Making a developmental perspective on planning activities explicit may be necessary not only for the formulation of a developmental psychology of planning but also for the development of planning by individuals. School-aged children have some knowledge about planning, but they focus very little on the central revisionary quality of plan construction and plan execution.

What Is Planning Development the Development of?

Roy D. Pea

We know very little about the development of planning, yet planning is so fundamental to the fabric of everyday experience that understanding its origins, components, and ways of developing is essential. Kaplan (1967, 1982) has emphasized how development is a concept distinct from ontogenesis. Persons not only progress but also regress, even during a single day. Different persona, stresses, anxieties, time demands, drugs, and brain injuries may all affect the developmental level of a person's planning. Since ontogenesis can be recognized as either regressive or progressive, "more developed" is a concept distinct from "occurring later in time." Development is a concept we apply to, rather than find in, persons or performances across time. Thus, we need to elucidate the criteria intrinsic to our grading of planning activities as more or less highly developed.

This chapter presents research conducted at the Bank Street College of Education and directed toward addressing these problems. Our general endeavor is to construct a practical theoretical perspective on planning devel-

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opment, specifying what develops and how it develops, as well as indicating methods for its advancement. The focus of our empirical work is microcomputer programming in elementary school classrooms, which constitute a rich and explicit context for examining dynamic planning processes. A key goal is to provide a foundation for research by investigating the role explicit planning plays in children's lives, and one project of our planning-development enterprise is to interview children on the criteria they use to distinguish better from worse plans and planners. Analogous studies of children's awareness of their own learning processes have yielded new understandings of how metacognition influences learning (Baker and Brown, 1980). Since many children see no need for planning to solve school-subject problems, but do plan in other areas of their lives, these results may indicate pathways for generalizing everyday planning skills.

This chapter has three parts. The first part is a reflective analysis of what makes up the planning process. In talking about how planning works, we shall assume the achievement of some crucial developments, such as the ability to distinguish between constructing plans prior to action and carrying out the plans. These are central genetic themes, but our focus will be on the development of the organizational components of planning processes, and our empirical studies of planning are presented in these terms. This discussion will owe much to Wapner and Cirillo (1974), whose work has inspired these reflections on the organizational aspects of planning. The second part of this chapter summarizes our interview protocols of children's perspectives on planning. The third part describes new research directions (including our current planning-developmental studies) prompted by this analytical work.

The Concept of Planning

Planning is a complex form of symbolic action that consists of consciously preconceiving a sequence of actions that will be sufficient for achieving a goal. It is set apart from undeliberated action, which is not preconceived. "Plan construction" refers to the process by which plans are formulated and "plan execution" to the process by which plans are carried out.

Theorists of planning distinguish four general steps in the planning process:

1. Representing the planning problem situation, a task that requires the planner to
   (a) define the goal state,
   (b) define the problem state,
   (c) note the differences between the problem and goal states, and
   (d) determine the constraints on planning (space, time, and causation) that for example, redefine the goal.
2. Plan construction, requiring formulation of a plan to eliminate the differences between the problem and the goal state.

3. Plan execution.
4. Planning-process remembering.

These steps are not independent; otherwise, they could never be integrated into a functional planning process (Stefik, 1981a, 1981b).

Representing the Planning Problem

1. ***Defining the Goal State.*** While goal definition in lab tasks, where goals are defined by instructions, is relatively trivial (see, for example, Anzai and Simon, 1979), goal setting for most everyday planning is a major problem. Dewey (1922), Bruce and Newman (1978), and Wilensky (1981) have urged that goal definition be considered as problematic and as requiring the integration of multiple goals. The concept of goal was decisively elucidated by the seminal work of Miller, Galanter, and Pribram (1960). In their view, planning consists of configuring a series of tests and operations that will be performed sequentially to achieve the goal and then "exit" (stop) when the plan is executed (test, operate, test, exit). Goals are defined and redefined throughout the planning process (as the consequences of carrying out plans reveal emergent goal conflicts, for example).

The need for goal resolution in the planning process makes apparent the central role of principles of metaplanning. Wilensky (1981) has expressed these principles as metagoals that plans should attain, and Kotarbinski (1965) has informally set out comparable principles. Schutz (1973) has raised similar points. We have taken key aspects of these approaches to planning and derived four primary principles, or metagoals, of planning. The highly developed planner is guided by metagoals to check whether the plan is feasible, flexible, economizes action, and maximizes goal value.

Principle of feasibility. Impossible goals should be avoided, so that plans to achieve goals are feasible, but avoiding impossible goals is more difficult than it may appear. Subgoals must be consistent—so that, for example, acts necessary to achieve one subgoal do not block achievement of others; but goal possibility is often indeterminate, particularly for unfamiliar territories. The developing planner must first recognize that plans have to be feasible, regardless of the domain they concern. How feasibiity is determined is subject to great developmental variation. Four dimensions of plan feasibility, which should reveal developmental change, can be distinguished.

First, there is a need for well-defined goals. Second, there must be strategies for determining a plan's feasibility. Knowledge of the prior success of a plan or of one similar to it is the default strategy for determining plan feasibility. Classifying the planning situation as comparable or designating a previously successful plan as similar to the one being considered calls for a generative taxonomy of situations and plans that are capable of incorporating new cases. Third, when no comparable plan can be used for goal achievement, a feasible plan must be constructed, and knowledge of the world context

(physical laws, social mores, and so on) plays a seminal role here. This third dimension—knowledge of the world context for the plan—provides the data for projecting the consequences of particular planning decisions. The development of techniques for plan projection constitutes the fourth major dimension of determining plan feasibility. A planner may have a richly structured knowledge base for the planning domain, but may not know or be able to use techniques for applying that knowledge to the plan-projection dimension.

It is clear, then, that mastery of the principle of feasibility involves knowing everything that will be relevant to the feasibility of the plan once it is in action. Projecting the consequences of plan execution tests the boundaries of human knowledge; even failed plans, if the planner is fully mindful of what went wrong, tell the planner something new about the world.

Principle of economy of actions. Processing resources such as attention, energy, and time should be conserved, from three perspectives on economy. Plan construction may be more or less economical, the effort to 'read' the plan during its execution may be more or less substantial, and the arrangement of plan component acts may require more or fewer resources to execute. Optimal planning activity minimizes processing resource expenditures from all three perspectives (Kotarbinski, 1965).

The development of this metaplanning principle requires cost-benefit analyses and has been a major goal of the high-risk activities of business, government, industry, and the military. Tradeoffs of resource economy from the three perspectives are difficult to conceptualize, but, unless the planner believes that the benefits derivable from planning efforts are greater than their costs, the generative planning that is a prerequisite of any comparative evaluation of plans is unlikely. One basic aspect of this principle of economy is realizing that planning resources are limited and need to be conserved. (Let us note here that an emphasis on the importance of cost-benefit analysis does not assign the values for such calculation. A value theory is also required. The abhorrent and antihumanistic consequences of some cost-benefit analyses proceed from misguided systems of values and should not be taken to indicate the inadequacy of cost-benefit analysis for decision making in general. A perfected conception of planning would integrate highly developed techniques into the promotion of highly "good" values as ends.)

Minimizing plan-construction efforts is an important facet of planning development. It is easier to apply a ready-made plan than to construct a new one, even if ready-made plans sometimes take longer to execute.

Concerning plan reading efforts, Meacham and Kushner (1980) have focused on "prospective memory" of a planned action, such as locking a door. Because of forgetting, "reading" a plan at its time of execution is problematic. Minimizing resource expenditures consists of developing such means for aiding plan "readability" as lists, diaries and help from other people. The collaborative aspects of prospective memory are known by school-aged children (Kreutzer, Leonard, and Flavell, 1975). Also, if the plan is to be "read" by

others (as a blueprint or a story), it must be in a code that can be deciphered by its audience and may be more or less economical in plan "readability" (Burke, 1945).

For economy of plan execution, methods have only recently been developed to calculate optimal paths for sequencing component acts of a complex plan (for example, the PERT technique used in Polaris missile development or the "critical path" methods described by Levy, Thompson, and Wiest, 1963). With respect to everyday or school activities of children and adults, little is known about when or why resources for plan execution are minimized.

Principle of goal-value maximization. In situations where goals are in conflict, a higher-order set of compatible goals must be chosen. A goal definition should be selected to maximize the value of the goals to be achieved. This principle takes as objects the planner's defined goals and the metagoals expressed in the metaplanning principles. The planner tacitly or explicitly assigns weights to different plan outcomes and chooses a plan accordingly; setting goal values is thus a basic developmental achievement. More highly developed planning and planners would employ this principle, but many persons opt for any plan that works, not comparing alternatives for relative goal-value maximization.

Principle of flexibility. Planners should be sensitive to newly arising circumstances, and plan precision should not exceed limits of possible adaptation. To increase flexibility, planners should avoid early commitment. One should not decide on a plan feature that unnecessarily narrows the range of possibilities for plan development (Kotarbinski, 1965; Stefik, 1981a, 1981b). One also avoids rigidity by not deciding on a definite action if it depends on unknown or indeterminable circumstances, because if circumstances block the action, the plan must be abandoned.

2. ***Defining the Problem State and Noting Differences Between the Problem and Goal States.*** Understanding the problem requires the planner to determine which aspects of the current situation distinguish the problem state from the goal state. The less-developed planner may have difficulty encoding the problem situation. For example, age changes with respect to encoding and attentional processes may be partly responsible for the generally "novice like" performances of children on problem-solving tasks (Case, 1978; Siegler, 1981). Problem-encoding deficits may characterize performances in new planning domains; and situational features relevant to plan design may not be attended to for problem representation (Newell and Simon, 1972). Encoding deficiencies hamper the developmental sophistication of any planning, not only children's.

3. ***Determining the Constraints on Planning.*** A crucial aspect of representing the problem is elaborating the constraints imposed on planning. These include the time available to construct or execute the plan, the characteristics of the physical spaces where the plan will be executed, consequences

of executing parts of the plan, and availability of resources (for example, attention, working memory, processing energies, the possibility of help from other persons, mnemonic aids, and so on). Constraints frequently pose as instructions: "Classify the objects in a new way." Some constraints remain tacit until violated, but all constraints restrict the range of feasible plan designs. The goal definition is thus qualified in terms of its constraints.

Plan Construction

Potential methods for eliminating differences between the goal and problem states must be proposed and evaluated. As Polya (1945) observed, the planner first asks whether a method for solving the problem is known. This move economizes plan construction. The "script" concept of Schank and Abelson (1977) describes such rote procedures. A ritual plan can be used, failing which a modification or an entirely new plan may work.

Many alternative models of plan-construction processes have been proposed in cognitive science. Recent models of planning reject earlier assumptions that planning consists exclusively of a hierarchical, top-down process of refinement (Ernst and Newell, 1969; Fikes and Nilsson, 1971; Sacerdoti, 1977). Six fundamental points of agreement emerge from this literature.

Point 1. Formulating an effective plan requires plan simulation, the hypothetical execution of alternative plans proposed by the planner. The development of this aspect of planning may be assessed from three perspectives. The first is whether and to what extent the planner considers possible alternatives. Goldin and Hayes-Roth (1980) found that less effective planners considered a wide range of plan alternatives, whereas more effective planners, mindful of plan constraints, restricted attention to a smaller and more promising set. From our developmental perspective, the optimal range of plan formulations will depend on the values intrinsic to the planner's metaplanning principles. Quickly constructing a plan that works (and which may not be the shortest path to the goal) may be more highly valued than a shorter path achieved with greater effort and over a longer time. Second, alternative plans may be formulated, but not (or only partially) simulated in thought, so that consequences of plan execution are not well specified. The less developed planner may not simulate plans, either because of inability or because of not recognizing the need to do so. And third, the planner may perform a faulty simulation of plans, because of the operation of a different system of causal reasoning (see Bullock, Gelman, and Baillargeon, in press).

Point 2. Plan simulation is very complex, requiring knowledge of what would happen if the simulated plan were executed. Planning skills interact with the specific-content domain for planning. The principle of feasibility requires extensive world knowledge for realistic plan evaluation. This is true both during plan construction and plan execution, and so the extent and organization of the planner's knowledge will be critical factors.

The development of time-estimation abilities for component acts of the plan relates to the principle of economy of actions. More highly developed planners make more accurate estimates of the time required for planning.

In fact, Hayes-Roth (1980) found that adult planners generally underestimated time for executing plans, and that time stress makes underestimation of such time requirements more pronounced. Furthermore, lacking experience or knowledge of plan component acts for new domains, more highly developed planners would seek out the advice of knowledgable others. More highly developed planners know how to promote their own planning development; they initiate progress through their "zone of proximal development" (Vygotsky, 1978).

Point 3. Planners may become aware of new goals during plan simulations or attempts at plan execution and may redefine the goal state accordingly. Fully effective planning would not require goal redefinition, since all outcomes resulting from plan execution would be anticipated, but the complexities of monitoring consequences, as well as potential world-event contingencies that could block the success of component actions, make goals redefinition a common feature of planning. Nevertheless, the more highly developed planner needs to engage in relatively less goal redefinition. "Goal," as used here, is qualified in terms of the metagoals specified earlier. For example, planners may give up details to save time, realizing that goal redefinition may be required later; therefore, a plan only partially specifying its consequences would suffice for their purposes.

Point 4. The plan-construction process consists of cycles of proposal, simulation, evaluation, and revision, until a plan is formulated that will achieve the goal state. Plan construction and execution are each subject to continual control and revision. As plans are constructed, planners are guided by knowledge, which imposes constraints and gives direction to the evolving plan design. Similarly, as plans are executed, contingencies may arise that require revision of the constructed plan so as to ensure goal achievement. Goldin and Hayes-Roth (1980) found that greater planning effectiveness was characteristic of those planners who frequently evaluated and revised their proposals in terms of their goals and their metagoals. This finding may provide a useful developmental criterion for planning, since the cost of frequent revision, in terms of the planner's values (for example, economy) would usually be lower than the benefits arising from the better plan that would result from such revisions.

More effective planning has also been shown to be associated with a least-commitment strategy (Goldin and Hayes-Roth, 1980; Stefik, 1981a, 1981b), in which the planner avoids becoming committed to a planning decision until commitment consequences are evaluated with respect to goals. Keeping options open is the point, but it is easier said than done. The complex trade-offs between resources used to compute the consequences of early planning decisions and the value of avoiding subsequent reformulation are still to be studied. We suppose that, on many occasions, a least-commitment strategy would be more likely to ensure plan feasibility, but only with much time and energy required to project the consequences of early planning decisions.

It is clear, too, that these trade-offs depend on familiarity with the planning domain, because consequences of component acts are more easily projected for familiar domains and are therefore worth the minimal efforts of the least-commitment strategy; less familiar domains will have the high costs associated with such a strategy.

Point 5. Plan construction involves many kinds of decision making, on more or less concrete levels, that guide the flow of the planning process and select features of proposed methods. Besides the need to decide on action at the most concrete level of plan determination, four other types of planning decisions have been identified in adult planning protocols (Hayes-Roth and Hayes-Roth, 1979): "The subject makes decisions about data—how long errands should take, how important individual errands are, what the consequences of a particular action might be, and so forth. He makes decisions about abstract features of plans—what kinds of plan decisions might be useful. He makes metaplanning decisions—how to approach the problem and how to constrain and evaluate the plan. Finally, the subject makes executive decisions about how to allocate his cognitive resources during planning" (p. 305).

In one study, ineffective adult planners focused on low-level planning decisions, rarely assessing data relevant to plan construction or making executive or metaplanning decisions about plan-construction processes (Goldin and Hayes-Roth, 1980). Furthermore, within each type of decision making, the construction of a repertoire of options is a major developmental achievement. Planners may recognize that decisions about abstract features of plans would be helpful in plan construction, but they may not know what kinds of plan-design options there are, in the sense that what exists is determined by what others have already invented. A great deal of learning must take place before the planner can build up an inventory of possibilities for each of the general types of decision making that planning involves.

Point 6. The process of planning flexibly and purposefully shifts among making the different types of planning decisions in an advantageous manner. Earlier models favored a hierarchical, top-down approach to planning in which plans are fully formulated at the highest level of abstraction and then successively refined to a fully specified plan of concrete actions. Data from real-world tasks such as errand planning (Hayes-Roth and Hayes-Roth, 1979), designing genetics experiments (Stefik, 1981a, 1981b), or designing software (Jeffries and others, 1981) reveal that plan construction often proceeds more advantageously. As Hayes-Roth and Hayes-Roth note, "Current decisions and observations suggest various opportunities for plan development. . . [and] subsequent decisions follow up on selected opportunities" (p. 276; compare Wilensky, 1981; Stefik, 1981a, 1981b). Planning, in this more comprehensive view, may proceed in some cases (for example, menu planning—see Byrne, 1977) in terms of a define-and-refine planning strategy, but a highly developed planner has the flexibility (Werner, 1957) to choose advantageous planning strategies when they are warranted by problem characteristics.

It has been suggested that a planner proceeding advantageously needs a larger working memory than a hierarchical planner, since many decisions at different levels of abstraction have to be remembered (Goldin and Hayes-Roth, 1980; Thorndyke, 1978). Nevertheless, studies that relate working memory to planning will miss a key point of planning ecology: A planner may use mnemonic aids (for example, lists or telling friends) to remember details of the plan.

More highly developed planners would thus be flexible at selecting a planning strategy optimal both for the problem (Hayes-Roth and Hayes-Roth, 1979) and for their own self-assessed skills, being capable of shifting attention to different levels of decision making during plan construction, and calling on mnemonic devices when demands for remembering the plan exceed working memory.

Plan Execution

The development of plan-execution skills has seldom been studied. Part of this neglect derives from top-heavy models of planning processes. Research is devoted to proposing, simulating, and revising tentative plans, which are executed only when perfected. Much everyday planning appears bottom-heavy by comparison. Plans are often not self-consciously differentiated from actions. People frequently spring into action, explicitly constructing plans only if their actions do not succeed or if they have failed badly in previous, comparable activities.

When people do construct plans, how is plan execution monitored and controlled? And if a plan has faults, how does the planner correct them? In other words, how do planners integrate the processes of plan construction and execution?

The control processes for plan execution are similar to those for plan construction. Plan feasibility, economy of actions, goal-value maximization, and flexibility are projected on the basis of the world-state information that the planner considers to be germane. When the plan is executed, however, new world states may arise that render the plan unworkable. Some of these happenings may be caused by the unanticipated consequences of actions based on shortsightedness, while others are beyond the planner's purview. We expect that the observance of plan-intrinsic flaws will promote greater efforts at plan construction, while plan-extrinsic problems may be written off to the vagaries of the world and to the many interactions among its component events.

Planning-Process Remembering

Remembering the plans we have constructed is a key part of planning development, whether or not we use mnemonic aids.The planner needs a

storehouse of useful methods for future goal-directed activities. Failed as well as successful plans should be remembered, and so, too, should their histories. Studies that describe the genesis of planning and subsequent recall of newly learned plans have yet to be carried out. Nelson and Gruendel (1979) have shown that preschoolers have rich "script" knowledge for activities like going to restaurants, but they have not traced the genetic route that leads from plan construction to plan execution to plan use. Case studies of planning development for new planning domains would be informative.

Summary

The need for instructional programs that guide the development of planning abilities is particularly acute, not only for school contexts, but also for everyday problem-solving activities involving career, financial, educational, and family planning. Preliminary to designing such programs is the identification of fronts on which developments may occur in component aspects of planning processes. Many of these fronts involve general metaplanning principles that are relevant to any planning domain, whereas other principles involved are quite specific, such as the extent and organization of plan-relevant knowledge. We need studies that chart how advances along the various fronts of planning-ability development are interrelated.

We suggest that metacognition drives cognition in significant ways. More highly developed planning may be facilitated when planners themselves have a developmental perspective on planning. Understanding the development of planning abilities will thus depend in part on articulating planners' own developmental perspectives on planning, as well as on probing the relationships between reflective activity and actual planning performances. As part of such an inquiry, we present here the results of a structured-interview study of school-aged children's talk about planning, and we make connections to the developmental framework we have outlined above.

Children's Perspectives on Planning

To get a first charting of conditions that may prompt planning in children, we used the clinical-interview method in our exploration of planning conceptions. We wanted to know how children define planning; what they see as occasions for planning or not planning, both for themselves and for others; how they assess the quality of plans and planners; and how they plan. We recognize the limitations of verbal reports in research on basic cognitive processes (Ericcson and Simon, 1980). Nevertheless, children's talk about planning is likely to advance our understanding of their reflective awareness of planning, its occurrences, its workings, and its functions. Our interview data therefore concern reflective rather than strategic metacognition (Brown and DeLoache, 1978); the latter is revealed in planning-task performances. In

another study (Pea, Jewson, and Sheingold, forthcoming), we shall compare the interview results with planning-task performances.

In this part of the chapter, we briefly review findings from in-depth, structured interviews with thirteen eight- and nine-year-olds (younger group) and thirteen eleven- and twelve-year-olds (older group) at the Bank Street School. For each age, half the children were boys and half were girls. Children were principally middle-class, of diverse racial and cultural backgrounds, and spoke English. Almost all the children defined planning solely as thinking ahead about what to do in the future. A few children also noted that plans "can be changed" before they are done.

Prototypic Cases of Planning in Everyday and School Actitivies

If an activity is one a child believes other people plan for or have planned for in the past, the child will probably be more likely to access and use their own planning skills. When children were asked about when they and others plan, three types of responses occurred: planning to do something, planning how to do something, and planning the specific conditions of doing something.

Planning to Do Something. Planning to do something in particular can be described as goal setting. The planning occasions of this type that children reported are listed in descending order of how frequently these occasions were mentioned. (See Table 1.)

Thirty-one other activities were mentioned once. Those mentioned by younger children included going to a movie, camp, choir, a relative's house, or a summerhouse; dedicating a book to someone; lighting a firecracker; having a dance for someone; having a secret; inviting people to a wedding; and making a nuclear bomb. Older children noted plans to attach a model-airplane wing; blow up a general's car; carry in subtraction; catch robbers; do a research project; perform gymnastics; balance a bank account; escape from jail; get married; go to a baseball game, bed, dinner, swimming, swimming practice, or on a day hike; have a slumber party; have lunch; interview someone; ride a bike; and take a bath. The principal age difference was reflected not in the absolute number of activities cited (younger, thirty-seven; older, forty), but, rather, in the number of different activities (younger, twenty-one; older, twenty-nine). There was greater commonality among the younger group of those activities felt to be appropriate for planning.

Planning How to Do Something. Children recognized that one can plan not only what to do but also how to do it. They distinguished goals from procedures and ends from means. Such means-end differentiation is a prerequisite to effective planning, for only with such ability can alternative means or plans be considered. The activities mentioned are listed in Table 2. Eleven other activities were mentioned once. Younger children noted plans for how to distract a baseball team, hurt someone, make a park, put a machine together,

Table 1. Frequencies of Specific Planning Goals

Plan	*Times Mentioned*	*Younger*	*Older*
1. What to do for your day/night	9	3	6
2. To go somewhere	8	4	4
3. To go home after school with a friend	6	4	2
4. To go on a trip	6	4	2
5. To have a surprise birthday party	5	4	1
6. To rob something	5	2	3
7. To write a story or a book	4	1	3
8. To tell a joke or do a trick	2	2	0
9. To get a job	2	0	2
10. To bring gym shorts to school	2	1	1
11. To move to a new house	2	1	1

teach someone to tie a shoe, and tease a brother. Older children referred to plans for answering interview questions, doing something (generic), reading a story, running football plays, and solving crimes. Overall, older children gave more method-planning responses than did younger children (twenty-two versus twelve), but they gave about the same number of different responses (twelve versus ten). Three response categories constituted most of the nineteen examples. Building activities (numbers 1 and 3) were the focus of twelve of thirty-four responses, activity scheduling (numbers 2 and 4) was mentioned for five of thirty-four responses, and game strategies (numbers 6 and 8) were the examples given for six of thirty-four responses. Method-planning for school activities (number 5) was generally neglected, with plans for how to study or do homework being mentioned only by older children.

Planning the Specific Conditions of Doing Something. Some children went beyond examples of planning to do something (at all) and beyond the generic-planning "how to do something" responses; they specified conditions of the plan. Such conditions constitute constraints, which further define the goal state to be achieved. Details of the plan were specified in terms of component acts, times and places for acts, and instruments required. The children noting

Table 2. Frequencies of Specific "How-to" Plans

Plan	*Times Mentioned*	*Younger*	*Older*
1. How to make or build something	7	2	5
2. How to do things in a certain order	4	0	4
3. How to build a building	3	0	3
4. How to arrange a schedule or a calendar	2	0	2
5. How to study for a test or do homework	2	0	2
6. How to play a game	2	2	0
7. How to solve something	2	1	1
8. How to put people in game positions	2	1	1

these constraints revealed a reflective awareness of the levels-of-abstraction dimension intrinsic to cognitive models of planning. We have distinguished four general classes of such responses: planning to do something at a certain time, planning to do something at a certain place, planning to do something with certain instruments, and planning the specific details of what to do in terms of a goal.

Planning to do something at a certain time. Eleven of the thirteen older children (but only 5 of the thirteen younger ones) mentioned time specifications for plans; eight older children (versus three younger children) gave the school-related example of setting a time to do homework or study for a test (see Table 3).

Planning to do something at a certain place. Children gave three examples: plans for where to stay during a trip (younger child), where to meet a person (one younger child, two older children), and where to meet to eat (older child).

Planning to do something with certain things. The only examples mentioned were planning what things are needed for a camping trip (younger child) or a vacation (older child).

Planning specific actions, given a prior goal choice. These are cases in which, once a decision has been made to do something (goal), greater goals specification becomes the aim of the plan. Two younger children each gave an example: planning what to buy while shopping, and planning how to celebrate a birthday. Two other examples were mentioned by older children: planning what to write for grammar class, and planning what to wear to school.

Prototypic Planners: Who Plans a Lot?

Asking children to talk about who plans a lot was another way to discover which activities children believe need planning. We reasoned that, from children's perspectives, people who frequently plan may serve as model planners, from whom children might learn how to better their own planning (see Table 4). Twenty other responses were contributed by different children. Younger children's examples included actors, company presidents, conductors, interviewers, managers, "my friends," robbers, and travelers. Older

Table 3. Frequencies of Time-Specific Plans

Plan	*Times Mentioned*	*Younger*	*Older*
1. When to do homework or study for a test	11	3	8
2. What time to go to school	3	1	2
3. When to do pet chores (feed cat, walk dog, clean bird cage)	2	0	2
4. When to go on dates	1	1	0
5. To wake up at a certain time	1	1	0
6. To schedule a time for class computer use	1	1	0
7. To meet friends at a certain time	1	0	1

Table 4. Frequencies of Specific Roles of Planners

Plan	*Times Mentioned*	*Younger*	*Older*
1. The President of the United States	8	3	5
2. Business people	8	3	5
3. Teachers	7	2	5
4. My family	3	2	1
5. Doctors/surgeons	3	0	3
6. Politicians	2	0	2
7. Architects	2	0	2
8. Rich people	2	1	1
9. Me	2	1	1
10. Everybody	2	1	1
11. Airline workers	2	1	1

children mentioned the Avon Lady, bakers and chefs, dentists, directors, garbage collectors, "important people," movie-star agents, "people with personality," producers, quarterbacks, scientists, and writers.

Reasons given for why these people plan a lot were generally that they have many actions to decide upon or to schedule. Less often, children noted the negative consequences that would occur if such planners did not plan: airplanes would crash, bakers would burn food, politicians would not get elected, robbers would get caught, and travelers would not go anywhere.

To Plan or Not to Plan?

It is crucial to understand the child's choice to plan or to proceed without explicit efforts at planning. With practice, one can attain a rich understanding of problems that arise in a content domain (such as in physics, for example; see Chi, Feltovich, and Glaser, 1981), so that adequate and efficient algorithms are available for solving problems and abrogate the need for explicit plan construction.

Are school-aged children reflectively aware of this distinction between "ritual" and "creative" plans? We approached this question by asking children to tell us about when and why they do not have to plan. Their answers can be categorized in terms of three major classes.

"You Don't Plan to Do Something You Are Just About to Do." These responses define nonplanning occasions as those when the activity will take place in the near future: "When it comes up, you just do the thing, you don't plan to do it" (five younger, three older).

"You Don't Plan to Do Something If Others Plan It for You." Here, children are noticing that if others (such as parents or teachers) plan for them they do not need to plan. The four older children who used this definition stated it generally: "When others plan for you"; only one of two younger children who used it did so. The other child gave specific examples: "When mom says, 'Go outside,' I don't plan to go outside, I just do."

"You Don't Plan If You Already Know What-to Do." Children expressing this idea revealed that they distinguished creative from ritual plans. They designated only the former as genuine plans: "If you know already, if it's an everyday thing, you just do what you usually do." Five older and two younger children gave generic responses, whereas six older and three younger children offered specific examples: "You don't plan to read the word 'the'," and "You just go to sleep, you don't plan to."

Consequences of Not Planning

What motivates children to plan? We expect that children are inclined to plan when necessary, if they are aware of the consequences of not planning, such as potential nonachievement of their goals. When asked, "When you have to plan ahead, what would happen if you didn't?", almost all children said that the activity just would not work out if it were not planned. Instances of nonplanning by these children are therefore unlikely to derive from ignorance of the potential negative consequences of not planning. Rather, the children appear to have different conceptions of which goal-directed behaviors require planning for successful performance.

Distinguishing "Better" From "Worse" Plans and Planners

How did children distinguish "better" from "worse" plans? Three major classes of responses were discerned (see Table 5). Most younger children appear to have a magical theory of plans: one will succeed with a good plan, but not otherwise. In this belief, they are different from the older children, who were more likely to view "better" plans as facilitators, but not guarantors, of goal achievement or as plans that allow alternative routes to goals as new circumstances arise. This last group of respondents recognized the tentative nature of plans and the revisionary nature of the planning process. Several other children offered responses based on four idiosyncratic criteria: *effort* ("Plans that are thought about more are better than those that are thought about less"); *trust* ("Plans that my friends, parents, and teachers tell me about are better than those I hear from other people"); *affect* ("Plans I like are better

Table 5. Concepts of "Better" and "Worse" Plans

Responses	*Times Mentioned*	*Younger*	*Older*
1. Better plans succeed; worse ones fail.	10	9	1
2. Better plans facilitate goal getting; worse ones do not.	6	0	6
3. Better plans are flexible, have several ways to work, and hence are well-adapted to their circumstances; worse plans have only one way to work.	3	1	2

than those I don't like"); and *morality* ("Plans that do good things are better than plans that do bad things").

In probing children's beliefs about what distinguishes "better" from "worse" planners, we found a wide range of responses (see Table 6). As we indicated earlier, planners need to believe that time and effort expended in planning will be rewarded by benefits from plan outcomes. It is therefore interesting that children believed effective planning to be time-intensive (numbers 3 and 5).

How Planning Works

Few children said anything about the specific elements of plan construction. Ericcson and Simon (1980) note that retrospection is reconstructive, in contrast with think-aloud reports during problem solving itself (which serve as "readouts" of working memory). It is possible that the difficulty of planning-process retrospection for these children arises from the demands of reconstructing a general process of planning from specific previous cases. Reconstruction would require a classifying of the similarities among all occasions of employing particular planning processes, as well as a self-reflective component-process analysis of planning activities. It is unlikely that children would remember their previous planning experiences or the similarities among them in such detail. In our current research, we ask children to think aloud while solving a planning problem that involves the integration of multiple goals. This method appears more promising as a key to revealing the organization of children's planning processes (Pea, Jewson, and Sheingold, forthcoming).

Three older children who referred to general features of planning processes said that they put the component actions of their plans in sequence: "I make up a schedule in my mind of what to do, in order"; "I make an order for

Table 6. Concepts of "Better and "Worse" Planners

Responses	*Times Mentioned*	*Younger*	*Older*
1. Better planners have more planning experience. that worse planners do.	8	3	5
2. There is no difference between them.	7	5	2
3. Better planners are patient and think for a long time; worse planners are in a hurry.	6	3	3
4. There is a difference but I can't say why.	5	2	3
5. Better planners start planning earlier than worse planners do.	2	1	1
6. Better planners make plans well adapted to circumstances.	1	0	1
7. Better planners make their plans in more detail.	1	0	1
8. Better planners are smarter.	1	1	0

what I'd rather do first, second, and third." Although some children mentioned a sequence for plan-component actions, none of them noted either the contingencies that may arise in plan execution and prompt plan revision or the other key features of planning processes. Only the second statement (above) reveals reflection of the role of goal priorities in the ordering of plan-component actions, yet goal priorities are an essential aspect of the principle of goal-value maximization, as discussed previously.

The Relative Difficulty of Planning Activities, and Factors Distinguishing "Easy Planning" from "Hard Planning"

All children felt that planning is sometimes hard and sometimes easy, but very few children mentioned identical factors as affecting the difficulty of planning activities. Planning was said to be harder if:

1. Component-act decisions are difficult: "It's hard if tough decisions have to be made on what to do."
2. Planning effort is great: "It's hard if you have to think really hard."
3. Plan size is large: "When you have more things to plan, it makes it harder to think and takes longer; it's easier with fewer things."
4. Plan revision is required: "It's harder when what's planned has to be changed."
5. Plans are not familiar: "It's easy if you know it, because you've done it before, but it's harder doing it for the first time."
6. Plans fail: "It's hard if the plan keeps on not happening."
7. Plan subject is disliked: "It's hard to plan if you don't like to think about it, as in math."
8. Efficient plan execution is desired: "It's easier to make it not work well, but harder if I want it to be better."
9. Planning context is noisy: "It's easier to plan when it is quiet than when it's noisy."
10. Plan execution is rapid: "If I have to do it in a rush, it's harder to do my best."
11. Plan is hard to remember: "It's easier if I write the plan down so that I can remember it, and check it off as I go along."
12. Plan domain is hard: "Whether it's easy or hard depends on what the plan's about."

Each child who mentioned a factor at all was unlikely to suggest any other features differentiating hard from easy planning. Collectively, this list is impressive, and reveals considerable sophistication and wisdom in children's thoughts about planning obstacles. Nevertheless, children seemed to respond with only a single difficulty factor, no matter how extensively they were questioned. The size of the plan (3), practice with the plan (5), attitude (7) and knowledge (12) regarding the planning topic, the effects of noise (9), selecting plan outcomes (1), and the need for greater effectiveness (8) are distinguished as factors that can make plan construction hard. Time constraints (10), plan

"readability" (11), plan failure (6), and the need for revisions (4) are marked as factors that make plan execution hard.

Making Planning Easier

Planning can be difficult, and a major feature of planners who are consciously developing their planning skills is knowing how to seek help. This help may be either self-centered (relying on written lists, physical props as reminders, and so on) or other centered (another person may take over the planning entirely or planners may ask for hints, assistance in revising plans, or collaboration on plan construction and execution). We asked children how they make planning easier, and their responses included ways of improving both plan construction and "readability."

Self-Centered Planning Aids. Relatively few of the suggestions for making planning easier had to do with children's own activities. There were aids mentioned for plan formulation and "readability" (see Table 7).

Suggested aids for enhancing the "readability" of a plan for execution are shown in Table 8.

Other-Centered Planning Aids. By contrast, children talked a lot about ways that plan construction and execution could be made easier by others. Titles are listed in Tables 9 and 10 to match the role the other serves.

Discussion

These results show that school-aged children have fairly elaborate views of those activities they consider appropriate to planning, as well as of the consequences of not planning, the factors influencing planning difficulties, and the ways of aiding planning. Few children noted the flexible and revisionary nature of those planning processes that characterize advanced planning

Table 7. Aids to Plan Formulation

Responses	*Times Mentioned*	*Younger*	*Older*
1. Think about the plan more.	6	2	4
2. Do fewer things in the plan.	2	2	0
3. Use tricks, as in math.	1	0	1
4. Start planning earlier.	1	0	1

Table 8. Aids to Plan "Readability"

Responses	*Times Mentioned*	*Younger*	*Older*
1. Write the plan down.	4	1	3
2. Have a good memory for plans.	1	0	1

Table 9. Aids to Plan Construction

Title	*Description*	*Times Mentioned*	*Younger*	*Older*
1. Tutor	Gives suggestions or ideas for my plan.	16	7	9
2. Reviser	Helps fix up or improve parts of my plan.	5	2	3
3. Collaborator	Does part of the planning, while I do the other part.	4	2	2
4. Planner	Makes the plan for me.	2	1	1
5. Guide	Tells me whom to ask for help or what to read.	1	0	1
6. Psychiatrist	Calms me down while I am planning.	1	0	1

Table 10. Aids to Plan Execution

Title	*Description*	*Times Mentioned*	*Younger*	*Older*
1. Mnemonic	Reminds me to carry out the plan.	2	1	1
2. Coexecutor	Carries out part of the plan.	2	1	1

activities. Metaplanning principles—so central to the revisionary character of goal definition, plan construction, and plan execution—were mentioned by only a few children, who revealed their use of goal priorities in scheduling multiple activities. It is very striking that the problem-solving settings of schoolwork were virtually absent from children's accounts of planning occasions.

New Research Directions

Great interest in planning has accompanied the recent recognition of metacognition as an integral aspect of higher mental functioning (for example, Brown and DeLoache, 1978; Flavell, 1977). Soviet psychological theorists have also recognized that planning activity is fundamental to the organizational dynamics of psychological activity (Leont'ev, 1980). Attention to planning development has been confined, however, to age differences in the quantitative measures of planning, such as more moves mentioned (Klahr and Robinson, 1981) and "increasingly conscious control and regulation of goal-oriented strategies" (Brown and DeLoache, 1978). Studies influenced by Vygotsky's (1978) conception of the progressive internalization of cognitive processes have also been limited to more-less comparisons; the tutor "scaffolds" by verbalizing goals and component aspects of plans, and the child progressively takes over, or internalizes, parts of the planning activity (Gearhart and Newman, 1980; Wertsch and others, 1980).

While recognizing the social embeddedness of planning development, we have chosen here to emphasize those qualitative aspects of plan organization for an individual (in terms of structure and process) that are subject to developmental analysis (in the sense of development toward an ideal), as well as to progressive and regressive changes that may (but need not) be predictable from the passage of time. These analytical considerations are complementary to Vygotskian studies, which are directed toward elucidating social processes of planning ontogenesis, and they may illuminate the way we investigate such processes.

Most of this chapter has been a critical-developmental synthesis of the recent planning literature as it illuminates what planning development is the development of. Future research could reveal specific interrelationships among the various fronts on which planning activities may develop, as well as encouraging a deeper, process-oriented understanding of social and individual conditions that can help or hinder the development of planning abilities. Knowledge of developmental processes could also be integrated into school curricula and adult-education programs that are devoted to promoting planning development.

Since the extent and organization of knowledge in any problem-solving domain plays such a central role in simulating tentative plans and in revising plans during their execution, planning skills will need to be studied, as well as taught, in relation to specific contents. There are serious problems of nontransfer to other domains, and they are troublesome to proponents of planning and problem-solving skills (Tuma and Reif, 1980; Urbain and Kendall, 1980), but we believe that these problems can be alleviated if, for whatever domain is utilized, a major instructional aim is to convey a developmental perspective on planning and thereby connect the workings of common, formal properties of planning (particularly metaplanning principles) to the workings of more familiar domains. Novice problem-solvers may not spontaneously recognize the commonalities among planning processes across content domains.

We take two approaches to this problem in our current work. A common belief, unsupported by research, is that the development of computer-programming expertise promotes problem solving and planning activities in general (Papert, 1980), so that the transfer of revision and problem-decomposition skills is to be expected. We are investigating the development of one group of children's expertise in planning to solve computer-programming problems (that is, domain-specific planning). We have also been videotaping sessions of think-aloud planning for carrying out a list of classroom chores, with the same children, as well as others and some adults for comparison. The chore-scheduling task was designed on the basis of ethnographic work, to ensure that all the children carried out such chores regularly. Presumably, then, there are no differences between the groups of children in terms of planning-domain knowledge, but, rather, only in their use of planning abilities.

This reserach enables us to examine microgenetic processes (Flavell and Draguns, 1957) as children proceed through a developmental sequence of multiple plan formulations toward their best (shortest distance) plans. Our

goal is to determine whether any developmental gains in planning skills that may have been achieved through programming experience will be demonstrated anew in the chore-scheduling task. The qualitative aspects of plan structure and planning processes that we have outlined will be the main focus of our analyses.

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