the addition of repeated tutorial interventions was not sufficient to significantly influence children's enjoyment of long division instruction. It is possible that a difference was not found within the tutoring conditions across these two studies because of the confound of social desirability. However, it is the opinion of the author that this hypothesis is rather unlikely. The author was very explicit in explaining the importance of honesty in responding to the questions in this situation. Furthermore, children did express feelings of confusion and uncertainty quite freely.

A more plausible hypothesis is related to the issue of novelty of the tutorial sessions. From qualitative nonsystematic observations, children appeared to have genuinely enjoyed the tutorial interventions, regardless of their condition. Thus, the only condition which scored lower here involved the control group, who did not participate in these tutorial sessions. These sessions provided children with the opportunity to leave the classroom and be exposed to a unique learning situation. Moreover, children may have been evaluating the session relative to their affect toward the group learning situation. For the children who participated in the present study, one-on-one instruction may have been more rewarding than the typical group instruction of the classroom setting.

Evaluation of Control Conditions

A total of four control conditions were employed in the present study, for comparison with the contingent tutored group. They included a no-train control condition, a moderate support condition, a high support condition, and a sequential support condition. The no-train control condition served as a general control for experimental manipulation and development. The moderate support condition served as an average levels control, as the overall average level of intervention for the contingent group was expected to fall within this range. The sequential support condition served as a control for the variety of tutor support levels that are typically characteristic of a more contingent style of tutoring. The high support condition served as a control for the demonstration strategy of instruction most common in group instructional settings. Clearly, however, none of these four conditions involved a pattern of tutoring that was fully contingent on the child's previous response, as in the shift rule condition.

Each control condition proved to be generally unsuccessful as a method of instruction. Obviously, the no-train control condition was unsuccessful because children in this condition were not exposed to the experimental manipulation. The high support, demonstration condition was also found to be generally unsuccessful as a method of instruction. The moderate support condition was initially somewhat successful. However, these immediate post-test effects were transient, as the child was not instructed in a way that allowed full internalization of the skill, and it was quickly lost. The results for the novel control condition in this study, sequential support, suggest that it is not the variety of levels a child is exposed to per se, but the fact that each intervention is contingent upon the child's previous response that facilitates learning. In this condition, the low support interventions could not be readily utilized by the children, as they reported a significantly higher level of confusion and frustration than the contingent group, as well as experiencing much lower levels of success. Thus, this condition appeared to violate the "controlled complexity" feature of the contingent tutoring method as described by Wood (1980), and generally failed to produce any learning in this setting.

Further Research

The results of the present study provide experimental support for the theoretical writings of Vygotsky, Wood, and Bruner. There is, however, considerable need for further research to more clearly delineate the role of the utilization of the region of sensitivity to instruction in the acquisition of cognitive skills in children. Logical, next-step research could include attempts at replicating the results of the present study across a variety of academically distinct domains, including the acquisition of skills in reading, writing, language, spelling, science, and social studies. The present technique for specifying levels of support does require some sort of step-by-step, algorithmic task analysis, but it seems conceivable that other definitions of scaffolding could be readily developed that might apply better to other, nonmathematical domains (e.g., Griffin & Cole, 1984).

Although the present investigation had a variety of controls for the more contingent "shift rule" condition, further experimental controls should be utilized to clearly delineate the role of the shift rule. The shift rule could be broken down into two distinct rules and experimentally investigated separately. For example, one could provide less support if success was experienced and the same amount of support when failure occurs. In essence, the experimenter would locate that level at which success was experienced and remain there.

More generally, research on tutoring clearly has various classroom implications. One example is the use of peer tutors, a currently popular technique. A very interesting research project would include replicating the present thesis as a training study. Older, "more experienced" children could be trained as tutors in one of the four tutoring strategies of the present study. Once these older children are successfully trained as tutors they could instruct younger, "less experienced" children on a given academic task. We would predict that the contingently-trained tutors would be the most successful, as measured by performance of the students whom they taught. The present study could be further replicated as a training study with parents, given that parental instruction is typically one-on-one tutoring.

Furthermore, research in the area of effective instruction should also be addressed toward children with learning disabilities. Research on effective tutoring with "normal" children has repeatedly shown that the type of instruction provided to children has a dramatic effect on subsequent performance on same and novel problems, as in the present study. It is clearly a worthwhile undertaking to investigate this possibility in children with learning disabilities. If the results of contingent tutoring were found to generalize to special populations, then the way we tutor these children might be improved.

Feuerstein (1969, as cited in Campione et al., 1982) has addressed this issue experimentally by devising a learning potential and enrichment program for these special needs populations. Feuerstein believes that the principal reason for the poor performance of many disadvantaged adolescents is a "lack of consistent mediated learning in their developmental histories because of parental nonempathy, ignorance, or overcommitment" (Feuerstein, 1969, as cited in Campione et al., 1982, p. 448). Feuerstein argues that the resultant picture is poor performance on a wide variety of academic tasks. The level of performance displayed by retarded performers, according to Feuerstein, is an underestimate of what they could achieve if subjected to intensive remedial, mediated learning experiences. Moreover, retarded performers who do poorly because of inadequate learning environments would greatly benefit from intensive interventions aimed at supplying the missing mediated learning experience (Feuerstein, 1969, as cited in Campione et al., 1982). "Mediated learning" in this sense refers to "scaffolding" experiences with an "expert" in the area.

Feuerstein developed the Instrumental Enrichment program (IE), an intensive intervention curriculum, to test this hypothesis. The IE materials are very similar to IQ test items and achievement batteries. Like IQ tests, the items in this battery systematically increase in difficulty. This program seeks to train the metacognitive skills of self-control and self-regulation. The essential aim of this program is, via the mediation of a supportive teacher, to make children aware of the significance of their learning activities, so that they will eventually, by internalization, perform tasks independently. This new learning, according to Feuerstein, is most observable in transfer of training. Feuerstein believes that in order to transfer newly acquired skills to novel tasks "the learner must be able to perceive the general applicability of a given concept" (Feuerstein, 1969, as cited in Campione et al., 1982).

Several authors (e.g., Budoff, 1974; Feuerstein, 1979) have made the claim that the notion of the region of sensitivity to instruction could further be utilized in the intellectual assessment of children. These authors argue that the information provided from the typical paper and pencil tests of intellectual assessment provide only a partial story of the child's intellectual competence. They propose that a great deal of valuable information is available in the "dynamic assessment" of children, that is, an assessment based on the child's responses while participating in instructional interaction with an adult or more capable peer. Further research could also serve to address this issue. Based on the results of the present investigation, one would predict that contingent tutoring would result in the most useful diagnostic information in such "dynamic assessment" situations.

In summary, the data of the present thesis in conjunction with the results of our earlier work, provide support for Vygotsky's notion of effective instruction. As noted by Campione et al. (1984), the notion of the region of sensitivity to instruction can contribute to our understanding of a number of issues of central concern to those interested in both basic psychological processes, as well as the application of research findings to issues of practical concern.

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Appendix A

Categorization of Levels and Examples

Coding System and Examples of Tutorial Intervention

Level	Division	Multiplication	Subtraction
0	No directive	No directive	No directive
1	General verbal ("Try this one")	General verbal	General verbal
2	General hints ("What do we do with these numbers?")	General hints ("What's next")	General hints ("What do you do with those numbers")
3	Label subcomponent ("Divide these numbers")	Label subcomponent ("Multiply them")	Label subcomponent ("Subtract them")
4	Specify step of subcomponent ("How many times will 2 go into 4")	Specify step of subcomponent ("Multiply 41 by 6")	Specify step of subcomponent ("Subtract 182 from 356")
5	Hint about step ("That looks like too many times")	Hint about step ("That looks too big")	Hint about step ("I don't think that is enough")
6	Give step answer or recording ("I would try 3," "Put the number up above")	Give step answer or recording ("4 times 2 is 8," "Put the answer under here")	Give step answer or recording ("When you borrow, you will get a 7," "Put it down here")
7	Give step answer and recording	Give step answer and recording	Give step answer and recording

	("That will be 4, put it above here (points)")	("6 times 6 is 36, and it goes down here")	("It's a 3, put it under the 6")
8	Tutor demonstrates	Tutor demonstrates	Tutor demonstrates

Appendix B

Letter to Parents

March 29, 1989

Dear Parent/Guardian:

This is a letter to inform you of a research project being conducted by Kathy Savoy of Wilfrid Laurier University under the supervision of Dr. Michael Pratt. We will be attempting to determine which of four tutoring strategies is the most effective for teaching mathematics, as well as how children feel about each of these different methods. Your child will be exposed to three brief tutoring sessions concerning long division math problems. Upon the completion of the final tutorial session, the children will be asked to complete two questionnaires regarding their feelings about the session and their learning experiences. Three post-tests will administered to your child in an attempt to determine the relative strengths and durability of each technique as a method of mathematics instruction. The post-tests will be administered immediately after the final tutorial session, after one week, and after one month. A measure of skill transfer will also be administered to the children at the one week and one month post-tests.

Each tutorial session will last about ten minutes. The sessions will be audio-tape recorded, but this tape will remain confidential. If you agree to permit your child to participate in this study, please complete the attached consent form and return it to your child's teacher at your earliest convenience. All information which your child provides will remain strictly anonymous. The child's verbal consent will also be necessary for participation in this study. All children who participate in this study will be explicitly told that their participation is completely voluntary and that they are free to withdraw at any time.

If you or your child have any questions, please feel free to contact me at 884-5579 or my advisor, Dr. Michael Pratt at 884-1970, extension 2824.

Your child's participation will be greatly appreciated.

Thank-you,

Kathy Savoy

Michael Pratt, Ph.D

Consent Form

I hereby agree to permit my child to participate in the research study on math tutoring strategies conducted by Kathy Savoy and Dr. Michael Pratt of Wilfrid Laurier University. I understand that my child's participation is fully voluntary and that verbal consent will be obtained from my child prior to the beginning of the study. I understand that all results are confidential and that my child may withdraw at any time.

Yes No

Signature

Thank-you for your cooperation.

If you wish to obtain a copy of the results of the study, please include your address below.

____

____

____

____

Appendix C

Pretest Mathematics Measure

1. 20/2=

2. 75/3=

3. 86/2=

4. 100/25=

5. 399/17=

6. 9162/29=

7. 7680/233=

8. 86745/379=

Appendix D

Coding Scheme

Example Problem:

```
     21
27 ) 493
     44
      53
      27
      26 R
```

Step 1. Estimation

In the above example, the child did not successfully estimate how many 27's there are in 49, therefore, no point is awarded.

Step 2. Multiplication

The child did not successfully multiply 27 by 2, therefore, no point is awarded.

Step 3. Subtraction

The child does successfully subtract 44 from 49 to derive the difference 5, therefore, one point is awarded.

Step 4. Bringing down the next digit

The child successfully brings down the 3, therefore, one point is awarded.

Step 5. Estimation

The child successfully estimates how many 27's there are in 53, therefore, one point is awarded.

Step 6. Multiplication

The child successfully multiplies 27 by 1 to derive the product 27, therefore, one point is awarded.

Step 7. Subtraction

The child successfully subtracts 27 from 53 to derive the difference 26, therefore one point is awarded.

Step 8. Remainder

The child successfully recognizes that 26 is the remainder, therefore, one point is awarded.

The child successfully solves six of the eight steps correctly. The child's percentage correct for this problem, therefore, is seventy-five.

Appendix E

Tutorial Session Problems

Set 1

1. 7281/48=

2. 8677/684=

Set 2

1. 4770/67=

2. 9632/329=

Set 3

1. 6683/81=

2. 7684/217=

Appendix F

Affect and Interest Measure

On a scale of 1 to 5, where 1 represents "not at all" and 5 represents "very much," please answer the following questions.

1. How much did you enjoy the long division teaching session?

   1 (not at all) 2 3 (moderately) 4 5 (very much)

2. If Kathy were to come back in two months and give a similar teaching session, would you be willing to participate?

   1 (absolutely not) 2 3 (perhaps) 4 5 (definitely yes)

3. How much do you enjoy mathematics in school?

   1 (not at all) 2 3 (moderately) 4 5 (very much)

4. How do you feel you did on the long division math problems?

   1 (not very well) 2 3 (average) 4 5 (very well)

5. How much do you feel you learned on the long division math problems?

   1 (nothing) 2 3 (a moderate amount) 4 5 (a great deal)

6. How hard did you find the long division math problems?

   1 (not very) 2 3 (moderately) 4 5 (very hard)

7. How frustrating was it for you to learn the long division math problems?

   1 (not very) 2 3 (moderately) 4 5 (very frustrating)

8. How confused did you feel while working out the long division math problems?

1 (not very)   2   3 (moderately)   4   5 (very confused)

9. How boring was this math session?

   1 (not at all)   2   3 (moderately)   4   5 (very boring)

10. How good a teacher did you think Kathy was?

   1 (not very good)   2   3 (average)   4   5 (very good)

Appendix G

Mathematics Post-tests

Set 1

1. 475/17=

2. 3295/59=

3. 9879/323=

4. 37986/799=

Set 2

1. 368/23=

2. 7610/77=

3. 6317/137=

4. 43980/935=

Set 3

1. 499/41=

2. 9857/99=

3. 2319/245=

4. 70849/854=

Appendix H

Transfer Measures

Set 1

1. You have been saving your pennies since your were three years old and you now have a total of 27,560. You want to deposit your pennies into the bank but you are required to roll then into stacks of 50. How many rolls of pennies will you have to deposit?

2. You have a 1,238 baseball cards and you want to divide them up evenly among the 19 children on your baseball team. How many cards will each child receive?

Set 2

1. On Halloween you and your buddies collect 21,427 pieces of candy. You want to be sure to eat the same amount of candy each day for the next year. There are 365 days in a year. How many pieces of candy do you and your friends get to have each day?

2. Your teacher gives you a stack of paper which contains 42,524 sheets. She asks you to divide the paper up into 72 piles. How many sheets will there be in each pile?

Set 3

1. Your father tells you that there are 1879 hours until Christmas. You want to find out how many days this is, and you remember there are 24 hours in each day. How many days are left until Christmas?

2. You have 18,239 marbles and your mother asks you to divide them up evenly

among all of the children in your neighborhood. There is a total of 28 children in the neighborhood. How many marbles will each child receive?

Appendix I

Written Transcripts of Tutorial Instruction

No-train Control Condition

The children in this condition were exempt from the tutorial interventions.

Moderate Support Tutoring Condition

The first step is estimation. In the first problem we must estimate how many times (number) goes into (number). Can you estimate how many times (number) goes into (number). The second step in long division is multiplication. We must multiple the estimated value of (number) by the divisor which is (give divisor) and put it right here. Can you multiply (number) by (number). The third step in long division is subtraction. Can you subtract (number) from (number). The final step in long division is bringing down the next digit. In this example the next digit is (number). We now start again by estimating how many times (number) goes into (number). Can you estimate how many (number) there are in (number). This pattern was continued until the problem was completed.

Contingent Support Tutoring Condition

In this condition, children were initially provided with moderate support however, all subsequent interventions were contingent on the previous directive.

High Support Tutoring Condition

Long division problems can be broken down into four steps. The first step is estimation. In the first problem we must estimate how many times (number) goes into (number) and it is (number). The second step in long division is multiplication. We must multiple the estimated value of (number) by the divisor which is (give divisor) and put it right here. The third step in long division is subtraction. We must now subtract the product of (give two numbers) by the dividend. This involves subtracting (number) from (number) to get the difference (number). The final step in long division is bringing down the next digit. In this example the next digit is (number). We now start again by estimating how many times (number) goes into (number). This pattern was continued until the problem was completed.

Sequential Support Tutoring Condition Script

We are going to begin this tutoring condition by letting you attempt to do the long division math problems independent of help from me. If or when you get stuck, I will help you out until we solve the problems successfully.

General verbal prompt, i.e. "You may go ahead and start the problem."

(If fails)

General hints, i.e., "The first step of long division requires that we estimate."

(If fails)

Label subcomponent, i.e., "Divide (number) into (number)."

(If fails)

Specify step of subcomponent, i.e. "How many times does (number) go into (number)."

(If fails)

Provide hint about step, i.e., "That looks too large to me."

(If fails)

Give answer or recording, i.e., "I would try (number)."

(If fails)

Give answer and recording, i.e., "That will be (number) and it goes here (point)."

OK, lets continue. Once again if or when you get stuck, I will help you out until we solve the problems successfully.

General verbal prompt, i.e. "You may go ahead and start the next step of the problem."

(If fails)

General hints, i.e., "The second step of long division requires that we multiply."

(If fails)

Label subcomponent, i.e., "Multiply them."

(If fails)

Specify step of subcomponent, i.e. "Multiply (number) by (number)."

(If fails)

Provide hint about step, i.e., "That looks too large to me."

(If fails)

Give answer or recording, i.e., "I would try (number)."

(If fails)

Give answer and recording, i.e., "That will be (number) and it goes here (point)."

OK, lets continue. Once again if or when you get stuck, I will help you out until we solve the problems successfully.

General verbal prompt, i.e. "You may go ahead and start the next step of the problem."

(If fails)

General hints, i.e., "The third step of long division requires that we subtract."

(If fails)

Label subcomponent, i.e., "Subtract them."

(If fails)

Specify step of subcomponent, i.e. "Subtract (number) from (number)."

(If fails)

Provide hint about step, i.e., "That looks too large to me." This pattern was continued until the problem was successfully completed.

Appendix J

Feedback Letter

March 29, 1989

Dear Parent/Guardian:

On behalf of Dr. Pratt and myself, I would like to thank the children who participated in the study on tutoring strategies in mathematics.

The purpose of this study was to determine the instructional effectiveness and affective consequences of four distinct tutoring strategies for teaching long division. Each child was assigned to one of the four tutoring strategies. One of the conditions involved "contingent" tutoring, where the tutor's instruction each time depended on the child's previous response. More help was provided if the child failed to answer correctly and less if the child had answered correctly the previous time. The remaining three conditions involved "noncontingent" tutoring. This included either instruction through demonstration, through constant support, with challenging questions and hints, or by initially providing very minimal support and sequentially offering more help to the child until success was finally experienced. There was also a group of children who did not receive any tutoring, for comparison purposes.

We found that those children who were contingently-tutored did better than the noncontingently-tutored children on both immediate and delayed post-tests on long division skill. Moreover, contingently-tutored children were able to successfully transfer these newly acquired math skills to long division word problems that they were given, showing that they had clearly learned the skills of long division and could use them by themselves in new situations. It thus appeared that contingent tutoring is a very effective strategy. In other studies we have found that it can be readily taught. One next research step may be to try to teach this strategy to peer tutors in the classroom, to see if it is as beneficial in this context as it seemed to be in the present investigation.

A measure of affect and interest was also administered which included asking the children how much they enjoyed the tutoring session, how willing they would be to participate in a similar tutorial in the future, and how confused, frustrated, and bored they felt while working on the long division math problems, as well as how much they felt they learned and how well they felt they did. The children who were tutored with the "demonstration" or "sequential" strategies were much more likely to report negative feelings toward the tutorial session than the children who were tutored with the "hint" or "contingent" strategies. We thus gathered from this that different types of tutoring may lead to differing levels of enjoyment in the learning situation, which can contribute to later interest in school success. We hope to learn more about how teachers, classroom tutors, and parents can best provide instruction to yield optimal learning and interest from the child from studies such as this.

If you have any questions or would like a more in-depth description of the study, please feel free to contact me at 884-4931 or my advisor, Dr. Mike Pratt at 884-1970 (ext. 2824).

Thank you for your and your child's co-operation in this study.

Sincerely,

Katherine M. Savoy

Michael W. Pratt,

Associate Professor