PLANNING STRATEGIES AND THE INFLUENCE OF TASK: A COMPARISON OF CHILDREN'S THINK-ALOUD PLANNING SESSIONS FOR WELL-DEFINED AND ILL-DEFINED TASKS

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ABSTRACT

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Planning is an important cognitive skill, a conceptual key, a tool that enables new cognitive work to be done. Planning skills are particularly important to the social and educational development of a child, but few studies have been conducted of these skills of children.

Although many questions remain unanswered, progress has been made toward the goal of understanding how adults plan. Research on adult planning has provided two opposing models of the adult planning process. These models are the hierarchical model and the heterarchical model of adult planning. It has been theorized that the type of task for which a person plans is an important variable in determining which planning model (s)he follows. Well-defined and ill-defined task structures are currently being studied as possible links in understanding the planning process. In the study reported here, two well-defined and two ill-defined tasks were randomly assigned to 78 fifth-grade students. These tasks represent a continuum of well-defined to ill-defined task structure.

The purpose of this study was to document children's planning processes and the influences that tasks had on these processes. How children plan was explored using the

think-aloud method of inquiry in which subjects verbalized their thoughts while planning. The think-aloud protocols were analyzed to determine if there were differences between task type and the planning model used by each subject.

The results of the study indicated plans created for ill-defined tasks differed from plans created for well-defined tasks. These differences are related to cognitive approaches or strategies appropriate for well-defined and ill-defined tasks. The results also indicated some support for a relationship between hierarchical and heterarchical models of planning based on type of task planned. Differences in task as they relate to adult planning, task difficulty, and cognitive schemata were also briefly discussed. Finally, recommendations for encouraging planning in classrooms and to increase student exposure to ill-defined tasks were discussed.

To my father

CHARLES ELMORE

and in memory of my mother

HELEN MARGURITE ELMORE

who together taught me to love learning

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CHAPTER 1

INTRODUCTION

Planning is an important cognitive skill that is receiving attention from researchers in many fields of inquiry. Cognitive science researchers are interested in the promise of understanding the cognitive skill of planning. Neurophysiologists, unraveling the chemical equations that make up human thought, point to planning as an example of higher cortical activity. A first priority for these researchers is to try to understand the complex mental thought processes of planning.

Although seldom discussed, planning is not a trivial aspect of our cognitive lives. The complex environments in which we live and work require planning skill. This cognitive skill can help to simplify a complex environment (Simon, 1979). Plans allow a mental "trying out" of a proposed action, a look ahead. Planning an event prepares one for what may follow. As an intermediate step between thought and action, planning provides for more efficient solution paths in problem-solving tasks (Newell & Simon, 1972). Planning can also be viewed as a conceptual key, a tool that enables new cognitive work to be done (Vygotsky, 1975). This view was expressed in Selz's (1922) work in

cognitive processes, in which he refered to planning as productive thought. In general, theorists characterize planning as a creative process, not as a predictable set of operations.

Evidence of planning is particularly salient in American culture (Miller, Galanter & Pribram, 1960). The adult role in this culture is partially defined by responsibilities for planning. The planning process may be a creative and complex process, as described by Selz (1922) and Vygotsky (1975), or it may involve planning for mundane activities, such as shopping and cooking meals. Other familiar examples of planning include planning for retirement and vacations.

Although research has shown that planning facilitates problem solving and simplifies our lives, very little is known about how people plan. In the past, studies of planning mirrored popular methods of inquiry, even when these methods limited the potential for understanding the planning process. They were methodologically neat studies, were well documented, and were characterized by the use of well-defined problems and/or the use of methods that did not require researchers to directly examine the planner's thoughts. The currently popular think-aloud method was not considered within the realm of scientific research.

But an inherent flaw in using a methodologically conservative approach to studying planning is that the researcher is not sure whether the model proposed reflects

the process of planning used by the participant. The exclusive use of artificial well-defined problems has not helped to further the understanding of planning. Well-defined tasks may contain the entire problem space in the problem statement, thus eliminating the complex but cognitively important step of defining the problem.

In more recent studies, researchers employing a cognitive science approach to the study of planning have used think-aloud protocols and tasks that represent real life situations (Hayes-Roth & Hayes-Roth, 1978; Clark & Yinger, 1979; Goldin & Hayes-Roth, 1980; Rogoff, 1982). The results of this research have provided a foundation for new theories of how adults plan and the cognitive components of these plans (Ben-Peretz & Silberstein, 1979; Yinger, 1977; Clark & Yinger, 1980) and have produced two different models of the process of planning. Debate continues as to which model is the correct one. Thus, further studies have been conducted attempting to prove one model superior to the other. These studies have used similar methods of analysis, but none of the studies has included more than one task.

The two conflicting models of planning are the Hayes-Roth (Hayes-Roth & Hayes-Roth, 1978) and Bryne (1977) models. The Hayes-Roth model of planning proposes a heterarchical model of the planner. Planning according to this model is referred to as opportunistic. The planner may move from detailed to abstract decisions or in the

opposite direction. In contrast, the Bryne model of planning defines a hierarchical process of planning in which planning becomes a process of linear decisions progressing from the most abstract decisions down to the most detailed decisions. The process is one of "successively refining abstract plans into more detailed plans" (Bryne, 1977, p. 326). Both the Hayes-Roth and the Bryne planning models were developed using adult planners and the think-aloud method.

Children as Planners

Progress has been made in documenting how adults plan, but there is a significant absence of research on how children plan, although children's planning has been studied as a side issue in investigations of problem solving. Planning is a skill that begins developing long before adulthood. The necessity of planning may be less obvious in the lives of children, but planning is an important cognitive skill that touches the lives of children both in and out of school (Peterson & Swing, 1982; Brown, 1981). For example, children plan when they: (1) prepare for exams, write essays, and complete projects or homework—progressively more so as they move through the educational system (Flavell, 1970), (2) solve problems (Klahr, 1980; Brown, 1981), and (3) arrange social events or call friends; save money; create carnivals, races, puppet shows; or choose friends (Flavell, 1970; Istomina, 1975). A child's day may

appear to be completely controlled by parents and teachers, but children have plans, too, and these plans may reveal much about how children think and solve problems (Flavell, 1970; Klahr & Robinson, 1981).

The study of children's planning has both theoretical and practical significance. It has been suggested that planning ability is a tool that will be an aid to the child in a rapidly changing world. This type of cognitive skill will not become obsolete, as may specific tasks children learn to perform in school (National Institute of Education, 1981). Thus, a new emphasis has been placed on teaching children cognitive skills, such as planning and problem solving—skills required to achieve in our technological world (Costa, 1984; Rosenfeld & Servo, 1984; Hodgkinson, 1984).

Planning for school activities is only one of the many uses the developing child has for planning. Social, familial, and personal needs call for both short- and long-range planning on the part of even young children. Though children's plans may or may not be as complex as adults' plans, they are as varied. Planning is also important in a child's development and his/her ability to partake in the social and academic worlds of childhood.

Similar to the early research in adult planning, the few studies that have investigated children's planning have focused on training students to plan and have omitted the important step of documenting how children plan (Presseley,

1977). In the judgment of this researcher, it is therefore necessary to understand how children plan before beginning to train students to plan.

Scope of the Study

Planning is an important cognitive activity that affects children's lives. Considering the paucity of studies of children's planning and the conflicting models of adult planning (which may be dogmatically applied to programs for training children to plan), studies should be conducted to investigate how children plan to broaden our understanding of children's planning. One way to do this is to allow children to plan and to listen to their plans. Also, it is possible to vary the types of tasks for which children are asked to plan. Allowing children to plan in addition to varying the tasks for which they plan may provide the broader view of planning necessary to understand the complex cognitive activity of planning.

In this study, the think-aloud method of inquiry was used to investigate children's planning for two dinner-planning tasks and two errand-planning tasks. The selection of these tasks was based on previous research with adult planners. The results of the previous research have indicated that the plans for well-defined problems (for example, a dinner-planning task and move-type problems, such as a river-crossing problem) reflect the hierarchical model of planning—a top-down or means-ends approach to

planning. The plans for ill-defined problems (for example, the errand-planning task) reflect the heterarchical or opportunistic model of planning; the planner does not follow a hierarchy or plan in a single direction.

One purpose of this study was to compare the fit of the hierarchical and heterarchical models of planning with children's planning for well-structured and ill-structured tasks. Two versions of each task (more constrained and less constrained) were included to further investigate the role of task in determining the planning process. The larger goal of this study was to investigate how children plan and to enhance current descriptions of the planning process. It was hoped the study, which drew from previous research on adult planning, would contribute to both cognitive modeling of the planning process and efforts focused on enhancing children's planning skills.

CHAPTER 2

REVIEW OF THE LITERATURE

"A problem arises when a person has a goal but does not know how this goal can be reached. Whenever one cannot go from the given situation to the desired situation simply by action, then there has to be recourse to thinking" (Duncker, 1945; p. 28). This thinking often takes the form of a plan—a blueprint for action—which allows a person to conceive of steps leading to a desired goal. Many theories about how and why people plan have been proposed, and the curiosity about planning has sparked interest in areas as varied as business, engineering, developmental psychology, and education. Theories of planning and methods used to investigate plans vary according to the field of interest and the research goals. Consequently, understanding the literature on planning is a troublesome task; one cannot be an expert in all of the areas in which planning has been researched.

The purpose of this study was to investigate children's planning processes from a cognitive perspective. Therefore, the major emphasis of this review was on the theory and tools of research on planning used in education and cognitive psychology. The literature reviewed also

demonstrated that much of the existing work in planning has focused on adults. As such, much of the review was concerned with the adult planner and theories that evolved from studies conducted in the areas of psychology and education. This study of children's planning was therefore undertaken to remedy the current lack of documentation on how children plan and to investigate two models of planning (the hierarchical and heterarchical models) discussed throughout this review.

A discussion of definitions of planning used in current research studies begins this review, and the definition of planning as it was used in this investigation is also described. Educational models of the planner are reviewed as well, but most of these studies of planning focus on the teacher as planner. The review briefly describes the traditional model of the teacher as a top-down planner. However, this viewpoint has been challenged in more recent studies of teacher planning, which tend to reject the linear model of planning once ascribed to educators. These studies help support the hypothesis that differences found in planning processes may be due to the type of task studied, an hypothesis which is further explored in the review of studies on children's planning and planning theory in psychology. Finally, both the hierarchical and the heterarchical models of planning are discussed. Since it was hypothesized that the two models of planning are related to the type of task studied, ill-defined and

well-defined tasks and studies supporting each model are then summarized.

Planning Defined

Most definitions of planning refer to mental processes by which individuals anticipate the future, set steps to achieve some future goal, and evaluate these anticipated steps (Newell & Simon, 1972). Planning has been viewed as a process of simplification (Bruner, 1957). The function of plans, using this definition, is one of breaking large or complex problems into components that are solved more easily. This function conforms to the view of planning as a heuristic in problem solving. The planning heuristic is:

> . . . used to search for a solution, not in an original problem space with all the details of the problem, but in an abstracted space from which much of the detail has been removed, leaving the essential skeleton of the problem more clearly visible. The so-called planning method of problem solving involves just such an abstraction (Simon, 1979, p. 63).

The definition of planning as an abstract-action schema was supported by Rumelhart (1977). In another work, Simon (1975) moved away from characterizing planning as purely a subset of problem solving. He explained planning as "a way to translate internal state descriptions of the world as sensed to a process description of the external world as acted upon" (p. 18). Planning has been assigned an even greater part in cognitive processes by other researchers in psychology. Posner (1973) proposed that

plans act as filters for attention and perception. Schank and Abelson (1977) went so far as to claim "responsibility for deliberate behavior that people exhibit can be attributed to plans" (p. 428).

The cognitive concept of scripts—the life scenes by which people are guided—has also crossed paths with plans; a plan used often enough is said to become a script (Abelson, 1973). This definition of a plan has been used as well in a computer program, Hewitt's PLANNER, in which plans are a series of actions that are controlled by rules. The steps in the plan correspond to a change in the planner's actions (Abelson, 1973). Such a definition of planning is especially amenable to programming computers to simulate human planning; the manner in which humans actually plan, however, may not be as amenable to programming.

Vygotsky (1975) cited planning as a tool for creative thought that makes possible a new repertoire of behavior, but he did not elaborate specifically on imagery and plans or on how plans are related to creative thought. Polya (1957) saw planning as central to creative problem solving:

> We have a plan when we know, or at least we know in outline, which calculations, computations, or constructions we have to perform in order to obtain the unknown. The way from understanding the problem to conceiving a plan may be long and tortuous. In fact, the main achievement in the solution of a problem is to conceive the idea of a plan. This idea may emerge gradually. Or, after apparently unsuccessful trials and a period of hesitation, it may occur suddenly, in a flash, as a bright idea (Polya, 1945, p. 8).

Yet another view of plans was proposed by Neisser (1976). Discussing the perceptual cycle, Neisser contended schemata detached from the perceptual cycle in which they were originally embedded are the bases of all higher mental processes, but these schema are "no longer part of perceiving; they become images, intentions, or plans" (p. 23). This means that plans originally are simply part of the perceptual cycle and may not be identified as plans. Once a part of the schema becomes independent of this cycle, it becomes a plan. The eclectic view of the role of plans in the perceptual cognitive cycle has not been addressed by other researchers.

All of the definitions of plans discussed thus far are limited in their application to cognition and planning. The concept plan has been largely defined through other processes (such as problem solving) or it has been defined for use in a particular model (such as Neisser's, 1976, model of the perceptual cycle) or for use in computer programming (Newell & Simon, 1972). Yet none of these definitions of planning were satisfactory for the present study of children's planning.

The definition of planning for the present study followed De Groot's (1966) definition of planning. De Groot defined a plan as a "framework for guiding future actions which will come about in the form of separate decisions or steps (moves); it is based on the features of the present situation, one into which a better insight can be obtained

through the investigation of possibilities" (p. 150). This method of planning is uncertain in strategy; "it is formed on the basis of an insufficient set of data, permitting it to be changed in mid-stream" (p. 150). Much of De Groot's work was conducted with chess players, and, as he described their planning, he concluded that a dogmatist could not become an expert or even survive in chess competition, as the planning skills called for a "relativist or even so to speak, an opportunist in his thinking (p. 151). Because it describes planning from a cognitive view without restricting the function of plans, De Groot's definition of a plan was chosen as the basis for the work in this study. This definition of planning is also consonant with the selection of the think-aloud method of data collection.

Planning Theory in Education

This section of the review focuses on current and past views of planning in education. Studies in teacher planning have yielded conflicting models of the planner (hierarchical versus heterarchical). It was theorized for this study that these models may be related to the type of task used: ill-defined or well-defined.

The influence of business theories of planning have significantly affected educational training programs. In the past, studies in education mimicked the business world in proposing models of teachers as rational planners (Tyler, 1950). Efforts were made to realize efficiency in

the classroom, and prescriptive models for how teachers should plan were developed. These models usually focused on curriculum development, with planning prescriptions for teachers included in the program.

One well-known early curriculum model was developed by Tyler (1950). In this means-ends model, teachers were instructed first to specify the objectives they desired and then develop learning activities and tests to achieve and evaluate these ends. Another model of curriculum development based on Tyler's work was constructed by Taba (1962). Taba's model provided for teacher evaluation of student needs by following a seven-step model. The assessment procedure did not vary greatly from Tyler's. The essential difference between the Tyler and the Taba models was the timing of the behavioral objectives. In Tyler's, the objectives were written first, then the activities or lessons followed to achieve the objectives or ends. In Taba's, the statement of objectives follows the seven-step assessment procedure. Even though Taba's model offered some assessment prior to the establishment of objectives, it still preserved the separation of means and ends.

For some time, the history of research in planning closely paralleled that of curriculum development; educational objectives were synonymous with teacher planning. Programs were developed to teach inservice teachers and student teachers how to write objectives (Popham & Baker, 1970). This prescribed style of planning was thought to

help teachers organize their day and make them more efficient in their jobs. Evidence that teachers were following this prescribed method of planning by writing objectives was, and often still is, required in the form of lesson plans turned into the school principal.

Researchers in education eventually questioned the view of curriculum development and teacher planning which centered on educational objectives. Some of those who first voiced their concerns reacted to the narrow definition of education as behaviorally measurable changes in students. These curriculum researchers argued that there was more to education than could be stated in behavioral objectives (Eisner, 1967). Educational researchers also began to realize that planning was an important part of a teacher's professional life and speculated that teachers did something more when planning than was evidenced in the objectives they were required to write. There was a growing sentiment that planning influenced the way classrooms were run.

Researchers who were convinced that planning was an important part of school life and that it was something more than the analysis of means and ends began to explore how teachers planned. Zahorik's (1970) study of teacher planning was an early example of research developed from an interest in how teachers plan. His work included a survey of teachers' self-reports about planning and a later study that drew Eisner's (1967) view of curriculum and teacher

planning. Eisner's model was not a means-ends model with educational objectives stated and then learning activities developed to support the objectives. Instead, Eisner suggested that teachers often planned learning activities first. Zahorik's work supported Eisner's view, with evidence that teachers spent much of their time planning content decisions. This integrated means-ends model of planning described teachers as selecting learning activities based on time, teacher knowledge, and material on hand. The ends and means were said to be integrated in that the objectives might develop simultaneously with the learning activity. A teacher might focus first on the type of learning activity, with objectives embedded in the activity. The objectives did not always precede the learning activity.

A study of teacher planning and its effects was conducted by Peterson, Marx and Clark (1978). Their laboratory study investigated teachers' reports of their cognitive processes during teaching. Teachers participating in the study were given social studies text materials to plan teaching to a class of students. The teachers actually taught the lesson they planned to three different groups of students. The researchers found that when confronted with behavior problems, process-oriented teachers reported changing their instructional process more often than did content-oriented teachers. Other relationships were found between the type of planning decisions teachers made and

student achievement scores. Those pertinent to this discussion included:

(1) Decisions about content accounted for most of the teachers' planning time;

(2) Instructional processes or the way things would run in the classroom were the second most time consuming aspect of teacher planning; and,

(3) Behavioral objectives were also part of teacher planning, but they accounted for the smallest amount of time.

These findings, which provided a clearer description of how teachers planned, did not support the rational model of teacher planning with its major emphasis on writing objectives.

The methodology of the Peterson et al. study was an important advance in the study of teacher planning. Teachers planned aloud, and prescriptions on how to plan were not given, nor were objectives required. Attention was also paid to the processes teachers used in planning the text materials. Such studies of teacher planning (Zahorik, 1975; Peterson et al., 1978) explored planning as a cognitive aspect of teaching. The researchers were asking questions about how teachers planned, not dictating how researchers thought teachers should plan. It was through these studies of the teacher as a complex information processor that the rational model of teacher planning was challenged. A new focus in planning research led to further

studies and cognitive models of how teachers actually did plan.

An example of this new focus was Yinger's (1977) study of a single teacher's plans during the school year. Yinger investigated teacher planning in the classroom before, during, and after teaching. His research findings challenged the model of the rational planner who wrote objectives while progressing through a hierarchically ordered planning process, completely solving one goal at a time and then moving on to the next goal. Instead, the teacher in Yinger's study most often planned around instructional activities. The process of planning evolved in a cyclical manner; that is, the teacher frequently returned to half-finished goals. Planning occurred, not just from the top level of abstraction down but also from the lowest level of detail back up. The Yinger process model of planning developed from this field study reflected these observations.

Yinger's (1977) model varied significantly from the early prescriptive models of teacher planning. In the rational model, teacher choice of action or choosing among several courses of action were considered the most important part of the planning process. The teacher in Yinger's study concentrated more on forming the problem and the design of the plan. The descriptions of teacher planning provided by Yinger's study stimulated more questions and further investigations in the areas of teacher planning.

Anderson and Smith's (1981) work in science curriculum planning further supported Yinger's model of planning. They observed teachers planning for teaching a science unit. The planning in this study often focused on accomplishing the details necessary to make the lesson happen and slighted the conceptual-change purpose of the lesson. Clearly, these teachers were not following the rational model of planning. According to the rational model top-level goals (which are the most abstract) were solved prior to the solution of lower, more detailed goals.

Yinger in conjunction with Clark continued the work on teacher planning through a questionnaire study of 78 teachers (Clark & Yinger, 1979). The purpose of this study was to further explore when and how teachers planned. The results of the questionnaire supported early findings that learning objectives were seldom the starting point for planning. Another interesting finding concerning the benefits of planning was that teachers found planning to be a source of psychological aid. Plans provided direction, confidence, and security.

Questionnaire results also indicated a difference in teacher planning for different content areas. For example, in the subject area of writing, teachers reported the form of their plans differed from those in mathematics. The researchers suggested that this finding was due to the structure of the planning task. In mathematics, the teacher was often an implementer of the textbook

curriculum. Planning was still necessary, but the plans looked different from those developed for writing, for which few curricular guides and materials were available. This lack of available, published teacher materials to aid in teaching and planning for a writing curriculum made the task of planning a less structured one. Thus, the lack of structure and increased complexity of the task might influence the plan (Elmore, 1979).

Another study of teacher curriculum planning was conducted by Smith (1977). Smith studied teacher planning through the use of teacher self-reports. One aspect of his work included an exploration of curricular constraints on teachers and how the constraints affected plans. Smith found that "for the individual teacher, the formal curriculum is more a constraint than an area for decision-making" (Smith, 1977, p. 11). A second constraint was the prior achievement of the pupils in the class, and a third was the instructional setting. These constraints were not completely under the teacher's control. Similar to the constraints exerted by planning with published curricula (which simplify the teachers' task by defining it for them), the constraints defined by Smith influence the planning task by redefining the problem space. This new problem space must account for all school, individual, and curricular constraints. The constraints described by Smith were difficult for teachers to ignore, while those created by published materials were easier to reject. For those

teachers who chose to reject published materials, the constraints on them were eased, but the planning task became much more complex.

This problem of the use of published curriculum materials and the effects on both teacher planning and on the curriculum was the focus of Ben-Peretz and Silberstein's (1979) work. They believed the curriculum as intended by the developer and the curriculum as planned and implemented by the teacher were likely to be different. Since part of the professionalism of teaching was to develop and plan curriculum goals and a program of learning for students, such a goal might lead to a different interpretation of the curriculum than intended by the developers. But teachers need to be more than transmitters of curriculum—the apparent goal of some teacher-proof materials (Ben-Peretz & Silberstein, 1979). The work of defining the problem might be a difficult one, but Ben-Peretz and Silberstein's work indicated planning is an important professional aspect of teachers' lives—important to both teachers and students.

Thus far, teacher planning as influenced by materials and subject matter has been discussed. But little attention has been given to how planning is affected by varying grade levels. Such a study was conducted by Koeller and Thomson (n.d.). Their work indicated planning was an important aspect of teaching across all grade levels. They found that instructors across all grade levels felt lessons most often failed because of a lack of planning.

Furthermore, this finding held up across varied grade levels as well as years of experience in teaching.

Koeller and Thomson (n.d.) also explored the model of planning teachers used. Although all teachers endorsed the need for planning, the model of how planning was accomplished differed across grade levels. Most teachers did not use the rational model of planning. But 47% of the teachers included objectives as a step somewhere in their plans. Unfortunately, the instruments and the analysis of the data included did not fully explain the models, the task for which teachers were planning, or the teachers' rationales for their plans. Perhaps different models of planning were found at the various grade levels because the tasks for which the teachers prepared were differently defined. Since data on how the teachers actually planned or their definitions of the task were not reported, interpretation of the results was difficult.

Summary

Educational models of teacher planning in the literature reviewed focused on the important role of planning in teaching. How these models related to the way teachers actually planned was largely ignored until recently. Researchers found that teachers planned in ways that were quite different from the prescriptive Tyler model. In fact, teachers even went to the trouble of transforming

"teacher-proof" materials. How and why did they do these things? Researchers answered this question in two ways.

One view found that planning was a hierarchical process, in which planning proceeded from the top, most abstract level down to the details. In addition, objectives or ends were viewed as separate from means or learning activities. This view was represented by Popham and Baker (1970) and Tyler (1950). The other view of teacher planning was best elaborated in Yinger's (1977) work. He proposed a cyclical model of teacher planning in which problem finding, problem formulation, and problem solution continued in a cyclical pattern until a sufficient plan was generated. These differences in representing the process of planning were found throughout the literature and are discussed further in the section "Planning Theory in Psychology."

Studies of Children's Planning

Until recently, as in the case in educational research, few studies of planning and problem solving investigated the cognitive processes of children. The recent increase in research on planning would indicate that researchers have begun to recognize planning as a basic cognitive skill important in children's lives (Brown & De Loache, 1978). But how children planned was discussed in the literature most often in the context of problem-solving studies. Planning represented a myriad of

cognitive activities. It was construed as the ability to inhibit responses (Shure & Spivack, 1972), as an aid to learning (Brown & Smiley, 1977), and it was used to estimate cognitive development (Klahr, 1973). Klahr and Robinson (1981) and Siegler (1976) researched young children's use of plans, but programs of research in children's planning have been a recent development.

In this review of children's problem solving and planning, evidence demonstrated that even young children could plan and participate in the think-aloud method of inquiry. Also, studies of older children revealed that instructions played an important role in children's performance. The types of plans children developed and the tasks for which they were required to plan were also examined. It is argued here that studies of children's planning have not fully explored the importance of the task and the influence the type of task may have on the resulting plan.

Cognitive Functioning in Young Children

Several studies of problem solving and planning have been conducted with young children. These studies indicated that even young children were capable of problem solving and planning. For example, Seigler (1978) conducted a study of problem solving and scientific reasoning in children three to five years old. Results of his study indicated that very young children did not use rules to help solve tasks they were assigned, and further analysis

indicated that they had difficulty encoding or representing the problem. Once this skill was taught to the younger children, they successfully used rules to solve the tasks. After this training, the younger children benefited from feedback, as did the older children. Although this study focused on the development of rule governedness and rule systems, the study demonstrated the complex cognitive functioning of which even very young children were capable. It also demonstrated that it was first necessary to document how children function before attempting to intervene to effect a change in processes (Simon & Simon, 1979).

Other researchers who have conducted research with young children include Staats, Brewer and Gross (1970). They favored early cognitive training even for complex tasks and argued that children were capable of profiting from training at an earlier age than traditional developmental literature indicated. Wellman, Ritter and Flavell (1975) and Luria (1928) also found that young children were able to engage in strategic behavior. The evidence indicated that more complex thought occurred at a younger age than previously believed. Yet, there is still a need for further study of metacognitive skills, such as planning, at this younger age and a need for further study of older children's planning processes.

Planning Studies Conducted with School-Aged Children

Case (1974), working with Vygotsky's (1975) theories of function and structure, studied children's cognitive capabilities. Case's interest was in functional limits and not structural limits. More specifically, his interest was in what children did with knowledge, the uses they made of it, rather than the structural aspects which dictated what types or forms of knowledge were possible. This position was also echoed by Duckworth (1979).

The studies mentioned thus far indicate that young children are capable of successfully engaging in experiments and that early cognitive skills might reach heights not observed in previous studies which concentrated on defining structure or testing children for product-oriented responses. In addition, training procedures in the studies discussed above were developed from observations of children naturally solving problems. Earlier studies tended to base training on an *a priori* model of how children should think rather than reflecting how they did think.

Other studies focusing on what children knew included Siegel's (1978) work. His work indicated that the important cognitive improvement that developed in children was not recognition, as some earlier researchers have claimed. Rather, meta-knowledge (knowing that knowing something is useful) was the important skill that developed. In his experiment of map reading, Siegel (1978) found that the meta-knowledge most useful in problem solving was knowing

that knowing something about the landmarks was important to the solution.

Kuetzer's et al. (1975) often-cited study of children's metacognitive ability or "knowing about knowing" contributed to understanding this concept of metacognition. In the Kuetzer et al. study, children ranging from age four to age seven participated in several experiments exploring their metacognitive knowledge. Experiments ranged from memory tasks to planning tasks. In one task, children were asked how they would remember to take skates to school to go ice skating on the following morning. In another task, the researchers asked children how they would remember a birthday party that was scheduled several weeks in advance. Plans the children developed were numerous and varied. Some of the plans included the aid of external sources, such as asking for a parent's help or writing a note to help the child remember.

Luria (1928), discussing this important source of cognitive aid, described it as the external or cultural resources which were used as an external memory aid. Writing a note to help himself remember was an example of a child's use of cultural resources to help memory. This functional use of external objects was to Luria the true sign of intelligence. This practical intelligence explained the cognitive gains accomplished by young children. Cognitive development, as viewed by Luria, was the improvement in the methods by which the child used natural

memory. The natural cognitive capacity was replaced by complicated cultural forms of auxiliary means.

As demonstrated in Kuetzer's (1975) study, planning was an excellent example of a child's use of a complicated cultural form. Miller, Galanter and Pribram (1960) found planning to be a particularly important part of American life, also suggesting the American propensity to plan was a learned cultural behavior.

Children's metamemory skills and metacognitive skills were also researched in training studies conducted by Brown, Campione and Day (1981). The goal of these training studies was "instruction aimed at improving students' self-control and self-awareness of their own learning processes" (p. 15). In this experimental study, students were assigned to two groups. There were four instructional conditions in each of the groups. The conditions varied according to how explicit the training was for a particular group. The training conditions included:

(1) Skills in self-management
(2) Training in rules
(3) Rules plus self-management
(4) Training in rules plus training the use and control of the rules

The model of learning on which the training program was based was the tetrahedral model of learning. The four elements in the model were: learning activities (strategies, rules, and procedures), characteristics of the learner,

critical tasks, and the nature of the materials or the text structure. This model was designed to "make the trainee more aware of the active nature of learning and the importance of emphasizing problem solving trouble shooting to enhance understanding" (Brown et al., 1981, p. 18).

Results of the training study indicated the training sessions in rule use benefited all students in their ability to select topic sentences. For remedial students, the most explicit training was most beneficial. Average students were helped by all forms of training. In general, even though performance was equal prior to the training, average students benefited more from the training than did remedial students. It appeared that remedial students were confused by the rules-plus-self-management training; they required more explicit instructions in how to use the skills.

Brown et al. (1981) argued that the use of learning to learn strategies could improve students' abilities to learn. They suggested these cognitive strategies were a more effective learning aid than continued drill and practice of specific facts. In short, planning strategies of how to learn a lesson might be a more valuable investment of a learner's time than additional time on task.

One of the goals of Brown's work was to aid children in making better use of study time. In an experiment conducted by Brown and Smiley (1977), children's recall of important elements of prose passages was studied. Subjects

from three years of age on up to college students participated in the study. The results indicated that children under grade seven did not show effective use of study time, such as reviewing material, when given extra time to study. Any improvement in recall was for the text, in general, and not for important elements of the text.

In examining their work and other traditional studies in memory and problem solving, Brown and De Loache (1978) conclude that cognitive development was characterized by "increasingly conscious control"; that is, "what develops is the metacognitive skills, plans and self-regulation or the thinker's knowledge control and coordination of his own cognitions" (p. 30). The ability to self-interrogate and to form goals and plans that enable a learner to study developed with age and with experience (Brown & Smiley, 1977; Brown, 1978; Brown & De Loache, 1978).

If cognitive development could be characterized as described by Brown and associates, then the reason children did so poorly on self-interrogation and self-regulation problems might be due, in part, to children's lack of experience with the problems they were assigned. This conclusion is supported by Hayes' (1972) work with young children. He found confusing instructions and tasks accounted for incorrect answers given by young children.

Metacognitive and cognitive monitoring skills were studied extensively by Flavell (1977). His emphasis was less on training children to plan than was the case with

Brown and associates (1981). Flavell was more interested in what metacognition was and how it related to the rest of cognition. He described two types of metacognition: metacognitive knowledge, which was used by an individual to monitor his or her own cognitive progress, and metacognitive experience, which was used to make cognitive progress in thinking. Metacognitive experience is, according to Flavell, "most likely in situations that stimulate a lot of careful, highly conscious thinking, especially where steps require planning before and evaluation after" (Flavell, 1979, p. 908).

Flavell explicated the connection between planfulness and metacognitions in a study of recall. He discussed planning as a change, a progression in the use of cognitive verbal mediators:

> . . . to search the repertoire for activities to perform now, the performance of which has no immediate relevance but will facilitate some other activity subsequently (in this case, recall). This propensity--we have recently come to term, planfulness or planning ability. It is not the exclusive skill component property of any one specific mnemonic mediator; rather it could be viewed as a kind of executive cognitive routine which tells the student that the search for mnemonic mediator is in order when faced with a recall task (Flavell, 1970, p. 205).

The term "mnemonic mediator," as used by Flavell, referred to a cognitive act that was planful, similar to problem-solving behavior. Flavell concentrated on recall tasks and the need for planfulness, as did much of Brown's work. But both Flavell and Brown supported the important

role planning plays in the development of children's cognitive lives.

Planning was also shown to be important in the educational success of college students as well as young children (Hayes, 1976). In a study of college students in mathematics courses, Hayes argued for studies of cognitive processes rather than tests of behavioral objectives. In an investigation of the processes used to solve mathematics problems, Hayes asked students to rate themselves on their ability in mathematics. He found that students who rated themselves poorly in mathematics ability appeared to be working without a pattern. An elementary planning procedure was taught to the students, which helped students identify "what relations were useful in a given problem and in what order they should be considered" (Hayes, 1976, p. 237).

An interesting finding in the Hayes study was that the students who rated themselves poorly often had correct answers, but the random or erroneous process used to solve the problems eventually inhibited their progress. These students appeared to recognize the weaknesses in their own thought processes, despite the fact that they might have received praise for their correct answers. After receiving training in the use of planning procedures, Hayes wrote, "the difference, of course, lays not in the answer that the student produced but rather in the processes he used to search for the answer" (1976, p. 245). This study

illustrated the importance of examining process, not only in college students but early on in the elementary years when children are developing their skills in all areas of cognition.

Still other researchers viewed planning as a process of behavior control, one of self-monitoring or self-regulation of action. They were interested in planning as a cognitive process important in learning. Training programs that promoted a cognitive approach to solving social adjustment problems were developed by Shure and Spivack (1972). Their programs focused on training disruptive children to control their behavior through self-monitoring strategies and was also conducted with elementary-aged school children who exhibited maladaptive behavior. These training programs were based on teaching young children means-ends thinking, which required children to evaluate the means or the behavior against the end or the goal statement. Shure and Spivack noted children who were not well adjusted frequently limited their problem solving to impulsive and aggressive behavior. Training students to plan using a means-ends model of planning helped alleviate the impulsive tendencies which lead to maladaptive behavior.

The studies of planning and self-control discussed thus far all defined planning as means-ends analysis and little more. The training of problem-solving skills and means-ends analysis as therapy for maladaptive behavior

sounded encouraging, but no evidence was offered to support means-ends analysis as a reasonable model of how children did or should plan. Children's use of plans for self-control was also studied by Carter, Patterson and Quasbeth (1979). Quoting from Miller et al. (1960), Carter et al. cited planning as the hallmark of mature adults. A plan, in their work, was a lengthy sequencing of behaviors. These researchers asserted that plans, as they defined them, were less characteristic of young children. This was supported by their research finding that younger children had difficulty in using elaborate or generalized plans to facilitate self-control.

Carter's et al. (1979) study included preschool, kindergarten, and second-grade children. The task the children were asked to perform was to feed marbles to a mechanical baby bird. The conditions for the task required that children used plans of various complexity. The complexity varied, depending on the group to which the child was assigned. The results indicated children followed instructions best when they were given a full plan and were required to verbalize the plan. A strong relationship between verbalizing the plan and completion of the task was found for kindergarten and preschool children. For second graders, there were no differences in the plans of the various groups. In contrast to the younger children, task completion and verbalizing the plan were independent of the complexity of the plan for the second-grade children.

These findings led the investigators to conclude that more structured plans were needed for younger children. Another explanation for the poor performance of young children is possible, however. The researchers might have found evidence of poor performance in planning by young children due to the children's inability to understand instructions or due to their lack of experience with the task (feeding marbles to a mechanical baby bird) or due to lack of experience verbalizing the plan.

This problem of understanding instructions has recently received attention in several studies (cf., Brown et al., 1981; Hayes & Simon, 1974; Hayes, 1972). Several researchers argued that a child might be capable of self-regulation but might also need experience with the task before these strategies were integrated into planning or the solution of a problem. Lack of experience with a task could also increase the level of difficulty, if the problem required both cognitive and motor skills.

Hayes (1972) also studied the problem of task definition and understanding instructions. In a study entitled "Understanding Written Problem Instructions," Hayes and Simon (1974) watched how students actually learned to solve a task. Naive subjects were observed as their understanding and experience with a task evolved. Hayes and Simon noted the importance of this early phase of performance. Often the protocols of people learning how to do a task were disregarded. These researchers stressed the

importance of investigating how something was learned before investigating what was learned.

The interpretation of a task and ability to understand as well as solve problems was also studied by Hayes (1972). These information processing studies of children indicated that a young child assumed the experimenter chose the wrong word when asked an anomalous question, such as, "Is it warmer in the afternoon or in the summer?" (p. 179). An older child believed he was being tested or was being put on. Braine and Schanks (1965) also found evidence that children misunderstood instructions. In a size and shape discrimination study, they found five-year olds thought the experimenter wanted apparent, not real, object sizes. Once the adult explained what was being asked, the children performed correctly.

These studies of cognitive processes in children called attention to the confusion children encountered when trying to understand adult instructions. The conclusions invariably included a call for more emphasis on process research to illuminate how children think. For example, Bransford, Nitsch and Franks (1977) called for less focus on the number of correct answers on a test as a measure of expert knowledge. They recommended greater effort to identify processes involved in going about knowing rather than focus on the products of these processes. It was acknowledged that this type of research was difficult and administration of performance tests might be more objective, but

process studies will further benefit the children trying to learn and the researchers whose tasks and instructions must be understood by children. The recommendation is for process studies focusing on how children learn, not what they learn (Goldstein & Brown, 1979; Nelson, 1978; Simon & Hayes, 1976; Piaget, 1929; Simon & Simon; Klahr, 1973; Bransford et al., 1977).

One difficulty in understanding the processes children used while planning was discussed above: the problem of understanding tasks and instructions. A second problem was understanding the processes children used to plan. Studies which focused on processes first and not on training or test scores would aid researchers in understanding children's cognitive processes and especially would provide evidence to document how children go about the important task of planning. The studies discussed below explored what children could do and what processes they used to plan and to solve problems.

In a study of learning and problem solving, Hayes (1966) found planning to be an important factor in the problem solution. Hayes asked students to solve spy problems. The students were instructed to imagine they were running a spy ring in which communication was restricted. After receiving and memorizing a list of spies who could talk to each other, subjects were asked to solve communication problems, such as getting a message from John to Stewart. Although the study focused on problem solving,

planning was found to be such an important part of the student's cognitive processes that it could not be ignored.

Documenting the process of problem solving followed by the students, Hayes found acceleration in the path to solution on some students' first trial through the problem. This acceleration could be accounted for by planning (Hayes, 1966). Attention to subgoals was found to be an important part of problem solving. The functions of these subgoals and their effects on planning were suggested for further study. A backward strategy was used as a secondary strategy by some students to solve the problems. This strategy was only used after a forward strategy had failed. Though Hayes (1966) found planning was important and helpful to students, he also found that planning had costs associated with it. Forming a plan and retaining it limited the amount of memory free for other cognitive activity (Hayes-Roth & Hayes-Roth, 1978; Newell & Simon, 1972).

Further analysis of the planning data indicated two general forms of planning: local planning and remote planning. Local planning, in which the student did not plan more than a few steps ahead, was labelled by Hayes (1966) as A-B type connections. When students engaged in remote planning labelled A-F type connections, their plans indicated a connection between A and F and at the same time a connection between E and F. This notion of local and remote planning was reflected in models of planning which defined planners as means-ends processors who only looked

one step ahead in planning. This local planning was the only model of planning considered in some training studies of planning. Hayes (1966) offered evidence that students looked further ahead than A-B connections, indicating there was a need to further document how students planned before assigning models of planning to train students in this cognitive skill.

In the literature reviewed thus far, the important role of planning in the cognitive lives of children was discussed frequently. The focus of many of the studies reviewed was not planning, and yet the investigators concluded planning played a significant role in cognition and merited further exploration. Although many of the researchers called for further studies of planning, none of the studies discussed thus far described how children planned when they had no special training or testing. A study conducted by Nagy and Baird (1978) and a second by Klahr and Robinson (1981) addressed the question, how did children plan? The method used in these studies was observation of children planning (Nagy & Baird, 1978; Klahr & Robinson, 1981).

Nagy and Baird's (1978) interest in how children represented space and the role of cognition in this representation led them to study planning. The 70 fourth- and twelfth-grade students who participated in the study used markers to set up a real and an ideal town. Constraints on the task required that the students change the position of

any items they had added to the board. In one part of the study, students were shown a playground and asked to demonstrate their recall of the playground by placing markers on a board. In a second condition, the children were asked to create an ideal playground by placing markers on a board.

Analysis of the planning strategies of the students involved examining how the children placed markers on the board. While planning the real environment, Nagy and Baird found children's plans appeared to be clustered. The children might have remembered one section of the board of environment. When asked to plan a hypothetical or ideal environment, the children's strategies changed. Planning for the ideal space was more difficult for the children than was planning for the real environment. Nagy and Baird attributed this difficulty to a lack of sensory-motor experience in manipulating this type of spatial information.

Although there were differences in the environments created by fourth- and twelfth-grade students (for example, young children did not balance the objects in the real playground but did balance the ideal playground) Nagy and Baird argue that the components of the plans were the same for people of all ages. The aspect of the plans that varied with age was the relative importance of the components of the plans. The model of the planner in this study was represented by a flow chart where decisions were made one step at a time, progressing from low detail to high detail. Although the model supported the means-ends model or

one-step-ahead planning (Jeffries et al., 1977), planning an environment using markers was not a task most children would be expected to have experienced; therefore, the interpretation of the results was clouded.

An ambitious assessment of problem solving and planning processes in children aged four to six years was recently conducted by Klahr and Robinson (1981). In designing their study, Klahr and Robinson searched for a task that demanded a strategy to reach the goal. Their reason for seeking a task with this qualification was due to their theory that the lack of evidence for planning strategies and goal-directed strategies in young children could be due to the use of tasks which did not require such behavior for solution. For example, in some of the neo-Piagetian experiments, the child is asked to determine which of two bottles holds the greater volume. This task does not require much of a strategy on the part of the child, and it does not tell much about how children solve tasks. In order to investigate the process of children's planning, Klahr and Robinson (1981) set criteria for their task which included: (1) that the task had a beginning and an end, and (2) that the child needed to plan a strategy to attain the goal. A problematic aspect of their design was to create a task that fit these criteria.

Klahr and Robinson wanted a task with a solution that "was not immediately apparent but must be produced through some combination of trial and error, systematic search,

testing, planning and so forth" (1981, p. 114). In addition, the researchers were interested in a task that adults had also performed, thus enabling them to compare cognitive processes in children and adults. The task that met their criteria was the well-known Tower of Hanoi task. The original Tower of Hanoi and several variants of it had been used in adult studies of problem solving (Simon, 1975). The problem, as it was adapted for children, required the participants to place cans on pegs to achieve either a tower or a flat solution. Constraints on the solution included movement of only one can at a time, and large cans could not be placed over a smaller can on any peg. A story about monkeys represented by the cans was used to motivate the childrens' interest in the experiment.

Since Klahr and Robinson were interested in the process of planning, they used the think-aloud method of inquiry, requiring children in the study to think aloud as they planned. Recognizing that planning could be confounded by the visible effects of movement of the cans, Klahr and Robinson asked children to tell the investigator their plan rather than moving the cans themselves. Children as young as three and one-half years of age successfully complied with the task constraints, although illegal move attempts were much more common in the plans of younger children than in the plans constructed by older children.

By first grade, Klahr and Robinson found children could develop plans with up to six moves. To describe the

process of planning evidenced in the children's protocols, the two reseachers developed nine models of planning. Although the models differed, the participants all used the same ordering of the subgoals: baby (the smallest can) first, then mother, then father. But the children differed in the manner in which they responded to difficulties or obstacles in their solution path. Some children responded to obstacles, such as not being able to move the can to the next peg, by focusing on an immediate move rather than a more remote obstacle. The children failed to develop a way to manage subgoals which required several recursive moves; "such abilities appear to be just beyond the capacity of almost all of our sample of pretty bright six year olds" (Klahr & Robinson, 1981, p. 144).

Age differences in planning were indicated in the analysis of illegal moves and the number of moves. For example, four-year olds produced more illegal moves than six-year olds. In addition, many of the four-year olds were unable to develop a flawless plan beyond two moves, whereas six-year olds were able to perform six-move plans perfectly. Klahr and Robinson suggested the performance deficits of the four-year olds might have been due to difficulties younger children experienced with the internal representation of the problem. This theory was tested in another version of the monkey-can experiment. This time the children were allowed to move the cans, facilitating internal representation of the problem. As expected, the

younger children were more successful in accurately solving the problem. Klahr and Robinson explained the increase in success when the children were allowed to move the cans because it was no longer necessary for the children to internally represent the problem without external aid.

Nine models of planning were developed by Klahr and Robinson (1981) to characterize the planning strategies. Six of the nine models best fit the data. Models one and two were characterized by strategies which ignored problem constraints and by strategies that focused on the visual stimulus in front of the child. These two models best characterized the youngest children in the study. The third and fourth models showed childrens' strategies as "limited in ability to respond to difficulties" (p. 136). Basically, children using strategies characterized by this model followed a means-ends process of comparing each move and the goal. Models five and six summarized strategies as "limited breath first search and depth first search" (p. 137). Using the fifth and sixth models, a child first would try to find any move that was legal and that would result in the largest can on a goal peg. In model six, the first move of the strategy was to move the smallest can, then move the next two cans in order.

The Klahr and Robinson (1981) study and the work of Nagy and Baird (1978) were a basis for beginning to understand the processes children used in planning. Klahr's and Robinson's documentation of the plans children developed

was especially valuable. Both of these researchers teams' use of the think-aloud protocols with children was a step forward in methodology. With the evidence of their successful use of childrens' think-aloud protocols, it is no longer necessary to rely on product assessment scores to describe how children plan.

In the Klahr and Robinson study (as well as in many of the other studies), the models of planning proposed, as they related to the task used in the study, were not critically analyzed. Although the researchers described different planning moves for the task depending on the type of goal—flat or stacked—the Tower of Hanoi task, as a problem in general, was not discussed. For example, the type of experience a child needed to have in order to solve or plan for this task was not discussed. The task was chosen because it fit specific criteria and because it was amenable to analysis. What effect did the type of task chosen have on the plans developed by a child? Klahr's and Robinson's research did not directly address the effect of task, nor did most of the psychological literature on children's planning.

Information on how children actually went about planning in their daily lives was vague. There were studies which required children to remember plans and to use spaces (Nagy & Baird, 1978; Lichenstein & Brewer, 1980). But these studies did not encourage or document the child's creation of a plan. Research on remembering indicated the

pervasive use of plans for remembering, even by very young children (Flavell, 1970; Kuetzer et al., 1975). The influence of context and content on the task might inhibit the child's planning strategy but still needs further exploration (National Institute of Education, 1981). Tasks which were highly artificial or required much imagination and memorization of rules, such as those used in the Klahr and Robinson study, might have made a problem unduly complex and revealed little about how children would plan naturally.

Summary

Presently, new programs are being used to train children to plan. But these programs for the most part are based on models of planning developed prior to documentation of how children plan. Training children to plan is an important goal, but, before training programs are begun, more documentation of how children plan in specific contexts and for specific tasks is needed.

Throughout the literature on children's cognitive processes, researchers were calling for more work on understanding processes (Brown et al., 1981; Brown & De Loache, 1978), especially those processes involved in the important cognitive skill of planning. The literature reviewed indicated children did plan at a very young age, and were capable of verbalizing their plans (Karmilloff-Smith & Inhelder, 1975; Brown & DeLoache, 1978; Duckworth, 1979).

More studies employing tasks familiar to children are needed (Istomina, 1975). Studies which assess processes in planning for tasks that are novel do not adequately represent the life tasks that involve much of children's planning time. This emphasis on studying processes in real-life tasks was also supported by Duckworth (1979), who called for less focus on speeding up of children's processes and more attention to how children mobilize knowledge they have and how they used the practical knowledge they had (Duckworth, 1979).

Results from studies indicated children developed goals and hypotheses and reacted to problem constraints with varied strategies (Istomina, 1975; Duckworth, 1979; Klahr & Robinson, 1981). Many of the proposed models of planning indicated children were means-ends planners who planned one step ahead, working from a higher level of abstraction down to details (Jeffries, 1977; Klahr & Robinson, 1981). Other research indicated children were capable of remote planning (Hayes, 1976). A parallel discrepancy existed in the literature on adult planners. These studies are discussed below.

Planning Theory in Psychology

Research on problem solving is plentiful, but this review only includes problem-solving studies that focused on cognitive processes and were relevant to the development of planning theory. The psychological studies discussed,

primarily of the Gestalt persuasion, are briefly reviewed. These studies conducted by Gestalt psychologists tended to be more descriptive and less explanatory than the studies by mediation theorists, who tested associations between overt and covert stimuli and responses. The long protocols of the Gestalt studies concentrated more fully on processes of thinking than on the quantitative experiments of the product-oriented mediation theorists (Wason, 1977). This concern for understanding process was the focus of this thesis.

History of Planning Theory in Psychology

Early work in problem solving touched on the issue of planning. Selz's (1922) work in the early 1900s reintroduced the method of thinking aloud as a valid research tool. Others who followed his model, notably Duncker (1945) and De Groot (1965), made significant contributions and advances in the methodology used to study problem solving.

Selz (1922) was an early foe of classical association theory. He championed the concept of heuristic thinking in problem solving and the concept of determined means abstraction. This concept broadened the view of how problems were solved. Selz argued that the explanation for problem solving did not lay solely in the problem solver's past experience with the problem or even in the solution. Instead of the classical association theory, the solution

to a problem was found to be in the leading to "the anticipation or the signaling of its specific solution or means propertied in each case" (Selz, 1922, p. 18). This leading to or anticipation of could be construed as a plan or a heuristic aid.

The theory of heuristic thinking in problem solving was pursued by students of Selz's work. An example is Duncker's (1945) now famous problem involving a patient with a stomach tumor which needed to be irradiated while at the same time protecting healthy body tissue from the radiation. Reflecting on the ability to solve problems, Duncker stated that all of the necessary information to solve the problem was in the problem. Thus, "every solution takes place on the concrete, specific substratum of the problem situation" (p. 34).

Duncker's theory of how problems are solved lived on in the work of Newell and Simon (1972) and in the work of current information-processing theorists (cf., Abelson, 1975; Ortony, 1978; Rumelhart, 1977). They referred to the substratum of the problem situation as the problem space. This space was defined by the task and the problem solver.

While investigating mathematical problems, Duncker (1945) generalized the methods of demonstrating a proof in mathematics to heuristics in problem solving. Specifically, the proof or solution could be attained either by starting from what was demanded (the goal) or what was given in the problem situation. Duncker (1945) labeled

these methods the organic one and the mechanical one, respectively.

In the organic method, the solution was approached in a top-down manner in which the solution was deduced from information in the initial goal. Duncker viewed this process as a hierarchical one. The mechanical method was equivalent to what was called bottom-up processing. Using this second approach, information was accumulated to form the solution. What was "demanded" was not of central concern to the solver. A combination of smaller parts equaled the whole in the mechanical method.

This discussion of organic and mechanical ways of thinking may sound vaguely familiar. The terms differ from more modern ones, but the discussion is still the same. The more recent working of the organic versus mechanical question is: do planners and problem solvers follow a top-bottom or bottom-up approach while planning? Although Duncker (1945) often found evidence in his studies of bottom-up or mechanical thinking, he favored the teaching and use of a top-down hierarchical process. This view of processing also implied a linear model of the problem solver.

Duncker supported a top-down theory of processing, and he subscribed to the rational view of the thinker. This view characterized the thinker as following a linear, logical hierarchical process of problem solving. Contrary to most researchers who endorsed this view, Duncker recognized

the importance of the task and its potential to influence a problem solution. His emphasis on the problem situation indicated an understanding of the importance of task description to the problem solver.

In his book *Thinking*, Bartlett (1958) investigated something he termed "adventurous thinking." Like Duncker (1945), Bartlett's experiments and understanding of cognition led him to believe there were different types of thinking. Bartlett used sectional map reading as the task for his experiments. Instructions to the subjects indicated the goal was to get somewhere in the northwest. When the subject had gone as far as he could on that plan, she/he was given another sectional map. There could be dead ends, which would cause the subject to have to backtrack. The roads were all rural, with no apparent highway.

The findings in Bartlett's study indicated subjects favored perseverance along a chosen route, even though evidence indicated the folly of the route. Similar to Duncker's (1945) concern with the problem situation, Bartlett analyzed the sectional map problem and identified the task as an "open system" (Bartlett, 1958). Bartlett found subjects in this task tended to "prefer evidence which releases the greater rather than the smaller number of possibilities" (p. 140). Bartlett attributed this behavior to the task which had little known structure. Working with this open system task, Bartlett also found evidence that subjects were attracted to this risky type of

problem. This was in contrast to the popular assumption at that time that the human brain preferred dual choice tasks. Bartlett recognized the importance of the task structure and found with greater freedom his thinkers became "less detail-ridden, and more schematic-minded" (p. 143). This early work had important implications for the later development of theories and tasks, but the notion of structure and its importance on outcomes had often been ignored.

De Groot (1965), influenced by Selz's (1922) theories of cognitive processes, also recognized the importance of the task structure in studying cognition. His work focused on chess playing and how experts and novices choose their chess moves. This work described how experts and novices viewed the chess board. De Groot found that experts actually perceived and remembered the chess boards differently from novices' boards. The experts remembered the board in chunks rather, than the individual chessmen as did the novices.

De Groot's work was of particular interest in this review for two reasons. First, he advanced Selz's method of think-aloud and protocol analysis, and second, his work highlighted the importance of planning and the role it plays in thinking. Many of De Groot's guidelines and suggestions for improvements in the think-aloud method are followed today. Specific contributions De Groot made toward developing and popularizing the think-aloud method of research are discussed in Chapter 3.

The implications of De Groot's work for research in planning has often been overlooked. His study of chess players provided evidence not only of how experts and novices differed in their chess moves but also documented the importance of planning. He found that planning was an essential part of chess playing. The protocols in the chess study indicated the uncertainty of planning strategies. A characteristic of a plan was that it was "formed on the basis of an insufficient set of data" (De Groot, 1965, p. 145), and this was clearly the case in the study of chess moves. Although the insufficient data might have increased uncertainty, it also increases flexibility, thus allowing the planner to change a plan in midgame.

De Groot also clearly recognized the importance of the task to the planning strategy. Discussing his findings, he detailed specific traits of thinking in chess. In particular, De Groot felt the demand for an understanding of spatial relationships and the nonverbal quality of the game made it a unique task. He contrasted chess playing with mathematical problem solving, arguing that the uncertainty of the chess game required extensive mental trying out of strategies, in contrast to mathematical problem solving in which a plan could be proved. It could be deduced *a priori* and the solver could be certain if the plan was correct. De Groot likened planning in chess playing to empirical research in which trying out and uncertainty were expected.

The chess player was seen by De Groot as an inveterate planner and as an opportunist in his thinking. Still, he viewed the process of planning from a linear rational model. Although he acknowledged the importance of flexibility in planning, his analysis of the protocols of chess players indicated a hierarchical model of planning.

Summary

In summary, the early work of Selz (1922), which influenced Duncker (1945), De Groot (1965), and others (for example, Wertheimer, 1958), occurred in an era of adventurous thinkers who pioneered the use of the think-aloud technique to study thinking. All of these works works were limited to theories of adult process, however. How or if these processes occurred in children was not considered. This tradition of method and the type of subjects studied was carried forward and further developed by numerous scholars. The works of these researchers is discussed below. Miller's et al. (1960) work continued to delve into the theory of how adults plan. More recently, the term "information processing" has become a part of the vocabulary of researchers interested in planning and problem solving. Numerous studies and modern theories of the planning process have evolved, but common assumptions and themes have persevered. These themes are discussed throughout this literature review.

Think-Aloud Technique

The think-aloud interview technique was used in this study to encourage participants to verbalize their thoughts while in the act of planning. The participant expressed all of his/her thoughts without interruption, except for an occasional prompt when a participant was silent for a long period.

As a method of inquiry, the think-aloud technique is both classic and modern. The technique was developed by Duncker (1945), who used it in his studies of medical problem solving. Verbalizations were recorded on audio tape. The transcripts of the think-aloud planning sessions were the data used to test hypotheses and build new models of cognitive processes.

History of the Think-Aloud Technique

The think-aloud method was developed to combat theoretical and practical problems in using retrospection as a research method. Retrospection, as it was used in early German research, required subjects to reconstruct what they had been thinking during problem solving. The difficulties with this method were abundant. The limitations of recall created a problem for subjects trying to report exactly what was occurring during problem solving. If a participant forgot what he/she was thinking, pure conjecture might have filled the void. The longer the time between problem solving and the retrospection, the more difficult was exact

recall. In addition, when provided the opportunity to reflect on their problem solving, participants in a study might have unintentionally rationalized or elaborated what they were doing or thinking during problem solving.

The use of the method of introspection by German psychologists met with much criticism. Prior to the work of Otto Selz (1922) and his students, turn-of-the-century German psychologists used introspective studies as actual descriptions of content or products. They treated verbal reports as the sole explanation of behavior. Their analyses explained introspective reports as causal paths in thinking which were treated as the "real" cause of psychic events (Newell & Simon, 1977). Introspection, as a tool to investigate cognitive processes rather than purely content analysis, was introduced by Otto Selz (1922) and his students. For Selz, verbal reports were not an explanation of overt behavior. Instead the verbalizations were treated as another form of data that must be accounted by theories of cognitive processes. In justifying verbal reports as data, Bryne (1977) equated the method of think-aloud with ethology, in which a very detailed record of the behavior of an animal or group of animals was used as the basic form of data. "Such a detailed record of behavior is liable to be a stringent test of any theory" (Bryne, 1977, p. 8).

Duncker (1945) and De Groot (1966), both students of Selz's work, helped develop and popularize the think-aloud method of inquiry, which avoided some of the disadvantages

of earlier introspective studies. Duncker's work in medical problem solving and mathematics and De Groot's painstaking protocols of chess masters became classic studies of information processing. Duncker's work, with think-aloud planning sessions, resolved some of the difficulties in the method and answered criticism of delayed recall by having subjects think aloud during the act of problem solving.

Recent criticism of the think-aloud method of inquiry centered on possible effects thinking aloud might have on the thought process. The question most often asked has been: does verbalizing change or influence the thoughts of the participants? Ericcson's and Simon's (1980) work indicated that the think-aloud method of inquiry did not interfere with thinking if two conditions were met in the design of the study: (1) instructions were brief and subjects were not directed to produce certain, specific kinds of information, and (2) instructions were given so the subject assigned first priority to the task. Both of these injunctions were followed in the present study.

The think-aloud technique, has allowed participants to complete their task without interruption and has provided the most complete and most easily analyzed transcripts. If an investigator interrupts the participants with questioning, the line of thinking may be altered. In addition, the interruptions or questions themselves may provide unintentional cues that may confuse the planner. In their

extensive information-processing work, Newell and Simon (1972) found think-aloud techniques without interruptions to be the preferred method of inquiry. This modern method of collecting think-aloud planning sessions was used in the study reported here.

Recent Planning Literature in Psychology

Plans and the Structure of Behavior (Miller et al., 1960) drove the concept of planning into the consciousness of numerous researchers in psychology who had previously overlooked, minimized, or even purposely ignored this complex cognitive function. This did not mean little research on problem solving and planning was being conducted at the time the book was published; in fact, studies of the human as an information processor were being conducted at or before this time (e.g., Newell, Shaw & Simon, 1960). Yet, until the time of these authors' treatise, the subject of planning was usually tucked into the folds of studies in problem solving.

Miller et al., (1960) proposed the TOTE model of planning. The acronym TOTE stood for Test-Operate-Test-Exit. These operations made up a feedback loop in which the planner continually checked moves with a goal, then exited when the goal statement was satisfied. The model was derived from earlier work by Lewin (1917) and seemed to succinctly sum up how an adult planned for action. The TOTE model postulated that "operations an organism performs are

constantly guided by the outcomes of various tests" (p. 29), and "TOTE represents the basic pattern in which our plans are cast" (p. 31). That is, the planner was viewed as continually searching for an end or satisfactory exit.

Although stimulus and response were a part of this model, the three researchers argued that TOTE differed from the behaviorist model of reinforcement. The definition of reinforcement for a true behaviorist stated that the reinforcer strengthened a certain response. This was not the case in TOTE, where the planner was reinforced for comparison and testing. Reinforcement in TOTE, perhaps, was simply, more information and was not really reward. Miller et al. claimed their use of the term feedback was much more general than the traditional behaviorist notion: In TOTE, feedback was immediate; in the behaviorist model, the feedback loop came only after the response.

Lewin's (1917) theory of images and intentions was the basis from which Miller et al. discussed their conception of a plan. Images were defined as all experience and knowledge, concepts, and facts—somewhat similar to the popular concept of schema. Lewin's thesis involved values and images as well as intentions. Although Miller et al. acknowledged the importance of understanding values as defined by Lewin, they rejected much of Lewin's analysis of values. To account for the influence that values might

have exerted on plans, the three researchers borrowed the concept of valence for use in their theory.

Valence was another of Lewin's concepts, and it was closely aligned to the idea of values. It was the criteria met before a plan was enacted. These criteria meant the execution of a plan must already have begun before the remainder of the plan could be labelled an intention. This definition differed from other definitions of the term intention (cf., Greenfield, 1978). Where did the plan fit into this discussion of images, valences, intentions, and action? According to Miller's et al., theory, a plan was the intervening step between the image and the action.

Miller et al., discussed several characteristics of plans, distinguishing between flexible plans and inflexible plans. The components of flexible plans could be performed in any order, but in an inflexible plan, more working memory was needed because inflexible plans were more specific and used often. As the term inflexible implied, the parts of this type of plan were rigid and had to be performed in a specified order only. The inflexible plan was similar to Yinger's (1977) notion of routines found in teacher planning. These routines also had a predetermined order and were accessed frequently. They functioned to help simplify the teacher's task of planning. Miller et al., took the concept of inflexible plans further and hypothesized that motor skills and habits were once voluntary plans that became rigid and inflexible.

"Plans are intimate to humans, as long as they are alive humans are continually executing a plan or plans" (Miller et al., 1960, p. 9). They argued that plans were pervasive. Understanding plans was viewed as necessary to understanding action. Plans were seen as an important part of education: "at the behavioral level, of course, communicable plans play the central role in educational processes" (p. 82).

Miller's et al. (1960) hopes for research in planning both succeeded and failed. Their success lay in their view of planning as a hierarchical process; this view prevailed throughout most of the literature. Their model was often an unquestioned and unmentioned assumption in research studies in planning and problem solving. But this hierarchical model of the planner was also popular prior to the researchers' work. The failure was in their efforts to generate further study of the TOTE model. Despite widespread reading of the treatise, specific studies explicating the TOTE model did not follow the publication of the model. In fact, even after the model was published, planning was still treated as a subset of problem solving. The work of Newell and Simon (1972), although progressive, still defined planning as a heuristic for problem solving. It was not until recently that planning was recognized as an important function in cognition. Despite the often cursory view of planning even after the publication of Miller's, et al. work, the research efforts of those that

followed are reviewed here. For it was in these studies, focusing on problem solving, that many of the definitions and assumptions about planning were formed. These definitions and assumptions clearly influenced current work in planning.

Scant attention had been paid to the important role of planning in education, with the exception of recent studies of teacher planning. Even fewer studies of children and how they plan were conducted. Though Miller et al. argued, "man's verbal abilities are very intimately related to his planning abilities" (1960, p. 38), planning has still been categorized as a skill—not a gift. Viewed as a skill, it has thus been amenable to practice and skill development. But only recently has research touched on this theory—that planning is an important cognitive skill that can be improved with training and practice (Brown et al., 1981; D'Zurrilla & Goldfried, 1971). Studies supporting this view were discussed above in "Studies of Children's Planning."

Miller's et al. view of planning as a hierarchical process found no greater support than in the work of Newell, Shaw and Simon (1960). Their early problem-solving studies portrayed planning as a series of list structures. This work characterized some of the first attempts to simulate human planning using a computer. Newell and Simon (1972) followed this early work with numerous articles, monographs, and books on information processing and

computer simulations (e.g., Moore & Newell, 1974; Schank & Abelson, 1977; Simon & Reed, 1976; Simon, 1979).

Newell's and Simon's (1972) computer program, GPS (General Problem Solver), was one of the most widely discussed computer simulations. These computer simulations began with a theory of information processing based on parameters such as problem space, heuristics, and means-ends analysis. The concepts, if not the actual labels, were similar to some of the earlier work in problem solving discussed previously. Newell and Simon acknowledged the influence of Otto Selz's (1922) work, and their terms and concepts closely followed the work of Selz's students. The term "problem space," a basic concept in their research, was similar to Duncker's (1945) work on defining the problem situation. Newell and Simon stated that methods of problem solving were determined by the structure of the problem space. Duncker's discussions, although not stated as clearly as Newell's and Simon's, also included this concept.

Other concepts adapted from earlier work were seen in the information processing models. Polya's (1957) rules and definitions of heuristics surfaced in the Newell-Simon (1972) theories. Means-ends analysis was another term harking back to Duncker's (1945) analysis of problem solutions in productive thinking. In his early work, Duncker had documented the tendency of subjects to first concentrate on identifying the problem or difficulty, then search

for a means to remove the difficulty. Newell and Simon (1972) advanced these concepts by defining and testing them and finally stating the parameters in terms of computer language. Their computer simulations were based on chess, logic, and cryptarithmetic problems. These three types of problems are discussed below, followed by a description of Newell's and Simon's model of the General Problem Solver (GPS).

Information Processing Studies of Planning and Problem Solving

Chess problems were often used in the Newell-Simon (1972) research. Subjects were asked to think aloud while playing chess games, similar to De Groot's (1965) research in chess. The chess players in Newell's and Simon's studies problem solved in much the same way as De Groot's subjects. This similarity was attributed to a common problem space shared by expert chess players.

A second type of problem used to define their theory of problem solving was the logic problem. Earlier work by Newell and Simon (1962) using such problems led to the Logic Theorist, a computer program (also the precursor to the GPS program). The logic problems were proof problems, but subjects in the study were not aware they were solving logic problems; they were asked simply to solve problems labeled as transformation or recoding of algebraic expressions. An example of one of these expression is:

(p x q) x v x (p x p). The goal of this problem was to transform the expression listed above to pq. The analysis for these problems was based on previous research of Moore and Newell (1975), which included protocols of 64 subjects. In addition, several new subjects tested by Newell and Simon were included in the data base used to define the General Problem Solver.

Lastly, cryptarithmetic problems were used as the problem-solving task in Newell's and Simon's (1972) research studies. While solving these problems, adult subjects thought aloud, and their protocols were recorded by the investigators. In a cryptarithmetic problem, the subject was presented with an addition problem in which the solution and the addends were alphabetical. In order to solve the problem, it was necessary to substitute numbers for letters to achieve the goal of correct addition. An example of a cryptarithmetic problem is: DONALD + GERALD = ROBERT. Protocols from the solution of these problems were also used to develop the GPS computer simulation program.

The GPS is a remarkable computer program and of interest in this review because it represents a planning method of problem solving. As a problem solver, the GPS requires the goal be described in exactly the same way it is given in the problem. It then tries to transform the problem givens into a goal for problem solution. This process restricts the types of problems handled by GPS, however, to

well-defined problems in which the structure, goals, and problem space are given.

Basically, the planning method used in GPS has four steps:

> (1) Abstracting by omitting certain details of the original objects and operators.
> (2) Forming the corresponding problem in the abstract problem space.
> (3) When the abstract problem has been solved, using its solution to provide a plan for solving the original problem.
> (4) Translating the plan back into the original problem space and executing it (Newell & Simon, 1972, p. 429).

This planning method enables the problem solver to first outline a strategy, then work out the details. The GPS follows a modified means-ends analysis. In means-ends analysis, the problem solver does just what the term implies: he or she classifies the problem components into functions they each serve, then—moving between ends or goals and means that attain the ends—solves the problem. There are several ways in which a person can use means-ends analysis, but the concern here is with why this method cannot adequately account for all problem solving.

One difficulty with means-ends analysis is that steps toward the solution can only be taken one at a time. This means the problem solver must re-evaluate progress after each step. More importantly, it means the problem solver is not capable of solving any further than one step ahead. Yet, protocols of subjects thinking aloud while problem solving demonstrate planning that involves several steps

into the future. Because of this limitation, the planning heuristic program described above was developed, allowing the computer to more adequately simulate human problem solving.

Within the models proposed by Newell and Simon (1972) were some explicit assumptions and some assumptions which are not readily apparent. The explicit assumptions included several properties of the human intellect, labelled by Newell and Simon as invariants. These invariants included:

(1) The size, read, and access time of memory remained invariant.

(2) The rate at which elementary processes could be performed and the serial character of information processing remain invariant.

(3) Programs the information processing system followed were global-like in character.

A more implicit assumption of the Newell-Simon model of the problem solver was that the planner followed a top-down model of planning. This use of planning was both important and creative, but planning was viewed as a subset of problem solving. Although the planner was able to solve more than one step ahead in the revised model, planning is still defined as an abstract process of simplification.

The theory of problem solving ascribed by Newell and Simon only concentrated on well-defined problems in which the problem space was already defined (Simon, 1976). The

GPS was developed for use exclusively with well-defined problems. Since the defining of this problem space in ill-defined problems took place while planning, this role of planning could not be observed in Newell's and Simon's work.

Some recent studies, such as those of Yinger (1977) and Goldin and Hayes-Roth (1980) studied planners as they defined the problem space. Their works are discussed below. The lack of work on defining the problem space is not a criticism of Newell's and Simon's work; rather, it points out the types of problems on which their theory was not tested and did not address. Simon himself recently called for studies of tasks in which it would be the subject's job to define the problem space (Simon, 1976).

The models proposed by Newell and Simon (1972) were developed with protocols from adult subjects, similar to much of the cognitive research literature. A few of the experiments discussed next investigated how children planned and problem solved, but the majority focused on adult subjects. These studies generally followed the example of Newell and Simon (1972); that is, they viewed the subject as an information processor, and the experimental tasks used were well-defined problems.

Plans, as characterized by Newell, Simon and Shaw (1957) are abstract representations of problems and solutions. This view appeared throughout much of the literature in problem solving and was supported by findings from

a well-known study using a river-crossing problem of hobbits and orcs. In the study conducted by Greeno (1974), plans were defined in consent with the mainstream view of planning as a process of simplification and abstraction. But Greeno attempted to improve the problem-solving model of planning by questioning the number of moves ahead a human solver was capable of planning.

The hobbits and orcs study consisted of 150 adults who were divided into three groups. The participants were asked to solve the hobbits-orcs problem repeatedly until they were able to solve the problem without errors on two successive trials. The goal of the problem was to transport hobbits and orcs across a river in a single boat. Three hobbits and three orcs had to cross the river. The boat could only hold one or two creatures at a time. The constraints were: the boat had to have at least one creature in it on each crossing, and hobbits on either shore could not be outnumbered by orcs or they would be eaten by the orcs.

Studies conducted by Greeno (1974) and Thomas (1974) indicated this problem was a particularly difficult one for subjects to solve while thinking aloud. One explanation for why subjects had difficulty was that each move required complex thought. In their separate studies, Greeno and Thomas both varied feedback and the starting point for the task. The purpose of such a strategy was to determine differences in problem solving dependent on feedback and to

determine which part of the problem presented the most difficulty for the subjects. The results were then compared to Newell's and Simon's (1972) GPS method for solving the problem, with the goal of determining if the GPS and the human subjects in the study experienced difficulty in the same phases of the problem.

The GPS did not solve the problem in the same way as did the human solvers. Greeno (1974) found a significant source of discrepancy in the construction of the goal. If a modification between the goal and the means was needed, the goal tree caused the GPS to go back to a previous goal and begin again, as dictated by the hierarchical model of planning. In human solvers, an immediate leap was made to the next operation. Needless to say, the GPS required many more moves to return to the previous goal and then needed to begin anew.

This problem was recognized and discussed by Quinlin and Hunt (1968) as a looping problem. These authors discussed the problem as basically a mechanical difficulty, but, in reality, the looping problem was part of the model of a theory of how humans solved problems. It was therefore necessary to consider this diversion in the GPS solution as more than a mechanical difficulty. The hobbits-orcs problem had demonstrated that humans did not have to return to the previous step when faced with goal modifications. Subgoals and new plans pushed the human solver

ahead in a more efficient manner than recognized by the GPS and similar models of the planner.

Another difference in results between the initial GPS model and the human-orcs problem was the human organization of information during problem solving. Thomas (1974) found subjects organized information in units which were much more complex than the problem behavior graph used to analyze protocols and to develop the GPS. Greeno (1974) also found evidence that subjects organized two or more moves into the future. The GPS did not plan in this sense. Though capable of remembering past moves, the GPS was guided by means-ends analysis between the current situation and the goal (Greeno, 1974). In contrast, humans used plans to find new opportunities and were more flexible in their problem solving.

Greeno addressed the importance of plans in the following example of differences between the GPS and human problem solving:

> GPS gets to state 021 from state 010 by saying in effect, "I want to move an orc across [now] but I can't, so I'll move the boat to the left side." Once the boat has been moved to the left, GPS returns to its earlier goal of moving one orc from left to the right side, but this goal is no longer appropriate. Human subjects in state 010 apparently say something like, "If I move an orc across to the left, I can bring both orcs back." The human subject has decided on one pair of moves that will complete the problem (1974, pp. 288-289).

Despite problems in the simulation of human processes, Greeno only faulted the GPS in terms of a looping problem

and for "utilizing only very weak look-ahead properties" (1974, p. 289).

In another problem-solving study focusing on the role of analogy in transfers between two river crossing problems, Reed, Ernst and Banerji (1974) and Simon and Reed (1976) also found evidence of subjects planning more than one move at a time. The river-crossing problems used in this study were isomorphs of the hobbits-orcs problem. Although the authors took issue with the GPS model of planning in problem solving, Thomas (1974), Greeno (1974), and Reed et al. (1974) all implicitly argued for a linear top-down model of planning in which plans were considered abstractions of the problem solution. Yet, the discrepancies they discovered between the plans constructed by humans and those constructed by the GPS indicated these researchers recognized that describing planning as simplification and abstraction of the problem solution might not adequately account for the processes humans used while planning.

Atwood's and Polson's (1976) water-job problems also supported the view of planning as a process of abstraction and simplification of the problem solution. Using a variation of Ernst's and Newell's (1969) water-job task, Atwood and Polson asked subjects to fill water jugs with specified amounts of water. This was accomplished through a sequence of moves determined by the subject. Seventy-five adults participated in the study.

Analysis of subjects' moves led Atwood and Polson (1976) to argue for a more conservative model of planning than those proposed by Greeno (1974) and by Thomas (1974). In contrast, Atwood and Polson (1976) found Newell's and Simon's (1972) GPS simulation of planning adequately accounted for subjects' solution behavior. Atwood and Polson argued that humans were not efficient forward planners due to memory limitations, and, in fact, the more efficient model was one which used means-ends analysis of local rather than global information, as did the GPS. Atwood and Polson favored a hierarchical model of problem solving, with little or no need to model planning for more than one move at a time. The authors stressed their model was for "move problems" in which the subjects were naive to the task and were required to find a sequence of moves to fulfill a goal, e.g., filling a water jug with a specified amount of water.

Another move problem popular in problem solving literature was the missionaries-cannibals river crossing problem (another isomorph of the hobbits-orcs problem). Again, adult subjects participated in the experiments. The tasks in the experiment included the hobbits-orcs problem, cannibals-missionaries problem, and several other isomorphs of move problems. The goal of the study was to propose a model of problem solving that would end the discussion about the role of planning or how many moves ahead a naive subject planned.

Several problem isomorphs were used to demonstrate generalizability-across-move type problems. This work by Jeffries et al (1977) supported a GPS-like model of problem solving. Arming their position with assumptions about the capacity of short-term memory and the unlikeliness of subjects to change strategies while problem solving, Jeffries et al argued for one step at a time problem solving. These researchers limited the role of planning even further than Greeno (1974), who had proposed subjects change from one-step moves to planning ahead.

Summary of the Models of Move-Type Problems

The models proposed by Greeno (1974), Thomas (1974), Jeffries et al. (1977), and by Atwood and Polson (1976) all viewed planning from basically the same perspective. They all proposed hierarchical models to explain adult planning, and they all subscribed to the role of planning as simplification and abstraction. Despite small differences, the researchers all found planners followed the hierarchical model of planning. Additionally, the studies all used well-defined tasks. It was hypothesized for this investigation, however, that differences in tasks result in different planning processes.

Two Models of Adult Planning

Two studies of planning representing the two different views of the planning process discussed throughout this

review and central to the thesis of this study were conducted by Bryne (1977) and Hayes-Roth and Hayes-Roth (1978). The Bryne study supported the hierarchical model of planning and used a well-defined task. The Hayes-Roths study supported the heterarchical model of planning and used a less-defined task.

The Hierarchical Model of Planning

In a study of adult planning, Bryne (1977) studied ten adults, each planning menus for six dinner parties. Since all six menus were planned for the same guests, the subjects had to plan a different menu for each dinner party. The think-aloud method of inquiry (in which the planner verbalized all thoughts while planning) was used. Analysis of the protocols focused on memory theory and how closely it accounted for the findings of this study.

The task—plan a dinner party—met Bryne's requirements for a task suitable for study of the planning process and the human memory system. These requirements included:

> (1) It must take sufficiently long to complete so that thinking aloud during its execution is a natural behavior.
> (2) A large and complex body of information should be already available to the subjects, and the search of this body should be a part of the task.
> (3) It should be an ordinary and everyday one to the subjects, to tap the normal use of the system and avoid laboratory-specific strategies (Bryne, 1977, p. 289).

The results of Bryne's protocol analysis of the ten subjects planning six meals each were discussed by Bryne in

terms of current memory theory and characteristics of the planning processes used. A goal of his analysis was to examine the protocols and "isolate recurrent patterns of behavior" (Bryne, 1977, p. 307.). The findings concerning planning processes were of primary interest in this review.

Planning was a hierarchical process, according to the results of Bryne's protocol analysis. Specifically, subjects in the study revealed a hierarchical structure of goals. They split the problem—planning a meal—into separate goals and then examined and achieved the goals one by one. This process of satisfying one goal at a time, then moving on to consider the next has often been referred to as a "goal stack." This has also been the process used in computer-simulation programs.

Although goals were approached one at a time, Bryne found these goals were not necessarily independent of each other. This was evidenced when satisfaction of one goal satisfied a second, indicating some dependence in the two goals. When a goal was satisfied in this manner, Bryne's interpretation of the protocols indicated the second goal was automatically deleted from the goal stack. The evidence of this statement was not conclusive, but the author indicated support for this explanation of data. Another finding, dependent upon the above explanation of goal dependence, was that:

> . . . choice of an item to satisfy one goal may restrict what items can be used for other goals. Thus after each choice of an item, the system

> checks to see if there are any outstanding goals which this item satisfies, and it checks what restrictions this choice will impose on later choices" (Bryne, 1977, p. 324).

Goal order appeared also important to the planning process; goals attempted in a less than optimum order could make a task more difficult. In most of the protocols in Bryne's study, subjects used the same goal order. He interpreted this as an optimal order of goals existing for the task. When subjects used a different goal order, the protocols were more confused, the planning process appeared to be more difficult, and, in some instances, the subject started over and changed an aberrant goal order to conform with the "optimum" order. The optimum order consisted of a hierarchy of goals approached one at a time from the most abstract to the most detailed.

Bryne's (1977) study of meal planning was carefully conducted and well-documented. The analysis was both detailed and objective. In addition, Bryne readily examined his own assertions. He found support in his data for a hierarchical process of planning. Such a planning process was goal directed and is referred to as the hierarchical or top-down approach to planning. In such an approach, the planner focused on one goal at the top, solved that goal, then proceeded to the next lower-level goal. The hierarchical top-down planner began planning at the highest level or most abstract decision.

The Heterarchical Model of Planning

Protocols of adult planning have contradicted the traditional top-down or hierarchical model of the planner. In their recent work in planning, Hayes-Roth and Hayes-Roth (1978), Goldin and Hayes-Roth (1980), and Hayes-Roth (1980) found evidence supporting a different model of planning, labeled the opportunistic or heterarchical approach to planning. Within this model, decisions were made at all levels of abstraction and could influence either higher or lower levels of thinking. In short, a defined hierarchy of planning was not assumed.

The Hayes-Roths (1978) and Goldin and Hayes-Roth (1980) examined the think-aloud protocols of adults planning for tasks familiar to them. In one study, subjects were required to plan accomplishing as many activities as they could schedule from a list of things to do. The subjects were also provided with a map of an area that was familiar to them. The map depicted stores and buildings associated with the errands on the list. Constraints were also introduced into the task. These constraints required participants to accomplish a certain errand or to be at a certain place at a specified time.

Goldin and Hayes-Roth (1980) analyzed only the surface content of the planning protocols they collected. This was in contrast to the analysis performed by Newell and Simon (1972) and others in which covert processing was inferred from statements made by the subjects. In the Hayes-Roth

and Hayes-Roth (1978) and the Goldin and Hayes-Roth (1980) studies, segments of the protocols were coded according to planning planes, levels of abstraction, and type of decision made. The four planning planes represented different categories of planning decision (Hayes-Roth & Hayes-Roth, 1978):

(1) Plan plane: A decision on this plane states actions the planner will take.

(2) Plan abstraction plane: Here, the planner describes what characteristics she/he would like the plan to contain.

(3) Knowledge base plane: On this plane, wordly information and everyday knowledge is related to the planning process.

(4) Meta-plan plane: The planners remove themselves from actual details of planning and consider how to approach cognitive researches, deciding how to allocate time and memory among the competing cognitive demands.

Decisions within each of these planes were made at varying levels of abstraction.

There was no systematic order or hierarchy to this planning process. The order of the decisions depended on the opportunity as seen by the planner. The Hayes-Roths (1978) study characterized the planning process as a blackboard on which changing decisions were represented by planes and levels of abstraction. Similar to Bryne's

(1977) model of planning, they found decisions were not independent; unlike Bryne, their model of the planner was not a model of an orderly or systematic process of planning.

Six types of decisions about the plan itself were found in the Hayes-Roth and Hayes-Roth (1978) data and in Goldin's and Hayes-Roth's (1980) data:

(1) Generate - make decisions about the plan.

(2) Evaluate the plan, in light of the planner's criteria for the plan.

(3) Compare the two planning decisions at the same time and choose one.

(4) Monitor acts, like the bookkeeper keeping track of time left for unscheduled errands.

(5) Review - the planner simply goes over the steps in the plan thus far.

(6) Revise - with this type of decision, the planner changes decisions or actions being considered or actions just decided.

These six types of decisions in varying frequency were found in all of the protocols.

The results of the Hayes-Roths (1978) study indicated support for their opportunistic model of the planner. They defined the opportunistic model as one in which the "planner does not take a systematic approach to formulating a plan. Instead, at each point in time, he works on whatever part of the plan appears most amenable to further

development" (p. 6). Thus, the planning process was characterized as a series of decisions about what to do and how to do it.

The Hayes-Roth (1980) and Goldin and Hayes-Roth (1980) studies built upon the findings of the first Hayes-Roth and Hayes-Roth (1978) explorations in planning. The more recent study focused on defining differences between good and poor adult planners. Once again, the errand-planning task was used, with participants planning aloud the errands for a day. A map containing stores and buildings where the errands could be accomplished was also included. The goodness of the plan was evaluated as to the efficiency of the route taken and the realism of the estimates of time necessary to accomplish the tasks.

In addition to describing good and poor planners, results from these studies supported the opportunistic model of planning. Analysis of the protocols indicated good and poor planners "used the same criteria for generating and evaluating plans" (Goldin & Hayes-Roth, 1980, p. 6). The difference between good and poor planners was in the frequency of the use of the planning criteria: good planners used the criteria more often than poor planners. Good planners made more decisions in defining and focusing on the initial problem. In addition to using criteria more frequently, good planners were more detailed in considering the content of their planned actions. They also reviewed and evaluated their previous decisions more often than did

the poorer planners. The task constraints were also considered more frequently by good planners. Interestingly, both good and poor planners included basically the same plan components. It was the creative use of these components that resulted in different plans.

Analysis of the errand-task protocols defined an opportunistic model of planning for both good and poor planners. The hierarchical model of the planner proposed by other researchers (discussed above) was not followed by either good or poor planners.

The works of the Hayes-Roths (1978) and Hayes-Roth and Hayes-Roth (1980) and Goldin and Hayes-Roth (1980) left unanswered questions about the model of the planning process proposed and the universe of people and tasks to which it might apply. Two questions that remain are:

(1) Do transcripts of children planning indicate that children follow either the heterarchical or the hierarchical model of planning?

(2) Why are two opposing models of adult planning (the hierarchical model and the heterarchical model) found in studies with basically the same methodology (think aloud) and similar subjects (intelligent adults)?

The question of children's planning was approached earlier in this chapter. A possible answer to the second question is addressed below in the "Well-Defined and Ill-Defined Tasks" section.

Summary of the Models of Planning

The hierarchical model of planning found throughout much of the literature on problem solving and planning proposed a top-down process of planning, beginning with the goal at the highest level of abstraction. The planner then proceeded to solve each goal as he/she went down the hierarchy. This hierarchical view of planning resulted in a complete plan at each level of abstraction.

In contrast, the heterarchical plan was multidimensional in nature. The planner's moves were characterized as opportunistic, moving among levels of abstraction and detail as the opportunity presented itself. No hierarchy of planning order was proposed in the opportunistic model. The planner did not necessarily complete planning for each goal before moving on to the next goal, as was the case in the hierarchical model of planning. Plans at the lowest level of detail might inform planning at a much higher level of abstraction. Hayes-Roth (1980) found low-level bottom-up planning in their errand task, but neither top-down nor bottom-up direction in planning was proposed in the heterarchical model.

Well-Defined and Ill-Defined Tasks

Why did Bryne (1977), Jeffries (1974), and others (e.g., Atwood & Polson, 1976; Newell & Simon, 1972) find evidence for a hierarchical model of planning, while Hayes-Roths (1978) and Goldin and Hayes-Roth (1980) found

evidence for a heterarchical model of planning? The Hayes-Roths suggested the different models of planning might be an artifact of the types of planning tasks. The meal-planning test studied by Bryne (1977) was described by the Hayes-Roths as a well-defined task. In contrast, the Hayes-Roth (1978) and Goldin and Hayes-Roth (1980) errand-planning tasks were described as ill-defined problems.

One theory that may explain the different models of planning is that characteristics of the two types of tasks (well-defined versus ill-defined) may elicit different forms or types of planning processes. Tower of Hanoi and the cannibal-and-missionaries problems are among many well-defined tasks that have been studied. Well-defined tasks have an identifiable beginning and end. A well-defined problem is a well-formed problem where the solution may not be obvious but the planner is sure to know the direction to follow to form a solution (Klahr & Robinson, 1981). At the other end of the continuum is the ill-defined task (Reitman, 1965). The Hayes-Roths (1978) claimed their errand planning task was an ill-defined problem. This class of problem has open constraints and no clear solution. An ill-defined problem may have several correct answers. Although many intellectual problems are ill-defined, it is a type of problem that has been least well researched (Simon, 1973).

In his treatise on the continuum of ill- and well-defined problems, Reitman (1965) questioned if programs for

ill- and well-defined tasks could or should use the same model to characterize planning. The Hayes-Roths (1978) voiced this same suspicion—that ill- and well-defined problems might produce different models of planning.

Simon (1979) also found evidence while studying the problem of recognizing plans that ill-defined problems might require a different model of planning. Means-ends analysis and the generate-and-test method of problem solving might not be the most appropriate models for the solution of ill-formed problems and the method of means-ends analysis might only be appropriate for problems with a fixed search space. Ill-formed problems might require more complex hypotheses with subplans and subgoals.

Schmidt, Sirdharan and Goodson (1978) proposed a hypothesis-and-revise paradigm to explain recognition in ill-formed problems. This paradigm required prediction and judgment and the formation and testing of complex hypotheses, since the problem solver had to wait until enough information or action was observed to judge the hypotheses. Judgment of the correctness of these hypotheses could require a significant amount of time. Although the Schmidt et al. study focused on plan recognition rather than plan formation, the findings suggested different models of planning for ill-defined and well-defined problems.

Well-structured and ill-structured tasks may appear to be treated as exclusive categories of problems, but, in reality, this is not the case. The boundaries are

sufficiently blurred to prevent a sharp distinction among types of problem structures. For instance, well-structured problems may have elements of ill-structured ones (Greeno, 1976), and some ill-structured problems may be broken into smaller well-structured problems (Simon, 1973). A continuum with ill-structured problems at one end and well-structured problems at the other more accurately portrays differences in problem types. Weighing the properties of a task suggests where to place it on the continuum of ill-structured and well-structured problems. If the problem can be solved through a simple algorithm (such as an addition problem), it would be placed at the well-structured end of the continuum. In contrast, the problem of formulating United States Foreign Policy would fall at the far end of the ill-structured portion of the continuum.

The nature of the problem solver also defines the type of task. The skills and developmental level of planners and problem solvers must be clearly acknowledged. Tasks do have intrinsic structures, but the planner's interpretation and method of approaching the problem figures heavily in the problem definition. The importance of the structure of the task was addressed in the following:

> If we are studying the behavior of rats solving a maze, we need information about the maze they are trying to solve. If we know nothing of the number and arrangement of paths or the location of cues and rewards, we cannot expect to grasp what the rats' behavior depends upon, regardless of what their gross performance turns out to be. Similarly, if we are trying to understand how people solve problems of some sort, it is

> necessary to have a good grasp of the structure of the problems they undertake (Simon & Hayes, 1976, p. 73).

Perhaps the structure of the task will help define the structure of the cognitive model of the planner. More studies documenting planning for ill-defined problems are needed, since most of the problems a person faces in life are ill-defined ones (Simon, 1979). The study of well-defined problems is clearer from the standpoint of defining and understanding the task, testing algorithms, and documenting possible solutions and plans. But well-formed problems are not as cognitively interesting; a well-formed problem is already half solved (Simon, 1979). The real task is in defining the parameters of the problem (Polya, 1957).

Summary

In summary, the literature reviewed for this study indicated that planning was an important cognitive process that could be profitably studied in school-aged children. Despite increased interest in the educational implications of teaching generic skills such as planning, much of the research focused on the adult planner. Studies of children's planning were limited in scope, often using artificial problems. This investigation addressed the question of how children planned for tasks that were nonacademic in nature and varied in structure.

Planning theories presented in this review revealed two competing models of the planning process, with numerous studies cited in support of each. But continued research supporting one or the other model does not hold promise for further understanding of the planning process. Instead this study took a new approach—focusing on the task structure. It was hypothesized that differences in how children plan might be attributed to differences in planning tasks.

In order to study how children plan, two types of tasks (ill-structured and well-structured) were selected from studies discussed above. These tasks were selected to test the hypothesis of this study, that the type of task (ill-defined versus well-defined) may be related to the model of planning followed (either hierarchical or heterarchical) by the planner.

In this study, children were asked to describe aloud their thoughts as they worked on well-defined and ill-defined tasks. The think-aloud method was chosen as providing relatively complete protocols with minimal experimenter interference. It was hypothesized that children planning the ill-defined tasks would follow the heterarchical model of planning, and those children planning the well-defined tasks would follow the hierarchical model of planning. It was also hypothesized that the decisions made by students would differ, depending on the type of task. Specifically, planners working on the well-defined task would be more likely to make detailed statements, and

ill-defined task planners would make more abstract-level statements. Further, it was hypothesized that the planners for the ill-defined task would make more statements critiquing their plans than would planners for the well-defined task. Finally, it was hypothesized that achievement level of the student would not affect the form of the plan, the level of the decision, or the critique of the plan.

CHAPTER 3

METHOD

This chapter describes the study design and procedures and includes discussion of independent and dependent variables; the method used to investigate children's planning; and an explanation of the coding procedures, research questions, and analysis.

Population and Sample

The participants in this study were fifth-grade elementary students from four classrooms. Of these 78 ten- and eleven-year-old students, 45% were male and 55% were female. Students of this age were selected for two reasons. First, by this age they have a well-developed sense of causality and skills in planning, whereas early elementary students have difficulty both in their ability to verbalize their thoughts and in their ability to recognize the connection between strategies and outcomes (Flavell, 1970; Strommen, et al., 1977; Rogoff, 1982). Second, children in this age group, although theoretically capable of planning, can be considered novices at it and therefore become especially interesting to observe as they develop and modify planning strategies.

Achievement Grouping. Students were divided into two achievement groups. Group assignment depended upon each student's score on the Metropolitan Reading Test administered while in the fourth grade and upon teacher rating of the individual. Fifty-one percent of the students were assigned to Group 1, and 40% were assigned to Group 2.

Task Assignment. Although efforts were made to assign an equal number of students to each task, a slightly greater number of students was assigned to the dinner planning task. This occurred because some students were absent during the initial permission period, and some students were late returning their permission forms. The delay was considered a minor problem, however, and did not appear to confound the results. Breakdown of student assignment to task is contained in Table 1.

Classroom Participation. Classroom 1 had an 85% participation rate and accounted for 28% of the total sample. Classroom 2 had the highest participation rate, with 90% of the students joining in the study and accounting for for 26% of the total sample. Classroom 3's participation rate was 80%, or 19% of the entire sample group. Finally, in Classroom 4, 86% of the students participated in the study, accounting for 27% of the total sample of planners.

Site

Four fifth-grade teachers and 78 students from two elementary schools near a large university participated in

Table 1. Assignment of Students to Tasks.

Task	Students	
	N	%
Well-Defined		
Dinner 1	22	28.2
Dinner 2	20	26.5
Ill-Defined		
Errand 1	18	23.1
Errand 2	18	23.1
TOTAL	78	

the study. The school populations included black, Spanish, caucasian, and Asian children. Although the schools were recipients of Chapter I funds, many of the children were from professional families.

The teachers had all previously participated in and/or worked on research studies in education, and research had been a common occurrence in all four classrooms. Though many researchers have considered working with students who have had prior research experience a problem, the familiarity students and teachers already had with the research process became an asset for this study. For the students, this was of advantage because the tasks they needed to perform required they feel comfortable and able to express themselves verbally. The teachers' experiences with research projects served not only to ease the introduction of the study to students but their enthusiasm also helped to encourage student participation.

Think-Aloud Technique

As a method of inquiry, the think-aloud technique is both classic and modern, having been first developed by Duncker (1945) and used in his studies of medical problem solving. When employing this technique, verbalizations are recorded on audiotape, and transcripts of the think-aloud sessions become the data used to test hypotheses and build new models of cognitive processes. In this study, the think-aloud interview technique was used to encourage

participants to verbalize their thoughts while in the act of planning. It was chosen because it allowed students to plan and express all their thoughts without interruption (except for an occasional prompt when a participant was silent for a long period).

Other methods of inquiry considered for this study either interrupted the students' planning or required them to recall what they had been thinking. The first (interruption) disrupts the thought process; questions asked throughout a session could redirect students' thinking. The second (recall) relies on students' ability to remember without distortion or correction what they have been thinking—a difficult task at best, even for trained adults. Thus, the think-aloud method was considered the optimum procedure to use for data collection in this study.

Procedure

After obtaining permission from the Human Subjects Committee of Michigan State University to conduct this study, it was also necessary to gain approval from the school district's research committee and from principals and teachers. The investigator then contacted four teachers interested in having their students participate in the project. At a convenient time, the classroom teacher and researcher discussed the study with the class and answered questions posed by students. Parental permission forms were distributed at the end of the school day (see

Appendix A). On the cutoff date for returning the permission forms, teachers divided the list of participating students into two achievement groups. Group assignment was based primarily on test scores from the Metropolitan Reading Test administered the previous year. Students were then randomly assigned to tasks according to the blind data collection procedure (Appendix B).

It was the researcher's desire to become familiar with as many of the students as possible, without disrupting the flow of classroom events. Teacher aids, university students, and parents were frequent visitors to these classrooms. Thus, following the students' initial interest in the researcher's presence in their class, they soon returned to their work and school concerns, requesting the researcher's help with problems in math or other subjects. The purpose of this exercise was twofold. First, both the students and researcher had opportunity to interact and observe each other prior to the one-on-one data collection session. The researcher was no longer a stranger. Second, the tasks students needed to perform in the session required they felt comfortable and able to express themselves. Familiarity with the researcher would help alleviate any inhibitions to speak freely.

Participation in the study was voluntary, and students were given opportunity to withdraw at any time during its course. Those who had agreed to participate were selected one at a time by their teacher to take part in a planning

session with the investigator. Each student was asked by the teacher if he/she was willing to participate in the study at that time. If the student was willing, the student and researcher left the classroom to begin the session.

During the planning session, a single participant and the researcher sat in a quiet room that was comfortable and familiar to the student. All utterances were audio recorded. To begin, the student and researcher engaged in a short discussion of planning, with any questions or needs for clarification addressed at that time. The researcher handed a written description of the problem to the student and read it aloud while the student-planner read it silently. This was followed by the student's completing a short practice task and discussing it with the researcher. Finally, the student-planner began the experimental task. Tasks were randomly assigned, one task per student, based upon an assigned student number.

Instructions and Participation

In their review of think-aloud studies of cognition, Ericsson and Simon (1980) noted the clearest think-aloud transcripts were found in studies in which instructions for the task were simple and short. The aim of these instructions was to facilitate subjects' abilities to verbalize what was in their short-term memory. Subjects were also not asked to perform other tasks, such as physical

manipulation of objects, during the think-aloud session, since any further instructions or requirements might interfere with the subject's ability to think-aloud while problem solving. Thus, instructions for the study were designed to be brief and simple, and children were not required to physically move objects while planning (Appendix C).

After instructions were read to the student, the child's willingness to participate was reconfirmed before the planning task was introduced. Reconfirmation was conducted to not only protect the child's right to decline participation but also to ensure his or her cooperation. If the scheduled one-on-one session was interfering with a preferred classroom activity, the student was encouraged to return to class and participate in the study at another time. Although teachers had been requested to release students only at times convenient to both, it remained important to ask the child directly if he or she was willing to participate at that time since teachers could not always predict what class activities are important to a specific student (Weinstein, 1980).

Data

Verbal reports are data and, as such, can be analyzed in a variety of ways. Data in this study consisted of tape-recorded oral reports of children planning. These reports were transcribed and analyzed according to a coding

system developed for this study. As suggested by Ericsson and Simon (1980), the researcher requested no information other than what was presently in the participant's awareness. Data therefore represented information obtained during the planning session that was in the child's short-term memory.

Development of the Coding System

The objective of the coding protocol was to simplify think-aloud planning sessions without altering the essential nature of the information (Duncker, 1945). The coding system for the analysis of the protocols was adapted on planning and problem-solving studies of adults and children. Since the primary concern in this study was hypothesis testing, basic coding categories were established in advance (Newell & Simon, 1972; Bruner, 1957). However, it was necessary to further expand and adapt some of the categories to more fully analyze the planning protocols collected in this study.

Development of the coding system was a long, continuously evolving process. Several systems of variables and concepts were tried, but they failed to adequately explain the data. These systems, including parts of the coding system used in the pilot study, were amended and used in the final analysis of the protocols. Components of the planning process were developed through a review and analysis of all the interviews and further review of previous

research results. After initial attempts to explain the data, more specific codes designed to fit the tasks used in this study were considered. Finally, a case study of two subjects was outlined to aid in the development of codes and explanations of student planning.

Coding Procedures

All planning interviews were tape recorded and transcribed. The transcripts were verified, and any inconsistencies between the audio and typed versions were corrected. Transcripts were then analyzed line by line and codes assigned to each statement. These codes provided both quantitative and qualitative data.

All interviews were coded by two trained coders, only one of whom was unfamiliar with the intent and conditions of the study. Although content of the planning tasks could be identified, specific task structure and condition were not labeled, nor were they apparent to the coders. Reliability of the coding procedures was determined by coder agreement, computed by counting the number of codes in agreement and number in disagreement. Codes computed on 20 variables excerpted from 16 planning sessions resulted in a 74% agreement between the coders. Disagreements were resolved through clarification of coding strategies, and adjustments were then made in the system to aid coders in reaching a consistent analysis of the planning interviews. Percent agreement was again computed after recoding and

further practice with planning protocols, reaching 84 percent. Disagreement centered around two problem codes which were discussed and resolved. Appendix D contains the coding instructions and outline.

Design

The central research question of this study was: Do children's plans differ with the task they are planning? A second question concerned student achievement level and its effect on children's planning. The question of achievement effects might confound any main effects or introduce an interaction between achievement and task. Therefore, achievement was included as a second factor in the study. In order to address these questions, planning tasks were developed, and several components of children's plans were identified.

Factors

Tasks

Interest in task and activity structures has been a relatively recent phenomenon in educational literature (Bossert, 1979; Doyle, 1979, 1981; Blumenfeld, 1979), and researchers have called for an increase in ecological research in classrooms, which includes accounting and documenting of activities and tasks. Much of this work has represented the sociological view of classrooms (Bossert, 1979). In contrast, both Doyle (1979, 1981) and Blumenfeld

(1979) moved from the sociological aspects of the environment in which activities were contained to the cognitive components of the task. Doyle (1979) stated that although it was important to recognize tasks were influenced by the context of the classroom, "the ecology of the classroom and the task can also be viewed as independent of each other. Differences in the setting will not change what is learned, although it may influence how much is retained" (p. 14), whereas if the task was changed, what was learned changed. It was the latter of these two concepts—changes in cognitive information processing that relate to task—that was of interest in this study.

In order to discuss changes in task, it is necessary to further analyze the tasks in this study. Doyle (1979), Blumenfeld (1979), and Bossert (1979) presented characteristics of tasks and environments. The discussion below elaborates and extends their analyses of task and the relation to information processing.

The four tasks presented to students in this study represented two types of content (dinner planning and errand planning) and differed in level of complexity. The tasks have been described as ill-defined and well-defined and are discussed in this manner by the previous researchers who used the dinner-planning and errand-planning tasks in their studies on planning. The terms ill-defined and well-defined described the structure and

complexity of each task and represented ends of a continuum of task structure (see Chapter 2).

Dinner-Planning Tasks. Students selected for these tasks planned three balanced meals. Dinner-planning Task 1 had little structure, resulting in few restrictions. Dinner-planning Task 2 also required students to plan three balanced meals but contained specific constraints that required students to plan for guests' likes and dislikes. Appendix E outlines these two dinner-planning tasks.

Errand-Planning Tasks. Planning for the two errand-planning tasks involved selection, sequencing, and timing of errands. The planner was provided with a list of errands and a map. He or she was instructed to accomplish as many of the errands as possible in a two-hour time period, being cautioned to travel efficiently and keep track of the time. Errands could be planned in any order. The errand-planning tasks, similar to the dinner tasks, differed in the number of constraints placed upon the planner (see Appendix F).

Student Achievement

The achievement variable was considered as a factor in the design of this study. Achievement was defined by students' scores on the Metropolitan Reading Test administered the prior school year and teachers' ratings of the students' overall school achievement. Students were divided into two achievement groups representing a continuum of

scores. Group 1 planners scored higher in comprehension (at least 52 or better) than had planners in Group 2. Discrepancies between test scores and teacher rating were discussed with the teacher prior to assigning a child to a group. Students from both achievement groups were randomly assigned a planning task.

Criterion Variables

Seventeen criteria or dependent measures (14 quantitative and 3 qualitative) were used to describe how children planned for the task in this study. For discussion purposes, these measures were organized into six components of planning: (1) goal statements, (2) form of the plan, (3) concomitant plan characteristics, (4) problem definition, (5) plan critique, and (6) plan success. These categories, conjunction with the factors task and achievement, were developed from theory based on concepts important to understanding children's planning. A brief description of each of the categories follows. Further information on the components and bases for the categories is found in Appendix G.

Goal Statements

Goal statements reflected the quantity and level of statements made by a planner. The decision-level variables were based on Goldin's and Hayes-Roth's (1980) study of planning and Bryne's (1970) dinner-planning study. Goldin

and Hayes-Roth used planning planes (similar to decision levels) to describe processing; Bryne analyzed decision levels to discover optimum ordering of goals. Decision levels ranged from abstract to detailed statements.

Although the levels did not have any value placed on them, they helped the researcher develop a descriptive profile of how planning flowed. For instance, some students might have made many statements about the details of a planning task while others might only have produced a very abstract plan, rarely or never making detail comments. In both cases, the planner might plan, for example, an equal number of errands, but the individual approach to planning might differ. More commonly, however, planning statements represented a mix of several levels of processing.

There were four levels of planning statements identified in this study: abstract, selection, route/step, and detail. Individual sequencing and patterns of these levels figured heavily in determining the form of the plan (discussed below). Abstract-level statements pertained to the overall plan and how it was developed. They were not tied to specific items of information; rather, they concerned the plan design.

The next level focused on the selection of errands or menus. Selection statements occurred when the planner was deciding which tasks to do. In the errand-planning tasks, for example, selection statements referred to specific errands the planner would run or had just completed.

"First, I'll go to the party store" would be an example of a selection statement.

Route- or step- level planning statements referred to the increments by which a student planned the route to accomplish an errand or the step necessary to prepare dinner. At this level, information was more concrete, and the focus was on completing an errand or preparing dinner. An illustration of a route statement would be, "I will go down Charles Street and turn right." Though planners could make all decisions on this level, generally higher level (abstract or selection) statements drove the step/route-level decisions.

Finally, the detail-level planning statement reflected extra information about a goal or decision just completed. Detail-level statements were usually contained within a higher-level decision. Frequently, information that seemed to be superfluous to the main task was found at the detail level. For example, "I hate to play pinball because I always lose" was considered detail information not directly tied to the route or design, though it still had the potential of influencing higher-level decisions. This detail information could change the plan; if the planner did not like pinball and was running short of time (in, e.g., the errand-planning task), he or she might change the design of the plan to exclude this errand. The detail-level statement might therefore provide valuable insight into decisions made at all levels.

Form of the Plan

One of the central questions of this study was: Does the form of the plan differ with the task or the achievement level of the planner? Two forms assessed in this study (and discussed in Chapter 2) were the hierarchical (Bryne, 1970) and heterarchical (Hayes-Roth & Hayes-Roth, 1978) models of planning. Both involved goal ordering and goal completion. The form of hte plan is based on Hayes-Roth's and Hayes-Roth's (1978) studies of planning and on Bryne's (1970) study of planning. These variables were created to help describe the type of planning model students followed while planning the assigned task.

In this study, it was hypothesized that form of the plan would differ for ill-defined and well-defined tasks. It was hypothesized that students planning the well-defined task would follow the hierarchical model and those planning the ill-defined task would follow the opportunistic model, varying the order of the goals and abandoning goals before completion.

Goal Ordering. One important measure of the planning process was the order in which the planning statements were made. This order was key in assessing if the planning form or model followed was an example of top-down planning or an example of opportunistic planning. If planning was hierarchical (top-down), then all statements would proceed from the top of the hierarchy (abstract level) down to the

detail level. If the heterarchical model was followed, then statements might occur in any order.

Bryne's (1970) characterized planning as proceeding one-way down the hierarchy. Detail-level decisions did not inform or change the higher-level statements. Planners in Bryne's study followed what was described as top-down planning. They approached the dinner-planning task solving one goal at a time from the abstract level to the detail level. Each goal in the hierarchy was completed before moving to the next one.

In contrast, Hayes-Roth and Hayes-Roth (1978, 1978, 1983) and Goldin and Hayes-Roth (1980) found evidence supporting the heterarchical model in their studies of adults planning errand tasks. Planning in this model was opportunistic; detailed or directing statements could inform decisions at a higher level. It was characterized as not necessarily following a top-down hierarchy; rather, planners might use a hierarchical planning strategy or they might deviate from it. In this study, opportunism was defined through the statement levels in planning interviews. If a planner made a detail statement which informed or determined higher-level abstract outcomes, then the planner was following the heterarchical or opportunistic model of planning.

Goal Completion. One determinant of which planning form was used by study participants was the completion of goals. Goal completion referred to whether or not a

planner followed a goal through to completion. It was measured by the number of times a subject moved on to the next goal before completing a previous one. If the planner abandoned a goal prior to its solution and moved on to another, or if the planner returned later to complete the goal, it was not considered a completed goal.

An example of an incomplete goal was if the planner began to plan the type of dinner but abandoned that goal to plan dessert and then resumed planning the type of dinner. In the errand planning task, a planner who began planning by scheduling the next closest errand followed by temporary abandonment of that goal to go to a favorite errand did not complete the original goal. An incomplete goal was more than a revision, however; if a change or revision occurred at the same level (e.g., the planner replaced a Chinese dinner plan with a Mexican dinner plan), such a change was not an incomplete goal. The goal—planning a type of dinner—was still being addressed. One abstract planning decision had replaced another.

Concomitant Plan Characteristics

Plan components that went beyond what was needed in the planning task constituted concomitant characteristics. Such components included goal statements that expanded, elaborated, or provided a rationale for other statements and, as such, were coded as concomitant planning statements. Another category of concomitant plan

characteristics—called extras—included planned errand or dinner items beyond the number required to complete the task. Artifacts, such as drawings or lists created by the planner during the planning session, were also included in the category of concomitant plan characteristics. Concomitant statements were found in Goldin's and Hayes-Roth's (1980) study of planning and were helpful in describing differences in planning protocols. Kuetzer, et al. (1975) also documented instances in which students used artifacts as external memory aids in a study of children's planning and metacognitive skills.

In this study, it was hypothesized that concomitant variables would occur more frequently in ill-defined planning tasks, which required students to work on structuring the task. All of these variables added depth and interest to the studetns' plans, although they were note required in the instructions given the children. By creating these statements, students elaborated and expanded upon the planning task.

Problem Definition

This group of measures depicted the planners' attempts to define the cognitive problem space in which they worked. Problem definition consisted of planner-created problem constraints and assigned task constraints discussed by the planner. A planner who was searching for direction and asked, "Where do I live?" provides an illustration of a

problem definition occurring early in the task. In this example, the planner was attempting, through further definition of the problem, to determine the best starting point for accomplishing the errands listed.

Defining the parameters of the task appeared to be an important component of the planning process in many of the studies reviewed (Goldin & Hayes-Roth, 1980; Klahr & Robinson, 1981; Lawson, 1984). For this study, it was hypothesized that well-defined task planners would not only define the problem in a different manner from ill-defined task planners and would also define the problem less frequently than ill-defined task planners.

Plan Critique

This series of qualitative codes was used to describe how a planner evaluated, reviewed, and revised a plan during the planning session, since the plan critique might be an important self-monitoring function in the planning process. Evaluation, review, and revision of the plan revealed glimpses of the cognitive work involved in planning. During one interview and after planning several errands, a student paused, looked at the list, and said, "I'm wondering if I should go to Pinball Pete's or not. I don't think I will. Hmm, by the time I get there it will be later." He then resumed planning errand tasks and reviewed and revised his own plan without any prompting or specific instruction.

The variables described in this category were developed from studies of children planning (Rogoff, 1982; Brown, 1978; Flavell, 1970) which found children employed such strategies in planning and problem solving. Goldin and Hayes-Roth (1980) found adults also critiqued their plans and that the more successful planners did more critiquing. For this study, it was hypothesized that plan critiquing, similar to plan definition, would occur more frequently in plans of students assigned to the ill-defined tasks because students had a greater role in structuring the task.

Success of the Plan

The criteria associated with success of the plan focused on measures of the number of task constraints met by the planner. Specifically, students were required to plan three balanced meals in dinner-planning Tasks 1 and 2. Successful planners met this constraint. Errand-planning Tasks 1 and 2 required planners to be at a specific location at noon; being there indicated task constraints were met. A second measure of success was the efficiency of the plan. Inefficient errand moves detracted from the success of the overall plan. Tracing a planner's moves and the list of errands selected indicated whether or not he or she followed an efficient path while planning errands.

The success-of-the-plan measure was adapted from Goldin's & Hayes-Roth's (1980) study of individual

differences in planning. For this study, it was hypothesized that students who planned well-defined tasks would be more successful planners than those assigned to ill-defined tasks. This result was expected because of the extra cognitive demands of structuring required to plan an ill-defined task.

Factors Affecting Design and Analysis

The goal of this study was to investigate children's planning, more specifically, to make statements and inferences about the relationship between plan characteristics and task. To test hypotheses and make statements, it was necessary to consider elements of experimental design while organizing the study and collecting and analyzing the data. The following discussion focuses on three goals of experimental design—internal validity, precision, and external validity—and the steps taken to achieve these goals in all phases of the study.

Internal Validity

Internal validity refers to attaining an unbiased estimate of the treatment main effects. Random assignment and control of confounding variables are two strategies used to achieve internal validity; both strategies were employed in this study. First, students were randomly assigned to the treatments, which included four levels of the variable task. Student achievement was also included

as an independent variable to investigate possible interaction between achievement and task. In addition, the student was treated as both the experimental unit and the unit of analysis, avoiding confounding in the analysis.

Maintaining internal validity necessitates addressing factors of history, maturation, testing, selection, and mortality. History and maturation were not of major concern in this study because the study was completed within a month of selection. Mortality was not a problem in that all students selected were included in the study. Selection, however, was an area of concern; to avoid bias in selection, all students were randomly assigned to the treatment or task.

Precision

The precision aspect of design was concerned with controlling Type 2 errors while holding Type 1 errors constant. Precision was achieved through careful design and analysis. In this study, the goal was to estimate treatment differences. A study with greater precision means there is better chance of detecting treatment differences and rejecting the null hypothesis. Although specific judgments of precision need to be discussed hypothesis by hypothesis, design strategies can contribute to increased precision. First, sample size may be increased; this decreases the standard error which, in turn, increases precision. For reasons of precision, the sample size in this

study was increased from a proposed 10 to 20 students to 78 children. Second, more homogeneous populations may increase precision. This was achieved indirectly in this study by grouping students on achievement. The last strategy discussed here involved increasing the reliability of the dependent variable. Efforts were made to develop dependent measures based on current theory, previous research, and data from a similar pilot study. In summary, efforts were made to increase power without compromising the alpha level.

External Validity

External validity involves one of the core reasons for planning and conducting a research study: generalizability. The sample of students who participated in this study, although not randomly selected from the population, were thoroughly described in the study, invoking the use of the Cornfield-Tukey Bridge. Additionally, the experimental unit and the unit of analysis were both the individual, avoiding the problem of generalizing from the class as a unit to the individual.

Although the study was conducted in a room apart from the classroom and the think-aloud method was an imposition on participants, the study did take place in familiar surroundings found in most schools. Students were also familiar with the investigator, and the tasks consisted of problems not uncommon in upper-elementary students' lives,

which was an important factor when considering ability to generalize to other tasks.

Finally, to ensure external validity, the range of conditions compared in the study was increased from two to four conditions. These extra conditions provided greater understanding of the differences in tasks and "greater confidence . . . in the extrapolation of the conclusions" (Cox, 1958, p. 18).

Analysis

The purpose of this study was to determine if children's plans differed with achievement level and with the type of task. The tasks included two well-structured and two ill-structured tasks. Seventeen measures of planning behavior (grouped under the six categories of form of the plan, goal statements, concomitant plan characteristics, plan definition, critique of the plan, and success of the plan) were coded and analyzed. Although the measures were grouped in categories for discussion purposes, it should be understood that 14 of those 17 variables variables were considered interval data in the analysis strategy and the remaining three variables were categorical data which were analyzed separately.

To more fully explain the dependent measures, six hypotheses are listed next. Each hypothesis includes a list of variables associated with the category. These six

hypotheses are only intended to provide a clearer, more succinct description of the variables.

(1) Form of the plan. Hypothesis 1:

Task type and achievement do not have an effect on goal ordering, bottom-up planning, or goal completion.

(2) Goal statements. Hypothesis 2:

Task type and achievement do not have an effect on the number of detail, procedural, selection, and abstract statements made during planning.

(3) Concomitant variables. Hypothesis 3:

Task type and achievement do not have an effect on number of statements that expand, elaborate, or provide rationales for planning behavior. Task type and achievement do not have an effect on the use of artifacts by the planner or on the type of initial planning statement made by the planner.

(4) Problem definition. Hypothesis 4:

Task type and achievement do not have an effect on the number of statements concerning planning constraints or robust planning statements.

(5) Plan critique. Hypothesis 5:

Task type and achievement do not have an effect on the number of statements concerned with evaluation, review, and revision of the plan.

(6) Success. Hypothesis 6:

Task type and achievement do not have an effect on the success of the plan.

Statistical Procedures

Inferential statistics used in the analysis included the Multivariate Analysis of Variance (MANOVA), which provided a test for interactions as well as tests of the main effects, and the Chi Square test of significance for three dependent variables at the ordinal level. Analysis procedures were conducted using the Statistical Package for Social Sciences (SPSS).

Multivariate analysis of variance is the suggested method of analysis for designs with multiple sources of input variables (Morrison, 1976).

> Multivariate methods are appropriate when a study contains multiple outcomes, or dependent, or criterion measures. They frequently constitute the most realistic statistical models for behavioral data, especially when the research evolves from a multiple-input, multiple-output paradigm (Finn, 1974, p. 7).

MANOVA procedures were used in this study to analyze differences between the two factors, task and achievement, on 14 measures or dependent variables. These multiple dependent measures were interval level measures and were not necessarily independent. Through the use of MANOVA procedures, it was possible to avoid over-inflating the alpha level that might occur when variables were separated into several ANOVA procedures. The variables included in the MANOVA procedure are listed below:

(1) Independent variables

Achievement	Group 1
	Group 2
Task	Dinner 1
	Dinner 2
	Errand 1
	Errand 2

(2) Dependent variables

Goal ordering
Goal completion
Bottom-up planning
Abstract statements
Selection statements
Step level statements
Detail level statements
Constraints by the planner
Robust statements
Statements that elaborate or expand
Evaluation or review statements
Revision statements
Constraints listed by the planner
Statements added to the end of the plan

Appendix G contains a grid of the overall design and variables.

Three additional dependent measures analyzed using Chi Square tests of significance for relationships between categorical data were: initial planning statement, artifacts, and success. Chi Square tests of significance determined if the factors and measures included in the design were related in a systematic manner; that is, they were statistically independent of each other. This test did not indicate how strong a relationship was, however; it indicated only if there was a significant relationship. The measure of association appropriate for the analysis was selected to describe the strength of any significant Chi Square tests.

CHAPTER 4

RESULTS

This study addressed the question: Do differences in planning tasks and achievement influence the cognitive model of planning? Stated in hypothesis form, this question was:

> Given four tasks (two dinner planning and two errand planning) of varying complexity and structure and given two achievement groups of students, there will be no differences in plans created by students in the task conditions or in achievement groups and there will be no task-by-achievement effect.

The analysis for this study addressed the concern that students' plans might be influenced by both achievement and task. Thus, achievement and task effects and interactions were investigated. Plans were analyzed using inferential statistics (MANOVA and Chi Square).

Multivariate and Univariate Analysis of Variance

The Multivariate analysis of variance (MANOVA) procedure tests for differences among groups. In this study, the factors achievement and task were analyzed using the MANOVA procedure. Although a single MANOVA procedure

was performed to test for differences between well-defined and ill-defined tasks, several *a priori* comparisons were also included in the design of the analysis. These comparisons were developed to further define differences between groups and included:

(1) For both Achievement Groups 1 and 2, a comparison of plans developed by students assigned to the ill-defined (Errand 1) Task 2 and plans developed by students assigned to the ill-defined (Errand 2) Task 2.

(2) For both Achievement Groups 1 and 2, a comparison of plans developed by students assigned to the well-defined (Dinner 1) Task 1 with plans developed by students assigned to the well-defined (Dinner 2) Task 2.

(3) For both Achievement Groups 1 and 2, a comparison of the plans developed by students assigned to the ill-defined (errand) tasks with plans developed by students assigned to the well-defined (dinner) tasks.

Comparisons 1 and 2 focused on differences at each end of the continuum of task structure. Specifically, the first one compared two ill-defined tasks which differed in the number of constraints: errand-planning Tasks 1 and 2. The second compared well-defined dinner-planning Task 1, which had few constraints, with Task 2, which had numerous constraints. Comparison 3 examined global differences in planning between both the ill-defined and well-defined

tasks which represented two ends of the continuum of task structure. MANOVA results of each of the three comparisons are contained in Table 2.

Interactions Between Task and Achievement

MANOVA tests for interactions among the main effects or factors in a design that may suggest explanations for differences found between groups. In the analysis performed for this study, the test for interactions between the factors task and achievement was not significant (see Table 2). This indicated any main effect differences found were not confounded by interactions with other factors included in the design.

Achievement

Although there were no achievement-by-task interactions, there was a significant main effect for achievement ($p = .023$), detailed in Table 3. Examination of the means and standard deviations for the two achievement groups indicated planners in Achievement Group 1 (high achievers) planned differently from planners in Achievement Group 2 (low achievers), regardless of the type of task. Cell-mean information for both groups is listed in Table 4.

In addition to the multivariate test, univariate tests were run to determine which variables accounted for the differences between achievement groups. Results of the univariate analysis indicated six variables contributed to

Table 2. Multivariate Analysis of Variance Results for Interaction Between Task and Achievement.

Sources of Variation	Degrees of Freedom	Significance of F
Comparison 1: Errand Tasks by Achievement	14, 57	.8570
Comparison 2: Dinner Tasks by Achievement	14, 57	.1084
Comparison 3: Errand and Dinner Tasks by Achievement	14, 57	.6508

Table 3. Multivariate Analysis of Variance Results for Main Effects of Achievement and Comparisons of Tasks.

Sources of Variation	Degrees of Freedom	Significance of F
Achievement: Group 1 versus Group 2	14, 57	.0233*
Comparison 1: Errand Tasks	14, 57	.0305*
Comparison 2: Dinner Tasks	14, 57	.1485
Comparison 3: Errand and Dinner Tasks	14, 57	.0008*

Significant at $\alpha = .05$ or less.

Table 4. Well-Defined and Ill-Defined Task by Achievement Groups 1 and 2: Cell Means and Standard Deviations.

	Achievement Group 1		Achievement Group 2	
Plan Variables	Dinner Tasks	Errand Tasks	Dinner Tasks	Errand Tasks
Goal Statements				
Abstract Level	2.2272 (1.5409)	3.5555 (4.2595)	1.5000 (1.1470)	1.3888 (1.2897)
Selection Level	12.3636 (3.9945)	12.1111 (3.7083)	9.3000 (3.8675)	11.7222 (2.5851)
Route/Step Level	.3636 (.9021)	1.3888 (1.5392)	.2000 (.5231)	.8333 (1.7235)
Detail Level	1.9545 (2.1486)	.7222 (1.3636)	.5500 (1.0500)	.0555 (2.357)
Form of Plan				
Goal Ordering	.5454 (1.100)	.6111 (1.5392)	.450 (.6048)	.1666 (.3834)
Goal Completion	.9090 (.4264)	.16667 (.5145)	.0500 (.2236)	.1111 (.3233)
Bottom-Up Planning	.2272 (.5284)	.8888 (1.323)	.2000 (.4103)	.6667 (.7669)
Concomitant Variables				
Planner Constraints	.9545 (.8985)	.9444 (1.1617)	.5500 (.8870)	.16667 (.3834)
Expand, Elaborate	3.3181 (2.6074)	.7222 (.9582)	1.0500 (1.468)	.3333 (.6859)
Extras	.5909 (1.0537)	.2222 (.5483)	.4500 (.8255)	0 0
Problem Definition				
Task Constraints	1.6818 (.5679)	1.3333 (.5940)	1.4500 (.6048)	1.1111 (.4714)
Robust Statements	.2272 (.5284)	0	.4500 (.8255)	0
Critique				
Evaluate, Review	1.5909 (2.1080)	2.1666 (2.3326)	.3500 (.8127)	.4444 (.6157)
Revise	.8181 (1.1806)	1.5000 (2.0934)	.3000 (.6559)	1.1111 (1.3672)

differences between the two groups: (1) abstract-level statements, (2) selection-level statements, (3) detail-level statements, (4) constraints developed by the planner, (5) statements that expanded or elaborated on previous statements, and (6) statements that reviewed or evaluated the plan. Univariate test results are shown in Table 5.

Examining means for the two groups, it is evident that students in the high achieving group generally made more abstract-, selection-, and detail-level statements than did students in the low achievement group (see Table 4). Univariate test results of the fourth measure (constraints developed by the planner) indicated planners in the high achievement group were also more likely to create constraints than planners in the low-achievement group (Table 4). Statements made by planners that expanded, elaborated, or provided a rationale for statements made earlier in the plan were more frequent among the high achievers (Group 1). Similarly, statements that evaluated or reviewed the plan occurred more frequently in plans made by students in Group 1, the low-achievement group (see Table 4).

A Priori Comparisons for Main Effect: Task

Comparison 1. Ill-Defined Tasks

Comparison of the two tasks described as well-defined (Errand Tasks 1 and 2) was significant ($p = .0305$). This indicated there were differences in the ways children

planned for Errand Task 1, which had few constraints, and for Errand Task 2, containing several constraints. These MANOVA results are listed in Table 5.

Examining the univariate test for differences in dependent measures showed only one measure was significant: the number of task constraints listed by the planner. This measure had a p value of .048 with 1 and 70 degrees of freedom (Table 6). Inspection of means and standard deviations in Table 7 showed a slightly higher mean for Dinner and Errand Task 2.

Comparison 2. Well-Defined Tasks

There were no significant differences between plans created for Dinner Task 1 and Dinner Task 2. The MANOVA results for this comparison appear in Table 3.

Comparison 3. Ill-Defined and Well-Defined Tasks

For this comparison, student plans for the ill-defined Tasks 1 and 2 were combined and plans for well-defined Tasks 1 and 2 were combined to test the hypothesis that there would be no significant differences between plans created for both the ill-defined and well-defined tasks. The results of the comparison (Table 3) indicated plans developed for ill-defined tasks differed from those developed for well-defined ones ($p = .0008$). This result allowed the rejection of the hypothesis that there would be no differences between groups.

Table 5. Univariate Tests of Achievement Effects.

Sources of Variation	Degrees of Freedom	Significance of F
Abstract level statements	1, 70	.01113*
Selection level statements	1, 70	.03442*
Route/Step level statements	1, 70	.21357
Detail level statements	1, 70	.00205*
Goal ordering statements	1, 70	.27214
Goal completion statements	1, 70	.56017
Bottom-up planning	1, 70	.5120
Planner constraints	1, 70	.00593*
Expand, elaborate statements	1, 70	.00600*
Evaluate, review statements	1, 70	.00230*

Significant at α =.05 or less.

Table 6. Univariate Tests of Ill-Defined Tasks 1 and 2.

Sources of Variation	Degrees of Freedom	Significance of F
Abstract level statements	1, 70	.2302
Selection level statements	1, 70	.1533
Step level statements	1, 70	.9422
Detail level statements	1, 70	.7180
Goal ordering statements	1, 70	.3553
Goal completion statements	1, 70	.2141
Bottom-up planning	1, 70	.5170
Planner constraints	1, 70	.0697
Expand, elaborate statements	1, 70	.4987
Task constraints listed	1, 70	.0481*
Robust statements	1, 70	.8399
Extras	1, 70	.3144
Evaluate, review statements	1, 70	.5813
Revision statements	1, 70	.7349

Significant at $\alpha = .05$ or less.

Table 7. Well-Defined Tasks 1 and 2 and Ill-Defined Tasks 1 and 2: Cell Means and Standard Deviations.

	Dinner		Errand	
Plan Variables	Task 1	Task 2	Task 1	Task 2
Goal Statements				
Abstract Level	1.425 (1.353)	2.35 (1.208)	2.333 (1.750)	2.610 (3.499)
Selection Level	11.525 (3.648)	10.050 (4.268)	11.610 (3.452)	12.222 (2.602)
Route/Step Level	.258 (.740)	.300 (.578)	.611 (.653)	1.610 (2.116)
Detail Level	1.308 (2.024)	1.200 (1.016)	.444 (.845)	.333 (.673)
Form of Plan				
Goal Ordering	.625 (1.060)	.350 (.499)	.111 (.333)	.666 (1.264)
Goal Completion	0	.150 (.974)	.111 (.333)	.166 (.277)
Bottom-up Planning	.516 (.354)	.300 (.560)	.944 (1.253)	.610 (.794)
Concomitant Variables				
Planner Constraints	.499 (.917)	.316 (.567)	.350 (.695)	0
Expand, Elaborate	2.291 (2.280)	2.05 (1.740)	.388 (.599)	.666 (.986)
Extras	.641 (.979)	.400 (.953)	.055 (.166)	.166 (.353)
Problem Definition				
Task Constraints	1.400 (.578)	1.750 (.507)	1.388 (.613)	1.316 (.515)
Robust Statements	.316 (.567)	.350 (.695)	0	0
Critique				
Evaluate, Review	.808 (1.150)	1.200 (1.760)	1.499 (1.584)	1.110 (1.258)
Revise	.483 (.726)	.650 (1.185)	1.277 (1.839)	1.333 (1.686)

Further analysis of the differences between groups was achieved through univariate tests on the dependent measures. Results indicated eight of the 14 measures included in MANOVA (Table 7) contributed to the difference between plans for ill-defined tasks and plans for well-defined tasks. These univariate results are contained in Table 8.

Differences Between Well-Defined and Ill-Defined Task Plans

Means and standard deviations for the responses appear in Table 7. Univariate results for the following measures are contained in Table 8.

Bottom-Up Statements. Planners differed in the number of bottom-up planning statements made for well-defined and ill-defined tasks ($p = .003$). (See Table 8.) The cell means for this measure indicated bottom-up planning statements occurred more frequently in plans for ill-defined tasks than in plans for well-defined tasks (see Table 7).

Step-Level Statements. These statements, indicating steps through which the planner went, differed for ill-defined and well-defined task conditions ($p = .003$). As shown in Table 7, more step-level statements were made during planning for the well-defined tasks.

Detail-Level Statements. Detail-level statements also differed between the two groups ($p = .008$). In contrast to

Table 8. Univariate Tests of Well-Defined and Ill-Defined Tasks.

Sources of Variation	Degrees of Freedom	Significance of F
Abstract level statements	1, 70	.2807
Selection level statements	1, 70	.2275
Step level statements	1, 70	.0038*
Detail level statements	1, 70	.0086*
Goal ordering statements	1, 70	.6249
Goal completion statements	1, 70	.4457
Bottom-up planning	1, 70	.0032*
Planner constraints	1, 70	.3046
Expand, elaborate statements	1, 70	.0000*
Extras	1, 70	.0187*
Task constraints listed	1, 70	.0065*
Robust statements	1, 70	.0051*
Evaluate, review statements	1, 70	.4240
Revision statements	1, 70	.0267*

Significant at $\alpha = .05$ or less.

results reported above, detail-level statements occurred more frequently in plans for well-defined tasks.

Robust Statements. Statements which made the plan robust to external factors were only formed in well-defined plans, resulting in a significant difference between groups ($p = .005$). Robust statements were made by students in both achievement groups for dinner-planning Tasks 1 and 2.

Statements that Expanded, Elaborated. These statements, which provided a rationale for earlier statements differed depending on the task ($p = .0004$). Statements of this sort occurred much more frequently in the plans for the well-defined dinner planning tasks than in those for the ill-defined errand planning tasks. There was also a difference between task groups for the measure of revisions ($p = .026$). In contrast to measures described earlier, statements concerned with revising the plan occurred more frequently in plans for the ill-defined tasks.

Task Constraints. Plans for well-defined tasks differed on the number of task constraints listed by the planner ($p = .006$). Planners were more likely to list constraints for the well-defined task than for the ill-defined task.

Additions to Plan. Finally, statements added to the end of the plan differed for the two task groups ($p = .018$). Again, plans for well-defined tasks were more likely to contain statements added on to the end of the plan. in that planners were more likely to list constraints

for the dinner-planning tasks than for ill-defined tasks. Finally, statements added to the end of a plan differed ($p = .018$) between the two groups because these additions were more likely to occur for plans of the well-defined tasks.

Chi Square Analysis

Three measures, all categorical variables, were analyzed using Chi Square analysis for relationships: (1) initial planning statement, (2) artifacts, and (3) success of the plan.

Initial Planning Statement

Analysis of students' first planning statements or attempts to understand the task resulted in six descriptive categories. The first two categories applied more to generic problem statements in contrast with the remaining four, which were task specific. These categories were as follows:

Initial planning statement

(1) Problem definition

(2) List of task constraints

Ill-defined categories

(3) Selection of a specific errand

(4) Description of route to first errand

Well-defined categories

(5) Selection of a main dish

(6) Selection of a drink

The initial planning statement and achievement groups were statistically independent. Specifically, there was no systematic relationship, as judged by the Chi Square test, between the initial planning statements of students in Achievement Group 1 or Group 2 ($p = .282$). Interestingly, the initial planning statement was related to success of the plan ($p = .0308$). The measure of association for this test indicated moderate strength for the relationship according to Cramer's V (.3972), selected because the Chi Square analysis involved a table larger than 2x2. These results are contained in Table 9.

Finally, there was a relationship between the initial planning statement for well-defined tasks and ill-defined tasks ($p = .000$). One cell of the table had zero frequency, and two other cells had low cell frequencies, making interpretation of the table tentative. Frequencies for this variable indicated that when considering all types of planning statements twice as many plans for errand tasks (19.2%) began with problem definition statements than did plans for the dinner-planning task (7.7%). These frequencies are listed in Table 10.

Table 9. Initial Planning Statement Analysis: Chi Square Tests of Significance for Variables Achievement Groups 1 and 2, Success and Task.

Initial Planning Statement	p	Degrees of Freedom	Cramer's V
Achievement	.282	5	.282
Success	.030*	5	.397
Task	.000*	5	.782

Significant at α = .05 or less.

Table 10. Initial Planning Statement Analysis: Crossbreak Results for Success and Task.

Initial Planning Statement	Success			Task		
	No	Yes	Total	No	Yes	Total
	N %	N %	N %	N %	N %	N %
Problem Definition	14 17.9	7 9.0	21 26.9	6 7.7	15 19.2	21 26.9
Dinner Task Main Dish	6 7.7	11 14.1	17 21.8	17 21.8	0	17 21.8
Dinner Task Beverage	1 1.3	1 1.3	2 2.6	2 2.6	0	2 2.6
Specific Errand	14 17.9	5 6.4	19 24.4	0	19 24.4	19 24.4
Listing Constraints	2 2.6	5 6.4	7 9.0	6 7.7	1 1.3	7 9.0
Steps	3 3.8	9 11.5	12 1.54	0	12 15.4	12 15.4
TOTAL	40 51.3	38 48.7	78 100.0	42 53.8	36 46.2	78 100.0

Artifacts

Student lists, sketches, or notes written during the planning session were collected by the researcher. The relationship between type of task and artifact presence or absence was examined. The analysis produced a significant result (x = .003), indicating a relationship between the four levels of task and artifacts (see Table 11). The Phi measure of association was .356, indicating the relationship was of moderate strength. Examining Table 11, it appears that students planning the dinner tasks were not likely to write or draw while planning. Students who planned errand tasks produced 72% of the written documents while dinner planners only accounted for 28 percent.

Success of the Plan

This measure was computed from several variables measuring success, with the resulting measure indicating successful and unsuccessful plans. The Chi Square test was run to determine if there was a relationship between the task being planned and the success of the plan. Results were significant (x = .0014). Using Cramer's V as the measure of association, the strength of the relationship between the measures was moderate (.4471). A review of Table 12 (cell frequencies and percentages per task group) shows a greater percentage (73.3%) of successful plans were created for the well-defined dinner planning task.

Table 11. Task and Artifact Analysis: Chi Square and Crossbreak Results.

Chi Square Test of Significance			
Variable	**p**	**Degrees of Freedom**	**Phi**
Artifacts	.0037	1	.356
Crossbreak of Task and Artifacts			
Task	**Artifacts**		
	No (Frequency) (%)	**Yes (Frequency) (%)**	**Total**
Well-Defined Task (Dinner)	35 44.9	7 9.0	42 53.8
Ill-Defined Task (Errand)	18 23.1	18 23.1	36 46.2
Total Frequency **Total %**	53 68.0	25 32.1	78 100

Table 12. Task and Success Analysis: Chi Square and Crossbreak Results.

Chi Square Test of Significance			
Variable	**p**	**Degrees of Freedom**	**Phi**
Success	**.0014**	**3**	**.447**
Crossbreak of Task and Success			
Task	**Success**		
	No (Frequency) (%)	**Yes (Frequency) (%)**	**Total**
Well-Defined			
Task 1	**5 6.4**	**17 21.8**	**22 28.2**
Task 2	**9 11.5**	**11 14.1**	**20 25.6**
Ill-Defined			
Task 1	**11 14.1**	**7 9.0**	**18 23.1**
Task 2	**15 19.2**	**3 3.8**	**18 23.1**
Total Frequency	**40**	**38**	**78**
Total %	**51.3**	**48.7**	**100**

CHAPTER 5

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

This study was developed from studies of teacher planning conducted by the investigator and Clark (1978). As a result of these studies, the investigator speculated about the role of planning in the classroom as a cognitive activity owned by students. It was proposed that "kids have plans, too," and their planning activities would thus undoubtedly affect life in the classroom. But before studying planning in the classroom, it was necessary to learn more about how students planned. This led to the first or major purpose of this study: to begin to form an empirical base for discussion of planning as a cognitive skill, important to life in the classroom.

A second purpose of this study was to explore how the planning process might be affected by differences in planning task. Several patterns of planning processes appeared throughout the literature on planning. As discussed in the literature review, there have been numerous studies of adult planning, but few, in comparison, on children's planning. These few studies are also concentrated in the area of psychology, with even fewer in education. Those that addressed children's planning in the educational

environment focused on skill training, without first documenting the planning processes used by students. Tasks in these studies were artificial and ones with which students had had little or no experience. Tasks were also almost exclusively well-defined ones; that is, the problem definition was contained within the task description.

The third purpose of this study was to examine two opposing models of planning cited frequently in the literature and to help explain why similar studies might produce results supporting either one. One model theorized that planning was a rational, logical, hierarchical series of decisions; the other supported planning as a cyclical, heterarchical, opportunistic series of decisions. Examining the studies supporting each of the models suggested the possibility that task might influence the actual planning process. Consequently, the study conducted here focused on defining the effects of the tasks for which students planned.

Discussion

Seventy-eight students were each randomly assigned to one of four planning tasks consisting of two errand-planning tasks (ill-defined) and two dinner-planning tasks (well-defined). The think-aloud method, in which students planned aloud without interruption, was utilized because it avoided problems of recall and/or interruption, both problems associated with methods of obtaining protocols of

children's thoughts. Each think-aloud planning session was audiotaped, transcribed, and analyzed using a coding system developed for this study. The analysis consisted of Multivariate and Chi Square analyses of quantitative and qualitative results, respectively.

Results of the first purpose of the study,to learn more about how children plan, were achieved through analysis of the protocols of planning tasks. Early iterations of the coding procedure indicated children did not plan as elaborately as was reported in research on adult planning. For instance, subgoals common in adult planning were not prevalent in the children's plans. Nevertheless, children's planning processes in many ways showed marked similarity to adults' planning. For example, children revised and evaluated their plans and exhibited a repertoire of planning behaviors similar to adults. The differences found between adult's and children's planning might be linked, then, to differences in children's cognitive skills as well as inexperience with thinking aloud. Analysis of students' plans also revealed the planning process did not vary with achievement, even for nonacademic tasks such as those included in this study.

Results of the second purpose of this study,to examine differences in the planning process through examination of task, yielded interesting aspects of how children plan. At first glance, differences in task planning appeared to be due to difficulty of the task. Thus, the obvious

explanation for these differences was task complexity. However, analysis of the plans of students in both high and low achievement groups across task refuted the simple explanation of task complexity. Achievement Groups 1 and 2 used the same categories for planning, and it appeared instead that there were task-related differences in planning for the dinner tasks versus the errand tasks, independent of ability.

Such differences may have been related to the schemata children had already formed for solution of well-defined tasks, thus facilitating the solution of such tasks having few constraints. But the schemata may also have impeded progress or made solution of well-defined tasks with many constraints more difficult because the planner had to adapt or specialize the generic plan stored in long-term memory for dinners.

In the case of the ill-defined errand task, fewer generalized schemata appeared and the planner was therefore required to engage in constructing or enhancing schemata related to this task. This was demonstrated by the type of statements made by the young planners. In general, errand planners focused on step-level decisions or process-type statements concerned with how to accomplish the errands. In contrast, dinner planners, already equipped with schemata of how-to's, made more detail statements, and a few ventured to make their plans robust with regard to certain problems. In short, dinner planners appeared to

have a repertoire of dinners similar to (though not as sophisticated as) adult plans. Errand planners focused less on constraints and more on the task itself, using written artifacts to aid construction of their plans.

Results pertaining to the third study purpose—to examine opposing models of planning—were not as clear cut as those discussed above. Although the model of planning followed by students appeared to differ depending on the type of task planned, support for the hierarchical and heterarchical models was not as strong as it might have been. Generally, well-defined task planners did follow the hierarchical (top-down) model, beginning with higher-level statements and proceeding down to detail-level statements. Most of these planners also followed the optimal goal ordering and did not skip steps or plan portions of the task in a unique sequence. This pattern could be explained in terms of guidance by established schemata for solving a well-defined task.

In contrast, some of the planners for the ill-defined tasks (in which schemata may not be as readily available to the planner) made decisions following no particular ordering and appearing to be directed by opportunity; that is, as opportunity arose, the planner took advantage without regard to the level of decision. In fact, detail-level decision might have informed or directed higher-level decisions in this heterarchical type of planning. The heterarchical model, then, became logical in a situation in

which the task was ill-defined, thereby (as theorized) requiring construction of the task by the planner.

Task

Plans for the well-defined tasks (Dinner Tasks 1 and 2) differed, as indicated by the overall MANOVA results. The univariate analysis revealed one significant measure: number of problem constraints listed by the planner. Although this was a statistically significant difference, the result may have been an artifact of task presentation. Well-defined Task 2 contained three times as many constraints as did Task 1. Therefore, a significant difference between the two tasks on this measure reflected constraints created by the investigator and not fundamental differences in the planning statements for the two tasks.

Differences were anticipated between plans for the dinner tasks and plans for the errand tasks. The overall MANOVA results were significant, and eight univariate tests of criterion measures were significant. One of these measures, bottom-up statements, contributing to assessment of the planning model was discussed above. The other seven measures reflected differences in plans ranging from the type of statements made to the type of strategies used in planning.

Errand planners made more step-level statements. This was expected in an ill-formed problem in which parameters were not well specified. In the well-structured

dinner-planning tasks (for which children had an established schema of how to accomplish the task) detail statements occurred more frequently. Plans for dinner tasks also had more additions at the end of the plan, indicating planners had an idea of what should be included in a dinner and added components as they were recalled. Dinner-task plans contained more statements that expanded or elaborated on previous statements. This indicated the children had a sense of how the task was connected, how the parts fit together. These planners were able to reflect this connection in their plans.

The errand plans for the tasks toward the less structured end of the continuum contained more revision statements, reflecting differences in planning strategies. It was expected more revisions would occur in ill-defined task plans in which a solution was not retrievable from memory but had instead to be created. Planners also began the errand tasks with statements helping them to define the task. According to Polya (1975), this was the first phase in a heuristic process of approaching problems. Such definition of the problem was not needed as much in the dinner task because the problem statement contained the complete task definition for most of the planners.

Achievement

The question, Does achievement make a difference in the plans created? was answered affirmatively. Although no

achievement-by-task interactions were significant, the overall main effect for achievement indicated differences between achievement groups. Achievement was included in the design of this study to look for interactions between task and achievement level. Although abstract, selection, and detail statements were all made more frequently by higher achievers and measures relating to thinking about the plan (such as reviewing, critiquing, and providing rationales for statements) also were made more frequently by the higher achievers, there were no interactions between task and achievement. The strategies of critiquing and providing rationale with metacognitive functions (Kirby, 1984) have been judged as learned experiences and not as measures of planning ability, as such (Lawson, 1984). Not surprisingly, though, higher achieving students appeared to apply a greater range of strategies in planning and were generally more verbal on the average.

Hierarchical and Heterarchical Planning Models

Three measures directly assessed the form of the students' plans: (1) bottom-up planning, (2) goals out of order, and (3) incomplete goals. Bottom-up planning was the only one of the three measures of form showing significant differences between groups. Although more students expressed incomplete goals in plans for the ill-defined errand tasks than in those for the well-defined dinner tasks, the differences were not significant.

Plans for the errand tasks were more likely to contain detail- or lower-level statements that informed abstract or higher-level decisions (e.g., bottom-up planning statements). This was the opposite of what was expected in the hierarchical model, in which abstract-level decisions always informed lower-level decisions. This finding supported Hayes-Roths' (1978) theory that ill-defined tasks called for different solution paths than well-defined tasks. Hayes-Roth (1980) found errand planners followed a heterarchical model of planning in which opportunity, as opposed to a hierarchy of decisions, directed planning. Although this finding lent support to the heterarchical model, significance on this one measure could not be considered as sufficient evidence that plans for the errand and dinner tasks followed different models. Significant differences in the number of incomplete goals and/or in the goal order would have contributed to a stronger case to establishing differences in the models of planning.

Two explanations for the lack of significant differences between groups were considered. First, students might not have verbalized as many thoughts as adult planners in other studies (the basis for the original model). Thus, student plans might not be as detailed as those of adults, making identification of these measures more difficult. Examination of the protocols showed that several plans for the errand task were what could be called procedural plans. These plans consisted of a listing of

errands and little or no indication of cognitive strategies.

A second explanation focused on aggregating the three variables of bottom-up planning, incomplete plans, and statement level and categorizing the overall plan as hierarchical or heterarchical. This would replace the current method of examining each variable individually and might be more likely to yield significant differences supporting differences in the two models. Further, the measures related to the model of planning were considered as interval-level data that could be dependent on other measures of the plans. These measures were therefore included in the single MANOVA procedure with the other 14 measures, further reducing the likelihood of finding differences among variables.

Conclusions

The results of this study indicated plans for ill-defined versus well-defined tasks differed. Errand plans (ill-defined) were more heterarchical in that bottom-up statements occurred more frequently than in the dinner plans (well-defined). Differences, such as number and nature of revisions, were also consistent with the expectation that ill-structured tasks would require more of a heterarchical type of plan monitoring. Interestingly, only one-half of the plans were judged to be successful, defined as having met all of the task constraints.

Some of the alternative explanations for differences found in the study were anticipated through incorporating achievement in the design and through analysis of tasks at four points on the continuum. Still, some task-specific variables (e.g., number of constraints) could be equalized in further studies. This would allow more accurate comparison of how planners treat task constraints.

The results of the study showed that children's plans for ill- and well-defined tasks differed and that skills required to create the plans also differed. These findings lent support to the call for curricula exposing children to ill-formed problems and guiding them toward solutions of these tasks. Fewer than half of the students were able to develop successful plans for the ill-defined task, while more than three-fourths successfully planned for the dinner tasks. While both tasks were familiar and nonacademic, the errand task involved using a map, which may have made it more difficult. Yet, when planners were asked if they thought the task was difficult, task and student assessment of difficulty were independent. This was viewed as further support for the hypothesis that plans differed because task structured differed, not because of task difficulty. The tasks actually called for different cognitive strategies in planning—an important result of this study which could have implications for classroom teachers. Once teachers become aware of this connection, they could be influenced to incorporate this knowledge into their teaching.

> The implicit theories of teachers cause them to teach the way they do because of their beliefs —implicit or explicit—concerning the child's mind and learning. Teachers may think the child can not understand abstractions or that intelligence heavily influences schoolwork or that children learn best through concrete activities (Ginsberg, 1969, p. 21).

If teachers can be convinced that planning is an important cognitive component of general intelligence, then perhaps children will be allowed to experience more opportunities to learn to plan and plan to learn.

Recommendations

One recommendation that follows from the results of this study is to recognize the vital importance of task demands. Students experiencing an education dominated by well-defined tasks are missing an important component in their schooling. Educators are becoming aware of the importance of higher-level cognitive skills such as planning. As an example, the State of Michigan is currently considering testing of higher-level skills as a part of its annual testing program, and results of these measures may succeed in pointing out the need for more attention to this important aspect of cognitive development.

It was found in this study that only half of the plans created by fifth-grade students successfully met the task constraints. Part of this lack of success may be attributable to the problem that there is little awareness or discussion of the importance planning may have on

children's lives. A goal of this research, then, was to provide ideas for teachers to encourage awareness of planning in their classrooms. These recommendations follow:

(1) Carefully consider the classroom tasks that you define for your students. Could any be turned over to students or worked on as a class with special attention paid to the planning that is necessary?

(2) Talk about planning and thinking during all subject-matter instruction. Help students learn to analyze tasks and recognize when algorithms will work and when heuristic processes are more appropriate.

(3) Prepare students; encourage them to think of problems that are ill-structured. Select tasks that are ill-structured and demonstrate as a class how to approach these problems. This can be used in all subject areas but is especially relevant in writing.

(4) Encourage group planning. This allows students to experience their peers' points of view as well as exposing them to new ways of thinking. This ability to work in groups will be even more highly valued in the future.

(5) Develop a planning board on which students are encouraged to tack all forms and phases of plans they are interested in or working on.

(6) Form a planning committee that will plan classroom events (real or imaginary) and, more importantly, provide a forum for discussion of plans.

(7) Allow students to see you plan and let them know how essential planning is to your profession. Share how you think about planning and strategies you use to plan for different types of tasks.

Although the results of the study support the need to recognize and attend to the tasks used to teach students, it does not indicate, nor was it designed to indicate, how students can develop their planning skills or what the differences are between successful and unsuccessful plans for ill-defined and well-defined tasks. The study does, however, provide evidence for further discussion of the structure of tasks and of structural influences on cognitive strategies. This information could be used to select tasks for curriculum development that will further facilitate certain planning strategies and allow children to explore their own thoughts.

APPENDICES

APPENDIX A

PARENT LETTER AND PERMISSION FORM

Dear Parent/Guardian,

My name is Janis Elmore, and I am working on my doctoral dissertation project at Michigan State University under the direction of Christopher M. Clark, professor of Educational Psychology.

My project is to study how children plan. An understanding of how children plan will serve as a guide to designing more effective programs to enhance children's skills. The ability to plan effectively is important in children's social and academic lives.

The children who participate in this study will be asked to plan aloud while solving a nonacademic task, during a ten-minute period. There are no right or wrong answers; no tests or student evaluations are involved. If a child volunteers to participate in the study and parental permission is obtained, he or she may change his or her mind and withdraw even after the study has begun. Your child and his/her teacher will determine when the interview will be scheduled.

A child's responses will be audiotaped and heard only by the interviewer. All responses to the tasks will be anonymous. Within the limits of confidentiality and anonymity described, a copy of the results of this study will be made available to you upon request.

If your child would like to participate in the study and you agree to give your permission, please sign the attached form and ask your child to return it to his or her teacher. If you do not want your child to participate, I would appreciate it if you would sign the form on the last line provided for signatures and ask your child to return it to his or her teacher.

This study has been approved by the East Lansing Public Schools policy committee on research and by the school principal and your child's teacher. If you have any questions or would like more details about the study, please contact me at 351-1040. Thank you for your cooperation.

Sincerely,

Janis Elmore

Attachment

RESEARCH IN PLANNING PROJECT

Consent Form

I give permission for my child to participate in the project described. The nature of the study and the processes involved have been adequately explained to me. Even though I have given my consent at this time, my child may at any time withdraw without recrimination from the study. I have been assured that my child's contribution to the study will be anonymous.

_____

Your Child's Name

_____

Signature of Parent or Legal Guardian

I do not want my child to participate in the study.

_____

Signature of Parent or Legal Guardian

APPENDIX B

OUTLINE FOR BLIND COLLECTION OF DATA ON ACHIEVEMENT

OUTLINE FOR BLIND COLLECTION

OF DATA ON ACHIEVEMENT

(1) List of students participating in study with a random number assigned to each was given to the teacher.

(2) Teacher listed reading score for each student and kept list of names. The list of names and matching numbers was not shown to the investigator.

(3) Teacher returned list of numbers and achievement data to the investigator.

(4) Investigator assigned each number randomly to a treatment (task).

(5) Teacher was given new and old numbers so (s)he can call students based on numbers. The investigator may have known students' first names incidentally but purposefully avoided any knowledge of last names. In this way, subject anonymity was ensured.

APPENDIX C

INSTRUCTIONS FOR PARTICIPANTS

INSTRUCTIONS FOR PARTICIPANTS

Hello, my name is Janis. What is your name? ___Student's name___, before I tell you about myself and why I am here, I would like to know if you are missing something in your classroom at this time that is important to you. We can meet at another time if you would rather by with your class at this time. Okay, I am a student at Michigan State University, and I am interested in fifth graders and how they think ahead or plan. During the next minutes, I am going to ask you to help me to learn about how you think about things or how you plan. By planning, I mean thinking ahead before you actually do something. For example, before you go on vacation, you usually make plans. You think about what you will do, how you will travel, whether you will fly or drive by car. You also need to plan what clothes you will wear. You may need to plan for a place where you can leave your dog or plan to take him with you. Can you think of a plan? Another example of when you might need a plan is when you want to figure out how you can do your homework and your chores and still have time to play with your friends, all before dinner. You would need a plan to help you get all these things done. Do you see what I mean by a plan? If you do not, please say so, as it is important that you understand this, okay?

Now, what I would like you to do is to make some plans for me. I will give you two problems, and I need for you

to tell me how you would solve them. This is not a test. I am not interested in right answers; in fact, there are no right or wrong answers. The most important part of your task is for you to tell me everything you are thinking. Can you talk aloud while you are thinking? That is what I would like for you to do while you are planning.

I will give you paper and pencil in case you would like to write something down. Once again, the most important part of your work here is for you to tell me everything you are thinking while you are planning how to solve the problem. Talking aloud is not always easy, but I am interested in what you are thinking.

No one else will hear what you say; neither your teachers nor your classmates will know anything about what we say. I would like to use a tape recorded to help me remember what you say, but no one else will listen to the tape.

Do you have any questions? Maybe we could try a practice problem, okay? Can you tell me what you plan to do after school today? If you don't already have plans for after school today, you can make a plan up now, you can tell me what you might do if you are not sure what you will do. Tell me as much as you can about what you will do after school. You can have all the time you need.

APPENDIX D

CODING MANUAL AND OUTLINE

CODING MANUAL

Each statement made by the planner during the planning session is to be coded for the measures discussed below. A single statement may be coded several times for different measures. First, we will review all of the codes, then we will code protocols and discuss them. The number of times a code appears throughout the protocol is summed at the bottom of the plan. Some measures are task specific; most of these are obvious. Others are explained in the manual. Codes about which you feel indecisive should be circled so we can easily identify them for discussion.

First, you will record subject number. The remaining demographic information will be completed later by a second coder. Then follow the codes as explained in the manual. You may review and reread the protocol for coding as many times as you need, but try to follow the order of variables presented in the manual.

You may write the code over the statement or in the margin next to the statement it applies to. Please be consistent in the method of coding you choose as another coder will also be summing the codes.

Please observe your own coding behavior and be consistent in your use of the codes. If you do not completely understand a code or find you may be using it in an inconsistent manner, stop and discuss the problem.

CODING OUTLINE

Column	Field	Variable	Code	Name	Values
1,2	2	d1	SN	Subj. #	1-78
3	1	d2	SCH#	Sch. Subj.	1-Donley 2-Bailey
4	1	d3	C	Class #	1-Class A 2-Class B 3-Class C 4-Class D
5	1	d4	S	Sex	1-Male 2-Female
6	1	d5	G	Group # 2-Low	1-High
7,8	2	d6	T	Task #	11-Dinner 1 12-Dinner 2 21-Errand 1 22-Errand 2
9,10	2	V2	GO	Goal Order	
11,12	2	V2	GIC	Goal Completion	
13,14	2	V3	B	Bottom-up	
15,16	2	V4	DL	Decision Level	1-Abstract 2-Selection 3-Procedural 4-Details
23,24	2	V8	TS	Total Statements	
25,26	2			Blank	
27,28	2	V11	CP	Constraints-Planner	
29	1	V12	I	Initial Planning Statement	
30,31	2	V13	R	Robust	
32,33	2	V14	EX	Rationale, Expand, Elaborate	

Column	Field	Variable	Code	Name	Values
34,35	2	V15	EV	Evaluate, Review	
36,37	2	V16	RV	Revision	
38,39	2	V17	N	Number of Plans	
40,41	2	V18	D/E	Balanced Dinners/ Errands Completed	
42,43	2	V19	CE	Constraints Met	
44-47	4			Blank	
48,49	2	V21	IT	Items in Meal/ Dinner	
50	1			Blank	
51-53	3	V22	TP	Time Planning	
54	1	V23	SU	Success	1-Not Successful 2-Successful
55	1	V24	L	Constraints Listed	1-No 2-Yes
56	1	V25	AD	Add-Ons	
57,58	2			Blank	
59	1	V26	AH	Achievement Group	1-High 2-Average
60	1	V27	A	Artifact	1-None 2-Yes
61	1	V28	E	# Errands Repeated, Meals Out of Order	
62	1	V29	WO	# Wrong Stores, Dinner Days Out of Order	

Column	Field	Variable	Code	Name	Values
63	1	V30	EX	Extras:	Items in Meal Errands
64	1	V31	IN	Inefficient Moves (Errand)	
65	1	V32	LV	Late or Violated a Constraint	
66	1	V33	D	Difficulty	1-Easy 2-Hard 3-In Between 4-Don't Know

APPENDIX E

DINNER-PLANNING TASK

DINNER PLANNING TASK 1

Your parents are going to be busy this weekend and they may even have to leave town suddenly. Since they are busy and in case they do have to leave town, they have asked you to plan dinner for the family for Friday, Saturday, and Sunday evenings.

You will not have to cook the dinners, but you will have to make a list of the menus. You should plan full, healthy meals for the family. Remember your parents may be home for the dinners, too, so it has to be a menu they will approve of and enjoy.

Now, tell me what you would plan to have for dinner on Friday, Saturday, and Sunday. Remember to think aloud while you are considering menus. Do not just tell me your final decision. I am interested in all of you thoughts. You may use the paper and pencil I have provided, if you would like, but it is not necessary. If you have any questions or if there is something you do not understand, how is the time to ask.

DINNER PLANNING TASK 2

This weekend you are having an old friend from out of town visit you. He will arrive on Friday and will stay with you for the weekend. He has lots of friends in the area, and you would like to make it easy for him to visit with them, so you have decided to invite several friends over for dinner each night during his visit. You will need to plan for these dinners. There are details about your guests that you will need to consider while planning your meals. These are discussed next.

On Friday night, you have decided to have six friends over for dinner. While you are planning this dinner, you discover that one friend coming for dinner on Friday is a vegetarian and does not eat meat. How would you plan this dinner?

On Saturday night, you have invited three friends and their parents to dinner. One of your friends mentioned that her parents are on a diet, and another friend mentioned that she is allergic to fish. How would you plan dinner for Saturday night?

On Sunday, four special friends are coming for dinner. You have discovered that Sunday is one of your friend's birthday, so you have decided to make your dinner include a birthday celebration. You have also noted that one friend hates chicken and two love fancy desserts, but one of the dessert lovers cannot eat chocolate. How would you plan for dinner on Sunday night?

APPENDIX F

ERRAND-PLANNING TASKS

ERRAND PLANNING TASK 1

This weekend on Saturday, you are going to go to downtown East Lansing. You will arrive downtown at 11:00 a.m., and you have to catch a ride home at 2:00 p.m. sharp. Because you have many errands to accomplish in so little time, you have decided to make a plan of the errands you will do and the order in which you will do them. A list of errands that you need to do and a map to help you plan your route are on the next page. The stores and other places in downtown East Lansing that you will need to plan to visit to accomplish your errands appear on the map.

You need to plan which activities you will do, in what order you will do them, and also do not forget to plan some time to accomplish each errand and to travel between places. Remember, sometimes in real life you cannot do everything on your list in one day, so do not feel badly if you cannot plan everything on the list in the amount of time given.

Remember to think aloud. I want to know everything you are thinking while you plan. I am interested in more than just your answers. If you need to use paper and pencil, there is some here for you.

The list of errands on this page represents all the things you would like to do while you are downtown on Saturday. During your planning, you will try to include as many errands as you can. You can do them in any order you like. The map on the next page will help you plan the order of the errands. Notice that two errands have stars next to them. These errands should be accomplished at the specified times, and both should be included in your plan.

If you have any questions, I will be happy to answer them now.

- You promised to buy your dog a bone.
- You want to buy a new book on your favorite hobby.

** - You promised to meet your friends at 12:00 for lunch.

- You need to buy a small plant or flowers for a sick friend.
- Your mother asked you to pick up her shoes from Jacobson's.
- You need to pick out a birthday card for your friend whose birthday is in two weeks.
- You need to buy a new pair of jeans.
- You want to buy your new favorite record.
- Your friends will be playing video games at Pin Ball Pete's at 1:00 p.m., and you would like to join them.

** - You must catch your ride home outside of Pin Ball Pete's at 2:00 p.m.

- You promised to pick up pictures that are ready at the photo shop.
- You need to pick up milk for your mom for dinner tonight.

ERRAND PLANNING TASK 2

It is Saturday morning, 11:00 a.m. You are going to downtown East Lansing for the day, and you must do as many of the tasks on the list as you can. Look at the map I have given to you to help you decide the order of places to go to accomplish as many of the tasks as you can. Remember to allow time to accomplish the task and to walk to the next store. The tasks or errands are listed below. You can do them in any order you like. If you do not have time to do all of the tasks, choose the ones you think are most important. The exception is, you must meet your friend at 12:00 noon for lunch at Olga's. So this is one errand you must include. You also have to leave for home at 2:00 p.m. sharp; you will be picked up in front of Pin Ball Pete's.

The stores and other places in downtown East Lansing that you will need to visit to accomplish your errands appear on the map. You need to decide which activities you will do, in what order you will do them, and also do not forget to figure some time to accomplish each errand and to travel between places. Remember, sometimes in real life you cannot do everything on your list in one day, so do not feel badly if you cannot accomplish everything on the list. Look at the map and read over the list. If you have any questions, please ask them now. Remember to think aloud. I know this can be hard, but I want to know everything you are thinking, not just your final decisions. You may use the paper and pencil provided.

It is Saturday morning, 11:00 a.m. On this page is a list of errands you will plan to accomplish today. Examine the list and ask any questions you may have at this time. You will have until 2:00 p.m. to complete as many of the tasks as you can. Notice that two errands have stars. These errands must be accomplished at the specified times. Look at the map and the errands and tell me how you would plan your day.

- Noah's Ark Pet Store	You promised to buy your dog a bone.
- Bookstore	There are several bookstores on the map. You may choose any one of them to buy a new book on your favorite hobby.
** - Olga's Restaurant	You promised to meet your friend at Olga's for lunch at 12:00 noon.
- Flower Shop	There are two flower shops on the map. You may go to either one to pick out a small plant for a sick friend.
- Jacobson's	You need to pick up shoes for your mother in Jacobson's shoe department.
- Card Shop	There are several shops on the map labeled "card shop." You may choose any one of them. You need to pick out a card for your friend's birthday in two weeks.
- Sam's Blue Jean Store	You need to buy a new pair of blue jeans.
- Record Shop	There are several record shops. You may choose any one of them to buy your favorite new records.
- Pin Ball Pete's	Your friends will be at Pin Ball Pete's at 1:00 p.m., and you have promised to meet them to play frogger.
** - Outside Pin Ball Pete's	You must catch your ride home outside of Pin Ball Pete's at 2:00 p.m.
- Photo Store	You promised to pick up pictures that are ready at the photo shop.

APPENDIX G

STUDY DESIGN:
DEPENDENT MEASURES AND SUMMARY TABLE

DEPENDENT MEASURES INCLUDED IN DESIGN

(1) Form of the Plan

Goal ordering
Goal completion

(2) Concomitant Statements

Statements that provide a rationale, elaborate, or expand
Robust statements
Written artifacts associated with the task
Add-ons or extras — beyond the required items

(3) Goal Statements

Decision levels of statements:
Abstract level
Selection level
Procedural level
Detail level

(4) Plan Definition

Constraints - planner defined and task defined
Initial planning statement

(5) Plan Critique

Evaluation, review, and revision

(6) Success of the Plan

Number of task constraints met by the planner

SUMMARY TABLE
DESIGN OF THE STUDY

	INDEPENDENT VARIABLES							
	Achievement Group 1				Achievement Group 2			
DEPENDENT VARIABLES	Dinner Tasks		Errand Tasks		Dinner Tasks		Errand Tasks	
	1	2	1	2	1	2	1	2
GOAL STATEMENTS Abstract Level Selection Level Route/Step Level Detail Level								
FORM OF PLAN Goal Ordering Goal Completion Bottum-Up Planning								
CONCOMITANT VARIABLES Planner Constraints Expand, Elaborate Extras								
PROBLEM DEFINITION Task Constraints Robust Statements								
CRITIQUE Evaluate, Review Revise								
SUCCESS OF PLAN								

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