Analogical Reasoning

In Academic and Social Problem Solving

by

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ABSTRACT

The role of analogical reasoning in academic and social competence was investigated in Grade 6 and Grade 8 children. Skill in analogical reasoning was assessed using a categorizaton task in which children had to sort according to underlying principles in vignettes with academic or social problem-solving themes. Academic competence was assessed using an achievement test, teacher ratings of success in school, and a self-report measure of academic success, while social competence was assessed using teacher ratings, a peer sociometric, and a self-report measure of social competence. Two studies, using different samples of children, were carried out. In both studies the same pattern of results was found. Analogical reasoning was found to be related to academic but not to social competence. Exploratory path analyses on the data obtained in Study One suggested two causal models to account for the factors influencing self-perception of academic success on the one hand, and those influencing self-perception of social competence on the other. These models were tested with the data from Study Two and were found to be a good fit for the data. The results are discussed in light of current theory and research on the nature and measurement of analogical reasoning and its role in academic and social problem solving.

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CHAPTER 1: INTRODUCTION

In education, the primary emphasis is on teaching and improving academic skills. Given our rapidly changing technological environment, it has become increasingly important for educators to focus on helping children develop higher-level cognitive skills of reasoning and problem solving, and not only on expanding knowledge in academic content areas. The emphasis is on how to learn new information, and not simply on what to learn. A wealth of research and training programs has been generated over the past twenty years looking at various aspects of cognitive problem solving (e.g., Newell & Simon, 1972; Feuerstein, 1980; Sternberg, 1985; Adams, 1989; Brown, 1989; Goswami, 1991; Schraagen, 1993). More recently, and out of necessity due to social and behavioural concerns, educators have also had to focus on helping children acquire more effective social skills. Social problem solving skill has been suggested to be a primary contributor to social competence (e.g., Spivack, Platt & Shure, 1976; Rubin & Krasnor, 1986; Crick & Dodge, 1994). It has been acknowledged for some time that children demonstrating inadequate social problem solving skills are `at risk' for psychological adjustment problems in later life (see Parker & Asher, 1987, for a review). As with cognitive problem solving, considerable research and specific training programs investigating and promoting social problem-solving skills have been conducted in the social domain (e.g., Spivack & Shure, 1974; Weissberg, Carnike, Toro, Rackin, Davidson, Cowen, 1981; Rubin & Krasnor, 1986; Andrews, Peat, Mulcahy, & Marfo, 1990). With the increasing demands on the educational system to address both academic and social competence, an important issue is whether it is possible to teach general problem solving skills that can promote transfer of learning across different domains. This assumes that similar processes underlie problem solving in social and non-social (academic) domains.

There has been considerable debate as to whether teaching generalized thinking skills versus domain-specific knowledge will enhance learning across disparate domains (e.g., Sternberg, 1985; Glaser, 1985; Bransford, Stein, Arbitman-Smith & Vye, 1985). If similar processes underlie problem solving in different domains, then one would expect that skills are generalizable across different domains. Certainly, learning would occur most efficiently if skills learned in one domain could be easily transferred to other domains. Conversely, if problem solving processes are not similar, then the acquisition of knowledge specific to a given domain would be of primary importance. This would mean that prior learning in other domains would not assist learning in novel domains. At present, this issue remains unresolved. However, although recent theories have attempted to strike a balance between these two perspectives (i.e., domain-specific knowledge versus generalized skills), the balance differs from theory to theory and remains somewhat weighted in one of the two directions (e.g., Sternberg, 1985; Chi, 1988; Nathan, Kintsch & Young, 1992). Thus, this issue continues to have implications with respect to which aspect of problem solving should receive greater emphasis in training.

Researchers have postulated similar problem solving processes in the social and non-social domains (e.g., Hayes, 1981: Crick & Dodge, 1994; Andrews, et. al., 1990; Holyoak & Thagard, 1995). Some have discussed how cognitive problem solving research can be applied to social information (e.g., Wyer & Gordon, 1984; Holyoak & Thagard, 1995), and others have compared academic and social competence (e.g., Wentzel, 1991). Moreover, a recent thinking skills program focuses on promoting transfer of learning in academic and social domains by training generalized problem solving skills (Mulcahy, Andrew & Peat, 1988). However, although parallels have been drawn in theoretical models and assumptions made that similar problem solving processes exist in the two domains, there are no known studies that have directly compared cognitive and social (social-cognitive) problem solving. Both social and cognitive information processing models have noted the critical importance of the early stages of solving a problem (e.g., Crick & Dodge, 1994; Anderson, Greeno, Kline & Neves, 1981). That is, how a person interprets or mentally represents a problem situation is considered to be a key aspect of successful problem solving. In the cognitive literature, two areas of study have examined the early stages of solving a problem, namely, studies of expertise and analogical reasoning. Studies of expertise have focused on the knowledge structures that individuals employ to conceptualize a problem (Chi, 1985). It is the acquisition of knowledge specific to a given domain that is considered to be of primary importance in successful problem solving. Conversely, studies of analogous thinking have emphasized the process of identifying similar relations needed to map information between two problems. Analogical reasoning is seen as a fundamental skill in learning and transfer (e.g., Vosniadou, 1988; Gentner, Ratterman & Forbus, 1993; Anderson & Thompson, 1989). Some have argued that it is the main method used to solve novel problems in all domains (e.g., Polya, 1957; Rumelhart, 1989). Of particular interest in analogies research is why relevant knowledge often remains inert even though it is potentially useful to solve an analogous problem (e.g., Gick & Holyoak, 1983; Perfetto, Bransford & Franks, 1983). Thus, analogies researchers focus on the **process** of identifying and accessing similar relations across problems, and expertise researchers focus on the **knowledge structures** in a specific domain.

The primary goal of the present research involves examining the assumption that there are similar problem solving skills in the social and non-social domains, and the implications for the transfer of learning in these domains. This will involve first, assessing the adequacy of `equated' indices of social and non-social problem solving. Second, the similarities and differences in problem solving that arise in social and non-social domains using these materials will be studied. Finally, the relationship between problem solving and competence (both academic and social) will be explored.

To this end, I will begin with an overview of cognitive and social-cognitive problem solving models. Particular attention will be paid to the mental activities involved in the early stages of solving a problem, namely, the mental representation of information. Studies of analogical reasoning and relevant studies of expertise will be described and the critical role of the representation of information will be highlighted. My investigation will focus on problem solving by analogies. Parallels will be made to the social literature by examining research on children's interpretation of social situations. The issue of generalized skills versus domain-specific knowledge will then be addressed by examining training studies in both domains that have attempted to achieve transfer of learning. Finally, a pilot study will be summarized and the present investigation will be described within the context of these issues.

Theories of Problem Solving

Prominent models of social problem solving have been developed from theoretical formulations in the cognitive literature. Therefore, I will begin by describing cognitive theories of problem solving and follow with social-cognitive theories.

Cognitive Theories of Problem Solving

Early experimental research on problem solving was initiated by Gestalt psychologists (e.g., Duncker, 1945), who studied problems of insight. They emphasized the tendency of the mind to perceive situations as total structures. Problems represented gaps or inconsistencies in these structures, and problem solving involved achieving good structure through cognitive organization. However, the narrow focus on insight problems limited the development of a general problem solving theory (Greeno, 1978). Around the same time, behaviorists and associationists were also studying problem solving (e.g., Maltzman, 1955). They focused on the probability of emitting a response. A problem arose when an appropriate response was weaker than other competing responses. Successful problem solving involved increasing the strength of the appropriate response. These researchers contributed information regarding conditions that facilitate or hinder problem solving, but there was little analysis of the components of the problem solving process (Greeno, 1978).

Significant gains in problem solving research occurred when researchers started to analyze the component processes of problem solving. Early information processing models of problem solving, most notably Newell and Simon's (1972) General Problem Solver, focused on general search strategies through states in a problem space. The problem solver was viewed as an information processing system that interacts with a task environment (the presenting problem). The problem solving system is organized as a series of productions which are condition - action rules that specify the action or operator to select, based on certain conditions/features. The problem situation is represented by the problem solver in a problem space. The problem space contains both actual and possible solutions the problem solver might consider, and ultimately determines the methods used for problem solving. A serial system, problems are tackled using the following processes:

1) sensory input from the task environment is attended to,

2) an internal representation of the external task environment is produced and a problem space is selected,

3) problem solving proceeds within the framework of the internal representation (i.e., general search strategies through the problem space),

4) a problem solving method is selected,

5) and implemented - if not implemented, the system may abandon the problem, or a different internal representation/method is selected (i.e., a feedback loop to steps 2 or 3).

Experimental investigations using this model have largely focused on well-structured, puzzle-like problems in which all knowledge needed to solve the problem is provided in the task environment. A variety of puzzle problems have been studied, including the Towers of Hanoi (Newell & Simon, 1974).

In order to explain more language-based problem solving, as with problems presented in text, problem solving is viewed as employing two complex processes: understanding and solving (Simon, 1978). The understanding process generates a problem space from the text of a problem by interpreting the language then constructing a representation. The solving process explores the problem space in attempts to solve the problem. Problem solving alternates between the understanding and solving processes, and between interpretation and construction. Problem solving begins as soon as enough information has been generated but will `back-track' to the understanding process to gain more information, when needed.

The information processing framework has been successful in modeling general search strategies in problem solving behaviour when the initial and goal states of a problem are well specified. More recent research using such problems has shifted from an emphasis on general search strategies through a problem space, to the important role of the internal problem representation (e.g., Kotovsky, Hayes & Simon, 1985; Kotovsky & Simon, 1990). Investigations into aspects of problem difficulty have found that it is not the size of the search space available in memory, but rather how the problem is represented that determines the difficulty of the problem. Problem solution depends on subjects working on the problem and developing a better internal representation of the problem. Similarly, with well-defined text problems (e.g., algebra word problems), performance differences have been found to reflect different mental representations of the problem. For example, Paige and Simon (1966) found that some subjects interpreted a text problem using a more direct, syntactic translation of the text, while others represented the problem semantically before solving the problem. Kintsch (1988) has developed a theory of word-problem comprehension that focuses on the early stages of interpreting a problem during reading comprehension. Errors are considered to be failures to produce an appropriate mental representation of the word problem. Nathan et. al. (1992) demonstrated that training targeting the interpretation of algebra-word problems resulted in improved comprehension and representation of the problem necessary for success in subsequent stages of the problem solving process.

Although Newell and Simon's (1972) information-processing model has been used largely with well-structured problems, the processes are assumed to be similar for ill-structured problems (Simon, 1973). `Well-structured' refers to problems that are clearly formulated, the desired outcome is clearly specified, and little latitude is possible in the steps leading to a successful solution (Yussen, 1985; Frederiksen, 1984). `Ill-structured' refers to problems that lack a clear formulation, the desired outcome is not clearly defined, and the ambiguity in the various alternatives possible in solving a problem creates uncertainty and confusion (Yussen, 1985; Frederiksen, 1984). There is no sharp division between what constitutes well- and ill-structured problems. Ill-structured problems rely more on information stored in memory and/or external sources to acquire additional information necessary to solve a problem, and consequently are more characteristic of `everyday' learning experiences. However, although Newell and Simon's information processing model is assumed to be appropriate for ill-structured problems, the similarities have not been well defined. The model therefore provides limited insights into real world learning.

More recent formulations of problem solving emphasize knowledge-based representations (e.g., Anderson, et.al., 1981) in the form of schemas (i.e., clusters of knowledge that contain typical characteristics of a problem type). Consistent with earlier models, the problem solving process involves the construction of a problem representation (i.e., problem space), search for a solution, and implementation of a solution. However, in `knowledge-filled' as opposed to `knowledge-free' domains, features of a problem may activate knowledge in memory during the construction of the problem representation. If a schema for a particular type of problem is activated, then the strategies and procedures found in the schema will be implemented. Otherwise, a search strategy is employed which may involve such strategies as means-end analysis (i.e., reducing the difference between the current and goal states), planning (i.e., decomposing the problem into subgoals), or problem solving by analogies (i.e., searching for similar problems with known solutions). Thus, problem solving is schema driven or search based, with the former leading directly to implementation of a solution. Hayes (1981) has expanded on Newell and Simon's information processing model and described how skillful processing at each step can lead to efficient and effective solutions to complex cognitive tasks. Similar to Newell and Simon's formulation, Hayes has used the metaphor of the computer to describe the steps involved in processing information and solving cognitive problems. He describes the following stages of information processing:

1) find the problem (be aware that one exists),

2) represent the problem (possibly assisted by analogies, schemas and imagery),

3) plan the solutions (where the use of a variety of search heuristics are possible, for example, trial and error, means-end strategies),

4) carry out the plan,

5) evaluate the solution (to determine if the intended goal has been reached), and

6) consolidate learning about the problem and its solution (by storing in memory to assist with future problem solving).

A considerable amount of research on problem solving has been generated based on these information-processing formulations. Moreover, these models have had a significant impact on models of social problem solving.

Social-Cognitive Theories of Problem Solving

The study of social cognition has been conducted by researchers in several different fields, including developmental, clinical and educational psychology, and communication (see Shantz, 1975, 1983, for a review). Earlier theories were largely adapted from those used in the non-social, cognitive literature. Global constructs were emphasized, including perspective taking, role taking and referential communication. Major changes in empirical and theoretical approaches occurred in response to mixed research findings and the growing popularity of information-processing theories.

One of the preliminary conceptualizations of social problem solving influenced by cognitive information-processing theories, was developed by Goldfried and D'Zurilla (1969). They proposed the following steps as the basis to behave in a competent manner in social interactions:

1) identify the situation as problematic,

2) search for possible alternatives to solve the problem,

3) consider possible consequences and choose an appropriate response, and

4) implement the chosen response.

This framework was expanded upon by Spivack and Shure (1974), who added three additional steps following step two. That is, after generating possible solutions to reach a goal, the individual would ideally engage in:

3.1 "means-end thinking", or consideration of the step-by-step means to achieve social goals,

3.2 "consequential thinking", or consideration of the consequences of social responses, and

3.3 identification and understanding of the motives and behaviours of others.

Spivack and Shure's (1974) model focused on developmental issues, a focus lacking in Goldfried and D'Zurilla's (1969) model. They proposed that the ability to produce alternative solutions developmentally precedes "means-end", "consequential thinking", and "identifying/understanding the motives and behaviours of others". The research generated as a result of this model has largely concentrated on the number of alternative solutions generated (e.g., Shure & Spivack, 1975), and "means-end" thinking in older children (e.g., Platt & Spivack, 1972) as indices of problem solving. Thus, the emphasis was on quantitative aspects of problem solving.

The limited scope presented with these social information-processing models led researchers to examine other aspects of interpersonal problem solving, emphasizing qualitative and not simply quantitative aspects of social problem solving (e.g. Krasnor & Rubin, 1981; Bream, 1989). With greater emphasis on the quality of responses, researchers have been concerned with the measurement of more process-oriented variables (e.g., flexibility of solutions, Rubin, 1982; consistency of solutions across problems, Hopper & Keirshenbaum, 1985; bias in interpreting social situations, Richard & Dodge, 1982; and indirect influences on problem solving such as personal goals, Renshaw & Asher, 1981). The variety of research generated has contributed to the formulation of more recent social problem solving theories (e.g., Rubin & Krasnor, 1986; Crick & Dodge, 1994).

Flavell's (1974) conceptualization of the steps involved in making social inferences has also contributed to more recent social problem solving models. He proposed four steps:

1) being aware of the internal events/cognition of another person,

2) recognizing the need to make an inference,

3) actually making the inference, and

4) applying or using the inference to guide behaviour.

The steps are assumed to take place sequentially during a social interaction. They are also assumed to develop sequentially with age.

Dodge (1986) has utilized these early models of Goldfried and D'Zurilla, and Flavell, as well as Newell & Simon's and Hayes' models, to postulate how children process social information to respond competently in social situations. His model has recently been reformulated by Crick and Dodge (1994). They propose a six step model. A child who responds skillfully at each level of processing increases his/her chances of behaving competently, while the child who does not, increases his/her chances of responding in a deviant or aggressive manner. According to the model, a child enters a social situation with biologically determined responses and a memory store of past experiences that predispose a child to respond in a particular manner. The child receives a set of cues as input from the environment and the following information processing steps are hypothesized to occur:

1) "encoding of external and internal cues": The child selectively attends to relevant social cues (both external and internal) and encodes that information in memory.

2) "interpretation and mental representation of these cues": A meaningful understanding of the social cues is constructed by using one or more of the following independent processes:

   a) a personalized mental representation is stored in long term memory,

   b) the child engages in a causal analysis of the events,

   c) inferences are drawn about the intent of others,

   d) previous goal attainment is evaluated,

e) past performance in a previous exchange is assessed, and

f) evaluations of self and others in terms of the prior and present exchange are Inferred.

3) "clarification or selection of a goal": A goal or desired outcome is selected for the situation or a pre-existing goal is continued.

4) "response access or construction": Possible responses are accessed from memory or new behaviours are constructed in novel situations.

5) "response decision": The most positive response is chosen from an evaluation of the possible responses (based on outcome expectations, confidence in being able to enact the response, and the appropriateness of the response).

6) "behavioural enactment": The chosen response is implemented.

The reformulated model is conceptualized as being cyclical in nature, with feedback loops between interpretation and encoding of information (steps 1 and 2), and between response decision and response access (steps 4 and 5). At each step, a data base of information stored in memory influences processing and is, in turn, influenced by the present social exchange, resulting in on-going changes to memory. Individuals engage in multiple social information processing activities at any given time. Consequently, processing is assumed to be simultaneous at each step. At the same time, response to a single situation is assumed to follow a logical sequence of steps. The problem solving process is <u>not</u> assumed to finish after the response is implemented. Processing is thought to occur at a very rapid rate, and can occur consciously or unconsciously. Awareness of processing is thought to occur during highly novel or complex tasks or in response to cues to attend to processing (e.g., when a child is asked what he/she is thinking). The reformulated model also encompasses several factors assumed important in the formation of social cognition, previously absent in the previous model. The revised model takes into account not only a child's perspective, but also how peer evaluations and/or peer responses to a child's behaviour will influence a child's cognition (i.e., reciprocal effects). In the model, peer evaluations and responses occur after behavioural enactment and influence encoding of the next social situation. Also, the new model proposes that there are two types of mental processes: latent mental structures and on-line processing. Latent mental structures are mental representations of past events that are stored in long term memory and integrated with other memories. These guide the future processing or on-line processing of social cues. Finally, emotions, typically a neglected aspect of information processing models, are proposed to be an important aspect of each step of the reformulated model.

While Dodge's model has been used primarily to study factors involved in social maladjustment, in particular aggressive responding, applications to the study of pro-social behaviour have also been made (see Perry & Perry, 1987).

This cursory review of some of the more prominent models of problem solving demonstrates the progression of theorizing about problem solving in the social and non-social domains over the past few decades. I am primarily concerned with the similarities proposed by these models as a basis for further investigation.

Integrating Cognitive and Social-Cognitive Models

Four of the problem solving models (i.e., Newell & Simon, 1972; Hayes, 1981; Goldfried & d'Zurilla, 1969; Crick & Dodge, 1994) are summarized and presented for comparison in Table 1. Presented together, the high degree of overlap in the theoretical frameworks suggests that similar processes underlie cognitive and social-cognitive problem solving. It is therefore not surprising that many researchers have proposed that there are similar processes that influence problem solving in both social and non-social domains (e.g., Wyer & Gordon, 1984; Wentzel, 1991; Mulcahy, Andrews & Peat, 1987; Holyoak & Thagard, 1995).

The complexity of the problem solving process has led some researchers to suggest that problem solving skills may best be investigated using component analyses of the various

TABLE 1
Cognitive and Social -Cognitive Problem Solving Models

Cognitive P.S. Models		Social - Cognitive P.S. Models	
Newell & Simon (1972)	Hayes (1981)	Goldfried & D'Zurilla (1969)	Crick & Dodge (1994)
Attend to the task environment.	Find the problem.	Identify the problem situation.	Encode the relevant social information.
Produce an internal representation and select the problem space.	Represent the problem space.		Mentally represent the problem and interpret social cues.
			Select or clarify goals.
Proceed with problem solving within the problem space.	Plan the solution.	Search for alternative solutions.	Access or construct possible responses.
Select a problem solving method.		Consider possible alternatives.	Evaluate alternative responses.
Implement a problem solving method.	Carry out the plan.	Implement the chosen response.	Implement the chosen response.
	Evaluate the solution.		
	Consolidate learning in memory.		

skills/steps involved in problem solving (see Butler & Meichenbaum, 1981). Following a `componential' approach, earlier models of problem solving in both the cognitive and social domains tended to focus on the latter stages of information processing, namely, the generation and selection of responses and/or strategies to solve problems (e.g., in the cognitive literature, Newell & Simon, 1972; in the social literature, Spivack & Shure, 1974). Attention later turned to the early stages of information processing (i.e., the internal/mental representation of information) as being critical in forming an initial understanding of the problem before solution procedures are implemented. I now turn to a discussion of the early stages of problem solving.

The Nature of the Internal Representation

Hassebrock, Bullemer & Johnson (1988) describe a problem representation as "the product of an active comprehension process through which an individual selects relevant information from the problem statement or task instructions, makes inferences based on prior knowledge and experience with the problem, and integrates relevant domain concepts and procedures" (p. 2). The nature of the problem representation and its formation has received considerable attention from researchers in several content areas. In the domain of academic/cognitive problem solving, this has included investigations of expert/novice differences (for example, in physics, Chi, Feltovich & Glaser, 1981; chess, Chase & Simon, 1973; social sciences, Voss, Tyler & Yengo, 1983; algebra word problems, Nathan et.al., 1992; medical diagnosis, Gruppen, Wisdom & Wooliscroft, 1991; text comprehension, Vosniadou, Pearson & Rogers, 1988; electronics, Egan & Schwartz, 1979; architecture, Akin, 1980; and children's dinosaur knowledge, Chi, Hutchinson & Robin, 1988), and analogical reasoning (for example, in classical analogies of the form A:B::C:D, Sternberg & Rifkin, 1979; puzzle problems, Gick and Holyoak, 1980, 1983; algebra word problems, Ross, 1989; text, Gentner & Landers, 1985, cf. Gentner, 1989; children's knowledge of biological themes, Brown & Kane, 1988; children's stories, Brown, Kane & Echols, 1986; and figurative comparisons, Gentner, 1988). In the social domain, attention has focused on the social information attended to and biases individuals make in interpreting interpersonal situations (e.g., use of social cues and schemata, Dodge & Tomlin, 1987; hostile attributional biases, Steinberg & Dodge, 1983; intention-cue detection accuracy, Quiggle, Garber, Panak, & Dodge, 1992; and perceived social competence, Harter, 1982).

I will first address the cognitive literature that focuses on the early stages of information processing in studies of expertise and studies of analogical reasoning, and follow with a discussion of relevant findings in the social literature.

Studies of Expertise

Studies of expertise have focused considerable attention on the early stages of information processing as a key aspect of problem solving. Investigations of the differences in expert and novice performance in a given content domain have all yielded the same general finding that experts conceptualize information/problem situations in a more abstract manner that highlights functionally important aspects of a problem. This has been demonstrated in the literature , where several different tasks have been used to explore the nature of the internal representation, including tasks of memory, sorting, text comprehension, and problem solving.

Memory Tasks

In studies of expertise, recall of information specific to a given domain has often been used to compare the memory of experts and novices. For example, Chase and Simon (1973) compared novice and master chess players' recall of chessboard positions. The chess masters were far superior to novices in their ability to reproduce meaningful configurations. When presented with random patterns of chess pieces, however, expert and novice recall did not differ. Thus, the experts' superior performance was attributed to the considerable amount of well-organized chess patterns experts had stored in memory. Similarly, in medical diagnosis, Patel, Groen and Frederiksen (1986) found that experienced physicians' (experts) recall of diagnostic case reports contained more inferences and relevant propositions than novice physicians and medical students, who provided verbatim recall and relatively more irrelevant details.

Memory studies have found that the recall of experts is organized around abstract and functionally important concepts, while novices tend to structure their recall according to more concrete and superficial aspects of available information. Experts typically demonstrate use of larger organized chunks of information in remembering task information.

Sorting Tasks

How information is represented in memory by experts and novices has also been compared on tasks that have individuals sort problems into different categories. The conceptual categories used provide information about the content and organization of knowledge in the problem representation. In the domain of mathematics, Hinsley, Hayes & Simon (1978) asked high school and college students to categorize algebra word problems. They found that the students grouped problems according to solution principles. They also found that errors were made by poor students when irrelevant information about a relation was introduced, while good students tended not to be misled by such information. In comparisons of the sorting behaviour of experts and novices in physics problems, (Chi, Feltovich & Glaser, 1981), experts categorized problems based on fundamental laws of physics (e.g., conservation of energy, Newton's second law) while novices focused on visual features (e.g., inclined planes, things that rotate). Similarly, in a categorization study with children differing in terms of their knowledge of dinosaurs (Chi, Hutchinson & Robin, 1988), the `experts' grouped dinosaurs on the basis of more abstract dimensions implied by the pictures (e.g., plant-eaters / meat-eaters). Novices, on the other hand, based their categorizations more on visible properties of the dinosaurs (e.g., small head). Thus, these and other studies have shown that experts typically classify problems based on shared abstract principles or concepts in a domain, while novices attend more to salient aspects or surface details made explicit in the problem.

The concept of a schema is useful in understanding the process of representation, and has been employed as a tool to account for the performance of experts and novices on sorting tasks. Schemas are structures in memory that contain prototypical information about frequently experienced situations (Rumelhart, 1981). A major function of schemas is to construct interpretations of new situations. Incoming information is `fit' into the corresponding variables or `slots' of a schema, and if enough slots are filled a schema is activated and is available to provide additional information typical of a particular situation. When presented with a problem situation, an appropriate schema is activated and the slots in the schema determine which features are represented internally. Features that do not fit into a slot are ignored, and missing information is `filled in' based on the schema. Thus, the schema provides the organization and structure needed to access the knowledge needed to solve problems. The categorization studies of expertise have shown that expert problem solvers are not misled by superficial aspects of a problem, as are novices. Rather, the schemata of experts are more complete, in terms of their quantity of knowledge, and complex, in terms of their organization of knowledge (i.e., organization based on abstract principles as opposed to surface features) (Chi & Glaser, 1985).

Text Comprehension Tasks

Another approach in assessing the mental representation of information has been to study individuals understanding of text by analyzing recall of information read. Studies have found that memory for text (e.g., Spillich, Vesonder, Chiesi & Voss, 1979), time to read text (e.g., Johnson & Kieras, 1983), and comprehension of text (e.g., Paige & Simon, 1966) are influenced by individual's representations of textual information. In a comprehension monitoring study, Vosniadou, et. al. (1988) found that children's failures to detect inconsistencies in text were related more to difficulties forming an accurate mental representation of text propositions than to difficulties comparing inconsistent information already represented in memory. Thus, the quality of the representation, including such factors as verbatim versus semantic representations of the text and the organization of the content, was related to the kinds of information that were recalled and understood after reading passages.

Problem Solving Tasks

In the preceding tasks (memory, sorting and text comprehension), it is assumed that the cognitive structures influencing performance on these tasks are the same structures involved in actual problem solving situations. Other studies have assessed individual's problem representation while actively engaged in problem solving. Typically, protocols during problem solving or recall after a solution is reached have been employed. For example, in the medical domain, Hassebrock, et. al. (1988) examined think aloud protocols of cardiologists, interns and medical students as they diagnosed cardiology case reports. The results indicated that expert representations specified the underlying principles of the cases. That is, the doctors identified subtle, but diagnostically relevant information. In contrast, novices tended to misread important information or focus on irrelevant details of the cases. Expertise differences have also been studied using problems from the social sciences. For example, political science professors, chemistry professors, and undergraduates were asked to solve the problem of increasing crop productivity in the Soviet Union (Voss, Tyler & Yengo, 1983). Strong knowledge effects were found, in which the experts provided the most comprehensive and detailed solutions. Expert solution protocols focused to a significant degree on the initial state of the problem, with particular emphasis on identifying constraints in solving the problem. Novice protocols, in comparison, contained very little of this type of information. Therefore, the findings again demonstrate experts use of more abstract principles or fundamental laws in a given domain, in comparison to novice's reliance on verbatim or obvious details.

In considering knowledge differences in the internal representations of experts and novices, it is important to note that it is not only the amount of knowledge, but also (and even more importantly) the structure of knowledge within a representation that is critical in successful problem solving. While the structure of knowledge is to some extent determined by the quantity of knowledge, it is the properties of the structure that effect the use of knowledge (Chi, Hutchinson & Robin, 1988). Chi et. al. (1988) have proposed that the properties of coherence and hierarchy are particularly important characteristics of a structure. They adopt the popular notion of a network, in which the structure of a domain of knowledge is described as a network of nodes (the concepts) and links (the relations between concepts), and define:

> a) hierarchy as the pattern of relationships among substructures, that is, how well the whole structure is integrated, and
>
> b) coherence as the patterns of interlinking and attribute-sharing concepts of the substructures, that is , how well integrated the substructures are that form the hierarchy of the structure.

To explore their proposal that coherence and hierarchy are meaningful aspects of knowledge structures, Chi et. al. (1988) had children, differing with respect to their knowledge of dinosaurs, sort pictures of familiar and novel dinosaurs according to which `go together', relate their knowledge about certain dinosaurs, and determine which dinosaur in a set of four does not fit (with differences based on a higher order relation, e.g., meat or plant eater, or visual detail e.g., physical feature). The results of these knowledge generation and categorization tasks found that expert children provided "more intelligent explanations, constrained inferences, categorical reasoning, hierarchical classifications, and classifications based on well-defined family structures" (Chi, et. al., 1988, p. 28). Novices provided explanations and inferences that appeared incorrect and irrelevant, and their classifications and reasoning were limited and based on perceptual as opposed to conceptual features. Thus, the structure of expert children's knowledge of dinosaurs was more coherent and hierarchical. In contrast, expert and novice children demonstrated comparable general learning skills of making comparisons and giving causal explanations when they possessed equivalent knowledge in a domain (here, the animal domain was used).

Thus, studies of expertise employing memory, categorization, text comprehension and problem solving tasks have demonstrated the importance of possessing knowledge structures specific to a given content domain for successful problem solving. Furthermore, studies such as that of Chi et.al. (1988) described above suggest that knowledge structures and not general learning skills (i.e., general processes) are critical aspects of problem solving. This position contrasts with analogies research, that focuses on the process of identifying and accessing similar relations across problems. While analogical reasoning research does not dispute the necessity of possessing relevant knowledge to solve problems, research efforts are directed at explaining learning and the transfer of learning to novel content domains. Studies of analogical reasoning are presented next, again with particular attention paid to the importance of the early stages of problem solving.

Studies of Analogical Reasoning

In contrast to studies of expertise, research in the use of analogies has focused on the process of mapping relations from a given (base) problem/situation to a new (target) problem/situation. Analogy is of particular interest as a mechanism that brings prior knowledge to bear on the acquisition of new knowledge (Vosniadou, 1988). Both adults and children are more successful at solving problems if they have previously solved similar problems (e.g., Holyoak & Koh, 1987; Novick, 1988; Brown & Kane, 1988). Analogical reasoning is thus considered fundamental in promoting transfer in problem solving. The process of analogical problem solving (involving retrieval, mapping and adaptation) is influenced by the nature of the representation constructed for the source and target problems (Novick, 1991). While researchers are interested in all component processes of analogical reasoning, an important question that involves the early stage of representing a problem is how information is encoded and relations identified that allow a mapping to take place.

Studies of analogical reasoning can be divided into two general categories, according to how analogical reasoning has been measured. These include more traditional analogies of the form A:B::C:D, and reasoning by analogy in problem tasks.

Classical Analogies - A:B::C:D

The traditional measure of analogy involves four terms, where the second term is related to the first, as the fourth term is related to the third. An example would be:

concert : audience :: game : spectators

Historically, Spearman (1923) proposed the first processing model of analogical reasoning. Verbal analogies played a dominant role in Spearman's theories of intelligence and cognition, as he considered verbal analogies to be the best measure of general intelligence, "g", and the prototype of intelligent thought. Spearman postulated three principles involved in reasoning with verbal analogies:

1) the apprehension of experience,

2) the eduction of relations, and

3) the eduction of correlates.

In contemporary terminology, these principles refer to:

1) encoding the terms of the analogy into a meaningful internal representation,

2) inferring the relation between the first pair of terms, and

3) applying the analogy to the second pair of terms by knowing the relation between the first pair of terms.

While Spearman's theory of cognition had little impact in its time, current processing models of analogical reasoning are related to Spearman's theory.

More recently, information processing theorists studying classical analogies have attempted to identify different component skills involved in analogical reasoning (e.g., Sternberg & Nigro, 1980; Goldman, Pellegrino, Parseghian & Sallis, 1982). Sternberg's Componential Theory of Analogical Reasoning is more detailed than Spearman's concerning the specifics of processing and how processing difficulty is influenced by stimulus content. At the same time, Sternberg's theory is more general than Spearman's with respect to stimuli content (i.e., encompassing verbal, figural and geometric items). Sternberg (1977) postulated six processing events or components when solving an analogy of the form A:B::C:D, namely,

1) **encoding** the terms,

2) **inferring** the relations between the first pair (A and B) of terms,

3) **mapping** the relation between A and C,

4) **applying** a relation analogous to the A and C relation to the B term to solve for D,

5) **justifying** that D is a good match among alternatives, and

6) **responding** or making a response.

Problem Analogies

More recently, researchers have moved from studying classical analogies to reasoning by analogy in problem solving tasks. Here, the analogy depends on the similarity of the relational structure between a problem that has already been solved (the base) and a new problem (the target). Theories of analogical reasoning are numerous, but for the most part differ in their emphasis as opposed to their basic elements. There is generally agreement that there is a one-to-one mapping of objects and a carry-over of predicates from one domain, the base, to another, the target. [As noted earlier, knowledge is represented here as propositional networks of nodes (concepts) and predicates (propositional links between concepts).] Also, researchers agree that there is some variation of a selection principle to determine which predicates are important in the match. However, accounts differ with respect to the nature of the selection principle, varying according to the degree to which they are guided by structural versus pragmatic principles. A model that is guided by structural principles is Gentner's Structure-Mapping Theory (1983, 1989), while Holyoak (1985, 1989) offers a pragmatic or goal-driven account of analogical processing. In between these extremes are models that propose a set of structural processes while also taking into account the role of plans and goals (e.g., Burstein, 1986; Kedar-Cabelli, 1985; Reed, 1987; Rumelhart & Norman, 1981; Winston, 1980, 1982). Whereas Gentner and Holyoak's models both emphasize the mapping of abstract principles, other models such as the Exemplar Model of Ross (Ross, 1989) have postulated that content specifics (i.e., either surface or structural information) are involved throughout the mapping process and are favored above abstract principles. These models and the different theoretical perspectives, particularly those of Gentner, Holyoak, and Ross, are discussed in greater detail later in this paper.

An example of how people map relations in reasoning by analogy has been shown in an experiment by Gentner (1983) that asked subjects to provide written descriptions of given objects, interpret analogical comparisons that used these objects, and rate the comparisons for interest/worth in reading. According to analogical reasoning theories, subjects should omit object attributes and focus on relations when reasoning with analogies. This was found. Subjects interpreted analogical comparisons (e.g., "Cigarettes are like time bombs") in terms of common relations, and ratings of interest/worth showed a preference for relational (as opposed to attributional) information. In contrast, simple object descriptions (e.g., "cigarettes") contained both attributes and relations. Thus, adults tended to focus on relational information and indicated a preference for such information when interpreting analogies.

Of considerable interest in the analogies literature is subjects' failure to detect analogous solutions to problems and the conditions under which analogous solutions are generated. This was demonstrated in an experiment using Duncker's (1945) "radiation problem" as a target problem (Gick & Holyoak, 1980). In the radiation problem subjects are told to pretend they are doctors with a patient who has a malignant stomach tumor who will die unless the tumor is destroyed. An operation is impossible. A high intensity ray can destroy the tumor, but it will also destroy healthy tissue. At lower intensities the rays will not harm healthy tissue, nor will it destroy the tumor. The problem is to find a way to use the rays to eliminate the tumor without destroying healthy tissue. A source analog was first presented to subjects, in which subjects read a story about a general who wants to capture a fortress. Many roads radiate from the fortress, but the roads are mined such that small groups could travel safely but a larger group could detonate the mines. The general needed all of his men to mount a successful attack. Subjects received different solutions to the military problem, such as sending small groups down multiple roads to arrive at the fortress simultaneously. Subjects were then presented with the radiation problem and asked to solve it. An analogous solution to the military problem would be to direct multiple weak rays from different directions (the convergence solution). Gick and Holyoak found that 75% of college students generated the convergence solution after receiving the military problem with the convergence solution and a hint to apply the solution. Only 10% of students generated this solution without receiving the base analog (i.e., the military problem). Subjects tended to use the solution provided in the source story to solve the radiation problem after a hint. Thus, variations in solution to a source analog resulted in the generation of qualitatively different solutions to the target. Of particular interest, however, was that despite receiving the target problem immediately following the base story, only 30% of subjects generated a solution without a hint (vs. 75% after a hint). The majority of subjects failed to spontaneously make use of the analogy.

Catrambone and Holyoak (1989) demonstrated the important role of schema induction in spontaneously noticing analogies in remote domains. They expanded on the experiments by Gick & Holyoak (1980, 1983) by presenting two convergence stories (e.g., the military problem and a fire-fighting story where converging water sources are needed to put out a large fire), or one convergence story and one disanalogous story. All subjects wrote summaries of each story, and half of the subjects wrote descriptions of the similarities in the two stories (the comparison condition). Then they all attempted to solve the radiation problem. An earlier study similar in method but without a comparison condition, found that two analogs as opposed to only one analog resulted in a higher incidence of spontaneous transfer of the convergence solution both before and after a hint. However, it was not clear from the results whether greater success was because the two analogs helped subjects to abstract a schema representing the structure of the two analogs, or whether they simply had two opportunities to be exposed to the analog. Hence, the comparison procedure was included in Holyoak and Catrambone's study to create a mapping between the two stories. This was predicted to result in an explicit representation of the shared schematic structure (i.e., schema induction). Conversely, if the comparison procedure is not crucial in schema induction and the stories are retrieved independently, then two analogs should produce greater transfer than one, regardless of whether the analogs are compared. The results indicated that subjects in the comparison condition that received two analogs generated the convergent solution before receiving a hint significantly more than subjects who received one analogous and one disanalogous story (60% vs. 20% before a hint). When no comparison was made, spontaneous transfer significantly dropped in the two analog group (35% in the no comparison group vs. 60% in the comparison group). However, once a hint was provided, transfer did occur with or without explicit comparison instructions in the two analog groups (overall 90% and 80% in the comparison and no comparison groups, respectively). Moreover, subjects receiving the analogous and disanalogous stories generated the convergence solution less frequently with or without a hint, presumably because the presence of a distracter story impeded the application of a source analog. The results were taken to support the schema induction hypothesis where direct instruction to make comparisons triggered schema induction that ultimately assisted in spontaneous transfer of the analogy to a target problem. Studies such as these have demonstrated how the general process of reasoning by analogies influences successful problem solving across disparate content areas.

Thus, in the cognitive literature, the nature of the early stages of information processing has been investigated in studies of expertise and analogical reasoning. Studies of expertise have demonstrated the importance of the structure of knowledge in a specific content domain. Studies of analogical reasoning have demonstrated the importance of the process of identifying and accessing similar relations among problems. I now turn to a brief overview of research in the social literature that highlights the role of the internal representation of information in interpersonal situations.

Studies in the Social Domain

Similar to findings in the cognitive literature, an understanding of the processes of encoding and interpreting social cues is very important since interpretations made at this early stage of information processing most likely influence subsequent processing of social information. Research findings have typically suggested that socially maladjusted children tend to make errors or produce biased interpretations of social situations. Several different tasks have been employed to demonstrate these findings, including hypothetical situation interviews or questionnaires, interviews about real-life social events, and self-report inventories.

Hypothetical Situation Interviews or Questionnaires

The hypothetical situation is the most popular approach used in studies of social information-processing. Children are presented with a hypothetical social situation (either a story with or without pictures, or a video of children in a social situation) and they are asked questions about the situation. Their responses are assumed to indicate how they have processed the social information. For example, Dodge and Tomlin (1987) presented children with hypothetical situations involving peer provocation and conflict. The children were asked to infer the intent of the provoking peer and explain how they arrived at this inference. Results indicated that aggressive children relied more on general mental structures from their own experiences (i.e., schemata) to interpret the intent of the peers. Conversely, non-aggressive children relied more on the immediate social cues presented in the story to infer intent. Similarly, other studies using the hypothetical approach have shown that aggressive children in particular tend to attribute hostile intent to peers when presented with ambiguous situations of possible peer conflict (e.g., Dodge & Frame, 1982). Moreover, the consistency of this finding across many studies demonstrates that the relationship between children's social maladjustment and hostile attribution bias is quite robust. These findings have typically been displayed by children with aggressive behavioural patterns. Few studies have looked at children with avoidant behavioural characteristics, and results have been mixed. For example, Waldman (1988) did not find evidence that a sample of withdrawn children attributed hostile intent to peers in hypothetical situations, while Quiggle et. al. (1992) found that depressed-nonaggressive children demonstrated hostile attribution bias. Certainly further research with nonaggressive children with avoidant behavioral styles is needed.

While hostile attribution bias has been found in ambiguous hypothetical situations, hypothetical situations have also been used in which the provocation is clearly benign, hostile or accidental. Here children's errors in inferring the intent of peers presented in a hypothetical situation is assessed (i.e., intention-cue detection accuracy). Studies have shown that socially maladjusted children (rejected or aggressive children) make relatively more errors than their well-adjusted peers in inferring intent in unambiguous situations (e.g., Dodge, Murphy & Buchsbaum, 1984; Waldman, 1988).

Interviews About Real Social Events

The use of interviews about actual social events has been used infrequently. Similar to the hypothetical method, children are asked questions about a social situation, but with this approach the children respond to an actual social experience. Steinberg and Dodge (1983) demonstrated hostile attribution bias in an actual play situation involving a peer who knocks down blocks of a building originally erected by a subject. Whether the act was intended to provoke the subject is ambiguous. Subjects were aggressive and non-aggressive children. Consistent with other findings using hypothetical situations, aggressive children were more likely than nonaggressive children to attribute hostile intent to the peer. These findings in actual and hypothetical situations suggest that the hostile attribution bias is ecologically valid.

Self-Report Inventories

Self-report inventories have also been employed, where children rate a series of statements according to how true each statement is for them. In this manner, and using factor analyses to construct meaningful scales, general mental structures can be assessed. One such self-report instrument developed by Harter (1982) has been used to assess children's perceptions of their own competence.

In on-going social interactions, the interpretative process includes an evaluation of past events/goals, the self and others. These self evaluations and evaluations of others are stored in memory as part of latent mental structures. Repeated instances of similar experiences are thought to result in the development of a child's perception of his/her social competence. Studies have shown a positive relationship between perceived social competence and peer status (social adjustment) in children beyond second grade (e.g., Kurdek & Krile, 1982; Ladd & Price, 1986). However, this relationship may vary somewhat depending on the behavioural styles of children. Studies by Hymel, Bowker & Woody (1992) and Rubin, Chen & Hymel (1995) have shown that rejected-withdrawn children perceive themselves more negatively than their peers (i.e., their view of themselves as socially incompetent is consistent with how their peers view them). Conversely, rejected-aggressive children did not view themselves more negatively than their peers (i.e., their view of themselves as socially competent differs from the view of their peers who see them as incompetent). These results suggest that perceived competence may or may not show a relationship with social maladjustment, depending on the type of deviant behaviours exhibited by the sample.

Thus, the importance of how an interpersonal situation is represented in memory in the early stages of information processing has been demonstrated in hypothetical situation and real life interviews, and self-report inventories. Biases in interpreting social situations have been found to be characteristic of children less competent socially.

In summary, brief reviews of the progression of theorizing about problem solving in both the cognitive and social-cognitive literature were presented. The high degree of overlap in the information processing theories show how similar general processes are assumed to underlie these different domains of human capabilities. Of particular import is an early stage of information processing, namely the internal representation. This was demonstrated in studies of expertise and analogical reasoning in the cognitive literature, and studies of attributional bias in the social literature. However, studies of expertise and analogical reasoning clearly differ in their emphasis on knowledge structures versus general processing skills, respectively. Consistent with the assumption of similar processes underlying problem solving in the cognitive and social domains, the analogies research suggests that the process of reasoning analogically is critical in learning and transfer across remote domains. In contrast, the expertise research highlights the role of knowledge structures in successful performance. Moreover, the inference suggested by some results is that general processing skills are necessary but not essential to competent problem solving. This issue of the relative importance of generalized skills/processes versus domain-specific knowledge is addressed in the following section.

General Processes vs. Domain-Specific Knowledge

In the 1960's and 1970's considerable research was directed at promoting thinking skills and transfer of learning. This was a continuation of the well-established tradition of training cognitive processes to enable students to learn in a wide variety of content domains (see Mann, 1979). The goal of developing general thinking skills is to permit transfer to tasks that may be quite different from those practiced. As a consequence, training programs focused on general processes, at times almost independent of a specific content domain (e.g., Feuerstein, 1980). And yet, results fell short of expectations (see Segal, Chipman & Glaser, 1985, for a review of several prominent programs).

The trend in the 1980's was a shift in focus to teaching domain-specific knowledge (e.g., Glaser, 1984). In reaction to the claims of `cognitive process training', it has been argued from as early as Thorndike, that transfer is specific rather than general, and that practice and training in specific content areas is most important. In this view, transfer is based on specific elements that are common across situations (e.g., Thorndike, 1913).

This process vs. knowledge issue was and continues to be an issue of great debate (e.g., Glaser, 1984, 1985; Sternberg, 1985, 1989). Of concern is "the trend to shift from over-emphasis on one aspect of cognition to over-emphasis on another aspect of cognition" (Sternberg, 1985, p. 571). No one has attempted to claim that general processes or domain knowledge is more important to the exclusion of the other, and it is generally accepted that both aspects of cognition complement each other. However, researchers continue to seek confirmation that one aspect, general processes or specific knowledge, is most important in promoting thinking and transfer of learning. Research findings from studies of analogies and expertise can be taken as support for the two different views of the importance of general cognitive processes (the focus of analogies research) versus knowledge specific to a particular domain (suggested by expertise research). Calling a truce in the debate of relative merit and acknowledging the importance of both process and knowledge structures does not necessarily assist the educational field in providing the most efficient means of teaching skills and (even more desirable) transfer. The directive from the literature is to `Teach it all'. And yet, given that expertise research over the past decade continues to focus largely on how knowledge is structured (e.g., Greeno & Simon, 1988; VanLehn, 1989), this suggests a directive to `Teach it all - but teach domain-specific knowledge more'. Despite this, researchers continue to recognize the importance of acquiring general thinking skills to learn more efficiently, that is, to help students learn to learn (Bransford, et.al., 1985).

In a return to earlier conceptualizations of learning and expertise, some recent research has demonstrated the importance of general strategies when specific domain knowledge is lacking. Schraagen (1993) compared the performance of subjects varying in terms of their level of expertise when presented with the problem of designing an experiment in sensory psychology. Of particular interest was his comparison of experts familiar with the given problem (i.e., experimental design experts in the field of sensory psychology) and experts for whom the problem was novel (i.e., experimental design experts who had not designed experiments in sensory psychology). The most notable result was that, although experts lacking domain knowledge produced inferior solutions when compared to domain experts, both groups of experts employed the same structural approach to problem solving. That is, all experts exhibited the schema-driven problem solving that characterize their routine problem solving. Thus, "although the **form** of the design experts' reasoning was similar to that of the domain experts, the **content** or **substance** of their reasoning was dissimilar" (p.305). As Schraagen points out "this result implies that expertise cannot only be considered the product of increasingly specialized domain knowledge, as current theories of expertise would claim (e.g., Anderson, 1987)" (p.303).

Many researchers concerned with process aspects or `mental actions' involved in problem solving have studied reasoning by analogy. It is considered by many to play a central role in solving problems and acquiring expertise (e.g., Novick, 1988; Gick, 1985), and some would even argue that analogical transfer is the main (and to some the only) method used for solving novel problems (Polya, 1957; Rumelhart, 1989; Moore & Newell, 1973). In order to better understand the process of reasoning by analogies, a brief overview of prominent theories and the development of analogical reasoning follows.

Theories of Analogical Reasoning

As noted earlier, theories of analogical reasoning are generally consistent in their assumptions that there is a mapping of objects/relations from one domain to another, and a selection principle determines what is mapped. Beyond this, theories differ in general with respect to their focus on structural versus pragmatic principles, and whether the development of analogical reasoning is seen as a deficit in competence or content knowledge. Three prominent theories reflecting the differing principles, including Gentner's Structure-Mapping theory (1983, 1989), Holyoak's Multiconstraint theory (1985, 1989; Holyoak & Thagard, 1995), and Ross' Exemplar theory (1989) are presented below. This is followed by a brief discussion of different theoretical perpectives on the development of analogical reasoning.

Gentner [illegible]

[illegible]

analogy [illegible]

system o[illegible]

reasoning [illegible]

base and [illegible]

Objects i[illegible]

manner th[illegible]

predicate [illegible]

linked by [illegible]

called the [illegible] of [illegible]

Ac[illegible]

a) [illegible]

b) [illegible]

preferring [illegible]

maps sema[illegible]

c) [illegible]

between tw[illegible]

d) th[illegible]

goals.

Gent[illegible]

mere [illegible]

tabletop glea[illegible] water"

litera[illegible]

like water" ([illegible]

analo[illegible]

the flow of w[illegible]

Gentner's Structure-Mapping Theory

According to Gentner's Structure-Mapping Theory (1983, 1989), in order to solve an analogy knowledge is mapped from one domain, the base, into another, the target, such that a system of relations among the base objects also holds among the target objects. Success at reasoning analogically requires noticing the similarities in the relational structure between the base and the target domains independent of the specific objects used to convey the relations. Objects in the base are placed in a one-to-one correspondence with objects in the target, in a manner that maximizes the structural match. There is a preference not to map isolated predicates (lower-order relations e.g., `bigger than'), but rather, to map systems of predicates linked by higher-order relations (e.g., `cause'). This is important in the mapping process and is called the **principle of systematicity.**

According to structure mapping theory:

a) the deepest - i.e., most systematic - mappable structure is selected,

b) the matching process between base and target is entirely structural, i.e., by preferring to match deep relational chains, the system acts as a domain-general matcher that maps semantic representations but not any particular pre-specified content,

c) interpretations of an analogy will differ depending on which predicates match between two domains,

d) the actual process of reasoning by analogy is independent of the problem solver's goals.

Gentner distinguishes between different kinds of similarity in reasoning, namely:

mere appearance match, where object attributes are mapped, e.g., "The glass tabletop gleamed like water" (p.207),

literal similarity, where both relational and object attributes are mapped e.g., "Milk is like water" (p.207),

analogy, where only relational predicates are mapped, e.g., `The flow of heat is like the flow of water' (p.202), and

relational abstraction, where the base domain only contains abstract principles, and thus, there are no object attributes omitted in the relational mapping, e.g., "Heat is a through-variable" (p. 208), (understandable given a knowledge of system dynamics).
These different kinds of similarity represent a continuum of reasoning based on attributes (often seen in novice learners) to reasoning based on abstract relations (characteristic of more successful problem solving performance).

Gentner's model does not take into account plans and goals. This omission has been a common criticism of her model (e.g., Holyoak, 1985), but has recently been addressed by Gentner (1989). While remaining adamant that plans and goals have no role during the analogy process, she does propose that plans and goals influence reasoning before and after the analogy process. Before the mapping begins, plans and goals constrain the input that forms the initial domain representation of the situation/problem (i.e., information in working memory and what gets accessed from long term memory). After a match, plans and goals will influence the evaluation of the structural soundness, relevance, and validity of the match. Other than these influences, the analogy process itself does not require plans and goals. An advantage of modeling the analogy process as structure-driven as opposed to goal-driven, is that it allows for the generation of unexpected matches, or even matches that contradict an individuals initial problem solving goals. This has certainly proven important in scientific discovery.

Holyoak's Multiconstraint Theory

In contrast to Gentner's Structure-Mapping Theory, Holyoak views analogical thinking as operating under the constraints of similarity, structure, and purpose (Holyoak, 1985, 1989; Holyoak & Thagard, 1995). Analogical problem solving involves constructing a mental representation of the base and target, accessing a relevant base as an analog to the target, mapping the components of the base and target, and using the mapping to generate a solution to the target. In this latter stage, the useful commonalities between the base and the target are represented as new knowledge structures (i.e., the induction of new knowledge). These stages are essentially the same as those proposed by Gentner. However, beyond this, the theories differ, as Holyoak postulates a pragmatic account of analogy where plans and goals control the mapping process. Thus, analogy is seen as part of a goal-driven processing system. Different goals result in different mappings from the same base problem. As Holyoak (1985) states; "In any problem model the components are directly relevant to the solution plan: the goal is a **reason** for it; the resources **enable** it; the constraints **prevent** alternative plans; and the outcome is the **result** of executing the solution plan" (p.70). If the goal, resources, operators and constraints are structurally similar, then they can be mapped from the base problem to the target problem. The common abstract structure in two problems is considered a schema for a general class of similar problems. Holyoak does not differentiate between properties (predicates with only one argument) and relations (predicates with more than one argument). He does distinguish between surface similarity and structural similarity. This distinction highlights the goal of the problem solver. Surface similarities are common aspects of two problem situations that play no causal role in determining possible solutions. Structural similarities are commonalities that influence whether or not a successful solution is reached. In retrieving cues from the target and accessing the base analog, success will depend on the problem solver's ability to identify structural similarities and avoid superficially similar but unhelpful surface similarities.

In their work on the use of analogies in problem solving, Holyoak and his colleagues have found that successful transfer of base information to a target analog is determined in large part by the development of an adequate schema (e.g., Gick & Holyoak, 1980, 1983). Schema induction is assumed to occur strategically (as opposed to automatically). That is, either by directly comparing two analogous problems (e.g., Catrambone & Holyoak, 1989) or mapping one analog to another during problem solving (e.g., Holyoak, 1985). While Gentner acknowledges that schema induction does occur (Gentner, 1989), structure-mapping theory provides no mechanism for schema induction.

Holyoak and Thagard (1995) have been successful in modeling analogical problem solving in the context of computer programs, one example being PI, or Processes of Induction. In PI, processing occurs using condition-action rules and spreading activation through associative links among concepts, all directed by goals and subgoals of the problem solver.

Criticisms of Holyoak's theory have been leveled at the inability to account for unexpected analogies that may be counter to expectations of the problem solver. Also, the immense size of the database needed to model all of the potential associations and possible mappings in a given domain may be too large for a system to handle.

Ross' Exemplar Theory

Exemplar models of analogical transfer differ from Gentner and Holyoak's accounts in their emphasis on the importance of the specific content as opposed to abstract features of the base and target. For example, in the theory developed by Ross and his associates (e.g., Ross, 1989; Ross & Kennedy, 1990), they propose that previously learned examples are what is mapped to a target problem . Retrieval of an analog is based on the degree of similarity between the base and target - including either surface or structural details. The assumption is made that specific information is favored over abstract information. General solution principles are induced from specific exemplars, and abstract information is used within the context of the specific information. While Gentner and Holyoak's theories both acknowledge the importance of specific content in the early stage of analogical mapping, Ross' theory emphasizes content throughout the mapping stages (including selection and application).

Empirical studies in the use of analogies in problem solving have demonstrated the utility of aspects of each of these theories in problem solving. For example, evidence for the principle of systematicity was found by Clement and Gentner (1991). They gave subjects a full base analogue, had them compare the similarities with an incomplete target problem and then asked them to rate information (analogous to the base story) as more or less important to the target story. They found that the subjects rated information consistent with a system of relations as more important than information that was not systematically related. Furthermore, their own inferences that they drew about the target story were consistent with the connected system of relations presented in the base story, and did not represent isolated predicates. The study described earlier by Catrambone and Holyoak (1989) demonstrated the strategic nature of schema induction in solving analogous problems. They found that two analogous stories as opposed to only one resulted in greater spontaneous transfer to the target problem, and this was enhanced when subjects were asked to compare as opposed to simply summarize the two analogous stories. In addition, presentation of an analogous and disanalogous story appeared to impede the application of the analogous solution to the target problem. Thus, as predicted by Holyoak's theory, subjects needed to work at schema induction. And finally, studies have shown that exemplar-specific information is retained and is often highly conducive to access and use of a base analog in solving a target problem. For example, in a variation of Duncker's radiation problem, Keane (1987) modified the similarity of the semantic domain (medical vs. military) and shared common surface details (e.g., doctor, tumor, 2 rays). He found that success in solving the radiation problem was enhanced when both semantic and surface details were similar. Similarly, Holyoak and Koh (1987) manipulated the similarity/dissimilarity of surface and structural elements in stories analogous to a target problem (Duncker's radiation problem). Stories that combined similar surface and similar structural elements demonstrated an additive effect in facilitating spontaneous transfer of the analogous solution. However, structural similarity was critical for overall success (i.e., with or without a hint) in solving the target problem.

The theories of Gentner, Holyoak and Ross were reviewed and contrasted by Reeves and Weisberg (1994) and used to account for the empirical evidence. Reeves and Weisberg concluded that "All of the theories of analogical transfer discussed herein receive partial support from the empirical evidence..." (p. 395). Moreover, "to explain all of the available data, a hybrid of the structural, pragmatic, and exemplar views is necessary" (p.396).

Theories of analogical reasoning have also differed in their account of how this general processing skill develops.

Developmental Considerations

A typical finding of research investigating children's use of analogies has been that young children are essentially unable to do it. Rather, analogical reasoning is thought to develop with age (e.g., Inhelder & Piaget, 1958; Sternberg & Nigro, 1980). For example, Sternberg and Nigro (1980) postulated two levels of performance. For younger children, analogical reasoning is incomplete but not absent and performance is characterized more by a reliance on associations among terms as opposed to analogical relations. At the second level, analogical reasoning is attained. For example, for the simple analogical problem:

bird : nest :: dog : ? (horse, doghouse, bone, walk)

a younger child (at level one) is expected to choose the associate `bone', while the older child (at level two) is expected to choose the analogical relation `doghouse'.

However, Goswami & Brown (1995) have recently found very different results that seriously question such a structural explanation of analogical development. They presented children with pictorial analogies in the traditional format (i.e., a:b::c:d) using **very familiar relations** that have been shown to be important in young children's knowledge structures (e.g., the relation `lives in'). These modifications to item difficulty and mode of presentation were sufficient to demonstrate that even children as young as four years of age were able to understand the relations upon which an analogy is based. Moreover, the children were not influenced by a simpler associative understanding of the analogy. Similarly, other research has demonstrated success with young children solving geometric analogies, as well as improvements in analogical reasoning following training in component processes (Alexander et.al., 1989).

The development of analogical reasoning is viewed by Gentner as similar to Sternberg's structural explanation of analogical development. Gentner (1983, 1989) postulates a "relational shift" in analogical processing from a focus on common object attributes to a focus on common relations. This developmental shift may be due to a competence deficit (a structural view) or limitations in domain knowledge.

Evidence for the relational shift was found in a test of children's development of systematicity in a story mapping task (Gentner & Toupin, 1986). Children aged 4 to 6 years and aged 8 to 10 years listened to a story read aloud, then acted out the story using toy animals. They were then asked to act out the story again with new animals. The animals differed from the story to test phase according to whether the animals were similar or different in appearance to the original characters, or whether they played the same or different role (hero, friend and villain). This resulted in three mapping conditions that tested the influence of surface similarity: high transparency (similar characters and roles, e.g., dog - cat), medium transparency (different characters and similar roles, e.g., dog - camel) and low transparency (similar characters and different roles, e.g., dog - seagull). Transfer (accurate re-telling and acting out of the story) was expected to be easier when the new animals looked similar, and more difficult when they looked different, and the most difficult when they looked similar but had different roles (i.e., a cross-mapped condition). Also, systematicity was manipulated by the inclusion of a moral in half of the stories. The moral provided a higher-order relation in the story, and it was predicted that the use of systematicity should make analogical mapping easier. The results indicated that transparency or surface similarity strongly influenced accuracy in transferring the story for both age groups, with performance falling significantly with decreasing transparency. There was also a strong effect of systematicity for the older age group only. Thus, the older children were able to benefit from systematicity in the mapping task while the younger children's performance was not affected by the inclusion of a moral. Gentner & Toupin concluded that for analogical mapping, surface similarity appears early in development while systematicity may appear later. They suggest that this may be due to a competence deficit (i.e., children lack the processing ability to map whole relations) or a lack of knowledge of higher-order relations. Once again the issue is raised about the influence of process versus knowledge in reasoning.

Holyoak, Junn & Billman (1984) explored the development of analogical reasoning by asking children from 4 - 6 years and 11 - 12 years to solve a problem of how to move balls from one bowl to another out of reach, after listening to a story that contained an analogous problem and solution. Two story analogs were used that described how a genie solved a problem of how to move jewels from one bottle to another bottle by using either his magic staff to pull the bottle over (the 'magic staff' analog) or commanding his magic carpet to roll into a tube and rolling his jewels into the other bottle (the 'magic carpet' analog). The target problem involved devising as many ways as possible to move balls from one bowl to another out of reach using a variety of materials, including a large sheet of paper (the analogous solution to the magic carpet story) or cane (the analogous solution to the magic staff story). A hint was provided to use the story if the children could not come up with an analogous solution. Results indicated that the younger children were able to use the magic staff analogy, but not the magic carpet analogy, while the older children were able to use both analogies. Holyoak et. al. concluded that, given the stronger surface similarity between the magic staff and cane, younger children may only be able to use analogy in the presence of surface similarity cues. This again suggests a competence deficit view of development.

Brown, Kane and Echols (1986) investigated these results further in a variation of the rolling analogy in the story-mapping paradigm. Children were presented with the magic carpet version of the genie story followed by a problematic story that required transfer of the solution of rolling a flat object into a tube (an Easter bunny moving eggs, or a farmer moving cherries). They found the same results as Holyoak et. al. when the children had to figure out the similarity themselves. However, performance on the problematic story improved significantly (70% transfer) when the structural similarity of the base story (i.e., protagonist, goal, obstacle and solution) was highlighted. Similarly, in another variation of the Brown et. al. (1986) study, Brown, Kane & Long (1989) again helped children focus on the analogy. They asked children to solve the genie problem, and if they were unsuccessful the experimenter helped them solve an analogous problem (the bunny or farmer problem), then the genie problem was re-introduced with an explicit hint that the bunny/farmer problem may help. Transfer performance improved significantly (about 50% compared to 20% in the control condition), and almost all subjects were able to solve the analogous story. Thus, children were able to focus on relational similarities even without surface similarities. These results do not support a competence deficit explanation of the relational shift.

Brown and Kane (1988) investigated the relational shift hypothesis in a reasoning task in which 3 year-olds were taught the required domain knowledge about previously unfamiliar relations about animal defense mechanisms (i.e., mimicry, changing color, and changing shape). After listening to stories about animals, children were asked transfer questions about the defense mechanisms. They found that almost all children demonstrated transfer by the third problem set despite differences in the defense mechanisms and the appearance of the animals. Therefore, after teaching the necessary knowledge about defense mechanisms, pre-schoolers were able to identify the relational similarities.

These studies suggest that the structural view (Sternberg & Nigro, 1980) or the relational shift (Gentner, 1983) is more a result of children's knowledge than a competence deficit. However, a strictly knowledge-based view is not sufficient to explain why children in control groups in the story-mapping analogies (e.g., Brown et. al., 1986) showed no analogical transfer when the performance of children in the experimental groups suggested that they have the requisite knowledge.

Goswami (1991) suggests that young children are able to reason by analogy, but changes in the nature of analogical reasoning occur later in development. Research suggests that the nature of this change is that children are able to reason by analogy with hints or surface similarity cues. However, research with adults has shown that they also benefit from hints (e.g., Gick & Holyoak, 1980) as well as surface similarity in tasks (Holyoak & Koh, 1989). An alternative explanation is that metacognitive skill is that aspect of competence that improves with development (Brown, 1989; Goswami, 1991). A metacognitive explanation suggests that, with development, children become better able to reflect on their own knowledge and actively seek out relational similarities in analogies.

However, returning to a somewhat more structural view, Holyoak and Thagard (1995) recently reviewed research that they feel demonstrates a developmental progression in the degree of sophistication in analogical thinking in the early years of life. Holyoak considers analogical thinking to develop in stages:

* by 18 months of age: mapping of similar attributes,
* by age 3: mapping of similar relations,
* by age 5: mappings are beginning to involve reasoning about higher order relations.

Holyoak and Thagard recognize that the knowledge of the relations is important at all levels of development before children are able to demonstrate analogical reasoning. However, in addition to the role of knowledge, they emphasize the development of reasoning about underlying relations and mapping, and credit children with analogical skills much earlier than the structural or relational shift views.

Thus, research has demonstrated that children are able to demonstrate analogous thinking at a much earlier age than was previously found. Developmental explanations of reasoning by analogy highlight the importance of possessing the requisite knowledge of the relations as well as process variables. Whether age differences arise from a developing understanding of the analogical process or metacognitive processes (or both) are as yet to be determined.

In summary, the theories of analogical reasoning are differentiated largely by what information is mapped. Gentner (1983, 1989) postulates a structural mapping based on higher-order relations that is domain-general. Holyoak (1985, 1989) proposes that the mapping process is guided by plans and goals. Ross (1989) suggests that both specific and abstract information are mapped, and moreover, specific information is focused on over abstract information. Thus, the theories differ largely in their focus on mapping abstract principles versus specific content, and whether the mapping is purely structural or goal-driven.

The developmental studies examined the issue of what exactly develops with age - competence in analogical reasoning or the knowledge base. Neither explanation appeared to account for performance variations at different ages. While awaiting further investigation, the research to date suggests that young children are able to reason analogically, but it is the nature of the reasoning that changes with development. Brown (1989) and Goswami (1991) suggest that metacognitive processes account for performance differences in analogous tasks in children as well as adults, while Holyoak and Thagard (1995) feel that the process of reasoning analogically develops with age. Further research is required to test these proposals. Thus, we return to the issue of the importance of a process account of analogical reasoning skill, while acknowledging the necessity of relevant content knowledge.

General Processes vs. Knowledge - the Social Domain

In the social literature, little attention has been paid to the issue of the relative importance of general processes versus domain-specific knowledge. However, Crick and Dodge (1994) do agree that both aspects of cognition are important. They hypothesize that social information stored in memory and schemata have an impact on behaviour by guiding on-line processing. They therefore propose that two types of mental processes are important:

1) latent mental structures (i.e., mental representation of past events stored in long term memory), and

2) on-line processing actions.

Moreover, Crick and Dodge (1994) point out that, while social research has focused on cognitive outputs (i.e., what children think), there is a need for studies of cognitive process (i.e., how children think). Thus, research using a process approach is needed to examine the "mental actions" a child engages in when interpreting social information.

Thinking Skills Programs Revisited

Thinking skills training programs have also been involved in the `general processes versus domain-specific knowledge' debate. Such programs, popular in the 70's and 80's, were based on the assumption that teaching generalized processing skills would promote learning and transfer across disparate domains. However, less than impressive results from training studies utilizing these programs have been taken as support for the view that the acquisition of information specific to a content area is the critical aspect that determines success in problem solving. On the other hand, given the accumulating evidence that general thinking processes warrant further consideration, it is necessary to re-consider why such theorizing was originally criticized and largely abandoned over the past decade. For this, a brief review of thinking skills programs and their `promise' is provided.

Thinking skills programs are process-oriented curricula. That is, they operate under the assumption that there is a certain set of skills or general processes that are common to thinking. The main objective of these programs is to teach these processes. Many programs have been developed to promote thinking skills, and they fall into two general categories. Some programs rely on abstract materials (e.g., geometric figures, dot matrices) to promote thinking skills (e.g., "instrumental Enrichment", Feuerstein, 1980; "Intuitive Math", Burke, 1971; "Think", Adams, 1971), while other programs utilize real-world problem solving (e.g., "CoRT Thinking Materials", deBono, 1975; "Philosophy for Children", Lipman, Sharp & Oscanyon, 1980; "Productive Thinking", Covington, Crutchfield, Davis & Olton, 1974). The programs are not mutually exclusive, and other programs integrate abstract and real-world experiences (e.g., "Odyssey", Adams, 1986).

The programs are similar in their focus on teaching critical and analytic thinking. Unfortunately, evaluations of programs, when data do exist, have often been flawed in design and content, and straightforward comparisons are difficult. On a positive note, every evaluation has included evidence of some gains, and there are some extremely positive results. However, all evaluations have demonstrated at least one of the following limitations:

a) transfer: Substantial gains tend to be found only on tests that are closest in structure and content to the course itself.

b) individual differences: Only some students appear to benefit from teaching problem solving.

A more recent thinking skills program has endeavored to train thinking skills in the learning environment (Mancini, Short, Mulcahy & Andrews, 1991; Andrews, Peat, Mulcahy & Marfo, 1990). In SPELT, or "Strategies Program for Effective Learning and Thinking", generalized thinking skills are taught in the context of domain-specific knowledge. Moreover, both social and non-social thinking and reasoning skills are addressed in this program. It is assumed that the same cognitive and metacognitive processes underlie both social and non-social (academic) tasks. The expectation is that training general processing strategies within specific content areas will facilitate transfer of learning to novel areas. While in-depth evaluations are still needed, the study is of particular interest to the present investigation because of it's specific targeting of both social and non-social domains, and it's assumption of similar underlying processes in the two domains. Indeed, others have supported the notion of the importance of training general processes in the context of learning specific knowledge. As Brown, Colins & Harris (1978) point out, teaching underlying domain independent cognitive processes along with learning strategies provides students with a basis for acquiring new knowledge and provides them with tools to face problem situations. However, the SPELT program and most other thinking skills programs have operated under an assumption about general processes that has not received strong empirical support. For a program to be successful in promoting transfer, successful strategies need to be identified first. It is only then that identified strategies may be taught successfully to children. There has been some evidence that this is the case (e.g., Palincsar & Brown, 1984; Bereiter & Scardamalia, 1987; Schoenfeld, 1985). Certainly more research is required. The relative success of teaching general processes versus domain-specific knowledge in thinking skills programs remains unclear.

The Present Res··rch

Earlier in this paper the theoretical models underlying cognitive and social-cognitive problem solving were compared and similarities were drawn. Considerable overlap in theorizing about the underlying processes was found. Thinking skills programs, in particular that of Mulcahy and colleagues (e.g., Andrews, et. al., 1990; Mancini, et.al., 1991), have also operated under the assumption of similar underlying processes in the academic and social domains. Similarly, studies of children's competence have demonstrated strong, positive relationships between academic and social competence (e.g., Dishion, 1990; Wentzel, 1991,1993). However, while various theoretical and empirical sources either assume or suggest similarities in processing across the academic and social domains, there are no known studies that have specifically examined these assumptions for academic and social problem solving. Thus, research is needed that directly investigates the assumption of similar underlying processes in the two domains. Such research would inevitably also address the issue of the influence of specific knowledge and general processes on academic and social performance. The present investigation seeks to explore these issues by examining how the mental process of analogical reasoning relates to competence in the academic and social domains.

Three studies were conducted, a Pilot Study, and two major studies, Study One and Study Two. The Pilot Study examined a variety of problem solving tasks for possible inclusion in subsequent studies. As a result of the pilot, a sorting task was found to warrant further investigation. The materials in the sorting task were expanded for use in Study One. The adequacy of employing the materials to address the issues of the influence of analogical reasoning skill versus specific knowledge on performance, and whether children's ability to think by analogy is related to competence in both the academic and social domains, were assessed in Study One. Causal relationships among the variables were also explored. The relationships between competence and analogical reasoning found in Study One were examined in Study Two. In addition, inter-rater reliability of the analogical reasoning materials was assessed. and two causal models were tested.

In the sorting task, children sorted four academic and four social themes. For each theme, children categorized a series of nine, brief scenarios into three related piles. Of interest, was whether the children focused on underlying principles (i.e., abstract concepts inferred by the content) or surface features (i.e., explicitly stated details), and how success at identifying analogous, underlying principles relates to academic and social competence.

In all three studies, multiple tasks were used to assess competence from a variety of perspectives. In this manner, the tasks provided converging data that together would more accurately reflect the general constructs of academic and social competence. Certainly an optimal assessment of social competence would include observations of problem solving in real-life social interactions. However, gathering direct observations was beyond the scope of the present research. In the absence of observational data of on-going social competence, the best alternative is to gather information from several different sources and in different ways (see Butler & Meichenbaum, 1981). Thus, for both domains, teacher ratings and self perception ratings of competence were employed. In addition, an achievement test of academic competence and sociometric rating scales of peer ratings of social competence were utilized. In the academic domain, achievement tests and teacher ratings are commonly used methods to assess academic competence, and are closely related. In the social domain, peer and teacher ratings are also common indices of social competence (e.g., Crick & Dodge, 1994). Self report ratings of a child's perceived competence were also included as a child's perceived competence has been found to be a predictor of behaviour (e.g., Maddux, Nolton, & Stoltenberg, 1986). It is thought that a person's beliefs about their capabilities help determine what he/she does with the knowledge and skills he/she has thereby influencing how he/she behaves (Bandura, 1986).

CHAPTER 2: STUDY ONE

Overview

Given the absence of research directly comparing academic and social problem solving, it was necessary to develop appropriate materials to perform this task. Tasks and methodologies in the existing literature were adapted and modified to allow comparisons across the two domains. These materials were then tested in a pilot study, which is described in detail in Appendix A and briefly summarized below.

The Pilot Study

Several tasks were developed from experimental tasks used in the cognitive and social-cognitive problem solving literature. Each task was believed to assess analogous processes in the academic and social domains that are thought to occur in the early stages of problem solving. Also included was an evaluation of several indices of academic and social competence. Thus, the pilot study represented an initial step in exploring the relationship between problem solving skill and overall competence in a given domain.

Of the problem solving tasks studied in the pilot, the Sorting task was found to warrant further investigation. The Sorting task comprised two sets of themes (one academic and one social), each containing a series of brief passages. The themes were adapted from Brown and Kane's (1988) analogies describing animals' use of defense mechanisms, and Bream's (1989) hypothetical-reflective situations of possible peer conflict. The academic and social passages were modified in the pilot study to create a series of brief passages which contained the underlying principles or general concepts used by Brown and Bream (i.e., animal defense mechanisms of camouflage, visual mimicry, and natural pest control, and possible conflict involving physical provocation, embarrassment, and rejection, respectively). In addition, common surface features or details explicitly stated in the passages were included. Subjects sorted the passages into related piles, and described their rationale. How the children categorized the scenarios was taken as an indicator of their sensitivity to analogous information (underlying principles) or conversely, specific details (surface features) in the passages. Analyses of the relationships among the problem solving tasks and between the problem solving and competence tasks in the pilot study indicated that children's analogical reasoning ability in detecting underlying principles in the Sorting Task was the most broadly related to competence and other problem solving activities. Thus, the pilot study identified an analogical reasoning task (the Sorting Task) as having potential value in comparisons of academic and social problem solving, and competence.

The Present Study

Several issues, explored in a preliminary fashion, are addressed in the present study. This investigation sought:

* to examine the use of analogical reasoning (a general problem solving process) in two highly disparate domains (namely, the academic and social domains), and

* to determine whether the use of analogical reasoning skills in tasks containing academic and social content is related to academic and social competence.

Examination of the relationship between analogical reasoning and competence in the academic and social domains addresses the issue of whether problem solving by analogy is a general process that influences performance in both the academic and social domains.

In addition, a knowledge test was created that assessed children's understanding of the specific content knowledge of the presented themes. Although the themes were created such that Grade 6 and Grade 8 children would be generally acquainted with the information, the data from the knowledge test were used to statistically control for differences in content knowledge. In this manner the results would more clearly demonstrate the influence of analogous thinking and competence. Also, information was obtained that addresses the influence of general processes as opposed to domain-specific knowledge in problem solving in two very different domains.

And finally, the present study utilized two grade levels, Grade 6 and Grade 8, to investigate possible developmental differences. Within Case's (1992) stages of cognitive development, he hypothesizes and has found evidence of substages that reflect increased understanding of the complexity of the relations among concepts. Thus, discernible differences in children's use of analogous thinking skills as opposed to surface details may be evident even within the two year gap present in the sample employed here.

Specifically in this study, groups of Grade 6 and Grade 8 students were seen over a period of three sessions. Initially they completed an achievement test, rated statements concerning how they feel about their own academic and interpersonal skills, and rated each of their peers' ability to get along with others. During this time the students' teachers also rated each student on aspects of academic and social competence. During the subsequent two sessions the students sorted the eight themes - four academic and four social, and recorded their rationale for sorting the scenarios. A Knowledge test was then completed by the students that assessed their understanding of the underlying principles presented in the themes. A variety of statistical procedures were used to analyze the data (e.g., descriptive statistics, graphs, t-tests, factor analyses, and correlations). Once the adequacy of the tasks was established, the relationships between competence and analogical reasoning were explored. That is, the data were examined to determine whether success in academic and/or social competence tasks is related to success in identifying analogies in short passages containing academic and social content. Correlational analyses were used to examine these relationships. Exploratory path analyses were also employed to build a model of the possible causal relationships among competence and analogical reasoning.

Subjects

One hundred eighteen children served as subjects, 54 from Grade 6, including 31 males and 23 females, with an average age of 12.0 years, and 64 from Grade 8, including 37 males and 27 females, with an average age of 14.0 years. The subjects were drawn from three classrooms at each grade level, all in one school in the Peel Board of Education. Participating classrooms were chosen by the Principal to represent a wide range of ability levels. Subjects who participated in the study were all children whose parents gave written permission. In total, 8% of the students in the three classrooms were not granted permission to participate in the study. Of the remaining students, the data from 10% of the students were not used due to absenteeism, incomplete data, or a student's inability to cope with the reading and written demands of the tasks. These latter students (n=3) were identified by their classroom teachers as having significant learning difficulties or an ESL background. Teachers also indicated that the subjects were from middle class families. The sample was largely Caucasian, with a minority of students (less than 5%) of Black and Asian races.

General Procedure

Data were gathered in late spring, during regular class sessions. Subjects were told that all of their answers would be confidential, and that they did not have to participate if they did not wish to. Teachers remained in the classroom during the sessions, and completed the academic and social competence items of Harter's "Teacher's Rating Scale for the Self-Perception Profile for Children" (Harter, 1982) for each child participating in the study. Three, one-hour sessions were needed to complete the collection of the data. Subjects were tested as a group in their classes.

During the first session, subjects were given the academic and social competence items of Harter's "Self-Perception Profile for Children" (Harter, 1982). Each item was read aloud by the experimenter while the subjects read silently. Then they recorded their answers.

Subsequently, they completed the Otis-Lennon School Ability Test (OLSAT; Otis & Lennon, 1979), followed by the two sociometric rating scales.

For the second and third sessions, the analogical reasoning materials were presented. Four themes were presented during each session, for a total of eight themes over the two sessions. Subjects were asked to sort the nine, brief passages (or scenarios) within each theme twice. They were asked to sort the scenarios into piles according to which ones "go together the best". Each subject received a random ordering of the eight themes, alternating themes containing academic and social content. After completing the two sorts for each theme, the experimenter checked each subject's response sheet to ensure that all nine scenarios had been sorted and written comments were provided on the response sheet.

At the end of the third session, after all the scenarios had been sorted, each subject completed the Knowledge Test. The Knowledge Test assessed subjects understanding of the underlying principles (i.e., the analogies) presented in the themes. One final visit was typically required to allow the few subjects absent from one of the three sessions to complete the missed activities.

The following sections describe the competence tasks, analogical reasoning materials, and Knowledge Test.

Competence Tasks

Materials

Academic Competence

Academic ability.

Subjects' academic abilities were assessed using the Otis-Lennon School Ability Test (OLSAT; Otis & Lennon, 1979), a group-administered, multiple choice, standardized test. Both verbal and pictorial analogy items (of the form: `A' is to `B', as `C' is to ___) are included in the OLSAT. Subject's performance on the OLSAT provided information about overall ability, as well as reasoning with analogies.

Teacher ratings.

Teachers rated each subject on those items of Harter's (1982) "Teacher's Rating Scale of Child's Actual Behavior" that assess teacher's perceptions of a child's academic competence (see Appendix B). For each item (three items in total), opposing statements were presented on a 4-point Likert-type scale. For example, teachers had to decide which of the following statements best describe a student and indicate if the chosen alternative is "sort of true" or "really true" about the student:

"This child is really good at his/her school work.

OR

This child can't do the school work assigned."

Child self report.

Each subject completed three items related to his/her perception of his/her own academic competence, on Harter's (1982) "Self-Perception Profile for Children". Subjects were asked to rate statements concerning how they feel about their academic ability and actual performance in school on a 4-point Likert-type scale (see Appendix B). This scale parallels the content and format of the academic competence items of the teacher rating scale, described above. For example, children were asked to decide which of two statements best describe how they feel about themselves, and to indicate if they felt the chosen statement was "sort of true for me" or "really true for me":

"Some kids feel that they are very good at their school work.

BUT

Other kids worry about whether they can do the school work assigned to them."

Social Competence

Sociometric rating scales.

Each subject rated each of his/her classmates on a 5-point Likert-type rating scale, according to two different criteria:

1) "... how well that person gets along with other people". (Subjects then rated their peers on a scale from 1 - poorly, to 5 - great).

2) "... how much you like to hang around that person". (Subjects then rated their peers on a scale from 1 - not very much, to 5 - very much).

The first criterion was felt to reflect peer perceptions of subjects' general competence in social situations. The second criterion was thought to reflect subjects' preferred peer group. For both rating scales, each subject received an average score (out of 5) from the ratings of same-sex peers.

Sociometric measures have been found to be highly reliable (especially using the rating scale technique), demonstrate high test-retest correlations (e.g., Oden & Asher, 1977), and show good predictive validity in terms of demonstrating a relationship to later life adjustment (Asher, 1977).

Teacher ratings.

Teachers rated each subject on the social competence items (six in all) of Harter's (1982) "Teacher's Rating Scale of Child's Actual Behavior" (see Appendix B). For each item, opposing statements were presented on a 4-point Likert-type scale. As with the teacher ratings of academic competence, teachers had to decide which of the following statements best describe a subject and indicate if the alternative chosen is "sort of true" or "really true" about the subject. An example follows:

"This child finds it hard to make friends.

OR

For this child it's pretty easy."

Child self report.

Each subject completed the three items related to social competence on Harter's (1982) "Self-Perception Profile for Children" (see Appendix B). Subjects rated statements describing how they feel about their popularity and friendships on a 4-point Likert-type scale. An example follows, and illustrates how this scale parallels the content and format of the social competence items of the "Teacher's Rating Scale". For each item, children were asked to decide which of two statements best describes how they feel about themselves, and to indicate if they felt the chosen statement was "sort of true for me" or "really true for me":

"Some kids find it **hard** to make friends.

BUT

Other kids find it's pretty **easy** to make friends."

Instructions

The academic and social competence tasks were presented during the first session. The session was introduced as follows:

"Hi. My name is Linda, and I would like to start off by thanking you for helping me with my study. I'm a student at the University of Waterloo, and I am studying how kids learn and think. What I'd like you to do is to help me learn what kids in grade 6/8 know, and how you think about different activities I give you. For today, we are going to look at things you know and I would also like to learn about how you get along with each other. Are there any questions?"

Subjects were then given the academic and social competence items of Harter's "Self-Perception Profile for Children" (Harter, 1982). Each item was read aloud by the experimenter while the subjects read silently, then they recorded their answers. The subjects then completed the Otis-Lennon School Ability Test (OLSAT; Otis & Lennon, 1979), followed by the two sociometric rating scales.

Scoring

Academic Competence

The academic competence tasks were scored by the author. All raw scores were converted to percentage scores. For all tasks, higher scores indicated greater success. Thus, scores on the OLSAT were the percentage of items answered correctly (i.e., # items correct / 80 x 100). For the academic teacher and self report rating scales, subjects received a score out of four for each item, and scores were summed over the three items for a total raw score on each rating scale. Raw scores were then converted to percentages (i.e., total score / 12 x 100).

Social Competence

The social competence tasks were scored by the author. Again, higher scores indicated greater success. For the social teacher and self report rating scales, subjects received a score out of four for each item, and scores were summed over the three items for a total raw score on each rating scale. Raw scores were then converted to percentages (i.e., total score / 12 x 100).

For the sociometric rating scales, ratings from same-sex and opposite-sex subjects for a given subject were summed and an average same-sex score and an average opposite-sex score was obtained for each subject. Given the cautions by Asher & Hymel (1981) about opposite-sex bias and same-sex preferences possibly affecting sociometric rating scale data, preliminary analyses were undertaken to determine whether such differences, if found, warranted the use of same-sex ratings only in subsequent data analyses of the sociometric data. Analyses using t-tests examining the differences between same-sex and opposite-sex ratings for the two sociometric rating scales indicated significant differences (Gr. 6 - $t(df\ 53) = 8.70$; $p<.001$: Gr. 8 - $t(df\ 63)= 7.06$;$p<.001$) for both grade 6 and grade 8 subjects. These results suggest that there was opposite-sex bias in the sociometric ratings, such that males and females rated their opposite sex peers lower on the sociometric scales. Same-sex ratings were therefore used in subsequent analyses.

The sociometric ratings were summed across same-sex peers for each subject and average scores (out of five) were computed for each rating scale (i.e., general competence in social interactions, and preferred peer group). For example, for female subject `i' rated on the first rating scale, f(i,1), her score was computed as:

$$f(i,1) = [f(1,1)+...+f(i-1,1)+f(i+1,1)+...f(n,1)]/(n-1),$$

(n = number of females)

That is, the ratings by all of the females for subject `i' were summed and divided by the total number of females, excluding subject `i'.

An average rating combining both sociometric rating scales was also computed for each subject. In the example above for female `i' this would mean:

$$f(i,1\&2) = [f(i,1) + f(i,2)]/2$$

That is, the average rating from each of the separate rating scales was summed and divided by two. As with the other social competence tasks, higher scores indicated higher ratings of social competence by peers.

Preliminary Analyses of Academic and Social Competence

Descriptive Statistics

Analyses of means, standard deviations, skew, and kurtosis (see Appendix F), and visual inspection of stem and leaf plots, suggested that the distributions of the scores from the academic and social competence tasks approximated a normal distribution. These results were observed for both the Grade 6 and Grade 8 data. There was some tendency for the scores to be slightly skewed to the left, indicating that subjects obtained scores or were rated toward the upper end of the scales (i.e., more successful) on the academic and social competence tasks.

Grade and Sex Differences

There were no differences in the academic or social competence scores as a function of grade or sex, as determined by t-tests of the differences between the means (see Appendix

G). The only exception occurred on the achievement test. As expected, the Grade 8 subjects performed significantly better than the Grade 6 subjects ($t(df\ 117) = 6.48$; $p<.001$).

Sociometric

Subjects rated each of their peers on two different criteria, describing their perceptions of each peers' general interpersonal competence, and their preferred peer group. Each criterion was thought to reflect somewhat different aspects of peer perceptions of social competence and therefore had the potential to provide more information about social competence than either scale alone. Pearson product-moment correlations indicated that scores on the two sociometrics were highly related ($r = .90$, $p<.001$, Grade 6; $r = .84$, $p<.001$, Grade 8). Also, factor analyses of the competence tasks (discussed below) demonstrated high loadings of both criteria on a Social Competence factor. Thus, given the high degree of similarity between the two scales, the combined data from both criteria (i.e., scores from each scale summed and divided by two) were used in subsequent analyses.

Inter-relationships Among Academic and Social Competence Tasks

Correlational Analyses

Pearson product-moment correlations using scores from the Grade 6 and Grade 8 groups indicated significant relationships among the academic competence scores and among the social competence scores (see Table 2). Very few correlations between the scores for the academic and social tasks reached significance. The few that did reach significance demonstrated weak relationships only (i.e., correlations of .2 - .4), with no notable pattern within or across grades. The pattern of intercorrelations was similar when male and female data were considered separately (see Appendix H).

Factor Analyses

Principal Component factor analyses using a varimax rotation were conducted on the intercorrelations between the academic and social competence scores to determine the degree to which these variables were measuring similar constructs. The intercorrelations of the

TABLE 2
Pearson Product-Moment Correlations Between Academic and Social Competence Tasks: Grade 6 (above) and Grade 8 (below) , Study One

	ACHIEVEMENT	ACADEMIC TEACHER RATINGS	ACADEMIC SELF REPORT	SOCIOMETRIC	SOCIAL TEACHER RATINGS
ACHIEVEMENT					
ACADEMIC TEACHER RATINGS	.47*** .50***				
ACADEMIC SELF REPORT	.43** .36**	.63*** .38**			
SOCIOMETRIC	.06 .03	.19 .27*	.24 -.16		
SOCIAL TEACHER RATING	-.00 -.15	.26 .24	.29* -.07	.70*** .44***	
SOCIAL SELF REPORT	-.15 -.10	.03 .04	.08 .08	.49*** .41**	.45*** .37**

*** p < . 001, ** p <.01, * p < .05

scores on these variables with the academic, social and overall scores on the Knowledge Test (see below) were also included. The Knowledge Test variables were included in order to determine whether they demonstrated differential relationships with the other competence tasks. The factor loadings for the Grade 6 and Grade 8 groups are presented in Table 3.

Three factors were identified that accounted for a total of 75% (Grade 6) and 70% (Grade 8) of the explained variance. The variables having the highest rotated factor loadings on each factor suggested the following descriptive labels:

Factor I: General Knowledge. The Knowledge Test variables all loaded highly on this factor. This was expected since the academic and social items on this scale are a subset of the total test items (see below). With the Grade 8 group, the achievement test and teacher ratings of academic competence moderately loaded on the factor. With the Grade 6 group, only the achievement test had moderate loadings. For the Grade 6 and Grade 8 subjects, this factor accounted for 25% and 29% of the explained variance, respectively.

Factor II: Social Competence. The sociometric ratings, and teacher and self-report rating of social competence all loaded highly on this factor. For the Grade 6 and Grade 8 groups, this factor accounted for 29% and 25% of the explained variance, respectively.

Factor III: Academic Competence. The achievement test, and teacher and self-report ratings of academic competence loaded highly on this factor. For the Grade 6 and Grade 8 groups, this factor accounted for 21% and 15% of the explained variance, respectively.

Thus, correlational and factor analyses suggest that the academic tasks assess an academic competence construct, and the social tasks assess a social competence construct. Also, the academic and social competence tasks are separable from each other. Finally, the Knowledge Test was distinct from academic and social competence but did show some moderate associations with academic competence.

TABLE 3

Principal Components Factor Analyses of the Competence Tasks and Knowledge Test - Grade 6 and Grade 8, Study One

	FACTOR I		FACTOR II		FACTOR III	
	Gr. 6	Gr.8	Gr. 6	Gr. 8	Gr. 6	Gr. 8
Achievement	.39	.51	-.09	-.06	.67	.57
Teacher Rating: Academic	.16	.53	.12	.29	.85	.54
Self Perception: Academic	.19	.06	.22	-.11	.78	.90
Sociometric Rating #1	-.08	.03	.89	.90	.22	-.02
Sociometric Rating #2	-.12	.04	.89	.89	.13	-.04
Teacher Rating: Social	-.02	.09	.82	.67	.19	-.10
Self Perception : Social	.12	-.10	.75	.62	-.27	.10
Knowledge Test: Total	.96	.97	-.05	-.01	.23	.13
Knowledge Test: Academic	.82	.84	-.18	-.10	.22	.11
Knowledge Test: Social	.83	.80	.12	.11	.17	.10
% Variance Explained	25	29	29	25	21	15

The Analogical Reasoning Task

From the pilot study, several modifications were considered to be necessary before employing the Sorting task in Study One. These included ensuring that the reading level of the materials was not too difficult for the grade level, increasing the number of academic and social themes such that the Sorting task was no longer a one-item test, providing two opportunities to categorize the themes, and controlling children's variations in content knowledge of the themes.

Materials

Subjects were presented with a total of eight different themes. Each theme contained nine scenarios, or nine brief, three-sentence paragraphs. Each scenario was presented on a separate card, and subjects were asked to sort the nine cards into three piles. The content of each theme or set of scenarios was created to allow categorization into three equal piles in terms of similar underlying principles (UP), and three different (again equal) piles in terms of similar surface features (SF). UP refer to abstract concepts that are inferred by the content of the scenarios. The ability to correctly categorize cards containing the same UP is taken here to be a measure of analogical reasoning skill. SF refer to concrete details that are explicitly stated in the scenarios.

Of the eight themes, four contained academic content (i.e., "Biological Principles", "Environmental Waste Control", "Arithmetic Word Problems", and "Water Principles"), and four described social situations (i.e., "Potential Peer Conflict", "Social Skills", "Rejection Situations", and "Unsuccessful Personality Types"). In the academic themes, the "Biological Principles" theme was adapted from Brown and Kane's (1988) `biological themes', which these investigators used to demonstrate the use of analogical reasoning by young children. Seven of the animals used by Brown and Kane were used to write scenarios describing UP of visual mimicry, camouflage and natural pest control. Two additional animals (the seahorse and the chameleon) were included by the author to create a balance of three scenarios for each

UP (totaling nine scenarios). The remaining three academic themes were created by the author. From informal discussions with teachers, topics were selected that allowed a sampling of various subject areas that children would be expected to know by grade five. The academic themes therefore reflected content learned in social studies (Environmental Waste Control - waste management principles of recycling, composting, and landfill waste), mathematics (Arithmetic Word Problems - problems of addition, subtraction, and multiplication), and science (Water Principles - concepts of sinking, floating, and displacement of water).

In the social themes, the "Potential Peer Conflict" and "Rejection Situations" themes were derived from situations of potential peer conflict and intentionality in rejection situations, respectively, created by Bream (1989) in her study of children's social problem solving skills. Several of Bream's passages were selected and modified by reducing the passages to three sentences and re-wording when necessary. Thus, for the "Potential Peer Conflict" theme, passages describing potentially aggressive, embarrassing, and rejecting situations were modified. For the "Rejection Situations", passages describing accidental (i.e., it was an accident that he was rejected), intentional - justified (i.e., he was rejected because he was mean), and intentional - not justified (i.e., he was rejected unjustly) rejection situations were modified. The remaining themes of "Social Skills" and "Unsuccessful Personality Types" were created by the author to reflect general themes described in the literature on children's social competence. That is, the UP in the "Social Skills" theme of participation, cooperation and communication are key concepts taught in many social skills training programs (e.g., Weissberg, et. al., 1981). Similarly, the UP in the "Unsuccessful Personality Types" theme of aggressive, withdrawn and selfish children, are behaviors that concern many researchers that study aggression and rejection in children (e.g., Dodge, 1985).

Half of the academic and half of the social themes presented unresolved problem situations ('problematic'), while the remaining themes were descriptive in nature ('descriptive'). This comparison was included to investigate whether problem situations (as opposed to descriptive passages) promote more active problem solving. The underlying principles and surface features for the eight themes are presented in Table 4. The eight themes are presented in their entirety in Appendix C.

Each scenario was written such that one sentence contained an underlying principle, one sentence contained a surface feature, and one sentence was a `filler' or neutral statement. After the scenarios were written, sentences were scrambled such that the order of presentation of the UP, SF and filler sentences was balanced across the nine scenarios. Table 5 shows the scenarios for one theme, "Environmental Waste Control", and the breakdown of UP, SF and filler sentences for each scenario.

The scenarios were written at a grade 4/5 level of readability, as measured by The Fry Readability Graph (in Cheek & Cheek, 1980). This ensured that the majority of children in the sample would be able to read the passages with ease. Given normal variability of performance within a grade, the passages may pose some challenge for a small group of subjects in grade 6, but this was not expected for the grade 8 subjects. Any data from children who, in their teacher's opinion would have difficulty with the reading level of the task, were excluded from the analyses. The data from 3 subjects were so excluded.

Table 6 presents the "Biological Principles" theme and an example of how it was sorted by one subject into underlying principles and surface features. As for every theme, this subject was given a packet of 9 cards, labeled as cards `A' to `I', and this subject sorted the cards into three piles, as shown. Here, cards D,G,I were included in one pile, cards A,E,H in another, and cards B,C,F in the third pile. The subjects written comments are presented below the piles in quotations. Below this, is the underlying principle or surface feature designation. The first pile contained the SF of what the animal feeds on, the second and third piles contained UP of visual mimicry and camouflage, respectively. As indicated, card H (UP - natural pest control) was erroneously included in the second pile.

TABLE 4
Summary of the Underlying Principles and Surface Features In the Eight Themes:

THEME	UNDERLYING PRINCIPLES	SURFACE FEATURES
Academic		
Descriptive:		
Biological Principles	animal camouflage visual mimicry natural pest control	eats lives physical characteristics
Environmental Waste Control	recycling composting landfill waste	containers job common use
Problematic:		
Arithmetic Word Problems	summation/addition difference/subtraction fractions/division	number hours money
Water Principles	floatation sinking displacement of water	man glass animal
Social		
Descriptive:		
Social Skills	sharing/cooperation joining nonverbal communication	computer 4 friends lunch hour
Rejection Situations	accidental intentional justified	party form a group weekend
Problematic:		
Potential Peer Conflict	physical provocation embarassment rejection	gym playground class
Unsuccessful Personality Types	bully / aggressive selfish shy / withdrawn	skating neighborhood at school

TABLE 5
Envionmental Waste Control Scenarios and the Corresponding Underlying Principles (UP) and Surface Features (SF)

Card A:

(filler)	Tin cans keep foods that go bad quickly, tasting good.
(UP-recycling)	Tin cans are made of metal, and after they have served their purpose, they can be melted down for more cans.
(SF-containers)	They are a great way to hold and store food for a long time.

Card B:

(SF-common use)	Disposable diapers are very common to use because they can be thrown out.
(UP-land fill)	People are starting to use cloth diapers more so we do not fill garbage dumps with disposable diapers.
(filler)	Babies go through many diapers each day.

Card C:

(SF-containers)	Glass bottles are good to hold and store liquids.
(filler)	People have been using glass bottles for a long time.
(UP-recycling)	When a glass bottle is empty it can often be sent back to the company and re-filled.

Card D:

(filler)	People do not like the smell of manure, but still use it on their lawns.
(SF-common use)	Using manure is a common way to help plants grow.
(UP-composting)	Manure comes from animal droppings and is helpful in all kinds of gardens, from a small patch of grass to a large field.

Card E:

(UP-recycling)	Once a newspaper is not of any use, it can be mixed with water, dried, and made into newsprint.
(SF-jobs)	Lots of kids have a job delivering papers.
(filler)	The news helps to keep people in touch with the world around them.

TABLE 5 (continued)

Card F:

(SF-job)	Some scientists have the job of studying strong chemicals.
(filler)	Many are part of our daily needs, like the chemical that keeps a fridge cold.
(UP-landfill)	Some are so harmful, that once we are done with them, we can not get rid of them.

Card G:

(filler)	In good weather, a lawn must be cut once a week.
(UP-composting)	Leaving the cut grass where it falls on the lawn is good for the grass, and it makes grass cutting an easier job, too.
(SF-jobs)	Lots of kids have a job cutting grass and get paid for each lawn cut.

Card H:

(UP-composting)	Fruit that is left on the ground will rot, and is healthy for the soil.
(SF-common use)	Fruits are a very common part of a good diet.
(filler)	You should not make a mess, but it's okay to throw pieces of fruit (like apple cores) on the ground.

Card I:

(UP-landfill)	When plastic containers are thrown out they will stay in one place and will not rot for years and years.
(SF-containers)	They can hold and you can store most things in them.
(filler)	The containers are cheap to make, and have many uses.

TABLE 6
Example of one Subjects' Categorization of the "Biological Principles" Theme and use of Underlying Principles (UP) and Surface Features (SF)

Pile #1	Pile #2	Pile #3
The Purple Martin feeds on mosquitos. In the places where they live, mosquitos are much less of a bother to people. It is a kind of bird.	If a dangerous animal is near, the Capricorn Beetle opens it's wings to look like a wasp. It is a type of insect. It has 2 stiff outer wings and 2 wings hidden underneath.	The Seahorse's head looks like a horse. It can hide from danger because it can mtach all back-ground colors. It has a long snout on it.
D	A	B
The Manatee eats the weeds that clog the river and hinder pleasure boating. It is a large water mammal. It is seen most often in Florida's water ways.	The Hawkmoth Caterpillar is a long worm-like larva. It is seen most often in South America. It turns over to show marks on its underside that look like a poisonous snake.	Gray in summer and white in the winter, the Arctic Fox blends into it's surroundings. It is from the dog family. It is most often seen up north in the Arctic.
G	E	C
The Crested Rat feeds on almost anything that can be eaten. It parts it's hair to show skunk-like markings to protect itself. It is in the rodent family.	The Ladybug is part of the beetle family. Its shell has bright colors on it. It kills little white bugs called aphids that grow on and can ruin hops and orange crops.	The Chameleon is a type of lizard. It feeds on insencts. It is able to change color, so that it is very hard to see in the shadows of the forest.
I	H	F
Subjects' written comments:		
"What these animals eat."	"How the animals protect themselves from the enemy."	"How the animal blends into the surroundings."
Designation (UP or SF):		
SF - what it feeds on	UP - visual mimicry (card "H" was incorrectly placed in this pile	UP - camouflage

Instructions

During the second and third sessions, the experimental materials were presented. Four themes were completed in each session, for a total of eight themes over the two sessions. The task was explained as follows, with demonstrations where appropriate:

"Today, I would like to look at how kids in grade 6/8 think about information. You will be given a small packet with 9 cards in each. Each card will contain three sentences. I want you to read all of the cards first, then sort them into 3 piles according to which ones seem to go together the best. There is no right or wrong answer, I just want you to think about how the themes in the cards are similar, remembering that I want 3 piles. There may or may not be an equal number of cards in each pile. Do whatever makes sense to you. When you've done that, take the answer sheet I have given you, and record the letters of the cards in each pile on the sheet and write a few words or a sentence or two describing why you put these cards together in this manner. Next, I want you to shuffle the cards together so that they are once again in a mixed up order, and sort them a second time in a different manner. As you did before, record each pile and your reasons for sorting them. Remember, there are no right or wrong answers since there are many different ways to sort the cards. I just want to know what similarities you see when given these cards. Let me review the procedure once more....If there are any questions, just ask. When you have finished both sorts, put up your hand and I will give you another set of cards."

The subjects quickly understood the task once they started working with the cards. Each subject received a random ordering of the eight themes, alternating academic and social themes. After completing the two sorts for a theme, the experimenter checked to ensure that all nine cards were listed and comments were provided on the response sheet. At times, the subjects were unable to make comments, even with encouragement to do so.

Subjects sorted each theme twice, in order to provide two opportunities to demonstrate sensitivity to both UP and SF. This manipulation differed from the single sort presented in the pilot study, and was added due to concerns that subjects may be aware of both types of information (UP and SF) but simply choose one over the other. Given that each theme contained a variety of possible UP and SF, it may be the case that two sorts are not enough. However, comments from subjects and analyses of protocols indicated that it was very difficult (and for some, at times impossible) to sort the materials a second time. Thus, it appeared that additional sorting opportunities were not warranted.

Scoring

Subjects' responses on the problem solving themes were scored according to their use of UP and SF. Given the varying content of the scenarios within the themes, it was clear that the passages could be sorted in a variety of different ways, and not simply according to the originally designated UP and SF. Other UP or SF identified by a subject that differed from the UP and SF originally built into the themes also needed to receive credit. Consequently, it was necessary to incorporate the various possible combinations of UP and SF into the scoring system. Preliminary analyses of responses from a pilot group of Grade 6 and 8 subjects and an adult sample, as well as close scrutiny of the themes, resulted in a scoring key containing a fairly exhaustive list of possible combinations of UP and SF (see Appendix D).

In scoring subjects' categorization of UP, both **Categorical** and **Quantitative** scoring systems were employed. "Categorical" scores indicated whether subjects were sensitive to different categories of UP or SF. For each theme, each UP or each SF identified received a score of one, resulting in scores that ranged from 0 to 3 (the total number of piles possible). This scoring system was identical to that used in the Pilot Study (see Appendix A). Scores of `omission', where subjects were unable to, or incorrectly categorized a pile as either an UP or SF, were also tabulated. "Quantitative" scores included the total number of scenarios correctly sorted. That is, each individual scenario sorted appropriately as an UP or SF received a score of one. This resulted in UP and SF scores ranging from 0 to 9 (the total number of scenarios) for each theme. By using these two scoring systems, it is possible to distinguish a subjects' ability to detect general categories of relationships within a theme versus each instance of a specific category. For example, a subject may have been aware of many instances of a particular category (i.e., he/she correctly sorted many scenarios in a pile), but was not aware of many different categories (i.e., only one or two piles correctly reflected UP and/or SF). In this case, quantitative scores would be relatively high and categorical scores would be relatively low. Conversely, a subject may have been aware of different categories, but had difficulty correctly sorting the scenarios within a category. Here, categorical scores would be relatively high and quantitative scores would be relatively low. To further illustrate the scoring systems, the nine scenarios of the "Environmental Waste Control" theme sorted by one subject and the two scoring systems are shown in Table 7. This subject sorted the nine cards and provided the written response for each pile, as shown. The categorical scores were obtained by summing each pile that contained an UP, a SF, or an omission. Thus, the first pile identified an UP, the second pile identified SF, and the third pile was too general and was therefore scored as an omission, resulting in scores of one each for UP, SF, and omission. The quantitative scores were obtained by summing the total number of scenarios sorted correctly in the UP and SF categories. Thus, the UP score was 3 from the first pile and the SF score was 3 from the second pile. One card was incorrectly placed in the first pile, and the third pile was too general to score. Consequently, this subject could not receive credit for these cards.

Performance on the first and **both** (first and second combined) sorts was also analyzed. Responses on the first sort allowed an investigation of the salient information <u>initially</u> obvious to each subject. Responses on both sorts allowed an investigation of how subjects performed given <u>further consideration</u> of (or two attempts with) the materials. An example of the first and both sorts of two subjects used for analysis is provided in Appendix D.

Subjects responses were scored for UP and SF. SF scores were included in order to calculate omission scores with the Categorical scoring system. The goal of the present study was to analyze subjects sensitivity to UP, taken here to be a measure of analogical reasoning.

TABLE 7
Example of the Categorical and Quantitative Scoring Systems (including Omission Scores) for one Subjects' Sorting of the "Environmental Waste Control" Theme

Pile #1	Pile #2	Pile #3
Disposable diapers are very common to use because they can be thrown out. People are starting to use cloth kispers more so we do not fill garbage dumps with disposable diapers. Babies go through many diapers each day. B	Tin cans keep food tht go bad quickly, tasting good. Tin cans are made of metal, and after they have served their purpose, they can be melted down for more cans. They are a great way to hold and store food for a long time. A	Once a newspaper is not of any use, it can be mixed with water, dried, and made into newsprint. Lots of kids have a job delivering papers. The news helps to keep people in touch with the world around them. E
People do not like the smell of manure, but still use it on their lawns. Using manure is a common way to help plants grow. Manure comes from animal droppings and is helpful in all kinds of gardens, from a small patch of grass to a large field. D	Glass bottles are good to hold and store liquids. People have been using glass bottles for a long time. When a glass bottle is empty, it can often be sent back to the company and re-filled. C	Some scientists have the job of studying strong chemicals. Many are part of our daily needs, like the chemical that keeps a fridge cold. Some are so harmful, that once we are done with them, we can not get rid of them. F
In good weather, a lawn must be cut once a week. Leaving the cut grass where it falls on the lawn is good for the grass, and it makes grass cutting an easier job, too. Lots of kids have a job cuttin ggrass and get paid for each lawn cut. G	When pastic containers are thrown out they will stay in one piece and will not rot for years and years. The can hold and you can store most things in them. The containers are cheap to make, and have many uses. I	
Fruit that is left on the ground will rot, and is healthy for the soil. Fruits are a very common part of a good diet. You should not make a mess, but it's okay to throw pieces of fruit (like apple cores) on the ground. H		
"How certain objects are food for the soil, lawns, etc."	"How certain containers hold different objects."	"How each one is a big part of our lives."

Score: (Underlying Principles - UP; Surface Features - SF)

		Pile #1	+	Pile #2	+	Pile #3	=	SCORE
Categorical	UP	1		0		0		1 UP
Scores	SF	0		1		0		1 SF
	Omission	0		0		1		1 Omission
Quantitative	UP	3		0		0		3 UP
Scores	SF	0		3		0		3 SF

Preliminary analyses of the SF data did not indicate any significant relationship between analogical reasoning and competence. That is, subjects' ability to identify surface features in the themes was not found to be related to competence (either academic or social). Thus, SF data were not included in subsequent data analyses. The UP scores will be referred to here as analogical reasoning scores (AR).

Categorical and quantitative scores on the first and both sorts were obtained for each individual theme. Scores were then summed across the individual themes to obtain separate scores for the descriptive and problematic themes (two themes each), academic and social themes (four themes each), and total themes (all eight themes). These groupings of themes are shown in Figure 1.

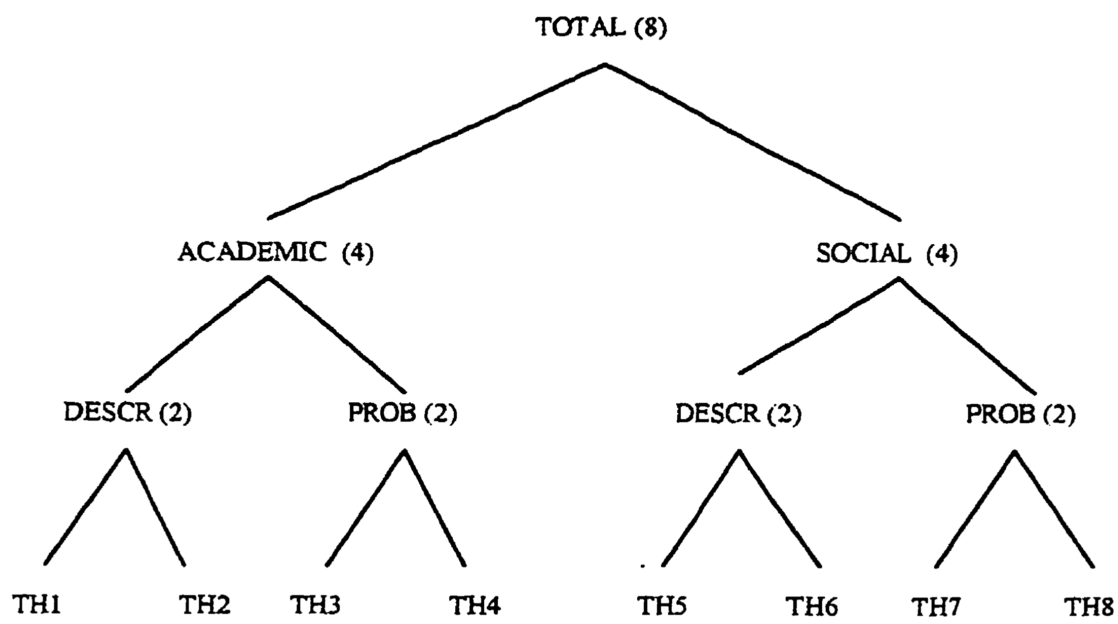
The reliability of the eight themes was assessed using the split half method. The eight themes were divided in two halves, each containing two academic and two social themes. Scores from the two halves were correlated and the Spearman Brown formula (Ferguson, 1976) resulted in reliability estimates of .58 and .52 using scores from both sorts for the grade 6 and grade 8 data, respectively.

The Knowledge Test

Materials

A multiple choice test format was used in the Knowledge Test, with each item measuring knowledge of a single Underlying Principle (UP). Thus, for the eight analogical reasoning themes, each containing three different UP, 24 test items were created. Twelve test items contained academic content and twelve items contained social content. Each item was scored as either correct or incorrect. The "Knowledge Test" is presented in Appendix E. An example of a question from the "Biological Principles" theme assessing knowledge of the UP of 'visual mimicry' follows:

FIGURE 1
Groupings of the Themes for Analysis:
Including all 8 Themes Combined (TOTAL), the 4 Academic (ACADEMIC) and Social (SOCIAL) Themes Combined, the Descriptive (DESCR) and Problematic (PROB)Themes Combined (4 groups of 2 themes), and the 8 Individual Themes (TH1,...,TH8).



Some animals can make themselves look like a more dangerous animal when they are about to be attaçked. They do this to:

a) hide from the attacker

* b) try and scare away an attacker

c) be seen easier so other animals will come and save them

d) warn other animals to go and hide

As can be seen from this example, the Knowledge test is not simply a test of factual knowledge. An understanding of underlying principles requires reasoning about the principles. Thus, the types of questions posed in the Knowledge test require knowledge of facts and reasoning to demonstrate an understanding of the underlying principles in the themes.

Instructions

Near the end of the third session, after each subject had sorted all eight themes, he/she was asked to complete the Knowledge Test by circling the best answer to each question.

Scoring

The Knowledge Test was scored by the author. Subjects received scores for the number correct for the total test (#correct/24), academic items only (#correct/12), and social items only (#correct/12). All raw scores were converted to percentage scores.

Preliminary Analyses

Descriptive Statistics

The inclusion of the Knowledge test was originally expected to be a mere formality to ensure that analogical reasoning skill and not differences in subjects' knowledge of underlying principles can account for the observed relationships with competence. Ceiling scores were anticipated since the content of the themes and consequently the questions on the Knowledge

Test were thought to be highly familiar material to all subjects. If only a small percentage of subjects did not receive perfect scores on the test, the original plan was to omit the data from these subjects in subsequent analyses. However, ceiling scores were not obtained for the majority of subjects, although the scores of the Grade 6 and 8 subjects on the Knowledge Test were quite high. Scores ranged from 58 to 100 and 62 to 100 percent correct for the Grade 6 and Grade 8 groups, respectively. Appendix F summarizes the means and standard deviations, and shows the considerable skew (to the left) of the scores. Stem and leaf plots confirmed that the scores approached, but did not reach ceiling. The errors subjects made were evenly scattered across themes, with no specific content items posing particular difficulty. Thus, as the majority of subjects did not receive perfect scores on the Knowledge Test, it is possible that differences in knowledge of the underlying principles in the themes may influence the results. Consequently, it was necessary to control for knowledge differences by partialling out of the analogical reasoning scores that part of the variance that is attributed to knowledge (this statistical procedure is explained in the "Scoring" section which is subsumed under the heading "Analogical Reasoning Tasks").

Grade and Sex Differences

t-tests of the differences between means for grade and sex (see Appendix G) did not identify any differences as a function of sex, but did show significant differences in performance between the two grades. The Grade 8 group was relatively more successful on the total and social items ($p<.05$) of the Knowledge Test.

Inter-relationships Between Competence Tasks and the Knowledge Test

Correlational Analyses.

Pearson product-moment correlations were calculated between scores on the Knowledge Test and the academic and social competence tasks. Scores on the Knowledge Test were found to be significantly correlated with performance on the academic but not social competence tasks (see Table 8). A similar pattern of results was observed for both

TABLE 8
Pearson Product-Moment Correlations Between the Knowledge Test and Competence Tasks - Grade 6 and Grade 8, Study One

	KNOWLEDGE TEST: total		KNOWLEDGE TEST: academic		KNOWLEDGE TEST: social	
	Gr. 6	Gr. 8	Gr. 6	Gr. 8	Gr. 6	Gr. 8
ACHIEVEMENT	.49***	.50***	.44**	.42**	.39**	.42**
TEACHER RATINGS: ACADEMIC	.35*	.51***	.26	.44***	.34*	.42**
SELF PERCEPTION: ACADEMIC	.34*	.24	.27	.21	.33*	.19
SOCIOMETRIC	-.08	.01	-.14	-.11	.02	.14
TEACHER RATINGS: SOCIAL	-.01	.06	-.10	-.06	.11	.04
SELF PERCEPTION: SOCIAL	-.05	.02	-.17	-.01	.13	.01

$^{***}p < .001$, $^{**}p < .01$, $^{*}p < .05$

male and female data (see Appendix H). Once again, these results demonstrate the separability of the academic and social competence tasks.

Factor Analyses.

Principal components factor analyses using a varimax rotation among the competence tasks and Knowledge Test (described earlier) also indicated that the Knowledge Test was distinct from the competence tasks (see Table 3). That is, the Knowledge Test variables (total, academic, and social items) loaded highly on a General Knowledge factor, and only demonstrated moderate loadings with academic competence. In considering the academic and social items of the Knowledge Test, the academic items did not show differential loadings on the Academic Competence factor, and the social items did not show differential loadings on the Social Competence factor. Thus, the content of the themes did not show distinctive relationships with academic and social competence.

Controlling for Knowledge Differences

In order to control for differences in knowledge of the underlying principles in the themes, it is necessary to compute a set of derived scores (ARr) in which the variance in the scores attributed to content knowledge has been partialled out of the analogical reasoning (AR) scores. Thus, for each subject on each theme, the variance in the AR scores can be considered to have two components: one that is predicted from the linear regression of AR on knowledge (ARp), and the other that is not predicted from the linear regression of AR on knowledge (ARr), i.e., the residual component. In computational terms:

$$AR = ARp + ARr \qquad (1)$$

This equation was solved in the following manner. First, standardized (Z) scores were calculated for scores on the knowledge test (KN) and analogical reasoning scores for each individual theme, resulting in Z(KN) and Z(AR), respectively. The predicted analogical reasoning scores (ARp) were then computed from the product of the standardized knowledge test scores (Z(KN)) and the correlation between the analogical reasoning and knowledge test scores (r(AR,KN)). That is,

$$ARp = Z(KN) \times r(AR,KN)$$

By substituting ARp into equation (1), it was possible to solve for ARr. Thus, the resultant residual analogical reasoning score (ARr) partials out of analogical reasoning (AR) that part of the variance that is attributable to content knowledge.

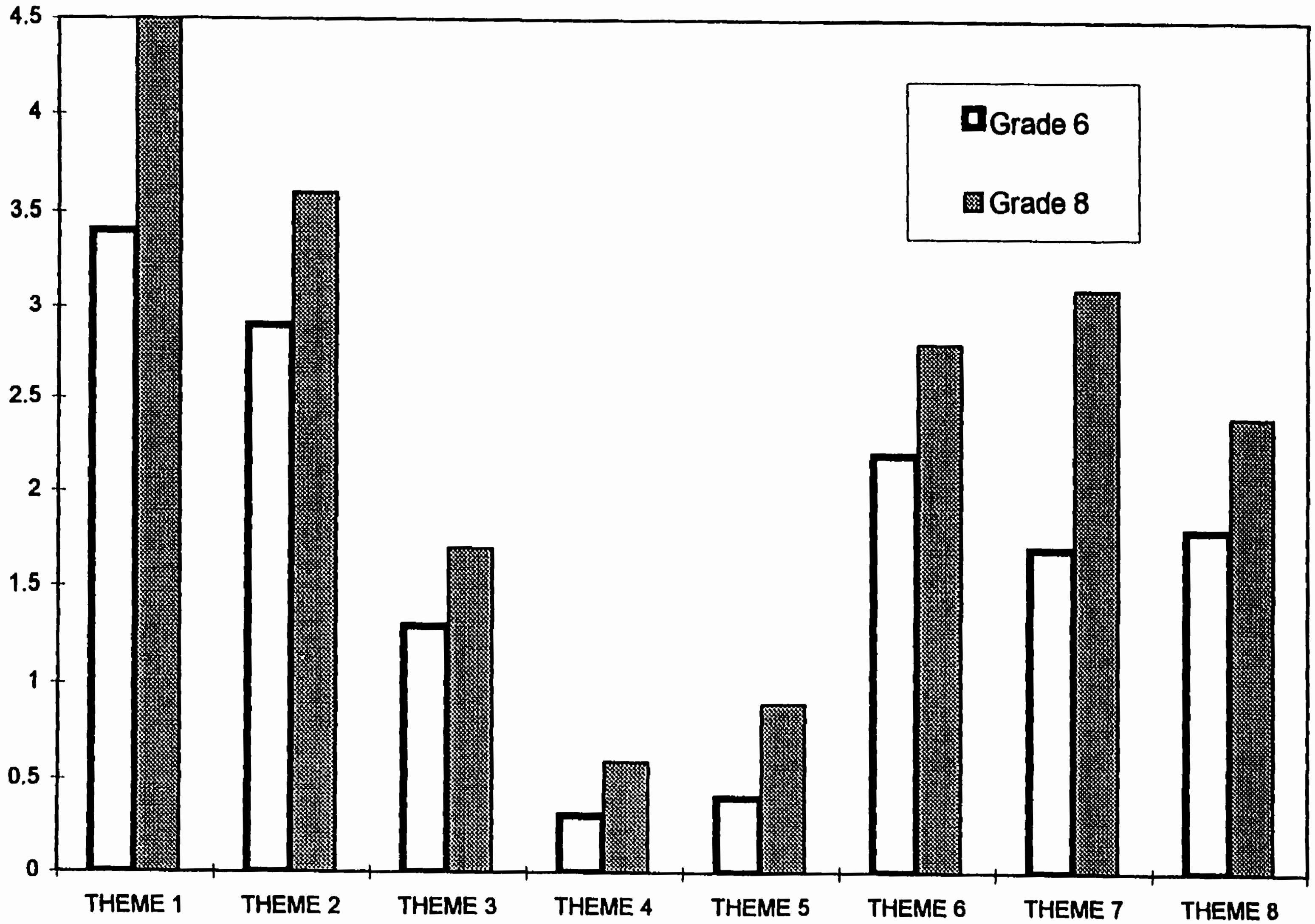
Preliminary Analyses of the Problem Solving Task

The problem solving data were analyzed by examining the difficulty level of the themes, grade and sex differences, and the differences among the themes (i.e., individual, descriptive and problematic, academic and social themes). The analyses were performed using the different scoring variations (i.e., full and reduced data sets, first and both sorts, categorical and quantitative scoring, and original and residual data). The various manipulations of the data were examined to determine whether they were informative and therefore worth pursuing in subsequent analyses.

Difficulty Level of the Themes

Analyses of performance comparing mean scores on the individual themes indicated that the themes differed in difficulty (see Figure 2). Most notably, the mean analogical reasoning scores (mean AR) for themes 4 and 5 (i.e., "Water Principles" and "Social Skills") were less than scores on the remaining themes for both grade levels. t-tests of the differences between the means of the individual themes supports this observation, as significant differences were evident between either theme 4 or 5 and all other themes (see Appendix G). Consequently, in order to determine whether the data were distorted in some way by these more difficult themes, in subsequent analyses the data were analyzed using the full set of eight themes, and a reduced set of six themes that excluded themes 4 and 5. Since the difficult themes included one academic and one social theme, the total number of academic and social themes remained equal in both the full and reduced data sets.

FIGURE 2
Means of Individual Themes - Grade 6 and Grade 8



Scoring Variations

Pearson product-moment correlations were conducted to analyze the different scoring manipulations, correlating scores from the;

- First and Both Sorts
- Quantitative and Categorical scoring systems, and
- Full and Reduced set of themes.

These correlational analyses were carried out for both grade levels with the data from all themes combined and for the academic and social themes separately. The results indicated that, whether these correlations were calculated using scores from the Quantitative/Categorical scoring systems, First/Both sorts, or Full/Reduced data, all correlations were significant (all r's >.95, $p<.001$). Moreover, employing any of these pairs of scores in subsequent analyses yielded the same pattern of results, regardless of which scores were used. Therefore, to simplify the reporting of results, only the analogical reasoning scores from:

- Both sorts
- the Quantitative scoring system, and
- the Full set of themes

are reported in what follows. These variables were chosen because they included the most data.

Descriptive Statistics

In general, the standard deviations of the analogical reasoning scores (AR) for the individual themes were large (see Appendix F). Stem and leaf plots demonstrated a clustering of scores in the lower range of values (i.e., few underlying principles identified), with relatively few subjects with higher scores. Distributions were typically skewed to the right, particularly for the Grade 6 subjects.

When an individual subjects' scores were summed over the academic, social and overall themes, the standard deviations of these composite scores were relatively smaller than for individual themes (see Appendix F). Composite scores were distributed across a broader range of values. Stem and leaf plots showed a cluster of scores in the lower range (demonstrating how the majority of subjects identified only a few underlying principles), and a cluster of scores in the upper range, (demonstrating how a minority of subjects were able to identify most of the underlying principles). Thus, these patterns of scores more closely resembled a bimodal distribution.

Grade Differences

The data were examined using t-tests of the differences between the Grade 6 and Grade 8 means for each problem solving theme (see Appendix G). Significant differences favoring the grade 8 subjects were found for the themes of "Environmental Waste Control" ($p<.05$), "Social Skills" ($p<.05$) and "Potential Peer Conflict ($p<.001$), and for the academic, social, and total theme groupings ($p<.01$). In general, identification of underlying principles (i.e., analogical reasoning) appeared to improve across the grades.

Sex Differences

Examination of t-tests of the differences between the means of boys and girls on each analogical reasoning theme did not identify any differences as a function of sex (see Appendix G). The only exception to this occurred on the "Unsuccessful Personality Types" theme for the Grade 8 group, in which girls obtained higher analogical reasoning scores (AR) than boys ($p<.05$). One possible reason for this difference comes from observations of the corresponding item on the Knowledge Test, in which the boys appeared to identify physically aggressive boys as problematic less often than the girls. Alternatively, this sex difference may not be statistically valid given the high degree of variance among the scores on the individual themes (see Appendix F).

Descriptive and Problematic Themes

Originally, the materials were created/adapted to allow comparisons between descriptive and problematic themes. Of interest, was whether subjects differed in their identification of underlying principles when presented with the potentially more 'passive' activity of reading short descriptive passages, versus the potentially more 'active' problem solving task of reading unresolved problem situations. However, it was not possible to make comparisons on this descriptive/problematic dimension because the two most difficult themes (i.e., theme 4 - problematic/academic, and theme 5 - descriptive/social), discussed earlier, created an imbalance in comparing the four groups. As a result, it was not possible to determine whether differences in subjects' performance on these themes were due to the descriptive/problematic manipulation or the imbalance imposed by the difficult themes. Therefore, it was felt that the descriptive/problematic distinction was not a useful comparison, and could not be utilized as a variable in subsequent analyses.

Individual Themes

In order to determine whether performances on the individual themes were related, particularly within the academic and social groupings, Pearson product- moment correlations were calculated using the scores on the individual themes. For the majority of correlations low, non-significant correlations were found among the individual themes for both grade levels (see Table 9). While some correlations were found to be significant, there was no discernible pattern among these correlations. More specifically, correlations were not higher among the academic themes or among the social themes. Thus, there was no indication that performance on the themes was differentially related based on academic or social content.

To further explore the relationships in performance among the individual themes, Principal Components factor analyses using a varimax rotation and eigenvalue set at one, were conducted on the correlations among the themes at each grade level (see Appendix I). For both the Grade 6 and Grade 8 data, the resultant factor loadings did not reveal any notable clustering of themes, but rather yielded eight separate factors, one for each theme. When a two-factor solution was forced, the loadings were not differentiated based on the academic/social distinction, but rather, were based on the difficulty level of the themes, particularly for the Grade 6 subjects. That is, the more difficult themes (four and five) had

TABLE 9
Pearson Product -Moment Correlations Between Individual Themes - Grade 6 and Grade 8 , Study One

THEME	1	2	3	4	5	6	7	8
1								
2	.29* .06							
3	.11 .11	.22 .32*						
4	.09 .13	-.16 .20	.27* .25*					
5	.07 .06	-.16 .20	-.32* .21	-.09 .60***				
6	.22 .32*	.39** .34**	.28* .07	.16 .03	.04 .27*			
7	.31* .14	.44** .18	.28 .03	-.03 .09	.09 .16	.22 .27*		
8	.18 .27*	.06 .12	.11 .23	.11 .27*	.18 .03	.20 .12	.16 .33**	

*** p.< .001, ** p < .01, * p.< .05

higher loadings on one factor, while the remaining themes had higher loadings on the other factor.

Academic and Social Themes

Pearson product-moment correlations between AR scores based on groups of themes (with scores summed across the individual themes) indicated significant correlations between AR scores based on academic and social theme groupings ($r = .45$, $p < .001$, Grade 6; $r = .46$, $p < .001$, Grade 8). Although significant, these correlations indicate that the shared variance is only 20 - 25%. Also, factor analyses of the individual themes (described above) did not differentiate academic and social themes. Overall, the results from these analyses do not support the calculation of separable scores based on the academic and social themes, and suggest that all themes may contribute to an overall analogical reasoning score. However, the content of the themes was chosen from the literature to capture academic problem solving on the one hand and social problem solving on the other. Therefore, for a priori reasons, in subsequent analyses scores were calculated so as to provide separate academic (ARa) and social (ARs), as well as total (ARt) measures of analogical reasoning.

Competence and Analogical Reasoning

Investigations into the relationship between competence and analogical reasoning employed Pearson product-moment correlations and causal analysis. As noted earlier, given the redundancy among different variables, the full data set with quantitative scoring for both sorts, were used. Also, analyses were conducted on the data with and without statistically controlling for differences in subjects' content knowledge (i.e., the 'original' and 'residual' data). Finally, although statistics did not indicate that separate analyses for academic and social themes were warranted, the data were analyzed using scores based on the total, academic and social themes for a priori reasons described above.

Correlational Analyses

Pearson product-moment correlation coefficients were calculated intercorrelating the scores from the competence and analogical reasoning tasks, and these correlations are presented in Tables 10.1 and 10.2 for the Grade 6 and 8 groups, respectively.

Academic Competence and Analogical Reasoning

For the Grade 6 subjects, the correlations in Table 10.1 indicate that analogical reasoning scores [i.e., academic (ARa); social (ARs); total (ARt)] were significantly positively correlated with scores on the academic competence tasks (i.e., achievement ACHT; academic teacher ratings, TRC; and academic self report, SPC). The only correlations that did not reach significance was the correlation between SPC and ARs. t-tests of the difference between correlations indicated that correlations between ARt and ACHT, and between ARa and ACHT, were significantly larger than correlations between ARt and SPC, and between ARa and SPC (see Appendix J). The correlations that included TRC [i.e., r(TRC,ARa), r(TRC,ARs), r(TRC.ARt)] did not differ significantly from either the correlations with ACHT [i.e., r(ACHT,ARa), r(ACHT,ARs), r(ACHT,ARt)] or SPC [i.e., r(SPC,ARa), r(SPC,ARs), r(SPC,ARt)]. Thus for the Grade 6 subjects, analogical reasoning (AR) scores were found to be significantly related to performance on the academic competence tasks, and these relationships were significantly larger with achievement than academic self report. Self perception of academic skill was only weakly related to analogical skill. [These correlational analyses were conducted for male and female data separately, and the same pattern of results emerged for both male and female subjects (see Appendix H).]

For the Grade 8 subjects, AR scores were also found to be significantly positively correlated with scores on the achievement test and teacher ratings of academic competence (see Table 10.1). Correlations between AR scores and self report of academic competence were not significant. Correlations between AR (ARt, ARa, and ARs) and ACHT were generally larger than correlations between AR (ARt, ARa, and ARs) and TRC. However,

TABLE 10.1
Pearson Product-Moment Correlations Between Analogical Reasoning and Competence Tasks - Grade 6 (above) and Grade 8 (below), Study One

	ANALOGICAL REASONING		
	ACADEMIC THEMES	SOCIAL THEMES	TOTAL THEMES
ACHIEVEMENT	.63*** .30*	.37** .38**	.58*** .40**
ACADEMIC TEACHER RATINGS	.47*** .34**	.30* .30*	.45** .37**
ACADEMIC SELF REPORT	.36** -.01	.23 .08	.35* .04
SOCIOMETRIC	.05 -.02	.09 -.14	.08 -.10
SOCIAL TEACHER RATINGS	-.03 .15	.21 .14	.11 .17
SOCIAL SELF REPORT	-.07 -.27*	-.01 -.19	-.05 -.26*

*** p < .001, ** p < .01, * p < .05

TABLE 10.2
Pearson Product-Moment Correlations Between Analogical Reasoning and Competence Tasks - Controlling for Knowledge
Grade 6 (above) and Grade 8 (below), Study One

	ANALOGICAL REASONING		
	ACADEMIC THEMES	SOCIAL THEMES	TOTAL THEMES
ACHIEVEMENT	.51*** .23	.28* .27*	.47*** .24
ACADEMIC TEACHER RATINGS	.41** .27*	.22 .18	.37** .21
ACADEMIC SELF REPORT	.29 -.04	.16 .02	.27 -.04
SOCIOMETRIC	.11 .00	.08 -.19	.11 -.10
SOCIAL TEACHER RATINGS	.00 .14	.19 .13	.11 .16
SOCIAL SELF REPORT	-.02 -.27*	-.05 -.19	-.04 -.28*

***P<.001, **P<.01, * P<.05

t-tests of the differences between correlations indicated that the correlations of the AR scores with ACHT were not significantly larger than their correlations with TRC (see Appendix J). Both the correlations of AR with ACHT and correlations of AR with TRC were significantly larger than the correlations of AR with SPC. Thus, for the Grade 8 subjects, analogical reasoning scores were significantly related to performance on both achievement and teacher ratings of academic competence , but not to subjects' perception of their own academic competence. Once again, despite expectations to the contrary, children's self perceptions of academic skill were not related to analogical reasoning skill. [As with the Grade 6 group, the same overall pattern of results was obtained when the data were analyzed separately for males and females (see Appendix H).]

Controlling AR for Knowledge

For the Grade 6 subjects, after controlling for subjects' knowledge of the underlying principles in the themes, analogical reasoning scores (including ARa, ARs, and ARt) were again significantly positively correlated with the academic competence tasks (see Table 10.2) As with the original scores, correlations with AR were largest with ACHT and significantly smaller (using t-tests of the difference between correlations; see Appendix J) with SPC Examination of t-tests of the differences between correlations indicated that correlations of AR with TRC differed significantly from correlations of AR with SPC but not AR with ACHT (see Appendix J). However, while the pattern of results was similar to the previous findings (before controlling AR for knowledge differences), the size of the correlations decreased after controlling AR for knowledge. t-tests of the difference between correlations comparing the original and 'knowledge controlled' data indicated that correlations using the controlled scores were significantly lower, particularly for the correlations of AR with ACHT and AR with TRC (see Appendix J). Thus, while analogical reasoning continued to demonstrate relationships with academic competence after controlling AR for knowledge differences, these relationships decreased in size. [There was no difference in the pattern of the results when the male and female data were analyzed separately (see Appendix H).]

Similarly, for the Grade 8 group, the size of the correlations between analogical reasoning and academic competence after controlling AR for knowledge differences was smaller when compared to the original data (see Table 10.2). Examination of t-tests of the difference between correlations of AR with and without controlling for knowledge differences indicated a significant decrease in the size of correlations, especially for the achievement and academic teacher ratings (see Appendix J). In contrast to the Grade 6 data, the correlations between ARt and ACHT and ARa and ACHT, and between ARt and TRC and ARs and TRC, did not reach significance. The only exceptions occurred for the correlation between ARs and ACHT and the correlation between ARa and TRC. However, even these correlations, although significant, were small. Moreover, the significant relationship between analogical reasoning scores and performance on the academic competence tasks essentially disappeared after controlling AR for knowledge differences in the data from the Grade 8 group. [The same pattern of results was found when the male and female data were analyzed separately (see Appendix H).]

__Social Competence and Analogical Reasoning__

For the Grade 6 group, Table 10.1 shows that no significant correlations were found between AR (ARt, ARa, or ARs) and social competence (i.e., the sociometric, SOCIO; social teacher ratings, TRS; and self report of social competence, SPS). [This was true for both male and female subjects (see Appendix H).] Thus, no relationship was found between subjects' ability to reason analogically in their identification of underlying principles in themes, and their competence in social situations as assessed by peer, teacher, and self ratings.

Similarly for the Grade 8 group, no significant correlations were found between scores on the analogical reasoning and social competence tasks (see Table 10.1). [This pattern was also found for both males and females (see Appendix H). The only exception occurred with the girls in the Grade 8 sample. Significant, __negative__ correlations were found between SPC and ARt, and SPC and ARa. That is, females __more__ skilled at identifying underlying principles tended to rate themselves __lower__ in terms of their perception of their own interpersonal skills.]

Controlling AR for knowledge

The same pattern of results was obtained after controlling for knowledge differences in the AR for both the Grade 6 and Grade 8 subjects (see Table 10.2). Again, no significant relationships were found between analogical reasoning and social competence tasks. The only exception was a negative relationship between analogical reasoning and social self report for the Grade 8 females. Again, Grade 8 female students more skilled at analogical reasoning rated themselves as less competent in social situations.

Summary

In summary, correlational analyses indicate that analogical reasoning skill is related to academic competence at both grade levels. This was particularly evident with the achievement test and teacher ratings of academic competence. Children's self perception of their own academic competence showed only a weak relationship with analogical reasoning in the Grade 6 group, and no association in the Grade 8 group.

Statistically controlling AR for differences in subjects' knowledge of the underlying principles in the themes produced a similar pattern of significant relationships between analogical reasoning and academic competence for the Grade 6 group. However, for the Grade 8 group, the relationship between analogical reasoning and academic competence no longer reached significance after controlling for content knowledge. Thus, for the younger subjects, both content knowledge and analogical reasoning skill were related to academic competence. For the older subjects, differences in content knowledge appeared to account for the significant relationship between analogical reasoning and academic competence.

In contrast, there was a complete absence of any relationship between success in analogical reasoning and social competence. Peer, teacher and children's self perception of social competence all failed to demonstrate any relationship with skill at identifying underlying principles in academic or social themes. The only exception occurred with the Grade 8 girls, with whom success on the analogical reasoning task was associated with less competent feelings about themselves in social situations. This result was explored further in the next study.

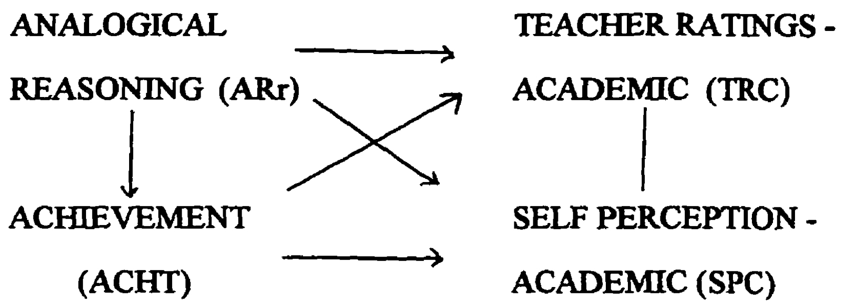
Causal Analysis

Given the exploratory nature of the present research, it should prove informative to examine not only the inter-relationships among variables, but also the pattern of causation among the variables. To this end, path analyses were employed to build a causal model of the relationships between analogical reasoning and competence. This method uses correlational data in a regression technique to estimate the causal sequence among variables (Kenny, 1979). A series of regressions are conducted to determine the direct and indirect effects that one variable has upon other variables. In this manner, path analyses can determine how much of the correlation between variables is due to a direct association or due to an indirect association through intervening variables. In the regression equations, the beta weights of the predictor variables are the path coefficients in a causal model that indicate the direct and indirect associations. Testing whether the path coefficient is significantly different from zero indicates the presence or absence of an effect on that path. Thus, by estimating the size of the relations between variables, these estimates can provide information about the underlying causal processes. To assist in `theory trimming', paths with non-significant effects are deleted. This trimmed or restricted model was tested in the next study.

In examining the influence of analogical reasoning on competence , two causal models can be constructed - one academic and one social.

Academic Causal Model

As Sternberg (1985a) and others have argued, analogous thinking is a fundamental component of cognition, a critical skill in learning and transfer, considered by some to be the main strategy used to solve novel problems (e.g., Polya, 1957; Vosniadou, 1988; Anderson & Thompson, 1989; Rumelhart, 1989; Goswami, 1992). From this, it seems reasonable to assume that analogical reasoning (ARr) influences achievement (ACHT). These variables (ARr and ACHT) in turn should influence teacher perceptions of a child's academic performance (TRC). A child's perception of his or her own academic skill (SPC) would be expected to be influenced by teachers' responses (TRC) as well as indicators of his/her academic performance (ARr and ACHT). The general path diagram for this model is as follows:



The standardized structural regression equations are:

$$ACHT = a(ARr) + error$$

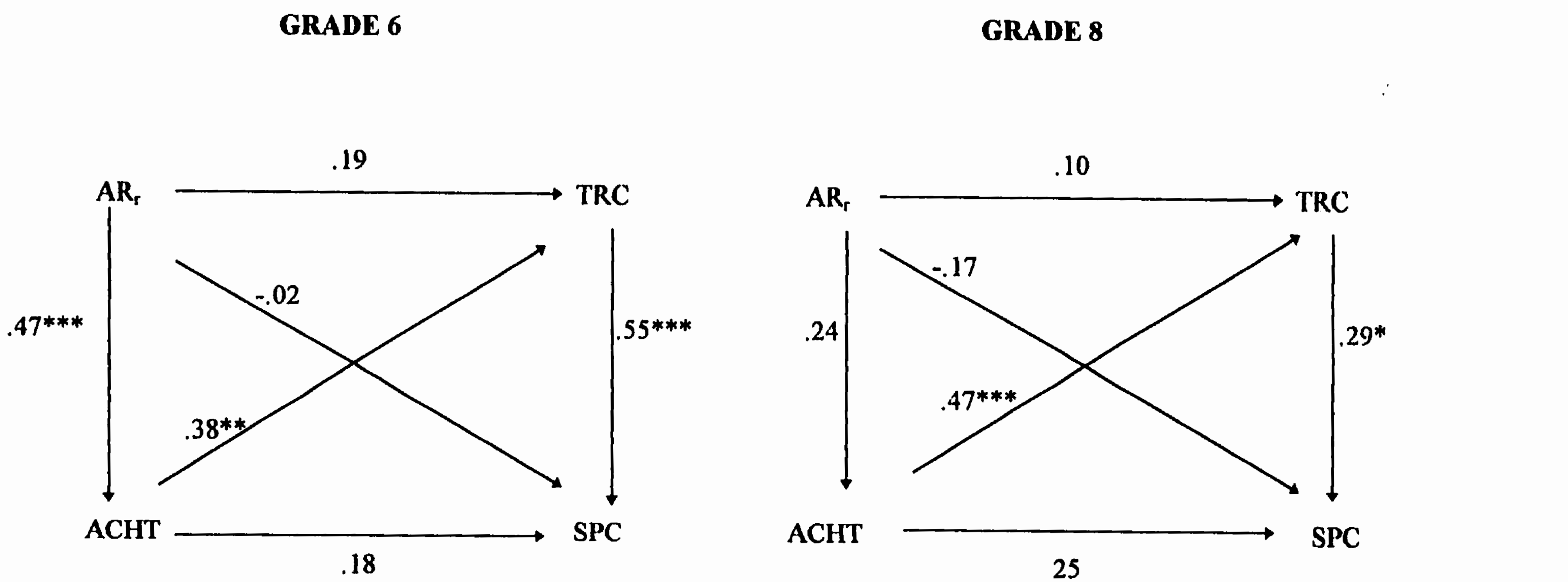
$$TRC = b(ARr) + c(ACHT) + error$$

$$SPC = d(ARr) + e(ACHT) + f(TRC) + error$$

These equations were solved controlling for content knowledge, including all eight themes, and using both Grade 6 and Grade 8 groups. The two path models, one for each grade, including path coefficients (beta weights) and significance levels, are presented in Figure 3. [The same pattern of results was obtained when using ARr scores from the four academic themes. See Appendix K for the path diagrams.]

For both grade levels, the path coefficients from ARr to SPC, ARr to TRC, and ACHT to SPC, were non-significant and in most instances near zero. Significant coefficients were found in the influence of ARr on ACHT, ACHT on TRC, and TRC on SPC. For the Grade 6 subjects, these paths were highly significant (p's of .01 to .001). For the Grade 8 subjects, the ARr to ACHT path did not reach significance (as noted earlier in the

FIGURE 3
Academic Causal Model, Study One



AR$_r$ = analogical reasoning, TRC= academic teacher ratings, ACHT= achievement, SPC= academic self report
*** p < .001, ** p<. 01,* p< .05

correlational analyses, it was significant before controlling for knowledge) and the TRC to SPC path was only moderately significant ($p<.05$), while the ACHT to TRC path was highly significant ($p<.001$). Taken altogether, these findings suggest the following model:

$$\text{ARr} \longrightarrow \text{ACHT} \longrightarrow \text{TRC} \longrightarrow \text{SPC}$$

That is, a series of direct effects in which analogical reasoning (ARr) influences achievement (ACHT), which then influences academic teacher ratings (TRC), which in turn influences academic self perception (SPC). [The same pattern of results was found for both the male and female data (see Appendix K).] In this restricted model, analogical reasoning and achievement only exert indirect effects on self perception. This model was tested in the next study.

Social Causal Model

As discussed in the Introduction, many researchers have hypothesized that `mental actions' (here, analogical reasoning) play an important role in information processing (Crick & Dodge, 1994). In the hypothesized social causal model, this would suggest that analogical reasoning should influence social competence. However, given the results of correlational analyses provided earlier, paths between ARr and all other social competence variables are expected to be non-significant. This is tested using the following social causal model, in which analogical reasoning (ARr) is thought to influence peer perceptions of a child's social competence (SOCIO). Teacher's perceptions of a child's social competence (TRS) would be influenced by a child's reasoning skill and how he/she is perceived by his/her peers (ARr and SOCIO). Finally, a child's own perceptions of his/her competence (SPS) would be influenced by teacher and peer reactions (TRS and SOCIO), and a sense of his/her own reasoning skill in social situations (ARr). The general path diagram for this model is as follows:

$$\begin{tikzcd} \text{ANALOGICAL REASONING (ARr)} \arrow[r] \arrow[d] \arrow[dr] & \text{TEACHER RATINGS - SOCIAL (TRS)} \arrow[d] \\ \text{SOCIOMETRIC (SOCIO)} \arrow[r] \arrow[ur] & \text{SELF PERCEPTION - SOCIAL (SPS)} \end{tikzcd}$$

The standardized structural regression equations for this model are as follows:

SOCIO = a(ARr) + error

TRS = b(ARr) + c(SOCIO) + error

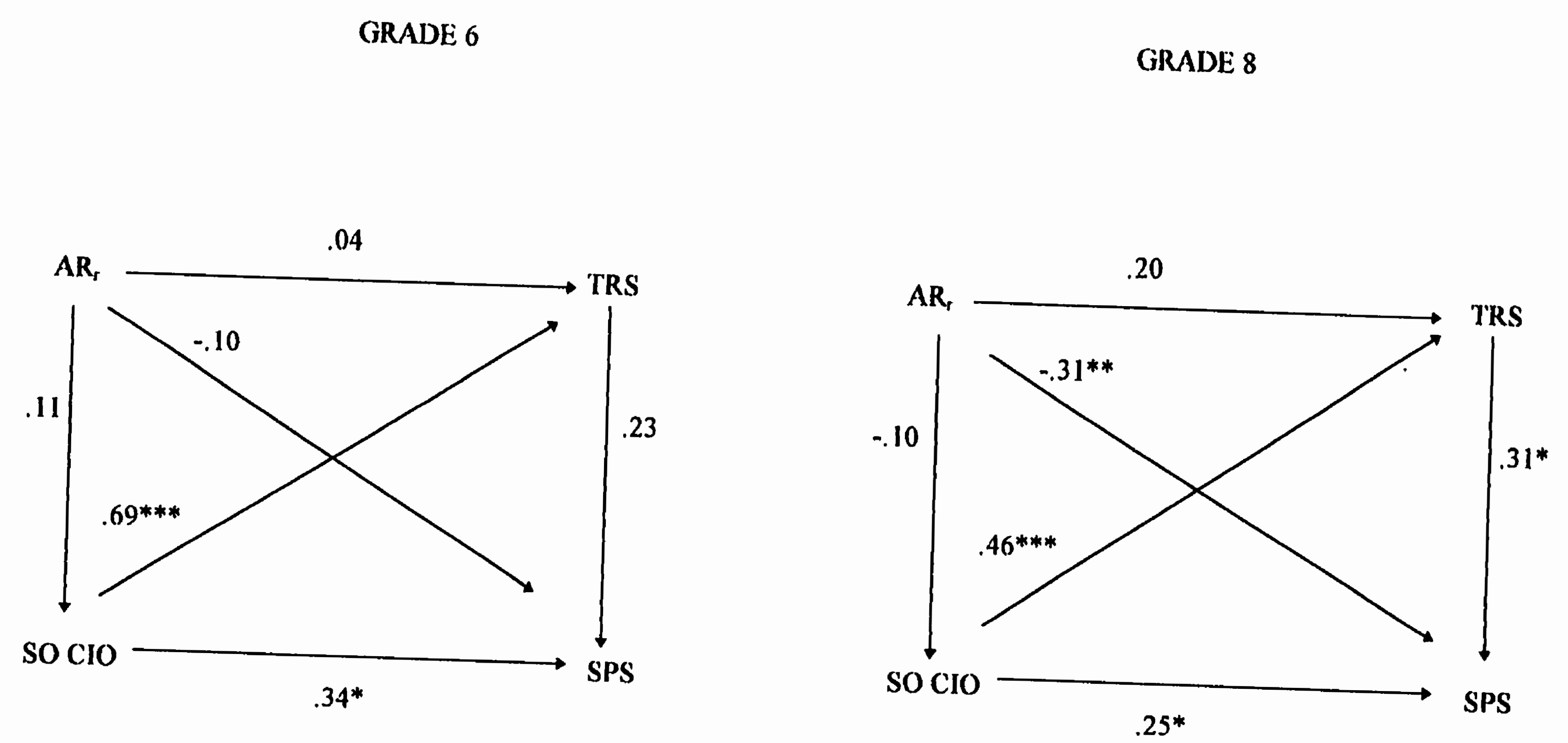
SPS = d(ARr) + e(SOCIO) + f(TRS) + error

These equations were solved controlling AR for content knowledge (ARr), using all eight themes, and for Grade 6 and Grade 8 groups. The two path models, one for each grade including path coefficients (beta weights) and significance levels, are presented in Figure 4. [Essentially the same results were obtained when using ARr scores from the four social themes.]

As expected, the results very clearly show no direct or indirect influence of analogical reasoning (ARr) on any indices of social competence (SOCIO, TRS or SPS). The only exception occurred with significant negative path coefficients between ARr and self report of social competence (SPS) in the Grade 8 data ($p<.01$). As noted with the correlational data , this is due to the female data, where Grade 8 girls who demonstrated more success on the analogical reasoning task tended to rate themselves as less successful in social interactions. Other than this one aspect of the results, the same pattern of results was found for both the male and female data (see Appendix K).

In general, examination of the paths among the social competence variables suggests that children's self perception of their own social competence (SPS) was influenced by peer and teacher perceptions, and <u>not</u> by analogical reasoning skill. However, these paths (i.e., SOCIO to SPS, and TRS to SPS) demonstrated only weak relationships for both the Grade 6

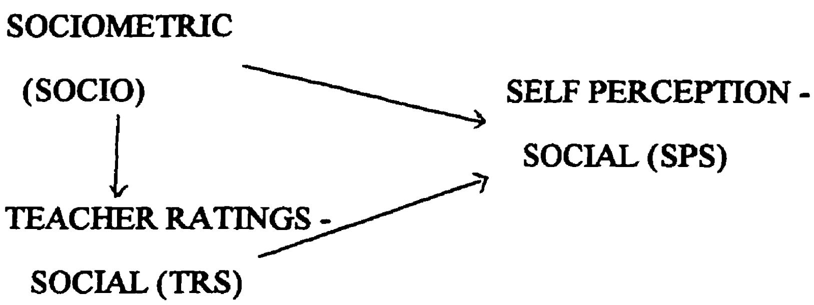
FIGURE 4
Social Causal Model, Study One



AR r = analogical reasoning, TRS = social teacher ratings, SO CIO = Sociometric, SPS = social self report
*** p<.001, ** p< .01,* p< .05

and Grade 8 subjects ($p<.05$ and non-significant paths). The path between the sociometric (SOCIO) and social teacher ratings (TRS) showed the strongest effects ($p<.001$) for both grades. These results suggest that there is at best, a weak relationship between how subjects view themselves socially and how they are viewed by their peers and teachers. Other findings reported in the literature have been somewhat mixed, but are generally in agreement in finding a weak but positive relationship between self and others' perceptions of social competence (e.g., Harter, 1982; Ladd & Price, 1986; Kurdek & Krile, 1982).

Given that there was no indication of any direct or indirect influence of analogical reasoning on any indices of social competence, this variable was omitted in the restricted model. Thus, these results suggest the following model, where analogical reasoning is excluded entirely and the sociometric and social teacher ratings are assumed to influence self report:



This restricted model was tested in the next study.

Summary

There were several findings of particular interest to the present investigation that were obtained from the correlational and causal analyses that require further examination.

First, analogical reasoning skill was found to be related to academic competence, and this relationship persisted (although it was somewhat weaker) after controlling AR for knowledge differences in the data for the Grade 6 but not Grade 8 subjects. For the Grade 6 data, these results demonstrate the important role in problem solving of both analogical reasoning and content knowledge in the academic domain. The findings with the Grade 8 data suggest that there may be some shift with development to more emphasis on content knowledge in problem solving in the academic domain, possibly once a certain level of analogical reasoning skill has been attained. The causal model analyses re-iterated these findings and suggested that the pattern of causation among the analogical reasoning and academic competence variables is a series of direct effects. In this model, analogical reasoning influences academic achievement which influences teacher ratings of a child's academic skill, which in turn influences a child's self perceptions of his/her academic skill. Confirmation of the correlational findings and a test of the model was investigated in the next study.

Second, the data are very striking in the absence of any relationship between analogical reasoning and social competence. Despite expectations to the contrary, analogical reasoning skill (with or without controlling for content knowledge) was not related to peer, teacher or self perceptions of social competence. This was again evident in the causal model, where analogical reasoning did not appear to influence any social variables whether directly or indirectly. One exception did occur with the Grade 8 females, and requires confirmation in the next study. The overwhelming finding of no association, however, could be due to some inadequacy with the materials, or possibly because competence in social situations is dependent on factors other than analogical reasoning. Replication of these findings and a test of the model was conducted in the next study.

CHAPTER THREE: STUDY TWO

Overview

The major objective of this second study was to test the relationship between analogical reasoning and competence that was explored in the previous study. Data were obtained from a new, somewhat larger sample of subjects from Grades 6 and 8. This new set of data was used to examine the relationship between analogical reasoning skill in academic and social domains, and academic and social competence. The data were also used to assess the academic and social causal models proposed in Study One. And finally, in order to ensure that the judgments required in the scoring of the subjects responses could be accurately replicated with an independent rater, inter-rater reliability was assessed.

Method

The results obtained in Study One provided information concerning the adequacy of the materials and how best to score and analyze the data, as well as preliminary information about the relationship between competence and analogical reasoning. One finding was that the different methods used to score the analogical reasoning data yielded redundant information. This was apparent when comparing the Categorical and Quantitative scoring systems, scoring protocols for omissions, using data from the first and both sorts, and comparing the full or reduced set of themes (i.e., 8 versus 6 themes). Since no new information was provided by these scoring variations, the decision was made to restrict data analyses to the full set of themes, analyzed using the Quantitative scoring system for both sorts. These choices were felt to make maximum use of the data for analyses. In addition, difficulties were noted in Study One in the attempts to compare descriptive and problematic themes. Also, correlational analyses among the individual themes did not reveal any notable pattern of relationships among the themes. Therefore, these analyses were not pursued in this second study, and only the total (8), academic (4), and social (4) themes were grouped for analyses. Although performance on the academic and social groupings of themes was not found to be related within each domain in the first study, the academic and social themes were again grouped for comparison to determine whether analogical reasoning scores would show stronger relationships within the academic and social themes, respectively. Finally, all of these variations in scoring and analyses of the data (i.e., categorical and quantitative scoring system, first and both sorts, full and reduced data sets, and individual and descriptive/problematic theme groupings) were performed on the data from the sample used in this second Study, and the same pattern of results was obtained as that found in Study One (see Appendix L).

Subjects

One hundred ninety children served as subjects in this study, 94 subjects were from Grade 6, including 56 males and 38 females, with an average age of 12.0 years, and 96 subjects were from Grade 8, including 47 males and 49 females, with an average age of 13.9 years. The subjects were drawn from four classrooms at each grade level, from three different schools from the Dufferin-Peel Separate and Halton Boards of Education. Two of the Grade 8 classes were chosen by the Principal of one school to represent a wide range of ability levels. The remaining classes were the only classes in the schools at that grade level. Subjects who participated in the study were all children whose parents gave written permission. In total, 4% of the students in the four classrooms were not granted permission to participate in the study. Of the remaining students, the data from 8% of the students were not used due to absenteeism, incomplete data, or the students' inability to cope with the reading and written demands of the task. These latter students (n=2) were identified by their classroom teachers as having a significant learning disability or an ESL background. Teachers also indicated that the subjects were from middle class families. The sample was largely Caucasian, with a minority of students (less than 5%) of Black and Asian races.

Materials

All materials were identical to those used in the previous study.

Procedure

Data were gathered in late spring, during regular class sessions. The procedure was identical to that used in Study One.

Scoring the Assessment and Experimental Tasks

All assessment measures and the Knowledge Test were scored by the author, as described in the first study. As noted above, the Quantitative scoring system and the full set of themes from both sorts were employed.

Inter-Rater Reliability

The scoring of underlying principles required judgments about the adequacy of the responses, and therefore a measure of the inter-rater reliability was necessary. An initial training session was used to introduce the materials and the scoring key to an independent rater (a Ph.D student). The rater then practised on data from seven randomly chosen subjects, and any discrepancies with the author's judgments were discussed. Following the training and practice, the rater received data from twenty subjects (representing 10% of the subjects). The sample was chosen by selecting the protocols from every ninth or tenth subject, with subjects ordered alphabetically.

Pearson product-moment correlations were computed between the ratings of the rater and the author for the underlying principles (UP) for each sort in each theme. The inter-rater reliability coefficient of the author's ratings with the independent rater was .93 for the practice protocols, and .94 for the test sample of 20 protocols.

Results and Discussion

Correlational Analyses

The scores from the competence and analogical reasoning tasks were intercorrelated using Pearson product-moment correlation coefficients. These correlations are presented in Tables 11.1 (without controlling analogical reasoning scores (AR) for knowledge) and 11.2 (controlling AR for knowledge).

Academic Competence and Analogical Reasoning

For the Grade 6 subjects, the correlations in Table 11.1 replicate the findings from the previous study of significantly positive correlations between analogical reasoning scores (i.e., academic - ARa; social - ARs; total - ARt) and academic competence measures (i.e., achievement, ACHT; academic teacher ratings, TRC; and academic self report, SPC). Self perception of academic skill (SPC) demonstrated an apparent stronger relationship with analogical reasoning (AR) skill in this second study than in the first, that was similar in size to the correlations between analogical reasoning (AR) and achievement (ACHT). [The same pattern of results was obtained when the male and female data were considered separately (see Appendix M.} Table 12 compares the significance levels across the two studies, for the correlational data from the Grade 6 and Grade 8 subjects.

Correlations with AR appeared somewhat larger for ACHT than TRC or SPC. Examination of t-tests of the difference between correlations indicated that the correlation between ARa and ACHT was significantly larger than the correlation between ARa and TRC, and the correlation between ARt and ACHT was significantly larger than the correlation between ARt and SPC (see Appendix N). Thus, although these correlations appeared larger for ACHT and smaller for TRC and SPC (similar to Study One), these differences only reached significance in a couple of instances.

Similarly for the Grade 8 subjects, AR scores were found to be significantly positively correlated with scores on all of the academic competence tasks (see Table 11.1). While the

TABLE 11.1
Pearson Product-Moment Correlations Between Analogical Reasoning and Competence Tasks
Grade 6 (above) and Grade 8 (below), Study Two

	ANALOGICAL REASONING		
	ACADEMIC THEMES	SOCIAL THEMES	TOTAL THEMES
ACHIEVEMENT	.55*** .58***	.40*** .33**	.53*** .52***
ACADEMIC TEACHER RATINGS	.39*** .37***	.36*** .36***	.43*** .43***
ACADEMIC SELF REPORT	.41*** .33**	.22* .40***	.35** .43***
SOCIOMETRIC	.09 .16	.10 .30*	.11 .21*
SOCIAL TEACHER RATINGS	.12 .12	.09 .22*	.12 .20
SOCIAL SELF REPORT	.07 -.08	-.02 -.09	.02 -.10

*** p < .001, ** p < .01, * p < .05

TABLE 11.2
Pearson Product-Moment Correlations Between Analogical Reasoning and Competence Tasks - Controlling for Knowledge
Grade 6 (above) and Grade 8 (below), Study Two

	ANALOGICAL REASONING		
	ACADEMIC THEMES	SOCIAL THEMES	TOTAL THEMES
ACHIEVEMENT	.44*** .31**	.28** .17	.33** .27**
ACADEMIC TEACHER RATINGS	.30** .23*	.25* .20	.25* .26*
ACADEMIC SELF REPORT	.36*** .26*	.18* .28**	.29** .33**
SOCIOMETRIC	.07 .10	.05 .16	.07 .15
SOCIAL TEACHER RATINGS	.12 .04	.03 .12	.08 .10
SOCIAL SELF REPORT	.09 -.02	-.03 -.06	.05 .03

***.p.<.001, ** p < .01, * p < .05

TABLE 12

Comparison of Significance Levels for the Analogical Reasoning - Competence Correlations across Studies 1 & 2, for Gr. 6 (above) & Gr. 8 (below), with and without Controlling for Knowledge

Without Controlling for Knowledge

	ARt		ARa		ARs	
	1	2	1	2	1	2
ACHT	*** **	*** ***	*** *	*** ***	** **	*** **
TRC	** **	*** ***	*** **	*** ***	* *	*** ***
SPC	* ns	** ***	** ns	*** **	ns ns	* ***

Controlling for Knowledge

	ARt		ARa		ARs	
	1	2	1	2	1	2
ACHT	*** ns	** **	*** ns	*** **	* *	** ns
TRC	** ns	* *	** *	** *	ns ns	* ns
SPC	ns ns	** **	* ns	*** *	ns ns	** **

ARt, ARa, ARs = analogical reasoning total, academic, social respectively
ACHT = achievement, TRC = academic teacher ratings, SPC = academic self report
***$p < .001$, ** $p < .01$, * $p < .05$

Grade 8 subjects in the previous study demonstrated significant relationships only between AR and ACHT, and AR and TRC (but not AR and SPC), the Grade 8 subjects in this second study demonstrated significant relationships between AR and all academic competence tasks (i.e., ACHT, TRC, and SPC). [The same overall pattern of results was obtained when the male and female data were analyzed separately (see Appendix M.] Therefore, in contrast to Study One, children's self perceptions of academic skill was found to be related to analogical reasoning skill at both grade levels in the second study (see Table 12 for a comparison).

Correlations between AR (ARt, ARa, ARs) and ACHT appeared larger than correlations between AR (ARt, ARa, ARs) and TRC, and AR (ARt, ARa, ARs) and SPC. However, examination of t-tests of the difference between correlations indicated that the correlation between ARa and ACHT was significantly larger than the correlation between ARa and TRC, and the correlation between ARa and ACHT was significantly larger than the correlation between ARa and SPC (see Appendix N).

<u>Controlling AR for Knowledge</u>

For the <u>Grade 6</u> subjects, after controlling AR for subjects' knowledge of the underlying principles in the themes, analogical reasoning (ARr) scores (including ARa, ARs, ARt) continued to demonstrate significantly positive correlations with the academic competence tasks (see Table 11.2). However, the magnitude of the correlations decreased after controlling AR for knowledge. [When the male and female data were considered separately, the same overall pattern of results emerged (see Appendix M).] Examination of t-tests of the difference between correlations comparing the original data and 'knowledge controlled' or residual data indicated that correlations using the residual (ARr) scores were significantly smaller than the correlations using the original (AR) scores (with the exception of the correlations of AR with SPC: see Appendix N). Thus, while analogical reasoning continued to demonstrate relationships with academic competence after controlling AR for knowledge differences, these relationships were significantly reduced in size when compared to the original data for the Grade 6 subjects. These results were similar to those found in

Study One. A visual comparison of significance levels for the correlational data in Tables 11.1 and 11.2 is presented in Table 12, for both grade levels, both studies, and with and without controlling for knowledge.

Correlations with ARr appeared larger with ACHT and smaller with TRC and SPC. However, these differences were small and did not reach significance in t-tests of the difference between correlations (see Appendix N).

Similarly for the Grade 8 subjects, AR and academic competence scores were significantly positively related after controlling AR for content knowledge. And, as with the Grade 6 subjects, there was a reduction in the size of the correlations when comparing correlations using the original data to those of the residual data (see Table 11.2). [The same pattern of results was found when the male and female data were analyzed separately (see Appendix M.).] Examination of t-tests of the difference between correlations of AR and academic competence with and without controlling for knowledge differences indicated a significant decrease in the size of correlations of AR with all academic competence tasks (with the exception of the correlations between ARs and ACHT, and ARs and TRC; see Appendix N). Thus, in this second study, the relationship between AR and academic competence was significantly reduced after controlling AR for differences in knowledge. However, despite this drop, the analogical reasoning - academic competence relationship still reached significance. This is in contrast to the findings of the previous study, where the significant relationship between analogical reasoning scores and performance on the academic competence tasks no longer reached significance after controlling AR for knowledge differences (see Table 12 for a comparison).

Correlations of ARr with ACHT, TRC and SPC did not appear to be very different from one another. No significant differences were found in t-tests of the difference between correlations (see Appendix N).

Therefore, the data from both grade levels in this second study indicated that subjects more successful in identifying principles in the analogies task also tended to be more successful on the achievement test, receive higher ratings from their teachers, and have a more positive view of their own academic skills. Moreover, after statistically equating the data for differences in subjects' knowledge of the content of the themes, the relationship (although somewhat reduced) remained significant. This suggests that both content knowledge and analogical reasoning skill are related to achievement, and teacher and self perceptions of academic skill.

Social Competence and Analogical Reasoning

For both the Grade 6 and Grade 8 subjects, almost all correlations between the analogical reasoning and social competence scores (i.e., the sociometric, SOCIO; social teacher ratings, TRS; and self report of social competence, SPS) were not significant, with or without controlling for knowledge differences (see Tables 11.1 and 11.2). Thus, no relationship was found between subjects' ability to reason analogically in their identification of underlying principles in themes, and their competence in social situations, as assessed by peer, teacher, and self ratings. This is the same result as was found in the previous study. [This pattern was also found in analyses of the data for both the male and female subjects (see Appendix M).]

The finding from the previous study that Grade 8 females with higher AR scores tended to have lower SPS scores was not found in this second study.

Causal Analysis

In the previous study, two models were proposed to describe the pattern of causation among analogical reasoning and competence - one academic and one social. Results from the first study suggested certain restrictions that could be placed on the models to simplify the relationships among the analogical reasoning and competence variables. These restricted models are tested using the data from subjects in this second study.

A restricted or hypothesized causal model can be confirmed or disconfirmed depending on the 'fit' between the obtained data and the proposed model. Results obtained for the restricted model are compared to the full model, using the Q statistic (Pedhazur, 1980), in order to determine whether the restricted model is an adequate representation of the data. The Q statistic is a measure of goodness of fit, and ranges from 0 to 1. Values of Q close to 1 indicate a better 'fit' of the data, and indicate that the hypothesized model is a good representation of the obtained data. Structural equations for the full academic and social models (described fully in Study One) were solved using the data from this second study (controlling AR for knowledge, using all eight themes, and the data from both Grade 6 and Grade 8 subjects). The full path models, including path coefficients and significance levels are presented in Figures 5 and 6 for the academic and social models, respectively. Not surprisingly, given the consistency in the patterns of the correlational data in both studies, the path analyses yielded a similar pattern of results. Calculations using the restricted models and the Q values follow.

<u>**Test of the Academic Casual Model**</u>

From Study One, the restricted academic causal model suggested by the data involved a series of direct effects with AR influencing ACHT, ACHT influencing TRC, and TRC influencing SPC. That is:

ARr--->ACHT--->TRC--->SPC

The standardized structural regression equations are a series of direct effects, namely:

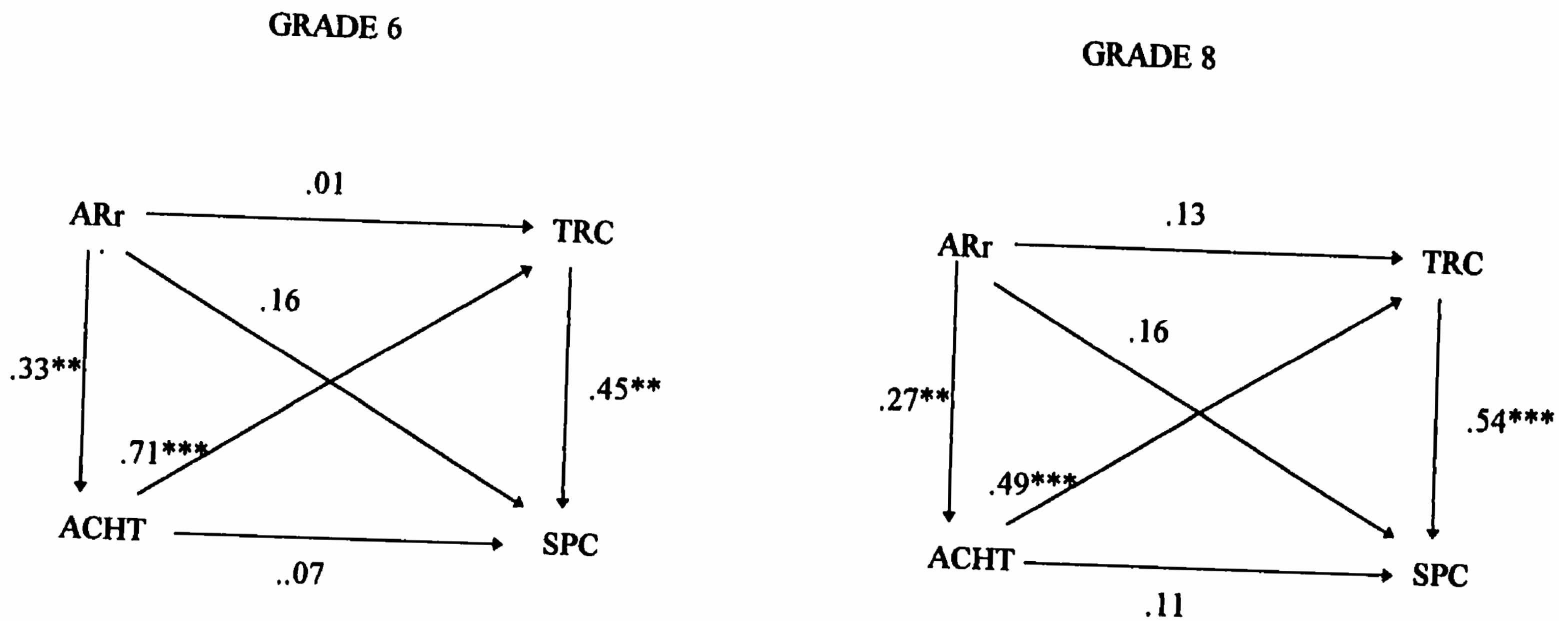
ACHT = a(ARr) + error

TRC = b(ACHT) + error

SPC = c(TRC) + error

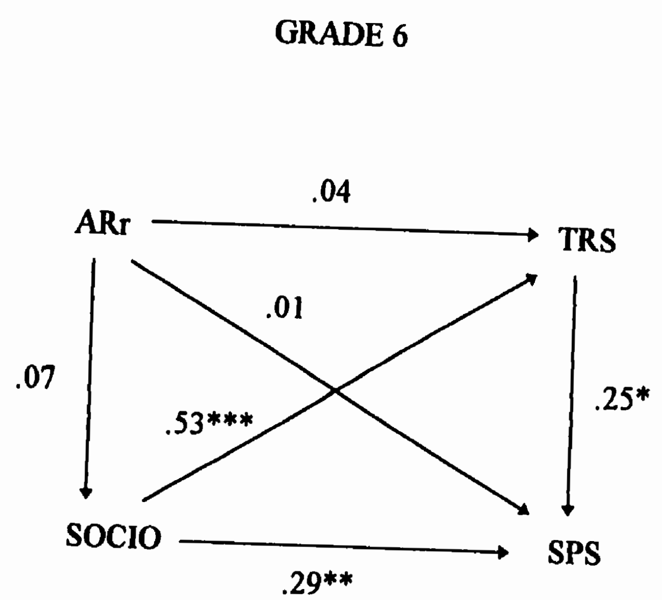
These equations were solved controlling for content knowledge, including all eight themes, using data from both Grade 6 and Grade 8 subjects. The two restricted path models, including path coefficients (beta weights) and significance levels are presented in Figure 7.

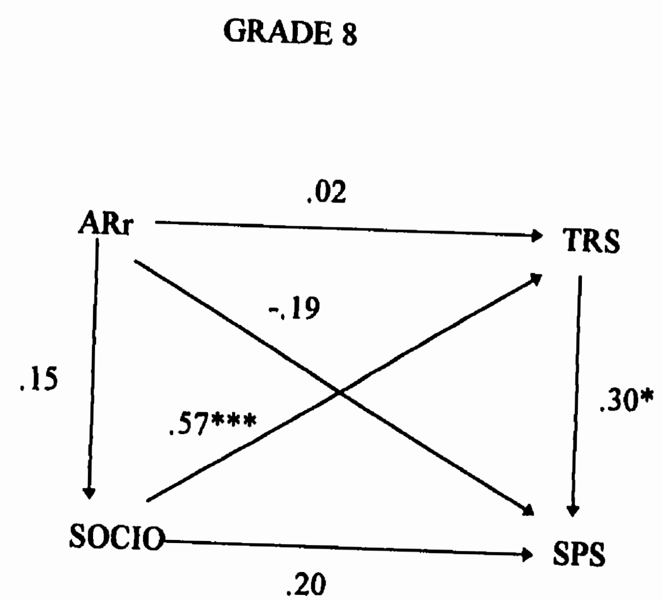
FIGURE 5
Academic Causal Model, Study Two



ARr = Analogical reasoning (residual scores), TRC = academic teacher ratings, ACHT = achievement, SPC = academic self report
*** p<.001, ** p<.01, * p<.05

FIGURE 6
Social Causal Model, Study Two





ARr = Analogical reasoning (residual scores), TRS = social teacher ratings, SOCIO = sociometric, SPS = social self report
*** p<.001, ** p<.01, * p<.05

FIGURE 7
Restricted Academic Causal Model

GRADE 6

$\text{ARr} \xrightarrow{.33^{**}} \text{ACHT} \xrightarrow{.72^{***}} \text{TRC} \xrightarrow{.53^{***}} \text{SPC}$

GRADE 8

$\text{ARr} \xrightarrow{.27^{**}} \text{ACHT} \xrightarrow{.53^{***}} \text{TRC} \xrightarrow{.64^{***}} \text{SPC}$

ARr = analogical reasoning (residual scores), ACHT = achievement, TRC = academic teacher ratings, SPC = academic self report
*** p<.001, ** p<.01, * p<.05

The results from the full model and the restricted model were compared using the Q statistic to determine whether the restricted model is representative of the data. Q values of .96 and .92 were found for the Grade 6 and Grade 8 data, respectively. This suggests that the restricted model is a good fit for the data. That is, the relationship between analogical reasoning and academic competence variables can best be conceived of as a series of direct effects, in which analogical reasoning directly influences achievement, which in turn influences teacher ratings of a child's academic skill, which then influences a child's perception of his/her own academic competence. Analogical reasoning acts as an indirect influence on teacher and self ratings of skill.

Test of the Social Causal Model

The restricted social causal model proposed in the previous study excludes analogical reasoning entirely as an influence on social competence. The model is as follow:

$$\begin{tikzcd} \text{SOCIO} \arrow[dd] \arrow[dr] & \\ & \text{SPS} \\ \text{TRC} \arrow[ur] & \end{tikzcd}$$

The standardized structural regression equations are as follows:

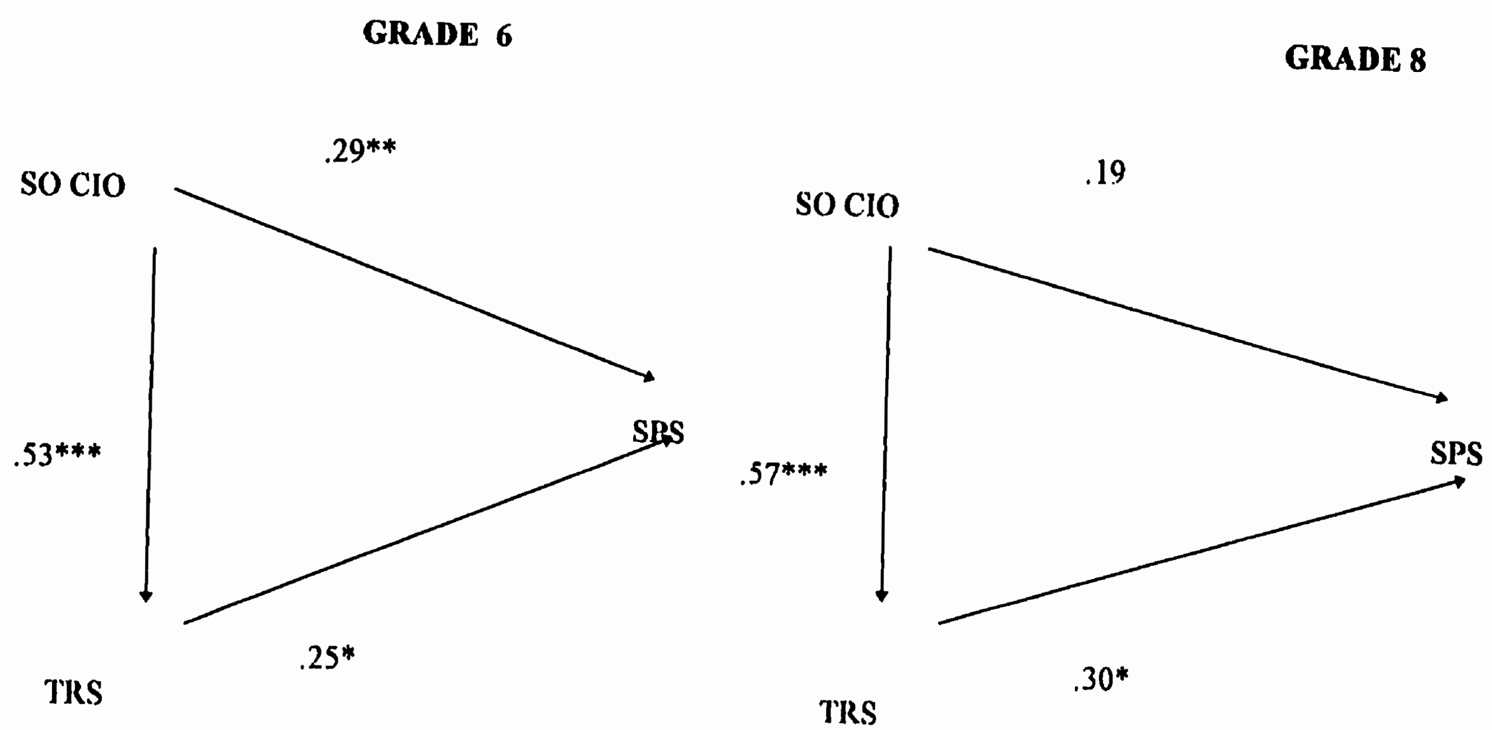
TRS = a(SOCIO) + error

SPS = b(SOCIO) + c(TRS) + error

These equations were solved, including all eight themes, using data from the Grade 6 and Grade 8 subjects. The two restricted path models, including path coefficients and significance levels, are presented in Figure 8.

Once again, the results from the full and restricted models were compared using the Q statistic. Q values of .99 and .97 were found for the Grade 6 and Grade 8 groups, respectively. Thus, the restricted model is a good fit of the data. Analogical reasoning does not appear to exert an influence on any of the social competence variables. It is this very clear absence of any influence that is particularly interesting as it leads to questions about whether analogical reasoning exerts any notable effect on social competence.

FIGURE 8
Restricted Social Causal Model



SO CIO = Sociometric rating scale, TRS = social teacher ratings, SPS = social self perception
*** P <.001, ** P< 01, *P< 05

CHAPTER FOUR: GENERAL DISCUSSION

Overview

Study One was conducted as an exploration of the materials used, and was followed by a confirmation of these initial findings, in Study Two. In both Studies One and Two, the same general pattern of results was found. That is, success in an analogical reasoning task was found to be related to success in academic competence tasks for both Grade 6 and Grade 8 students. Even after holding differences in content knowledge constant, analogical reasoning was found to be related to academic competence, although to a lesser degree. In the first study, these results were evident in the performance of the younger subjects. While the same general pattern of results was found with the older subjects in the first study, the analogical reasoning - competence relationship was weaker and did not reach significance after controlling for content knowledge. The relationship between analogous thinking and academic competence was more robust in the second study that utilized a somewhat larger sample. Subjects at both grade levels demonstrated a positive relationship between analogical reasoning skill and academic competence.

Exploratory path analyses were employed to analyze the inter-relationships among the analogical reasoning and academic competence variables (i.e., achievement, teacher and self ratings). A theoretical model of the causal relationships among variables was constructed in Study One and subsequently tested in Study Two. The model suggested that there is a causal relationship among the variables in the form of a series of direct effects, in which analogical reasoning influences academic achievement, achievement influences teacher ratings of academic competence, and teacher ratings influence an individual's perception of his/her academic competence. These results make several suggestions about factors that may or may not influence success in academic tasks and perceptions about success by an individual and others (here, teachers). First, skill in reasoning by analogy appeared to play an important role in academic achievement. Second, teacher ratings of a child's academic competence were directly influenced by a child's level of achievement - skills that are similarly and regularly measured in the school environment. However, teacher perceptions of academic competence were not found to be influenced (at least not directly) by a child's ability to reason by analogy - a skill that is not typically measured in the classroom environment. That is, although teachers appeared sensitive to measurable aspects of achievement, they either did not appear to be as aware of a child's analogous thinking, or analogical reasoning did not carry much weight in their ratings of competence. And finally, a child's self report of his/her own academic competence was reliant on teacher feedback, and not directly on achievement measures or a sense of their own ability to reason by analogy. Thus, in terms of the present variables (analogical reasoning, achievement, teacher ratings, and self report), the results suggest the following:

* a child's perception of his/her competence is influenced by teacher feedback,
* a teacher's perception of a child's competence is based on measurable aspects of achievement, and
* achievement is influenced by the ability to perceive analogous relationships.

In marked contrast, success in analogical reasoning was <u>not</u> found to be related to social competence, with or without taking into account content knowledge. Exploratory path analyses reinforced this finding and illustrated the important role of both teacher and peer perceptions of social competence as influences on a child's own perception of his/her interpersonal skill. The absence of any relationship between analogical reasoning and social competence was contrary to original expectations based on current formulations of cognitive and social-cognitive problem solving in the literature. That is, a relationship should exist. I will return to a discussion of this issue later. First, I will address the relationship between analogical reasoning and academic competence. The present findings are discussed in terms of the issue of knowledge structures versus a process account of performance. Also, implications for theories of analogical reasoning and development are addressed. This is followed by a discussion of the possible reasons for the absence of a relationship between analogical reasoning and social competence. The results question the assumption of similar processing in cognitive and social-cognitive problem solving. Measurement issues concerning the assessment of social competence and analogical reasoning are addressed. The nature of the representation of information is also discussed in terms of how the findings lend support to cognitive theories that propose separate but inter-dependent conceptual structures. The implications of the present findings for thinking skills programs are then considered. And finally, limitations of the present research and possible directions for future research are presented.

Analogical Reasoning and Academic Competence

Analogical reasoning is viewed by many as a central component of intelligence (e.g., Sternberg, 1984a; Rumelhart, 1989; Goswami, 1992). It is therefore not surprising that the present investigation found that success in identifying analogous information was related to academic competence. Moreover, this relation was found whether the analogous materials contained content typically found in the academic domain (i.e., biology, math, social science) or content reflecting social issues (i.e., social skills, personality styles, bias, and potential conflict).

The analogical reasoning - academic competence relationship found in the present studies is discussed below in terms of its relevance to the issue of knowledge structures versus a process account of performance, and to theories of analogical reasoning and development.

General Process versus Domain-Specific Knowledge

The majority of studies of expertise have examined performance on tasks that have employed subjects differing considerably in their knowledge and experience in a given domain (e.g., Gruppen, et.al., 1991; Nathan, et.al., 1992). In contrast, the present investigation utilized a relatively homogeneous group of subjects. Even without the wide fluctuation in expertise, subjects' sensitivity to underlying principles was found to be characteristic of the academically more successful children.

Much of the research analyzing expert/novice differences has focused on the structure of knowledge in memory to account for the differences (e.g., Chi, 1985; Chi et.al., 1988). The present investigation also demonstrated that content knowledge influenced performance. However, after statistically controlling for differences in content knowledge, analogical reasoning skill continued to demonstrate a significant relationship with competence. Thus, the ability to identify similar relations as opposed to less significant surface details in a passage , was found to be related to academic competence. However, as Chi points out (Chi et.al., 1988), it is not the specific knowledge per se, but rather the organization of knowledge that is critical in discriminating levels of expertise. The use of knowledge is affected by the properties of a structure, in particular, hierarchy and coherence. Hierarchy refers to the pattern of relations among substructures, and coherence refers to the patterns of interlinking and attribute-sharing concepts of the substructures. Of interest is that as aspects of the organization of knowledge are defined and elaborated by researchers, what becomes striking is the similarities that emerge with definitions of analogical reasoning. In theories emphasizing the structure of knowledge in problem solving (e.g., Chi et.al., 1988), coherence and hierarchy are the pattern of relations among concepts and substructures, respectively. Theorizing about analogical reasoning has also postulated a similar emphasis on the systems of relations in knowledge needed to solve analogies (e.g., Sternberg, 1977; Gentner, 1989; Holyoak & Thagard, 1995). That is, successful use of analogies involves the mapping of objects and relations between the solved problem and a new problem.

Thus, the distinction begins to blur between what can be considered properties of knowledge structures, and relational mappings involved in a 'process' account of performance. Certainly, based on the present investigation and other research (e.g., Chi, et.al., 1988; Schraagen, 1993), it seems reasonable to conclude that both domain specific knowledge and general processes are important aspects of cognition (see Sternberg, 1985b;

Case, 1992). The present investigation supports this notion. Attempts to determine the relative merit of either one or the other aspect of cognition may ultimately cloud the issue that both are important. Conceivably experimental situations could be contrived in which the results favour process or knowledge accounts of problem solving. However, the utility of such work seems questionable, as researchers continue to demonstrate the role of <u>both</u> accounts in cognitive problem solving (e.g., Case, 1992).

Theories of Analogical Reasoning

Analogical reasoning was found to be related to academic competence when an individual's scores across several themes (i.e., four academic or social themes, or all eight themes) were grouped for analyses. The academically more successful children tended to focus on underlying principles more consistently over several themes.

Theories of analogical reasoning generally agree that analogous thinking involves a one-to-one mapping of objects/relations from a known, base domain to a novel, target domain. It is the selection principle which determines what information is chosen for the mapping that largely distinguishes the theories. While Gentner (1989) and Holyoak (1989; Holyoak & Thagard, 1995) both emphasize the mapping of abstract principles, Ross (1989) postulates that it is content specifics (both surface and structural features) that are critical in mapping.

Gentner's Structural Mapping theory (1989) focuses on systems of relations in solving analogies. She distinguishes analogy from other kinds of similarity that lie on a continuum according to the degree of attribute overlap. She defines analogy as occurring only when relational predicates are matched. This she contrasts with 'literal similarity', where relational predicates and object attributes are mapped, and 'mere appearance' matches, where only object attributes are mapped. In this framework, the present results may reflect all three types of similarity. That is, identification of surface features indicates that the subject is engaging in mere appearance matching or literal similarity, identification of underlying principles, the use of analogy. Certainly Gentner is attempting to discriminate much more finely, different types of similarity. In doing so, she effectively eliminates the role of surface features in theories of analogical reasoning. However, given her acknowledgment of the overlap that exists among the different types of similarity, such distinctions may not be valid.

In trying to arrive at a better understanding of the factors that influence the use of analogies in problem solving, Holyoak and Koh (1987) demonstrated how both surface and structural features were involved in reasoning by analogy. Subjects were presented with one of four versions of the 'lightbulb story', an analogue to Duncker's (1945) radiation problem. The lightbulb story was varied according to whether or not the story contained similar/dissimilar surface or structural features with the radiation problem. Subjects were subsequently asked to solve the radiation problem. This was followed by a hint that the lightbulb story might be useful in solving the radiation problem. The results supported the notion that both surface and structural features were influential in subjects spontaneously applying an analogy to solve a target problem. Holyoak and Koh proposed that these results indicate that retrieval of analogies is based on the summation of activation from multiple shared features that serve as retrieval cues, that is, both surface and structural features. They also found that once the relevance of the source analogue was pointed out (i.e., after the hint), only structural similarity (not surface similarity) affected subjects ability to make use of the source analogue.

Ross and others have shown how surface features that are irrelevant in the solution of a target problem may affect the solution indirectly by influencing the selection of an inappropriate source analogue (e.g., Ross, 1984; Gilovich, 1981).

The present investigation pitted surface features against structural features. The surface features could be considered to be irrelevant and possibly distracting to identifying underlying principles. That is, in order to successfully categorize all nine scenarios according to underlying principles, subjects needed to ignore the surface features. Likewise, categorization of all nine scenarios according to surface features required subjects to either ignore or not appreciate the underlying principles. In case the subjects were aware of the underlying principles but chose to categorize according to surface features in their initial sorting of the scenarios, a second opportunity was provided to sort the scenarios. Although subjects typically identified more surface features than underlying principles, there did not appear to be a preference for subjects to sort underlying principles or surface features in either the first or second sort. Also, subjects did not necessarily focus on either surface features or underlying principles. At times, of the three piles sorted, one or two represented underlying principles and the remaining pile(s) surface features. That is, subjects' categorization of the scenarios often involved a consideration of both surface features and abstract principles present in the themes. Thus, there did <u>not</u> appear to be a noticeable emphasis on abstract principles or surface features alone, but rather a sensitivity to <u>both</u> abstract principles and surface features. This is supportive of theorizing that takes into account both surface and structural features.

Thus, the data from the present investigation supports Reeves and Weisberg's (1994) contention that a theory of analogical reasoning needs to encompass aspects of the structural (e.g., Gentner, 1989), pragmatic (e.g., Holyoak, 1989), and exemplar (e.g., Ross, 1989) views.

The Development of Analogical Reasoning

Subjects at both grade levels studied in the present investigation demonstrated a similar relationship between analogical reasoning and academic competence. However, in the first study, the magnitude of the effect was reduced with the older children. That is, although the same pattern of results was obtained, the analogical reasoning - academic competence relationship failed to reach significance with the Grade 8 data. This decrement in performance, however, was not evident in the second study that utilized a somewhat larger sample. Thus, for both the Grade 6 and Grade 8 subjects, domain specific knowledge and analogous thinking skills were found to be related to academic competence. The only differences were that Grade 8 children possessed better academic skills, more content knowledge, and were more successful in identifying analogies.

The data from the present investigation do not contribute to a better understanding of the development of analogical reasoning. In order to accomplish this, the materials would need to be revised in a manner that would allow systematic comparisons of relations varying in their degree of complexity. This is discussed further in the section "Limitations and Directions for Future Research".

Analogical Reasoning and Social Competence

A striking finding from all three studies is that of no association between performance on tasks of analogical reasoning and social competence. The only exception to this was some suggestion in the first study that Grade 8 females who were more successful on analogical reasoning tasks rated themselves as less successful socially. However, this finding was not replicated and could be due to a rather small sample size. Other than this negative relationship (in the opposite direction to expectations), there was a clear absence of any relationship between peer, teacher and self ratings of success in social interactions and success in thinking analogically. This is certainly contrary to expectations based on assumptions of information processing theories that a relationship should exist. For example, Holyoak and Thagard (1995) have demonstrated the utility of analogical thinking in everyday life. They have shown how people use analogies in a variety of different tasks in both non-social and social domains, including the domains of political science, psychology, science, philosophy, anthropology, literature, and business. Why then, does the present study find no relationship between analogous thinking and social competence? Several reasons may account for the present results, and these are addressed below through a consideration of:

a) the assumption of similar processing in cognitive problem solving and social-cognitive problem solving,

b) the assessment of social competence,

c) the assessment of analogical reasoning, and

d) the nature of the representation of information.

The Assumption of Similar Processing

The general finding that analogical reasoning skill was not associated with social competence poses several questions about the assumption of similar processing of information in cognitive and social-cognitive problem solving. The possibility that the results reflect differences between reflective processing of information versus more automatic processing of information is discussed. The assumption of similar processing is also addressed by questioning whether reasoning by analogy is a critical aspect of social problem solving and whether other factors may play a more significant role in social problem solving in every day life.

Reflective versus Automated Processing

One possible reason for the absence of an association between analogical reasoning and social competence may be found by examining whether information is processed in a reflective or automated fashion (Crick & Dodge, 1994). Holyoak and Thagard (1995) have shown how analogy is an integral part of problem solving, decision making, explanation, and communication - all skills requiring a more thoughtful, planful approach to problems. In the present investigation, performance on the academic and social analogical reasoning tasks was found to be related to performance on the achievement test. All of these tasks require effortful or reflective processing of information to solve the problems. (Similarly, it is expected that teacher and self report ratings of academic competence would be based on a variety of experiences with problems in which conscious effort is required to solve academic problems.) In contrast, the indices of social competence (i.e., the sociometric, teacher ratings, self report ratings) may be based on an accumulation of experiences in situations that largely involve habitual, spontaneous responses. The extent to which processing of social stimuli is reflective is not known at the present time, but most likely responding in social situations is highly automated (Crick & Dodge, 1994). If this is true, then the presence or absence of a relationship with analogical reasoning may be influenced by the reflective versus automated nature of processing involved in the academic versus social indices of competence, respectively. That is, the reflective analogies tasks should demonstrate a relationship with the reflective indexes of academic competence, but not with the automated indexes of social competence.

Conversely, there is evidence to suggest that reflective tasks may under-represent the magnitude of the effect that would be had under more automated processing conditions. A study by Rabiner, Lenhart and Lochman (1990) examined the performance of children in reflective and automatic responding situations. They found that the socially maladjusted children processed information adequately under reflective but not automatic conditions. These results suggest that reflective measures (used in most social problem solving studies as well as the present investigation) may under-represent real-life processing that requires more automated responding. In the present investigation, this would suggest that the analogical reasoning task may under-represent processing involved in real-life social situations. However, since near zero correlations were found between social competence and analogical problem solving, it seems unlikely that the reflective task under-represented the relationship to such a considerable degree.

It is possible that the assumption of similar processing of information in academic and social domains is more applicable in situations where individuals must stop and think, and consciously process information in order to employ/recognize an analogy. If indeed responding in everyday social situations is largely automated, this raises questions about the adequacy of the information processing models of social cognition to describe behaviour in everyday (i.e., automated) social interactions. Support for information processing theories of social problem solving has largely been generated from studies requiring reflection in hypothetical situation interviews and questionnaires (e.g., Bream, 1989), interviews about actual social events (e.g., Steinberg & Dodge, 1983), and self-report inventories (e.g, Harter, 1982). Other studies in the literature, while largely using reflective experimental tasks, have also employed similar indices as the present investigation to assess social competence (i.e., indices reflecting more automated responses). In contrast to the present findings, they have consistently demonstrated the robustness of the relationship between various aspects of the information processing model (i.e., encoding, interpretation, clarifying goals, accessing responses, response decision) and social maladjustment (see Crick & Dodge, 1994, for a review). However, the difference between the findings in the literature and the present results may be due to the focus here on the `mental action', analogical reasoning. Crick and Dodge (1994) indicated a need for research specifically addressing `mental actions'. While the present results may not address the relationship between reasoning and social competence in reflective situations, the results do suggest one of two possibilities concerning the relationship between analogous thinking and social competence in automated situations. One possibility is that `mental actions' - at least analogical reasoning - are not a critical aspect of information processing that influences social competence. A second possibility is that analogical reasoning is related to social competence as an additive factor, where other aspects of information processing must also be considered. A discussion of these two possibilities follows.

Output versus Process

Research in social problem solving has tended to focus on what children think (i.e., output) as opposed to how children think (i.e., process). Crick & Dodge (1994) have noted the need for research using a process approach to determine the mental actions employed by individuals as they interpret and evaluate social information. The present investigation has sought to do this by studying the process of analogous thinking. And yet, the results indicate that analogical reasoning skill is not related to social competence. It may be that on-line processing skills - here analogical reasoning skills - are not as important or utilized to the same degree in the social domain as they are in more effortful problem solving typical of the non-social domain. Thus, while more research is needed to investigate `process' aspects of problem solving, the results from the present investigation suggest that reasoning by analogy may not be a critical aspect of performance in every day social interactions.

The Role of Analogical Reasoning in Cognition

One could argue that the process of reasoning by analogy is only one of many important components involved in information processing. Theorists have postulated that processing actually occurs in simultaneous parallel paths (Rumelhart, McClelland and the PDP Processing Group, 1986). This is represented in the social information processing framework by multiple feedback loops to demonstrate that children are always encoding, interpreting and accessing responses (Crick & Dodge, 1994). For the social domain, the impact of analogical reasoning on performance may not by itself be enough to demonstrate a relationship with social competence. It may be that problem solving in everyday social interactions is influenced by several different aspects of information processing, including other factors such as pre-emptive processing (i.e., script-based, automatic, "without thinking" thinking), previous experiences, peer responses and emotion (Dodge & Somberg, 1987; Crick & Dodge, 1994). Indeed, both pre-emptive processing and emotional arousal have shown an association with social maladjustment (Dodge & Somberg, 1987). However, the problem that arises with this explanation is that analogical reasoning is considered to be a central component of cognition (e.g., Sternberg, 1985; Polya, 1957; Holyoak & Thagard, 1995). If this is true, then analogous thinking should be related to social competence. Given that this was not found here, it may be that various aspects of cognition are more or less critical in problem solving, depending on the domain under consideration. Possibly other factors (e.g., pre-emptive processing, emotion, peer responses, experience) play a much more significant role in the social domain. This would again suggest that the social information processing model that presently acknowledges but does not fully account for these other factors, may not adequately represent social problem solving in every day life.

The Assessment of Social Competence

The previous discussions are based on the assumption that the tasks employed were in fact valid assessments of social competence and analogous thinking. An optimal assessment of social competence would include observations of problem solving in real-life social interactions. Such data are difficult and time consuming to gather. The best alternative is to gather information from several different sources and in different ways (see Butler & Meichenbaum, 1983), as was done in the present study. However, despite this, the indexes of social competence that were chosen may not be adequate measures of social competence. The following is a discussion of possible reasons for the inadequacy of the measures, including a consideration of the distinction between the response of versus the reaction to a child, and automated versus reflective responding.

Behaviour versus Peer Status

Teacher, peer and self ratings of social competence were employed here. These measures are used extensively in the literature to assess social competence (Butler & Meichenbaum, 1983; Rubin & Krasnor, 1985; Crick & Dodge, 1994). Underlying the use of these indexes is the assumption that a child's behaviour towards others is an important factor in determining his/her social status (e.g., Asher & Hymel, 1981). Furthermore, research has provided support for this assumption (e.g., Coie & Kupersmidt, 1983). However, although related, there is a distinction between the actual social <u>response</u> <u>of</u> a child (i.e., behaviour) and the <u>reaction</u> <u>to</u> a child (i.e., status). The peer sociometric assesses the pattern of likes and dislikes within a group (Butler & Meichenbaum, 1983). The two scales used in the present investigation provided peer ratings of a child's popularity with others (i.e., getting along with others and inclusion in the peer group). Similarly, although the teacher and self-report scales contained specific items about social behaviours, these indexes can be directly related to peer status (Crick & Dodge, 1994). Thus, the three indexes employed here may be primarily assessing peer, teacher and self ratings of <u>status</u> - all <u>reactions</u> <u>to</u> a child, and hence indirect measures of social competence.

The distinction between behaviour and status has important implications for social information processing. That is, some aspects of information processing would be expected to lead directly to behaviour (e.g., response generation), while other aspects might be a reaction to peer status (e.g., a child's self perceptions) (Crick & Dodge, 1994). In the present studies, the analogical reasoning tasks and academic competence tasks are indexes of the behaviour of a child. The social competence tasks, on the other hand, may be more of an outcome of peer status. It would then follow that the present investigation cannot determine whether or not a relationship exists between analogous thinking and social behaviour. Rather, the only conclusion that can be reached is that no discernible relationship was found between analogous thinking and a child's social status.

Automated versus Reflective Responses

The earlier discussion of process differences on tasks employing reflective versus automated responses is also relevant to the issue of the adequacy of the social competence tasks. As was discussed, the absence of a relationship between analogical reasoning and social competence may be partially accounted for by differences in the type of response (i.e., reflective vs. automatic). As mentioned earlier, ratings by peers/teachers/self are hypothesized to be based largely on automated responding in everyday social situations, while academic competence and analogical reasoning measures involve more reflective responses.

The Assessment of Analogical Reasoning

The analogical reasoning task involved reading a passage, categorizing the scenarios, and writing comments. This task may not be the best comparison for social competence as it is a reflective, planful activity. In this respect, it does not approximate automated social responding in interpersonal interactions. Viewed in this manner, the analogical reasoning task, regardless of academic or social content is basically an academic activity, as is the achievement test. Consequently, the results may reflect the similarities in performance on two academic tasks. Analyses of results in Study One did in fact find that performance was not differentiated based on analogies that contained either academic or social content. Thus, the analogies materials may not be emulating responding in social situations.

The Nature of the Representation of Information

A final explanation for the absence of an analogical reasoning - social competence relationship may rest in the assumption that information is represented in a similar fashion in both the academic and social domains. As noted earlier, instead of assuming that cognition is the same in both domains, it may be that there is something inherently different in the conceptual structures in memory in social versus non-social problem solving. The results of the present investigation are noteworthy in light of Paivio's Dual Coding Theory of cognition (Paivio, 1986; Sadoski, Paivio & Goetz, 1991), and Case's theory of cognitive development (Case & Griffin, 1990; Case, 1992). Both theories propose that two separate but inter-dependent conceptual structures are involved in cognition. The two theories are discussed below.

Paivio's Dual Coding Theory

Paivio's Dual Coding Theory of cognition (Paivio, 1986; Sadoski, Paivio & Goetz, 1991) postulates the existence of two separate mental subsystems - a language system and an imagery system. The language system specializes in the representation and processing of verbal information. The imagery system specializes in the representation and processing of non-verbal information (including information from visual, auditory, haptic and affective modalities). The two systems are interconnected and can function independently in parallel, or in an integrated fashion. Within each system information is represented in a hierarchy and associations are formed between units of information within a system. The language system is seen as being organized in a sequential syntactic manner, while the imagery system is organized in a holistic, nested manner. Relations between systems are called referential connections that allow language to evoke imagery and vice versa. Associations and interconnections are all probabilistic, with experience and situational constraints determining the probability that an association or interconnection is made. Sadoski et.al. (1991) offer Dual Coding as an alternative to schema theory and present data that they feel either discounts schema theory and/or demonstrates how Dual Coding is a more optimal explanation for findings in schema and reading research.

The results of the present investigation could be seen as lending support for a theory of cognition that differentiates between mental systems for verbal and non-verbal information. With visual, auditory, haptic and affective information represented in the imagery system, it is likely that social interactions are represented to a considerable degree by this system. Thus, factors that are involved in a child's social competence (e.g., interpretation of visual and auditory cues, emotion, pre-emptive factors, previous experiences) may be represented to a greater degree by associations within the imagery system. In the academic domain, it would be expected that information is largely represented in the language system. In the present investigation, performance on the academic competence tasks and the academic and social themes would require involvement of the language system. Overlap will certainly exist. However, the differential results found in analogical reasoning performance between the social and non-social domains may be due to the different properties of the imagery and language systems, within which the two domains are represented.

Case's Theory of Cognitive Development

Similar to Paivio's Dual Coding theory, Case also postulates the existence of distinct central conceptual structures (Case & Griffen, 1990; Case, 1992) in social and non-social domains. `Central conceptual structures' refer to internal networks of concepts and relations among concepts that are represented semantically (as opposed to syntactically). These networks guide a person's thinking about particular situations. In a series of experiments, Case and his colleagues identified structures that were applicable to a broad range of content but only within specific domains. Of particular relevance to the present investigation is that they identified one central conceptual structure thought to mediate performance on more quantitative problems such as scientific or numerical tasks, and a second structure thought to mediate performance in social situations. In his theory, Case outlines various stages of intellectual development corresponding to:

* level 0 (4 years) - pre-dimensional stage, characterized by thinking that focus on global aspects of a situation,

* level 1 (6 years) - dimensional stage, characterized by thinking that focus on a single dimension or variable,

* level 2 (8 years) - bi-dimensional stage, characterized by thinking that takes into account two variables/dimensions in a meaningful fashion, and

* level 3 (10 years) - inter-related bi-dimensional stage, characterized by thinking that takes into account two variables/dimensions in an integrated fashion.

Within each stage there are hypothesized substages that reflect increased understanding of the complexity of the relations among concepts (see Case, 1992 for a more detailed account of his theory). Case and Griffin (1990) examined the developmental progression of skill in 4 to 10 year olds in a series of experiments involving quantitative problems (e.g., time-telling, handling money, understanding concepts of the balance beam, and the projection of shadows) and social problems (e.g., identifying feelings, understanding feelings, predicting responses in social situations). For each set of problems, quantitative or social, performance was very consistent across tasks, at each age level. In order to illustrate the developmental stages and the social and numerical central conceptual structures, the general findings from the `time telling' and `understanding feelings' tasks are described here. For quantitative problems, Case and Griffin (1990) consistently found the following progression:

* by age four: understanding about variables in a global/polar manner - knowing that hours are long and minutes are short,

* by age six: representing variables on a continuum - knowing that 2 o'clock precedes 3 o'clock,

* by age eight: thinking in terms of two independent variables - knowing hours and minutes on a clock,

* by age ten: making comparisons among any two independent variables - knowing that 1 hour 30 minutes is longer than 80 minutes.

For social problems involving understanding feelings, Case & Griffin (1990) found the following general developmental progression:

* by age four: understanding that involves a focus on an internal or external state but not both - knowing that something made him sad,
* by age six: understanding how an event sequence is related to an internal event - knowing that she did it to make him happy,
* by age eight to ten: understanding how an event sequence is related to two distinct internal states - knowing that she did it to make him happy because she loves him and doesn't want him hurt.

As these examples illustrate, as children mature, they exhibit a progression in their complexity of understanding about the inter-relationships among variables. Very simply put, in the domain of numerical reasoning, development proceeds from a focus on a unitary dimension to multiple dimensions, with complexity further increased by an expanding understanding of the inter-relationships among these dimensions. Similarly in the social domain, development progresses from attention to one internal state then several internal states, with complexity further increased by understanding these internal states in an integrated fashion. Several different research efforts in other domains (e.g., spatial representations, Dennis, 1992; music sight-reading, Capodilupo, 1992) have found similar results. That is, it appears that children develop a central conceptual structure in the social domain (or spatial, or music) that is unique in its specific elements and relations, but exhibits the same general progression in form as children's central conceptual structure in the quantitative domain. The data accumulated by these researchers also suggest that the central conceptual structures are subject to a common set of constraints, for example, in speed of processing or in working memory, as well as experience and cultural factors (Case, 1992).

Interestingly, this developmental progression is also similar in form but different in content to Holyoak's (Holyoak & Thagard, 1995) conceptualization of the development of analogical reasoning skill. As noted in the introduction, Holyoak proposed that the development of children's analogical reasoning skill progresses from the ability:

* by 18 months: to map similar attributes,
* by age three: to map similar relations,
* by age five: to reason about higher order relations,
* beyond age five: to understand increasingly complex relations.

Thus, the development of analogous thinking is thought to proceed from the mapping of attributes, then to the mapping of relations, and then later to the mapping of multiple relations with more complex inter-relationships. In a broad sense, this is a very similar progression as in Case's (1992) formulation. Analogical reasoning is thought to be a central component of intelligence, essential in the acquisition of new learning, in particular (e.g., Sternberg, 1985; Goswami, 1992). It is therefore not surprising that there is considerable overlap in Case's theory of cognitive development and Holyoak's theory of the development of analogical reasoning.

The results of the present investigation could be taken as evidence of two central conceptual structures in the academic and social domains, thereby lending support to Case's theory. The findings of a relationship between analogical reasoning and academic competence but none between analogical reasoning and social competence could be accounted for by differences in the conceptual structures of the academic and social domains. The research by Case and others cited above demonstrates that, despite differences in specific elements and relations across domains, the form of the conceptual structures was similar. In contrast, the present results appear to highlight the differences between the two central conceptual structures. One might expect, given the similarities of form described by Case, that the mapping of relations involved in analogies should have demonstrated similar form across the academic and social domains, despite the differences in content and relations. There was in fact evidence of this similar `form' in the results. Despite the academic themes reflecting four different content areas, overall performance on the four themes (not the individual themes) was related to academic competence. In contrast, the absence of a relationship between analogical reasoning and social competence can be taken as evidence that, although similar in form, the central conceptual structures are distinct. Factors that contribute to these differences may relate to the constraints on the central conceptual structures (Case, 1992). Constraints on performance could involve processing constraints and/or working memory constraints.

Processing Constraints

We return to the issue of the difference between automated versus reflective processing of information. The research cited as evidence of a social central conceptual structure involves reflective responses to social situations (e.g., Goldberg-Reitman, 1992: Bruchkowsky, 1992; McKeough, 1992; Griffin, 1992). However, as noted earlier, the social competence tasks utilized in the present investigation are likely derived largely from automatic responses to social interactions. The sorting task, in contrast, is a reflective problem solving task. If the central conceptual structures are constrained by the type of processing, it would be reasonable to expect differential results dependent on whether processing involved automated versus reflective responses. Crick and Dodge (1994) also questioned whether the structure of social information processing varies according to conscious and novel situations versus non-conscious and highly learned situations. The present results support the notion that the structure of social information processing does indeed vary in controlled versus automatic processing circumstances.

Furthermore, consideration of the type of processing (automated versus reflective) could account for the lack of differential results in the academic versus social themes. That is, despite content differences, performance on both academic and social analogous themes was found to be similarly related to academic competence. This finding could be taken as evidence that, despite different content and relations, the form of reasoning was similar in the two domains, thereby allowing performance on both academic and social themes to demonstrate a relationship with academic competence.

Working Memory Constraints

Working memory may also be a constraint on performance. The amount of knowledge needed to solve the academic achievement test and sort the analogous themes is essentially fixed in terms of the number of concepts and relations among concepts that are presented in the problems. In the social domain, however, the load on working memory is different. If the subject responds automatically or habitually, with little thought, then conceivably the load on working memory is minimal, particularly in comparison to the problem solving load in academic tasks. Conversely, in more reflective situations, additional factors such as emotion, previous experience, and pre-emptive factors, make social problem solving a more complex process with heavier demands on working memory when compared to academic tasks. That is, there would be a lot more to think about. However, I suspect given the time and effort subjects used to complete the categorization task, that the greater complexity would lie with the reasoning task. Social responses while potentially influenced by a myriad of factors, are more habitual (Crick & Dodge, 1994) and may ultimately be restricted to the influence of only a few factors. Thus, constraints on working memory may be different in academic and social problem solving, and this reflects distinct central conceptual structures.

Thus, the differential results in comparing analogical reasoning skill with academic and social competence suggest that something `different' is occurring in the two domains. These results are consistent with two system theories of Case and Paivio, as well as the recognition of others that visual images and affect may be represented differently in memory than verbal information (e.g., Stein, Brock, Ballard & Vye, 1987; Nelson & Castano, 1984; Iran-Nejad, 1987).

Thinking Skills Programs Revisited

As a preliminary investigation, the results are far from conclusive on many issues, including making recommendations for instruction. However, the results do support some practices that are in place, and raise questions about other assumptions that guide other programs.

The present results support the notion of the importance of promoting a solid knowledge base and developing analogical reasoning skills. Reasoning by analogy involves skill in working out the relations in a particular situation and applying these relations to another situation. Fundamental to analogous thinking is an understanding of the relations on which an analogy is based. Moreover, an individual will be more successful in using an analogy when the critical relational knowledge is part of a well-integrated system of conceptual knowledge. Failure to apply an analogy may arise for a variety of reasons. This could happen if the relations are not worked out or fully understood. The information could be embedded in the knowledge structure in a manner that does not allow access to the information. Also, performance factors could interfere, such as not recognizing that an analogy is appropriate, or being easily distracted by extraneous task factors. Here, metacognitive skill will be important as individuals will benefit from an understanding of their own knowledge and learning, and the ability to monitor and evaluate their own thought processes. Instruction in analogical reasoning has been shown to be effective, particularly when subjects are told to use an analogy (e.g., Gick & Holyoak, 1981, 1983), when they are provided with the requisite relational knowledge needed to solve a problem (e.g., Brown, et.al., 1986), when they receive direct instruction and coaching in cross-domain transfer of reasoning skills (e.g., Lowenthal & Pons, 1987), and when care is taken to identify and correct the application of misleading analogies (e.g., Spiro, Feltovich, Coulson & Anderson, 1989). Holyoak and Koh's (1987) finding of summation of activation of multiple features would suggest that instruction and transfer will be promoted by multiple cues, both salient surface features and structural principles. Case (1992) would further argue for the utility of instructing and training small incremental steps in relational reasoning. Brown and Goswami (1992) would recommend the promotion of metacognitive skills.

A significant number of thinking skills programs include instruction in analogical reasoning as part of their program (see Chipman, Segal & Glaser, 1985, for a review). Typically this is presented in a separate lesson or skill to be acquired (e.g., deBono, 1980; Feuerstein, 1981). Perhaps one problem with such programs is that analogical reasoning is treated as an isolated skill to be learned. Certainly, as a critical aspect of intelligence, and given that we are becoming more sensitive to effective methods to induce analogy, then attention to factors important in developing analogical reasoning should permeate thinking skills programs to a greater degree.

While the above seems pertinent to a wide range of content domains, the present investigation casts some doubt on the transfer of these skills to the social domain. Certainly this raises questions about the assumption underlying such programs as the SPELT program (Andrews, et.al., 1990) that endeavour to teach reasoning that is expected to transfer to both the social and academic domains. In the present investigation, something dramatically different occurred in the children's performance when analogical reasoning was compared to academic performance versus social performance. It may be an artifact of the materials used, the procedure, or the reliance on analogical thinking, but no relationship was found between analogical reasoning skill and social competence as rated by the subjects, their peers and teachers. While school-based social problem solving training programs have demonstrated effectiveness in influencing the social skills of children (e.g., Gesten & Weissberg, 1986), it does not yet follow that effective training in academic problem solving will necessarily influence social problem solving. Many questions remain to be answered, but certainly caution is needed before the assumption of similar processing in the academic and social domains can be accepted.

Limitations and Directions for Future Research

As a preliminary investigation that has attempted to directly compare cognitive and social-cognitive problem solving, it is not surprising that many questions are raised and far fewer answered.

Analogical Reasoning and Academic Competence

The present investigation was successful in demonstrating that success in identifying analogies is related to academic competence. This relationship was evident even after statistically controlling for differences in domain-specific knowledge. Several unresolved issues were raised by the findings. Consequently, future research would involve examining the following areas:

* modifications to the experimental materials (i.e., the analogical reasoning task and knowledge test) and procedures,
* further examination of the role of general process versus domain specific knowledge,
* exploration of developmental differences across a wider spectrum of ages, and
* further exploration of transfer of learning across academic and social learning situations.

Modifications to the Experimental Materials

The Analogical Reasoning Task.

The themes employed in the present investigation represented content from several different domains of knowledge within the more general academic domain. Correlations among individual themes were small, while correlations among the group of academic themes were more noteworthy. It would be interesting to expand the themes to include several themes within each academic content area (e.g., several themes from the domains of arithmetic, science, biology, environmental issues) in order to examine more closely the relationship between competence and analogies, and the role of content knowledge.

The themes were constructed such that each scenario contained three sentences; one containing the underlying principle, one containing a surface feature, and one 'filler' or neutral sentence. The scenarios were written at a grade 4/5 level. A variation on these materials would be to construct the themes with greater attention paid to the relations involved in order to successfully map the analogy. This could involve creating themes varying the complexity among the relations. Similarly, the themes could be fashioned after Case's (1992) conceptualization of central structures, with a focus on controlling the number of variables and the inter-relationships among the variables across the themes.

Finally, to give the social themes a more appropriate social 'flavour' (i.e., to come closer to an approximation of the social situation), the scenarios could be presented in pictorial as opposed to sentence format.

Future research should also deviate from the use of these materials to other methodologies. Of choice would be the examination of actual problem solving situations, within which the sensitivity to underlying principles can be determined. As some researchers have suggested, this technique is the most valid in generating appropriate conclusions about real-life problem solving (e.g., Schraagen, et.al., 1993).

The Knowledge Test

The content of the scenarios was originally chosen to be well within the knowledge base of the Grade 6 and 8 subjects. As a result, scores near ceiling level were anticipated. However, there was enough variation to warrant the need to statistically control for knowledge differences. Unfortunately, the restricted variance of the knowledge data was not an optimal situation within which to interpret the statistical analyses. Future research should include a more demanding knowledge test such that the distribution of subjects' scores would more closely approximate a normal distribution.

General Process versus Domain-Specific Knowledge

In entering the debate over the relative contribution of general process factors and content knowledge, the present investigation indicated that both are important. Instead of attempting to argue in favour of one or the other, it would be more fruitful to examine the elements in both that lead to successful problem solving. In order to accomplish this, the use of the think-aloud procedure may be helpful. This technique would allow more detailed analyses of the thinking that is involved in completing the categorization task. Conceivably information could be had about content and the relations among the content that result in more successful performance. Information about the knowledge structures could be acquired, including how aspects of cohesion and hierarchy relate to competence (Chi, et.al., 1988). Similarly, think aloud protocols could indicate how analogous information is successfully mapped between scenarios, and the relative influence of underlying principles and surface features. This could conceivably have implications for theories of analogy, in determining the importance of the relations among elements (e.g., Gentner's (1989) Structure Mapping theory), goals in problem solving (e.g., Holyoak's (1989) pragmatic theory), and specific details (e.g., Ross' (1989) Exemplar theory) in the successful solution of analogies. In addition, think aloud protocols in conjunction with the categorization task could also contribute information about the relationship between competence and the use of metacognitive knowledge/skills in identifying analogous information.

Developmental Issues

Grade 6 and Grade 8 children were utilized in the present investigation. While the Grade 8 children were more successful in identifying analogies and had a better knowledge base than the Grade 6 children, the same relationship between analogical reasoning and academic competence was found. The nature of the materials did not allow for closer consideration of developmental differences due to competence, knowledge, or metacognitive differences. However, systematic modifications to the problem solving materials could begin to address a variety of developmental issues.

Developmental theories of analogical development are divided by the view of development occurring in stages (the competence deficit view, e.g., Sternberg, 1977; Holyoak, 1989), versus viewing developmental differences as being due to increasingly sophisticated and effective metacognitive skills or relational knowledge (e.g., Goswami & Brown, 1992; Goswami, 1992; Vosniadou, 1977). This discrepancy could be addressed by presenting these materials to subjects at different ages (ensuring that difficulty level is controlled), and determining whether knowledge/analogical reasoning exert differential influence at different ages. Including think aloud protocols (as described above) may provide more information about stage versus metacognitive influences. Alternatively, the themes could be created in a manner that increases the complexity of the conceptual relations presented in the themes across the various age levels (according to Case's (1992) or Holyoak's (1989) theories of the development of cognition/analogical reasoning). Ideally , it would be interesting to modify materials according to Holyoak's (Holyoak & Thagard, 1994) and/or Case's (1992) developmental stages (discussed earlier as overlapping), and to then examine performance on these tasks utilizing think aloud protocols to also explore metacognitive influences.

Transfer of Learning and Training Studies

One final area to consider in looking to future endeavours is that of training studies that address academic and social problem solving simultaneously (e.g., Andrews, et.al., 1990). The findings of the present investigation suggest that problem solving in the two domains is quite different. Much more research is needed before any conclusions can be drawn. However, the present results suggest that even if training general processes may assist in transfer of learning across the disparate domains, this transfer is not going to occur in a simplistic, straightforward manner. This issue is further discussed below.

Analogical Reasoning and Social Competence

An important issue raised by the present investigation is why analogical reasoning skill did not exhibit a relationship with perceived social competence. Certainly the implications/ramifications of this finding (as was discussed) is to question the role of analogical reasoning in social cognition, and the underlying assumptions about process in the information processing models that have been proposed. There are several questions that need to be addressed in future research.

1) Can the absence of an analogical reasoning - social success relationship be accounted for by inherently different processing of information under automated versus reflective conditions?

Studies have compared children's automatic and reflective processing of information (e.g., Rabiner, et.al., 1990). Children differing in social status have been found to respond differently depending on the type of processing. For example, Rabiner (1990) found that rejected non-aggressive boys processed information adequately under reflective circumstances but inadequately under automatic conditions. As a follow-up to the present research, it would be interesting to replicate the studies presented here in two ways, according to the following modifications:

* Reflective processing: Retain the original analogous materials and academic competence tasks (as well as the social competence tasks, for comparison), and introduce hypothetical-reflective measures of social competence. In this design, all tasks would involve responding under reflective circumstances.

* Automated processing: Retain the original measures of social competence and modify the measures of analogical reasoning and academic competence such that they are assessing more automatic processing. The actual mechanics of designing this latter alternative would be far more difficult than the former. One means to accomplish this would be to change the materials from a categorization task to solving everyday social and non-social problems. The problems could be presented such that problems initially presented could potentially assist in solving subsequent analogous problem (similar to Gick & Holyoak, 1983, or Holyoak & Koh, 1987, but with real-life problems). A second method would be to retain the categorization task, but present the themes as a speeded task requiring quick responses. This would limit (although probably not eliminate) reflective processing of information. Subjects would need to quickly determine which scenarios are similar, thereby demonstrating

subjects' sensitivity to underlying principles and surface features, but with minimal time to reflect on their problem solving.

2) As indicators of peer status, have the indexes of social competence employed here provided an adequate assessment of the general construct of social competence?

In order to address the differences between indexes of peer/other reaction to a child versus a child's actions in social situations, more tasks assessing competent behaviour in social situations need to be included in the design. Ideally, this would include direct observation. A related technique would be to create contrived situations using child confederates to study how targeted children respond in what they believe to be actual situations.

3) Is analogical reasoning a component of problem solving, but not adequate on its own to demonstrate a relationship with social competence (i.e., an additive factor)?

If analogous thinking is only one aspect of many that determines success in problem solving, then a more adequate research design would be to address several aspects of information processing. For example, this could potentially involve a similar but expanded design that may include (some, all or more than) the following:

* free recall of the scenarios - to examine how the problem situation is initially represented (i.e., "identify the problem"),
* categorization of the scenarios - to examine how analogous information is r presented and similarities mapped, (i.e., "mental representation and interpretation"),
* generating lists of various possible solutions (i.e., "search for alternative solutions"),
* choosing the best response (i.e., "implement the chosen response"), and finally,
* rating how well the scenarios were sorted (i.e., "evaluate the response").

If the influence of analogical reasoning is indeed additive, then several measures of different aspects of processing may reveal a relationship with social competence.

4) Do other factors such as emotion, pre-emptive factors, and previous experience, play a more significant role in social information processing than has yet been determined?

The involvement of factors such as emotion, pre-emptive factors (i.e., script-based, automatic, "without thinking" thinking), and previous experience are recent additions to the social information processing framework (Crick & Dodge, 1994). Little empirical research has been conducted examining the role these factors play in information processing. It would be interesting to contrast the present investigation - which focuses on process aspects of information processing - with comparative research examining these 'other' factors. This could possibly involve manipulating the emotional arousal or previous experiences of a child prior to receiving the scenarios (e.g.,, see Dodge & Somberg, 1987). Again, if these other factors do show a significant relationship with social competence, then conceivably their role in information processing needs to be elaborated more fully.

5) Are 'mental actions', as yet little studied, an important aspect of social-cognitive information processing, and what are critical process variables in social cognition?

Crick & Dodge (1994) recommended more research be conducted on process aspects of social information processing. Much of the social literature has focused on 'what children think' as opposed to 'how children think'. Results from the present investigation would suggest that analogous thinking is not a significant factor in social competence. However, before any conclusions can be reached, studies employing a variety of different analogous materials, as well as many of the manipulations suggested above need to be conducted. Also, other process variables (e.g., how outcome expectations are used to select responses; evaluations of responses) would be worthy of exploration.

6) Although there is considerable evidence that analogical reasoning is a central component of cognition (e.g., Polya, 1957; Sternberg, 1985; Holyoak & Thagard, 1995), is it a central component of social cognition?

Future investigations should include several different measures of analogical reasoning, as those found in the literature, with attention to both automated and reflective responding, and the need to expand the assessment of social competence. For example, analogous social situations (similar to Gick & Holyoak's (1983) work) could involve presenting a problematic social situation with a solution, then following this with an analogous social situation and asking subjects to solve the problem. An even more real-life situation would be for subjects to be a bystander in a `staged' problem situation that is solved successfully by another, and observing whether the subjects are subsequently able to solve an analogous problem. The materials used in the present investigation may not be representative of or sensitive enough to measure analogous thinking that takes place in social situations and relate to social competence. However, if future research continues to turn up an absence of a relationship between social competence and analogous thinking, then the critical role of analogical reasoning in cognition needs to be re-considered as it relates to social cognition.

7) Is the information-processing framework sufficient or even adequate to account for social problem solving behaviour? Or more generally, is it a reasonable assumption that similar processes underlie cognitive and social-cognitive problem solving?
The cognitive and social-cognitive models of problem solving postulate similar underlying processes (e.g., Newell & Simon, 1972; Hayes, 1981; Crick & Dodge, 1994). Also, analogical reasoning is considered to be a central component of cognition. If the analogical reasoning - social competence relationship remains non-existent despite further research, then the social-cognitive information processing framework would need to be revised or an alternate framework formulated to reflect the differences found.

Concluding Comments

The present research identified an analogical problem solving task that was equated across the social and non-social domains. Of particular interest to the general processing versus domain-specific knowledge debate, the results demonstrated the importance of both content knowledge and analogical reasoning skill as influences on academic competence. However, as the `knowledge' and `process' accounts of problem solving become more elaborated and finely tuned, the degree to which they reflect different positions seems blurred. Both accounts demonstrate considerable overlap in the critical aspects of reasoning, namely, the importance of an understanding of the inter-relationships among relations in analogical reasoning.

The analogical reasoning - competence relationship was evident with academic not social competence, thereby raising questions about the assumption of similar processing in theoretical formulations of cognitive and social-cognitive problem solving. Furthermore, the results do not provide support for training programs that endeavour to promote transfer of learning across social and academic domains. However, the results are supportive of theories of cognition that postulate two (or more) central conceptual structures.

As a preliminary investigation that directly equates problem solving in the social and academic domains, few answers but many questions were generated. Certainly the questions raised have implications for currently accepted problem solving theories and warrant attention in future research.

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APPENDIX A: THE PILOT STUDY

Introduction

Reasoning and problem solving are highly valued skills. Traditionally, these skills have been associated with intellectual and academic achievement. More recently, research interest in reasoning and problem solving skills has been extended to include behavioural and social aspects of human functioning. It is assumed in much of this work that similar general cognitive processes underlie these different domains of human capabilities (e.g., Hayes, 1981; Dodge, 1986; Mancini, Short, Mulcahy & Andrews, 1991). The present study was a preliminary investigation of the issue of whether similar processes underlie social and academic (non-social) problem solving. It's major purpose was to evaluate a variety of tasks for possible inclusion in subsequent studies. Five tasks were developed to assess putative analogous processes in the academic and social domains that have been postulated to occur in the early stages of problem solving. The study also began to address the issue of whether skill in solving problems in a particular domain is related to overall competence in that domain. An additional interest, then, was to evaluate for subsequent use a variety of indices of academic and social competence.

Information Processing Models of Problem Solving

Many of the more recent, prominent theories of cognitive and social - cognitive problem solving are based on Newell and Simon's (1972) information processing model (e.g., Hayes, 1981; Dodge, 1986; Rubin & Krasnor, 1986). Newell and Simon's model views the problem solver in terms of a serial information processing system that interacts with a task environment (the presenting problem). Problem solving is thought to involve the following stages:

1) attending to sensory input in the task environment,
2) constructing an internal representation of the problem,

3) searching for a solution,

4) selecting a solution, and

5) implementing a solution.

This framework has been successful in modeling general search strategies in solving well-structured problems that have clearly defined initial and goal states. However, such problems provide limited insights into real-world learning which requires the acquisition of domain specific knowledge. Consequently, other formulations of problem solving have emphasized knowledge-based representations in the form of schemas (e.g., Anderson, Greeno, Kline & Neves, 1981). While the same stages of problem solving are assumed in these models, it is additionally assumed that, in 'knowledge-filled' as opposed to 'knowledge-free' domains, features of a problem may activate knowledge in memory during the construction of the problem representation. If a schema for a particular type of problem is activated, then the strategies and procedures found in the schema will be implemented. Otherwise, a search strategy is employed to search for an alternate solution to the problem.

In the social problem solving literature, Dodge (1986) has developed an information processing model of social problem solving that is based on Newell and Simon's model. Dodge's model describes how children process social information, and how this processing of information directly influences their responses to social situations. He proposed that social problem solving involves:

1) encoding social cues in the environment,

2) creating a mental representation and interpreting the social stimuli,

3) engaging in a response search involving generating a number of possible alternatives,

4) deciding on a response, and

5) enacting the response.

The stages are essentially the same as Newell and Simon's problem solving stages, and are based on similar assumptions.

The information processing models assume that problem solving occurs in a sequential fashion, with later stages influenced by earlier stages. Thus, problem solving proceeds within the framework provided by the internal or mental representation. This suggests that the mental representation of information is a crucial, early stage in the problem solving process. The present study focuses on this aspect of problem solving.

Social versus Non-Social Problem Solving

While the models of cognitive problem solving and social-cognitive problem solving are based on essentially the same theoretical framework, there is no known research that has directly compared problem solving in social and non-social (academic) domains. There have been discussions in the literature that have drawn parallels between existing research in cognitive and social-cognitive problem solving (e.g., Wyer & Gordon, 1984), but no known empirical testing using equated materials in the social and non-social domains. Relationships between academic and social competence have also been studied (e.g., Wentzel, 1991). Furthermore, at least one thinking skills program (i.e. SPELT; Mulcahy, Andrews & Peat, 1988; Andrews, 1987) is based on the assumption that generalizable skills are involved in academic and social problem solving. In this program, training academic and social problem solving skills is thought to promote transfer and generalizability of the skills across the academic (non-social) and social domains (e.g., Mulcahy, et al., 1988; Andrews, 1987). It is also assumed that competence is associated with problem solving ability in both domains. Extensive training sessions with large groups of students have been conducted. However, there is no known research that has directly examined the assumption that there are general skills underlying academic and social problem solving. Moreover, there is no known research that has studied the relationship between competence and problem solving in both the social and non-social domains.

In order to investigate whether similar processes underlie social and academic problem solving, the present study employed tasks from the existing problem solving research in one domain (academic or social) and developed 'equivalent' measures in the other domain. In addition, measures of competence were obtained to examine the relationship between competence and problem solving in the two domains.

Clarification of Terminology

Before proceeding, clarification of terminology used in this study is needed. The distinction between social and non-social domains lies largely in the difference between the processing of information in social interactions, versus the non-social information children deal with every day in academic tasks in the school setting. Clearly, the two domains are not mutually exclusive. In an attempt to minimize confusion and to allow a comparison of the differences between the two domains, the 'academic' in academic problem solving, academic competence, or the various academic tasks presented to subjects in this study, refers to cognitive processing of information that is non-social.

Problem Solving

Five tasks were used to assess skill in problem solving:

1) Towers of Hanoi (TOH)
2) Picture Vignettes (PV)
3) Unfinished Stories (US)
4) Analogous Situations (Anal)
5) Sorting Task (SRT)

The tasks were modeled on tasks which have been employed in the experimental literature on cognitive and social-cognitive problem solving. Each task was considered to contribute information about how subjects construct mental representations of problems as part of the early stages of solving a problem, as postulated by Newell and Simon (1972) and Dodge (1986). Each task and the rationale for its inclusion is described below.

Tower of Hanoi (TOH)

In this task subjects were given three poles, with three discs increasing in size on the first pole. The goal was to move the discs, one at a time without placing a larger disc on top of a smaller one, to the last pole (see Appendix A.1). Subjects' 'think aloud' protocols were recorded and later analyzed. The TOH has been employed in modeling general search strategies in problem solving behavior when the initial and goal states of a problem are well-specified (e.g., Newell & Simon, 1972; Kotovsky, Hayes & Simon, 1985). The TOH represents the 'classic', 'knowledge-free' problem solving paradigm (e.g., Newell and Simon, 1972), which is still being used and continues to provide new insights into problem solving skill (e.g., Kotovsky, Hayes & Simon, 1985). Although no 'equivalent' social materials were created, the TOH was included to explore the relationship between 'knowledge-free' problem solving and 'knowledge-rich' problem solving.

The strategy chosen to solve the TOH will depend on how the problem space is represented internally by the problem solver. It was felt that the variables of number of errors committed and time to complete the task would reflect the efficiency and accuracy with which subjects understood the problem (i.e., their internal representation). Thus, measures of time to solution and number of errors would provide insight into the adequacy of the subjects' mental representation. Longer time and more errors made before the problem was solved would be indicative of a less accurate mental representation of the problem space.

Picture Vignettes (PV) and Unfinished Stories (US)

In these tasks brief stories were presented about problem situations that ended just short of a problem solution. All stories were created by the author. Subjects followed along as a story was read to them, then answered questions about the story. Four stories were presented to subjects for both the Picture Vignettes and Unfinished Stories. Two stories contained social content (i.e., problem situations of possible provocation (PV) and joining games (US), and two stories contained non-social content (i.e., themes of using tools (US) and displacement of water (PV) to solve problems). The difference between the two tasks was that the Picture Vignettes (PV) stories were line-drawing pictures with captions, while the Unfinished Stories (US) presented the text only. The US passages were longer than the PV pictures-plus-captions. Blanks were distributed throughout the US stories that omitted information that explicitly stated the goal of the story. That is, subjects needed to make the correct inferences in order to understand the problem. The 'picture-plus-caption' versus 'text only' difference between the PV and US stories contrasts visual versus verbal only information. PV more closely approximated the visual information provided in social situations through the use of pictures. Thus, it was thought that with its emphasis on pictorial information, performance on PV might show a stronger relationship with social competence. Similarly, with its emphasis on reading text, performance on US might show a stronger relationship with academic competence.

The use of 'picture stories' has been used in the social problem solving literature to approximate the social cues present in real-life social situations (e.g., Rubin, 1983). Also, the PV and US are hypothetical-reflective passages, similar to those used in the social problem solving literature (see Bream, 1989). 'Hypothetical-reflective' refers to presenting subjects with a hypothetical problem situation, and asking subjects to pretend they are in that situation and solve the problem. Although hypothetical-reflective measures are not thought to be equivalent to real-life problem solving, they are thought to assess the ability to reason and think about social dilemmas. According to developmental theorists (Damon, 1977; Cooney & Selman, 1978), real life problem solving is thought to lag behind hypothetical problem solving. Of particular interest to the present investigation in using hypothetical-reflective materials, is subjects' perception or interpretation of the problem situation.

In the cognitive problem solving literature, researchers studying reading and schema theory, for example, have used subjects' recall of passages to investigate aspects of reasoning and problem solving (e.g., Vosniadou, Pearson & Rogers, 1988). The common element is the use of story recall to infer how information essential in stories is represented (or not represented) in memory. The current investigation was interested in how problem situations in stories are internally represented. This was addressed through analyses of subjects' recall of essential problem solving elements in the stories. PV and US contrast visual information (felt to approximate social cues) with text only information (more common in academic situations).

Analogous Situations

This task was adapted from one used by Holyoak, Junn and Billman (1984) in studies of analogical reasoning in young children. They presented children with a story about a genie who had the problem of how to move his jewels from his current home/bottle to a new home/bottle. The genie solved his problem by rolling up his magic carpet and rolling his jewels through the tube into his new home. After having each child recall the story (and ensuring that the problem situation was recalled), subjects were presented with a transfer task. This involved generating as many different ways as possible to move balls from one bowl to another, using a variety of materials. Of interest, was whether a solution analogous to that used by the genie was applied (i.e., whether the children rolled up the construction paper that was provided and rolled the ball through this 'tube'). In the present research, the genie story and ball problem were used as the non-social or academic materials. Social materials (story-plus-problem and transfer task) were created by the author. The story was about a monster who wanted to eat a rabbit, but the rabbit talked him out of it by reaching a reasonable compromise. In the transfer task, subjects were asked to act out (using various characters and a school setting that were provided) different ways to resolve the social dilemma of a school bully wanting to beat up the subject after school. The analogous solution was to talk out the problem and arrive at a mutually beneficial solution.

Holyoak et. al. (1984) found that young children were able to use the analogous solution presented in the preceding story to solve the transfer problem. However, performance varied according to whether the children needed a hint. In the present study, no need for a hint was considered a benchmark of better problem solving skill and competence. It was expected that generation of the analogous solution would depend on whether subjects' internal representation of the story solution made the relationship to the transfer task obvious (i.e., no need for a hint) or whether prompting was needed.

Sorting Task

Subjects received two sets (one academic and one social) of nine, brief, three-sentence scenarios. One set or theme described different animals' use of defense mechanisms (academic materials), and the other set or theme described social interactions in situations of possible peer provocation (social materials). Subjects were asked to sort the scenarios in each theme into three related piles, and to describe their rationale in sorting the cards.

The academic problem solving materials were drawn from Brown's (Brown & Kane, 1988) research on pre-schoolers use of analogical reasoning skills. She used brief animal stories to teach young children about biological concepts of visual mimicry, natural pest control and camouflage. She found that the children were subsequently able to use these general concepts in analogous animal stories. That is, children were able to identify the analogy or underlying principle (UP) when presented with novel animal stories. For the social materials, modified versions of the hypothetical-reflective scenarios created by Bream (1989) to study social problem solving in situations of potential peer conflict, were used. Underlying principles of possible peer embarrassment, rejection and provocation were depicted in the scenarios. The academic and social passages were modified in the present investigation to create a series of brief stories or scenarios of similar length which contained the underlying principles or general concepts used by Brown and Bream. In addition, common surface features or details explicitly stated in brief stories/scenarios were included.

Examination of subjects use of underlying principles is also a primary focus of investigation in the expert-novice literature (e.g., Chi, Feltovich & Glaser, 1981). How subjects categorized the scenarios in the present study indicated sensitivity to analogous information (underlying principles), or conversely, the tendency to focus on more obvious, details (surface features). Thus, subjects' mental representation of information, in terms of sensitivity to analogous information versus less relevant details, was studied.

Relationships of performance on the sorting task to other problem solving and competence tasks were also explored. It was expected that identification of UP would be related to more success on other tasks of problem solving and competence.

Competence Tasks

Several tasks were selected to provide converging data about the broad constructs of academic and social competence. This included measures of non-verbal IQ, academic achievement, a sociometric rating scale, and teacher ratings (both academic and social).

IQ

General intelligence was assessed using a non-verbal standardized test (TONI; Brown, Sherbenou & Johnsen, 1982), to allow comparisons between performance on the problem solving tasks and on an index of general reasoning. Problem solving skills are considered to be an important aspect of intelligence (Sternberg, 1980). Investigation of the relationship between IQ and the problem solving tasks would provide information about the validity of the materials to demonstrate subjects' use of generalized reasoning skills (i.e., problem solving).

Academic Achievement

An assessment of academic achievement was obtained using a standardized test of reading (Woodcock, 1987).

Sociometric

Sociometric rating scales have been used to obtain peer perceptions of an individual's social competence (e.g., Singleton & Asher, 1977). A sociometric rating scale was used, where each subject was rated according to how much they are liked by his/her peers.

Teacher Ratings

Teacher ratings have been found to demonstrate significant relationships with both academic and social competence (e.g., Green, Forehand, Beck & Vosk, 1980). Three different rating scales were used in the present study, including two general statements that rated academic and social competence and problem solving skill, and one rating scale using academic and social content items from the Teacher-Child Rating Scale (TC'eRS; Hightower, Work, Cowen, Lotyczewski, Spinell, Guare & Rohrbeck, 1986). These items on the TC'eRS are thought to describe the constructs of academic and social competence.

Subjects in Grade five were seen individually and completed the academic and social competence and problem solving tasks. Due to time constraints, subjects completed four of the five problem solving activities, alternately omitting either the PV or US tasks. Correlational analyses were largely used to examine the relationships among problem solving activities, and between competence and problem solving tasks. Of particular interest was the degree of similarity in the processing involved during the early stage of problem solving, namely the mental representation of information. Interrelationships among problem solving tasks in a single domain would indicate the degree of similarity in the processes that underlie these tasks. Intercorrelations between the academic and social tasks would address the issue of whether generalized skills versus skills specific to a particular domain predominate in problem solving. Finally, correlations between competence and problem solving tasks would indicate how early problem solving processes are related to overall competence in a domain.

Method

Subjects

Forty-three children served as subjects in this study. There were 19 females and 26 males, from two, Grade 5 classrooms in a school in the City of York Board of Education. The average age was 10.9 years. Subjects who participated in the study were all those whose parents gave written permission.

Materials

Assessment of Cognitive and Social Competence

Subjects' overall, academic and social competence were assessed by using standardized tests and rating scales.

General intelligence was assessed using the Test of Nonverbal Intelligence (TONI; Brown, Sherbenou & Johnsen, 1982). For each item on this test, subjects chose one out of four or six abstract figures to complete the relationship depicted by a given set of abstract figures. Subjects needed to know the rule depicted by the set (e.g., shape, direction, size, pattern) in order to select the correct response alternative. With the majority of experimental tasks heavily dependent on verbal skills, this was a language-free test of cognitive ability. Percentile ranks were used as scores.

Academic competence was assessed using the "Word Identification" subtest of The Woodcock Reading Mastery Tests - Revised (Woodcock, 1987). This is an oral reading test of isolated words, and is a measure of academic achievement. Given time constraints, this test allowed a quick assessment of achievement. Performance on the "Word Identification" test has been found to be highly correlated with overall achievement in school (Woodcock, 1987). Subjects received percentile scores based on their performance.

Social competence was assessed using a 5-point Likert-type sociometric rating scale. Subjects were provided with a list of students in their class participating in the study, and a series of five faces beside each name showing a gradient of expressions from sad to happy. Subjects were told that the experimenter was interested in childrens' friendships, and were asked to select the face that best describes how much he/she likes each child on the list. An overall average rating across peers was obtained from each subject. These peer ratings, obtained for each subject, provide information about an important aspect of a child's social competence, that is, how well a child is liked or accepted by his/her peers.

Teacher ratings of subjects' academic and social competence were also obtained by using the "Teacher-Child Rating Scale" (TC'eRS; Hightower et. al., 1986). The items on this

5-point rating scale produced three subscales reflecting social, academic, and behavioural competence. Additionally, global teacher ratings were obtained from four, 5-point rating scales of each subject's overall academic, academic problem solving, overall social, and social problem solving skills.

Problem Solving Tasks

The following five experimental tasks were used in this study and are described in the subsequent sections:

a) Towers of Hanoi (TOH),

b) Picture Vignettes (PV),

c) Unfinished Stories (US),

d) Analogous Situations, and

e) Sorting Task

a) Towers of Hanoi (TOH):

The three-pole version of the TOH (Newell & Simon, 1972) was presented. Subjects were asked to move three rings (increasing in size) from the first pole to the last pole, one at a time, such that at no time could a larger ring cover a smaller ring (see Appendix A.1). Subjects obtained scores for the time it took to arrive at the solution, and the number of errors made before the solution was reached. All subjects were able to solve the problem, and therefore, a measure of success/failure on this task was not obtained.

b) Picture Vignettes (PV):

Four stories containing unresolved problem situations were presented as pictures with captions. The stories were created by the author and included two `social' stories, "Cards" and "Snowball", and two `academic' stories, "Camp" and "Gardener" (see Appendix A.2). Subjects received social stories containing same-sex characters. They were told that each picture story contained a problem that could happen to anybody. Stories were written in the first person, and subjects were told to pretend that they were the person in the story and it was their problem. Following each story, subjects were asked the following questions:

1) Tell me what is happening in the story.

2) What is your problem in this story? (What's wrong?)

3) What do you want to happen?

4) Explain exactly what you would do next.

The protocols were analyzed according to structural aspects of stories, using Stein and Glenn's (1979) story grammar. That is, subjects' responses were categorized into propositions that described elements of the story (e.g., setting, initiating event, problem, solution). Only those propositions that described aspects of the story that were essential in solving the problem were scored. As each story contained a total of four propositions describing important aspects of the problem situation, each subject received a score out of four.

c) Unfinished Stories:

This task was similar to the Picture Vignettes. However, the stories were presented in text format only (i.e., no pictures). There were blanks scattered throughout the stories that deleted information that explicitly stated the goal of the story. Thus, subjects were required to infer the goal from the information presented in the story in order to understand the problem situation. They were not asked to 'fill in the blanks' as the story was read. Four stories, two "social", "New Kid" and "Skateboard", and two "academic", "Crow" and "Fox", were read aloud by the author, while the subject followed the text (see Appendix A.3). The "Crow" story was adapted by the author from a children's story, and the remaining stories were created by the author. Each story ends just short of a problem solution. In the social stories, subjects received stories containing same-sex characters.

After each story, subjects were asked the following questions:

1) Pretend that I don't know anything about this story. Tell me the whole story in your own words.

2) If you only had a very short time to tell me this story, so that you only had time to tell me the most important parts of the story, what would you tell me? (i.e., What would be the most important information to remember about this story?)

3) The person who wrote this story has left out parts of the story. There isn't an ending to the story and there are some blanks in the story. What information is left out or missing that we should know about in the story?

4) What is the [crow's/foxes'/boy's/girl's] problem in this story? (What's wrong?)

5) What did the [crow/fox/boy/girl] want to happen?

6) I'd like you to finish the story.

Similar to the PV, the protocols were analyzed according to structural aspects of stories using Stein and Glenn's (1979) story grammar. Responses were divided into propositions that described elements of the story (e.g., setting, initiating event, problem, solution). Recall of the propositions describing essential aspects of the problem situation were scored. There were a total of ten propositions describing important aspects of the problem situation, and each subject received a score out of ten.

c) Analogous Situations:

Subjects were presented with two stories, one academic and one social, describing how a problem situation was solved. Each story had an accompanying transfer problem. Each transfer problem involved manipulating materials to solve a problem that, on the surface, did not appear related to the previously read story. However, the problem solution used in the story could be used as an analogy in solving the transfer problem.

For the academic 'story plus transfer problem', Holyoak et. al.'s (1984) "Magic Carpet" story was used, followed by an adaptation (by the author) of his transfer task, the "Ball Problem" (see Appendix A.4). The "Magic Carpet" story describes a genie solving the problem of how to transfer his jewels from one bottle to another by rolling up his magic carpet and rolling his jewels through this 'tube' to the new bottle. In the transfer "Ball Problem", subjects were asked to generate ideas for a new toy a toy company is creating, of how to move ping pong balls to a bowl just out of reach. The materials provided for the subjects to use included a dowel, a ping pong paddle, scotch tape, rubber bands, string, paper clips, scissors, and a sheet of construction paper. The various methods used by the subjects to solve the problem were recorded. For example, many subjects hit the ball with a ping pong paddle, used the elastic bands like a sling shot, or taped the ball on to the end of the dowel, in order to get the ball into the bowl. The solution analogous to the solution used by the genie in the story involved rolling up the construction paper into a tube and using it to roll the ping pong balls into the bowl.

For the social 'story plus transfer problem', a story the "Rabbit's New Friend" and a transfer task, the "Fight Problem", were created by the author to be similar to the "Magic Carpet" story and "Ball Problem" in structure, length and format, but to contain social content (see Appendix A.4). The "Rabbit's New Friend" story describes a rabbit threatened by a monster, who talks out the problem and arrives at a solution that allows them to be friends. In the transfer "Fight Problem", each subject was told that he/she had accidentally ruined the math homework of the class 'bully'. The bully thought it was done on purpose and was going to seek revenge after school. Subjects were presented with a board illustrating a school and the surrounding area, and several figures representing the bully, the subject, and other relevant adults and peers. Subjects manipulated the figures to act out possible solutions, and the various strategies were recorded. For example, some subjects used the figures to demonstrate running away, telling the teacher, or fighting the bully. The solution analogous to the solution used by the rabbit in the story involved talking out the problem and working out a plan to be friends, not enemies.

If, during the transfer problem, the subject ran out of ideas without generating the solution analogous to the story, a hint was provided by asking, "Does anything in the story help?". If this did not elicit the analogous solution, a more specific hint was provided: "What did the genie/rabbit do, and could you do anything like that?". If the analogous solution to the story was chosen, the subject was asked, "What made you think of that?"

Of interest was whether subjects were able to spontaneously generate the analogous solution, or whether a hint was needed to assist in drawing the analogy. Subjects received scores of 0 or 1, depending upon whether or not a hint was required before the subjects generated the analogous solution.

d) Sorting Task:

Subjects were given two sets of cards, describing an academic theme ("Biological Principles") and a social theme ("Potential Peer Conflict"), balanced for order of presentation (see Appendix A.5). The academic theme was adapted from Brown's (1989) "biological themes", which she used to demonstrate the use of analogical reasoning by young children. The social theme was adapted from Bream's (1989) use of "potential peer conflict" situations to analyze children's social problem solving skills.

Each theme or set of cards contained nine scenarios, or nine brief, three-sentence descriptions about an animal ("Biological Principles") or a peer interaction ("Potential Peer Conflict"). The content of the scenarios within a theme was adapted to allow categorization into three equal piles discriminated by Underlying Principles (UP), and three different (again equal) piles discriminated by Surface Features (SF). The UP and SF for the "Biological Principles" and "Potential Peer Conflict" themes are shown in Appendix A.5. UP refer to abstract principles that are inferred by the content of the scenarios. SF refer to concrete details explicitly stated in the scenarios.

Subjects' responses were scored according to their categorization of UP's and SF's. In order to be considered a 'correct sort', the majority of cards in a pile needed to be representative of that category. Each pile was scored as 1 or 0 for UP and SF. No response, an unknown rationale, or clear errors, produced a score of 0 for that pile. If the pile described an UP, it was scored as '1' for UP and '0' for SF. Similarly, if the pile described a SF, it was scored as '0' for UP and '1' for SF. Thus, given that the subjects categorized each theme into three piles, UP and SF scores ranged from 0 to 3, for each theme. Included in Appendix A.5 is an example of one subject's categorization of the "Biological Principles" theme, and the resultant scores for UP and SF. Higher scores for UP indicate greater sensitivity to the underlying principles suggested in the scenarios, while higher scores for SF indicate attention focused on the more obvious details stated in the scenarios.

Procedure

Subjects were seen individually during regular school hours for approximately one hour, to complete the competence tasks and three of four problem solving tasks. They were seen again several days later in small groups of six to eight for approximately 20 minutes, to complete the final problem solving task (the Sorting Task). During the study, the classroom teachers filled out the Teacher-Child Rating Scale (Hightower et.al., 1986), and the four, five-point rating scales for each subject, which rated overall academic, academic problem solving, overall social, and social problem solving skills.

Each child was told that the purpose of the study was to see "what kids in Grade 5 think about or do with different kinds of puzzles or problems".. They were also told that "there are no right or wrong answers, just whatever kids think about when given these tasks". The following competence activities were then presented in the order below:

a) the Word Identification subtest of the Woodcock Reading Mastery Test (Woodcock, 1987),

b) the Test of Nonverbal Intelligence (TONI; Brown, Sherbenou & Johnsen, 1982), and

c) the sociometric rating scale.

Subjects were then presented with the following experimental tasks:

a) Towers of Hanoi: The rules were explained and subjects' 'think aloud' verbalizations were tape recorded, and sequence of steps and time to reach the solution, were recorded on paper by the experimenter.

b) Picture Vignettes (PV): and

c) Unfinished Stories (US): Due to time constraints, each subject was given either the PV or US measure. By the end of testing, 18 subjects had completed the PV and 25 subjects had completed the US. Subjects followed along as the experimenter read aloud four stories - two academic and two social. This ensured that reading difficulties did not influence the processing of information. The order of presentation of the stories was balanced across subjects, with academic and social stories alternated. After each story, subjects were asked specific questions concerning the problem aspects of the stories. All responses were tape recorded and later transcribed.

d) Analogous Situations: An academic story and an accompanying transfer problem, and a social story and an accompanying transfer problem were presented to each subject. The order of presentation was counter-balanced across subjects. Subjects followed along as the story was read aloud by the experimenter. This was followed by a free recall of the story. If the problem solution described in the story was not recalled, specific questions about the problem solution were asked. If the subject clearly had not comprehended or could not recall the problem solution, the story was re-read. (This only occurred in one instance). The appropriate transfer problem was then presented. Of particular interest was whether the solution presented in the story was used as an analogy to solve the transfer problem. Materials were laid out, the problem was described, and subjects were asked to manipulate the materials to demonstrate possible solutions to the problem. If the solution analogous to the story solution was not attempted, hints were provided to use the solution suggested by the story. All responses were tape recorded, and the need for a hint was noted. Subjects were then given the second story, followed by the accompanying transfer problem, and the same procedure was followed.

e) Sorting Task: Subjects were presented with the academic and social themes, with the order of presentation counter-balanced across subjects. Each theme was comprised of 9 cards, with each card containing a brief descriptive passage, or scenario. Subjects sorted the cards into three piles according to which scenarios were similar. They labeled the piles, and briefly recorded (with pencil and paper) their rationale. Each subject was then asked to complete the second theme in the same manner.

Design and Analyses

As an exploratory study of five problem solving tasks, data analyses investigated first, the adequacy of the tasks as measures of competence and problem solving. Secondly, the relationship between performance on the competence and problem solving tasks was analyzed.

Information concerning the adequacy of the competence tasks was obtained primarily through the use of correlational analyses. Significant correlations among the scores would suggest that the various tasks assess similar constructs of academic and social competence, and would indicate whether competence in these two domains is discriminated by the different activities. That is, are the tasks thought to assess academic competence related, and are these relationships distinct from the relationships found with the social competence activities. Of additional interest, given the various teacher rating scales employed in the study (i.e., academic and social competence items of the TC'eRS, ratings of academic and social problem solving, and global ratings of academic and social skills), an exploratory factor analysis was conducted. This provided information concerning how well the different scales described similar constructs and which ratings appeared most appropriate to use in future studies.

The adequacy of the problem solving tasks to provide information concerning problem solving skill was similarly explored through correlational analyses. Significant associations among the scores would suggest that the tasks are similarly assessing a problem solving construct. In addition, performance on the academic and social versions of each problem solving task was compared through correlational analyses. The relationships found were expected to provide information concerning the degree to which general problem solving skills are transferable across the academic and social domains, or conversely the lack of similarity across domains. Also, the associations found, combined with observational data, would provide information as to whether the content of the academic and social materials was adequate to use to assess similar problem solving processes. This would assist in further refinement of the materials, if needed.

Finally, correlational analyses were also used to analyze the relationships between the competence and problem solving tasks. This provided information about which problem solving activities were related to aspects of academic and social competence, and whether the relationships found were consistent for the academic and social versions of the problem solving tasks.

Due to time constraints, subjects completed four of the five problem solving tasks. Just over half of the subjects (n=25) completed the Unfinished Stories (US), while the remainder (n=18) completed the Picture Vignettes (PV). Analyses of the problem solving activities were therefore conducted on two subgroups from the sample, an US group and a PV group.

Results

The results of the data analyses are presented as follows:

a) descriptive statistics (means, standard deviations),

b) sex differences among tasks,

c) factor analysis of the teacher ratings,

d) correlations among competence tasks,

e) correlations among problem solving tasks, and

f) correlations between competence and problem solving tasks.

Descriptive Statistics

The means and standard deviations for all scores on the assessment and problem solving tasks are presented in Table A.1. In general, the means and standard deviations were similar across tasks, particularly the five problem solving tasks.

Sex Differences

Pearson product-moment correlations were calculated for boys and girls separately, correlating all of the competence scores with the problem solving scores. t-tests were also performed to determine whether there were differences between the scores obtained by boys and girls. The results did not reveal any significant relationships between sex and competence or problem solving. Therefore, no further analyses were conducted differentiating by sex.

Factor Analysis of Teacher Ratings

A total of seven teacher rating scales were subjected to factor analysis. Included were ratings of academic and social skills as related to general problem solving, overall competence, and relevant items on the "Teacher-Child Rating Scale" (TC'eRS; Hightower et.al., 1986), as well as the 'behavior' scale of the TC'eRS. A Principal Components factor analysis (with eigen values = 1) using a varimax rotation was conducted to determine the degree to which the various rating scales were measuring similar constructs. The summed scores of the relevant items on the academic, social and behaviour scales of the TC'eRS, and item scores on the remaining rating scales were used. Two factors were identified, an Academic and a Social, that accounted for 86% of the variance. The Academic factor accounted for 35% of the explained variance, and the Social factor accounted for 51% of the explained variance. The data are presented in Table A.2. In general, ratings of overall academic functioning and ability to solve academic problems, as well as more specific ratings of achievement and work habits loaded on the Academic Factor. Ratings of getting along with peers and ability to resolve interpersonal problems, as well as more specific ratings of

TABLE A.1-Means & Standard Deviations of Competence & Problem Solving Tasks

Variable Name	Mean	Standard Deviation
IQ (TONI)	36.6	28.6
Reading	48.2	33.1
Sociometric	69.2	10.1
TR - overall academic	55.6	21.4
TR - cognitive problem solving	57.6	20.1
TR- TC'eRS, academic	51.0	25.2
TR - overall social	66.9	15.5
TR - social problem solving	65.3	17.1
TR - TC'eRS, social	54.7	21.7
TR - behaviour	51.0	27.7
TOH - time	100.9	72.4
TOH - error	1.3	0.5
PV - academic	66.9	15.5
PV - social	65.3	17.1
US - academic	54.7	51.0
US - social	51.0	27.7
Analogy - academic	57.5	20.1
Analogy - social	51.1	25.2
Sort - UP, academic	36.6	28.6
Sort - SF, academic	48.2	33.1
Sort - UP, social	69.2	20.0
Sort - SF, social	55.6	21.4

TR=teacher ratings; TOH=Towers of Hanoi; PV=Picture Vignettes; US=Unfinished Stories, UP=underlying principles; SF=surface features interpersonal skills, loaded on the Social factor. While the two factors appeared to discriminate social and academic competence, a moderate loading was also evident for the academic TC'eRS on the Social factor. These results suggest that teachers rated their students similarly on academic and social scales, but the separate factors also show that the teachers did discriminate the two constructs. Given the very high similarity and consequently the redundancy of information among the academic and social teacher rating scales, it was not considered necessary to include all rating scales in subsequent analyses. The academic and social TC'eRS rating scales were chosen for inclusion in future studies since the scale contained multiple items. The remaining rating scales were only one item scales.

TABLE A.2 - Factor Analysis of the Teacher Ratings

	Factor I - Social	Factor II - Social
Overall Academic	.13	.95
Academic Problem Solving	.40	.87
TC'eRS, Academic Items	.69	.64
Overall Social	.92	.17
Social Problem Solving	.91	.19
TC'eRS, Social Items	.79	.42
TC'eRS, Behavior	.81	.31
Percent of Total Variance Explained:	51%	35%

Relationships Among Competence Tasks

Correlational analyses using Pearson product-moment correlation coefficients were conducted to investigate the relationships among the measures of intelligence, and academic and social competence. Of interest in the present investigation is whether the various indices of competence within a domain are related, and whether the results discriminate academic from social competence. The correlational data are presented in Table A.3.

TABLE A.3 - Pearson Produce-Moment Correlations Among Competence Tasks

	IQ	Reading	TR-academic	Sociometric
IQ				
Reading	.49***			
TR-academic	.39*	.52**		
Sociometric	.02	.14	.43**	
TR-social	.63***	.58***	.81***	.36*

*** p<.001; ** p<.01; * p<.05

Significant correlations among the tasks were consistently found in the total sample and US group. None of the correlations in the PV group reached significance (with the exception of the correlation between the academic and social teacher ratings). This lack of significance may be due to the smaller size in the PV group. The following summary of the results will therefore focus on the total sample and US group.

For both the total and US samples, intelligence was found to be significantly correlated with academic competence (i.e., with reading, $r = .49$, $p < .001$, with academic TR, $r = .39$, $p < .05$) and with social TR ($r = .63$, $p < .001$). No relationship was found between intelligence and the sociometric. Scores on the academic competence indices (reading and academic TR) were found to be significantly related ($r = .52$, $p < .01$). Significant correlations were obtained between academic competence and the social TR (i.e., with reading, $r = .58$, $p < .001$, with academic TR, $r = .81$, $p < .001$). The social competence tasks (sociometric and social TR) also showed a significant relationship with each other ($r = .36$, $p < .05$). The sociometric only demonstrated significant correlations with the social TR and the academic TR ($r = .43, p < .01$).

In summary, significant relationships were found among intelligence and academic competence tasks, and among the social competence tasks. This suggests that similar constructs are being assessed by the academic and social competence tasks. On the other hand, the TR data were related to both academic and social competence, and intelligence. Thus, while the TR scales showed considerable overlap with competence tasks in both the academic and social domains, the intelligence, reading, and sociometric activities appeared to discriminate academic and social competence.

Relationships Among Problem Solving Tasks

Pearson product-moment correlation coefficients were calculated on the problem solving scores, and are presented in Tables A.4.1 and A.4.2. These analyses were conducted in order to determine whether the problem solving tasks are related to each other, and whether consistent relationships are seen between the academic and social problem solving materials.

Subjects either completed the US or the PV, and therefore, the results are presented for each group separately. Detection of underlying principles (UP) in the Sorting Task was the only problem solving activity found to be related to all of the other problem solving tasks. That is, sensitivity to UP in academic themes showed significant correlations with less time needed to complete the Towers of Hanoi (TOH) (US group; $r = .44, p < .05$) identification of more essential problem solving elements in the academic Unfinished Stories ($r = .49, p < .05$) and no need for a hint in the social Analogous Situations (PV group; $r = .58, p < .01$). Identifying UP in social themes demonstrated significant correlations with fewer errors on the TOH (PV group; $r = .46, p < .05$), and more essential problem solving elements detected in academic Unfinished Stories (US group; $r = .46, p < .05$).

TABLE A.4.1: Pearson Product-Moment Correlations among Problem Solving Tasks

Unfinished Stories Sample

	1	2	3	4	5	6	7	8	9	10
1 - TOH-time										
2 - TOH-error	.53**									
3 - US-academic	-.13	-.19								
4 - US-social	.14	-.13	.45*							
5 - Analogy-academic	-.13	-.17	.31	.20						
6 - Analogy-social	-.02	-.02	-.24	-.39	-.12					
7 - Sort-UP-academic	-.44*	-.24	.49*	.23	.46*	.13				
8 - Sort-SF-academic	-.08	-.09	-.40	-.33	-.27	.14	-.38			
9 - Sort-UP-social	-.36	-.33	.46*	.22	.01	.18	.50*	.03		
10 - Sort-SF-social	.22	.39	-.08	-.11	.08	.19	-.28	.12	-.41*	

*** $p<.001$; ** $p<.01$, * $p<.05$

TABLE A.4.2: Pearson Product-Moment Correlations among Problem Solving Tasks

Picture Vignettes Sample

	1	2	3	4	5	6	7	8	9	10
1 - TOH-time	.50*									
2 - TOH-error	.50*									
3 - PV-academic	-.15	.09								
4 - PV-social	.12	.25	.01							
5 - Analogy-academic	.26	-.13	.08	-.02						
6 - Analogy-social	.11	.13	-.12	.41*	-.45*					
7 - Sort-UP-academic	-.05	-.40	.24	-.49*	.38	-.58**				
8 - Sort-SF-academic	-.21	-.46*	-.23	.23	-.08	.32	-.19			
9 - Sort-UP-social	-.30	-.46*	.13	-.49*	.01	-.33	.48*	.33		
10 - Sort-SF-social	.30	-.04	-.08	.00	.37	.25	-.29	-.16	-.42*	

*** p<.001; ** p<.01, * p<.05

For the remaining problem solving tasks, few correlations reached significance. No significant correlations were found between the academic Picture Vignettes and any other problem solving activity. Fewer errors on the TOH were related to quicker completion on the TOH, but this is an expected finding and of little interest to the present investigation. Significant correlations were found between the social PV and UP of the Sorting Task and between the social PV and the social Analogous Situations. However, these correlations were in a direction opposite to that expected given good problem solving skill. Specifically, more essential elements identified in picture stories was associated with fewer UP detected in academic and social themes ($r = .49$, $p < .05$ and $r = .49$, $p < .05$, respectively). Similarly, more essential elements identified in picture stories was related to the need for a hint to use the analogy in solving the social transfer problem of the Analogous Situations ($r = .41$, $p < .05$). For the Analogous Situations, the need for a hint in one domain was related to no hint being needed in the other domain for the PV, but not the US group. This is again an unexpected finding. Thus, the few significant relationships found were either of little interest to the present investigation, or the results were somewhat questionable. These questionable results found with the Picture Vignettes and Analogous Situations cast some doubt on the adequacy of these tasks.

Within each problem solving task, performance on the academic and social materials was also compared using correlational analyses. A significant correlation was evident between the academic and social US ($r = .45$, $p < .05$), indicating that identification of essential problem solving elements in one domain was related to identification in the other domain. Similarly, for the detection of UP in the Sorting Task, significant correlations were found between the academic and social themes (US group; $r = .51$, $p < .05$, PV group; $r = .49$, $p < .05$). Thus, significant relationships between the academic and social materials were only evident with the Unfinished Stories and UP of the Sorting Task.

Comparing the Competence and Problem Solving Tasks

Pearson product-moment correlational analyses were conducted to explore the relationship between intelligence, academic and social competence, and the five problem solving activities. The results are presented in Table A.5.

The competence tasks, with the exception of the sociometric, demonstrated fairly consistent relationships with sensitivity to underlying principles (UP) in the Sorting Task in particular, as well as identifying essential problem solving elements in Unfinished Stories. That is, for the UP detected in the academic theme of the Sorting Task, significant correlations were observed (for both the US and PV groups, respectively) with higher reading scores ($r = .59$ and $r = .55$, $p < .01$), academic TR ($r = .51$ and $r = .44$, $p < .05$) and social TR ($r = .40$ and $r = .47$, $p < .05$). For the UP identified in the social theme of the Sorting Task, significant relationships were observed for all competence tasks, with the exception of the sociometric. That is, UP found in the social theme were associated with intelligence (US group; $r = .56$, $p < .01$, PV group; $r = .47$, $p < .05$), reading (US group; $r = .78$, $p < .001$; PV group; $r = .58$, $p < .01$), academic TR (US group; $r = .46$, $p < .05$; PV group; n.s.), and social TR (US group; $r = .54$, $p < .01$; PV group; n.s.), but not with the sociometric. For the Unfinished Stories, significant correlations were found between the academic US and IQ ($r = .56$, $p < .01$), and between the social US and IQ, reading, and social TR ($r = .44$, $p < .05$; $r = .54$, $p < .01$, and $r = .41$, $p < .01$, respectively).

In contrast, very few significant correlations were found between the competence tasks and the Towers of Hanoi, Picture Vignettes, or Analogous Situations.

Discussion

This study investigated the relationships among five problem solving tasks, and how performance on these tasks was related to academic and social competence. The problem solving activities were derived from existing problem solving research and modified in order to allow comparisons between academic and social problem solving.

TABLE A.5 - Pearson Product-Moment Correlations between the Competence Tasks and Problem Solving Tasks (US and PV samples)

	IQ		Reading		TR-academic		Sociometric		TR-social	
	US	PV	US	PV	US	PV	US	PV	US	PV
TOH -time	-.06	.14	-.31	.11	-.18	.08	-.36	-.41*	-.24	-.07
TOH-errors	-.21	-.21	-.30	-.11	-.31	-.11	-.09	-.17	-.46*	-.32
US-academic	.56**		.39		.34		.16		.33	
US-social	.44*		.54**		.32		-.05		.41*	
PV-academic		-.09		-.06		.39		.22		.24
PV-social		-.04		-.30		.19		.43*		.01
Anal'y-acad'c	.25	.43*	.09	-.04	.29	.33	-.14	-.35	.15	.13
Anal'y-social	-.16	-.32	.16	-.23	.14	-.24	.07	.08	.10	-.15
Sort-UP-ac	.31	.37	.59**	.55**	.51*	.44*	.15	-.23	.40*	.47*
Sort-SF-ac	-.08	.04	-.19	-.05	-.13	.16	.28	.29	.05	.28
Sort-UP-soc	.56**	.47*	.78***	.58**	.46*	.01	.30	-.01	.54**	.23
Sort-SF-soc	-.27	.25	-.22	-.21	-.30	-.22	-.27	-.24	-.34	-.25

*** p<.001; ** p<.01; * p<.05

TR = teacher ratings; TOH = Towers of Hanoi; US = Unfinished Stories; PV= Picture Vignettes; UP = underlying principles; SF = surface features

The goals of the present investigation were first, to assess the adequacy of the tasks used to assess competence and problem solving. This involved determining whether the competence tasks chosen were valid measures of academic and social competence, and whether the tasks discriminated academic and social competence. The adequacy of the materials as tools to assess problem solving was also investigated, as well as whether the academic and social materials provided valid indices that discriminated problem solving within the academic and social domains. Second, performance on academic and social competence tasks was compared to performance on the problem solving materials to investigate the relationship between competence and problem solving, and to discover similarities and differences in problem solving processes within the same domains or across the academic and social domains. Finally, the theoretical implications of the results in demonstrating the use of generalized problem solving processes and how it relates to competence was explored.

Adequacy of the Competence Tasks

Several teacher rating scales were employed in the present study, including global ratings of academic and social competence and academic and social problem solving, and ratings on academic and social items of the Teacher-Child Rating Scale (TC'eRS). A factor analysis showed that all rating scales were highly related within the academic and social domains, and that the scales discriminated two separable constructs - academic and social. The academic items on the TC'eRS did show a moderate relationship with the Social factor, indicating some similarity in teachers perceptions of academic and social competence in children. Use of the academic and social items of the TC'eRS alone was recommended for future investigations given that this scale contained multiple items (as opposed to a global item to rate).

A variety of activities were used to provide convergent data on academic and social competence. In assessing academic competence, correlational analyses indicated significant relationships between nonverbal IQ, reading skill and teacher ratings of academic competence. Among the social competence tasks, the peer sociometric rating scale and teacher ratings of social competence were found to be correlated. Thus, the expected associations were found among the competence tasks within each domain. The teacher rating data suggest that there may be generalized problem solving skills that subjects are using in academic and social situations, or at least skills that the teachers perceived to be similar. At the same time, the factor analysis showed that teachers did discriminate academic and social competence. Whether the associations found among academic and social teacher ratings reflect generalized competence skills versus similar teacher perceptions of children, will be further explored in subsequent studies by increasing the size of the sample and the number of competence tasks.

A non-verbal measure of intelligence was used to provide information about intelligence with verbal demands minimized. The TONI is considered a test of problem solving where subjects must identify relationships among designs in order to solve the problem (Brown, et.al., 1982). Performance on this non-verbal measure of cognitive ability did show significant relationships with academic and social competence indices (but not the sociometric), and with the Unfinished Stories and Sorting problem solving tasks. However, the original intent in using this task was to contrast competence with the problem solving tasks. While these results were informative in showing that this IQ measure was related to the experimental problem solving tasks, it was merely an additional problem solving task as opposed to a specific measure of academic or social competence. Therefore, for the purposes of comparing academic and social problem solving with academic and social competence, this IQ task was not included in subsequent investigations.

Given time constraints, the reading task was chosen as a quick assessment of academic achievement. Significant relationships were found with most problem solving tasks. However, the task may be limiting in its focus on reading single words. If time permits in subsequent studies, a task that involves more active thinking and problem solving skills (e.g., a school ability test), should be used to provide a broader measure and 'richer' source of information about children's academic competence.

Almost no significant relationships, apart from that between the sociometric and teacher ratings, were found between the sociometric and other competence or problem solving activities. Sociometric rating scales are sensitive to the wording of the statement rated by the subjects (Asher & Hymel, 1977). Asking subjects to rate how much they 'like' other children may not have been specific enough to be an adequate measure of social competence. A criterion more specifically focused on peers' social competence or preferred peer group, and possibly the use of more than one scale, will be used in future investigations.

Finally, while attempts were made to 'equate' the academic and social materials in each problem solving task, this only occurred with the teacher rating scales of the competence tasks. It may not be possible to equate all competence tasks, due to the nature of the academic and social domains. For example, a sociometric and ability test would be difficult if not impossible to equate. However, increasing the number of tasks that can be equated, should be included in subsequent research.

Adequacy of the Problem Solving Tasks

The five problem solving activities used in the present study represent a variety of methods that have been employed in the literature to assess both academic and social problem solving. Analyses of the relationships between the problem solving tasks and between the problem solving and competence activities, resulted in some problem solving tasks showing meaningful relationships while others did not.

Subjects' ability to detect underlying principles in the Sorting Task was the most broadly related to competence and other problem solving exercises. The Unfinished Stories also showed relationships with the competence tasks and underlying principles of the Sorting Task. All other problem solving tasks (i.e., Towers of Hanoi, Picture Vignettes, Analogous

Situations, and surface features of the Sorting Task) demonstrated few (and at times contradictory) relationships among problem solving tasks and with competence.

Therefore, the Sorting Task, more specifically sensitivity to underlying principles, appears to warrant further investigation. While the Unfinished Stories also demonstrated significant relationships, these relationships were not as widespread as those found with the Sorting Task. Inclusion of the Unfinished Stories does not appear to provide any additional information to that of the Sorting Task.

Modifications in Assessing Problem Solving in Future Research

The Towers of Hanoi (TOH) was originally included as an example of a 'classic' problem solving activity. However, given that few significant relationships were found with other competence or problem solving tasks, the TOH did not contribute much information concerning the relationship of problem solving to competence. Indeed, whatever skills are tapped by the TOH appear unrelated to the academic or social abilities or problem solving skills assessed here. Also, since the author was unable to create TOH materials for both the academic and social domains, no comparisons could be made between domains. Furthermore, subjects appeared to have difficulty 'thinking aloud' without practice, and thus, omitting a practice session may have affected the results. A practice session was omitted due to time constraints, but should be included if this task is used in future studies.

Picture Vignettes (PV) were not found to be consistently significantly related to competence or problem solving, whether academic or social. This may be due to the smaller sample size used, and/or the materials themselves. Analysis of the means and standard deviations (Table A.4) indicated that there was variability among the scores and the task was sufficiently challenging (i.e., scores were not at ceiling). However, observations of subjects as they recalled the stories suggested that the simple, line-drawn pictures with brief captions did not elicit much elaboration of story content. The task appeared to tap memory of content as opposed to promoting thinking skills needed for problem solving. The task therefore appeared too simplistic to elicit problem solving, and would require modifications to the materials (e.g., a more complex story plot, and/or pictures that required more inferences to be drawn in order to understand the story) if used in other studies.

Analogous Situations was related to very few other variables. It was hypothesized that no need for a hint would be related to better competence and problem solving. However, it was found that the need for a hint was, at times, related to competence and other problem solving tasks. These results were observed largely with the Picture Vignettes group. Scores from this group were often inconsistent and demonstrated some questionable relationships with other measures. In addition, the Analogous Situations represented an attempt to more closely approximate `in vivo' problem solving by presenting materials to manipulate. However, observations suggested that subjects went through the motions of completing the tasks but did not involve themselves as much as was hoped in the transfer task, particularly with the social materials. This task, therefore, did not appear to simulate `in vivo' problem solving.

In comparison to the Towers of Hanoi, Picture Vignettes and Analogous Situations, performance on the Unfinished Stories demonstrated more significant associations with academic and social competence and with the various problem solving tasks. There was some question, however, as to what exactly was being measured with this task. Given the nature of the task (i.e., recalling information by answering questions), the results may be more a reflection of verbal expressive skills than general problem solving skills. In comparison, the Sorting Task may provide a better opportunity to study problem solving skill with less emphasis on verbal skills.

Ability to detect underlying principles in the Sorting Task was widely related to both competence and problem solving, in both the academic and social domains. In contrast, no significant associations were found between identification of surface features in the Sorting Task and either competence or problem solving. Therefore, the Sorting Task was selected for future investigations. The task appears to tap skills of analogical reasoning in the identification of underlying principles in brief scenarios. These skills are considered important in problem solving and demonstrated a relationship with academic competence and some aspects of social competence (i.e., teacher ratings but not sociometric ratings).

Several modifications were deemed necessary before employing this task in a subsequent study. First, the reading level of the materials, although appearing to be well within the ability of Grade 5 students, was never formally assessed. Since the Sorting Task required subjects to independently read the scenarios, the reading level would have had an impact on performance if the passages were too difficult for this age group. If this were the case, the relationship between problem solving and competence would reflect differences in reading ability. Indeed, UP scores were found to be highly correlated with reading scores (r's of .55 to .78). Therefore, the materials need to be assessed for their readability level (e.g., using the Fry Readability Scale; in Cheek & Cheek, 1980), and appropriate modifications made to the materials, if necessary.

A more serious problem with the Sorting Task is that it was essentially a one-item test (i.e., with only one academic theme and only one social theme). Therefore, the observed effects may be due to the specific content of the materials used. In subsequent studies, several themes in both domains were developed to allow for more general conclusions to be drawn about the findings.

Finally, since the themes were created to contain underlying principles and surface features, subjects may initially attend to one type of information in the themes (UP or SF), but be aware of the other type of information. Providing a second opportunity to sort the scenarios may reveal the use of underlying principles by subjects who previously had focused more on surface features. Thus, further investigations will allow two opportunities to categorize the materials in order to determine whether more competent individuals are better problem solvers, or are simply attending to this information as an initial response to the materials.

Theoretical Implications

The finding that more academically competent individuals are better able to identify underlying principles in the Sorting Task is similar to the findings in the expert-novice literature that experts in a particular domain demonstrate greater use of underlying principles when sorting problems in that domain, than novices. This has been observed with both adults (e.g., Chi & Glaser, 1985) and children (e.g., Chi, Hutchinson & Robin, 1988). The present study did not use a sample of experts and novices that represent the extremes of ability in the academic and social domains. Rather, the same effects were observed with children of similar age and presumably educational experiences. Differences in academic competence covered a much smaller range, as compared to that typically found in expert-novice studies. Even so, the greater sensitivity to underlying principles seen in the literature with experts was observed with subjects with higher scores on academic tasks. Other recent studies have also shown similar cognitive differences between stronger and weaker novices (Chi & Bassock, 1988; DeJong & Ferguson-Hessler, 1986; Zajchowski & Martin, 1993).

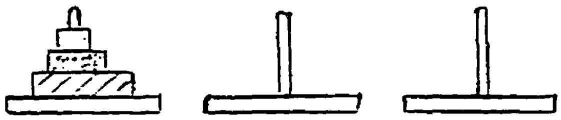
The results also relate to findings in the analogical reasoning literature. The `Biological Theme' used in the sorting task was adapted from Brown et. al.'s (1988) "biological themes". They were interested in demonstrating analogical reasoning in young children. They found that young children did possess generalized problem solving skills of analogical reasoning, as long as they had the requisite knowledge about the materials. The present study focused on an older age group and looked at their ability to reason analogically. Analogical reasoning has been studied at various age levels. Here, the spontaneous use of underlying principles or analogies by Grade five subjects showed a relationship with competence.

Researchers studying expert-novice differences argue that the relationship between competence and sensitivity to underlying principles is due to differences in the knowledge structures that the subjects possess (e.g., Chi & Glaser, 1985). Conversely, researchers studying analogical reasoning skills would argue that this relationship largely reflects differences in generalized problem solving skills (e.g., Sternberg, 1985; Holyoak, 1989; Schraagen, 1993). These researchers do acknowledge the importance of the knowledge available to a person, but as long as adequate knowledge exists, competence would be related to generalized reasoning skills. The present investigation does not discriminate between these perspectives. This is because differences in subjects' knowledge were not assessed or controlled. The observed relationship between competence and problem solving may be due to sensitivity to underlying principles/analogies, or may be due to more or less sophisticated knowledge structures among the subjects. Thus, in subsequent studies a test of subjects knowledge of the underlying principles found in the themes is included. Scores on this `Knowledge Test' can then be used in statistical analyses to control for differences in subjects knowledge of the underlying principles. In this manner, the relative influences of knowledge versus generalized problem solving skills can be determined.

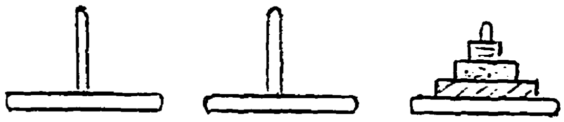
Finally, the theoretical models of problem solving in both the academic and social domains assume that information is processed in a similar manner, whether it be more academic or social in orientation. This would suggest that the relationship between competence and problem solving could be similarly seen in both academic and social tasks. However, this was not the case in the present study, where a relationship between competence and reasoning was observed with academic but not social competence tasks. This may suggest that aspects of social situations differ in some integral way beyond that proposed by information processing models. Alternatively, the tasks assessing social competence were not sensitive enough to social variables. These issues will be explored in further studies, by including two sociometric scales that focus more closely on social interactions among peers, and additional self report measures of academic and social competence.

APPENDIX A.1: Towers of Hanoi (TOH)

Initial State:



Goal State:



Rules:

1) Discs can only be moved one at a time.
2) A larger disc cannot be placed over a smaller disc.

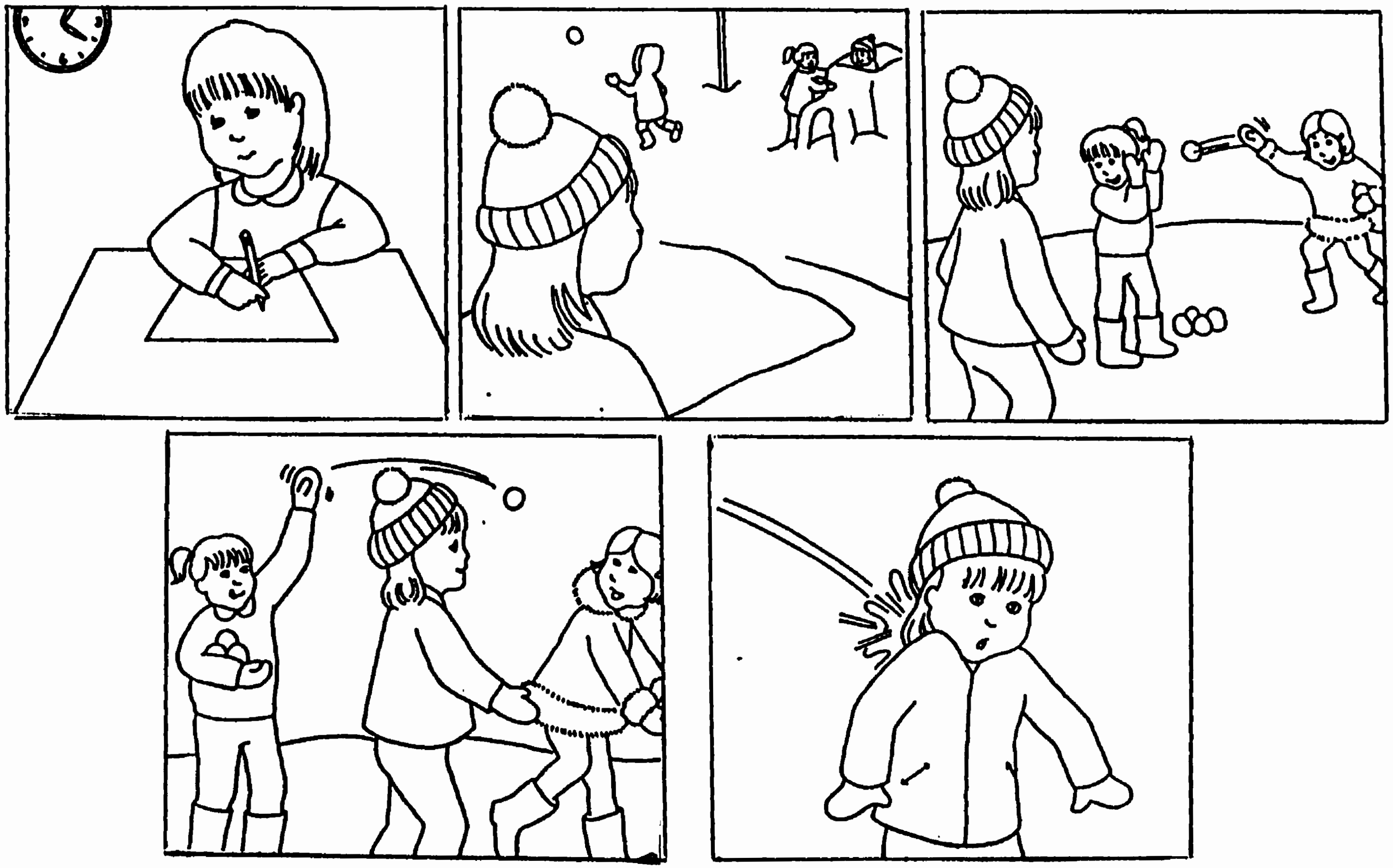
APPENDIX A.2: Picture Vignettes (PV)

The following are the four picture-plus-caption stories for the Picture Vignettes problem solving task. The materials for the female subjects are depicted here, where the characters in the social stories depict girls. Identical stories were constructed utilizing boys in the social stories for the male subjects. Each of the original pictures filled an 8 1/2" x 11" piece of paper, but are presented here reduced in size.

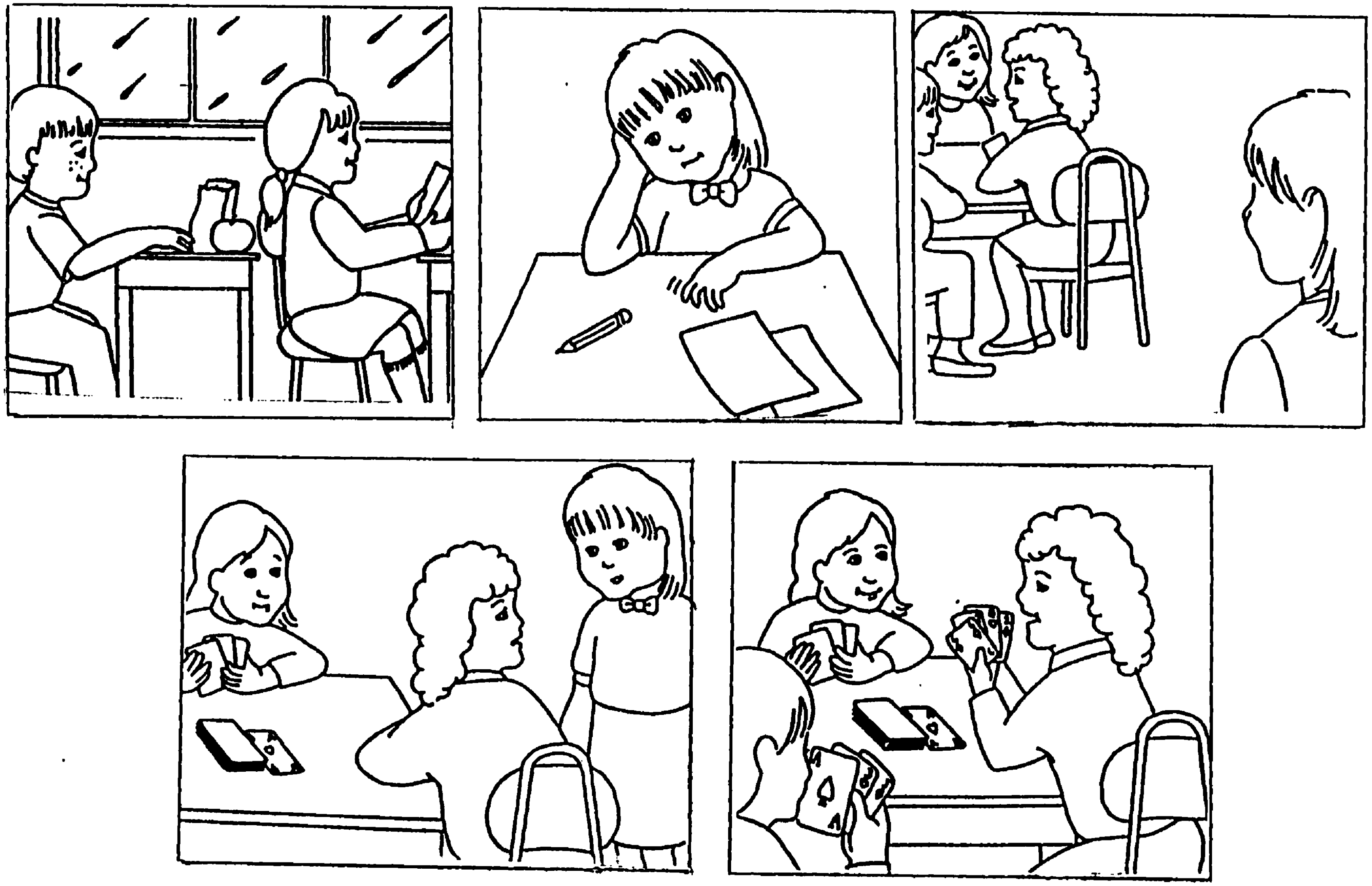
The Academic Stories are "Camp" and "Gardener".

The Social Stories are "Cards" and "Snowball".

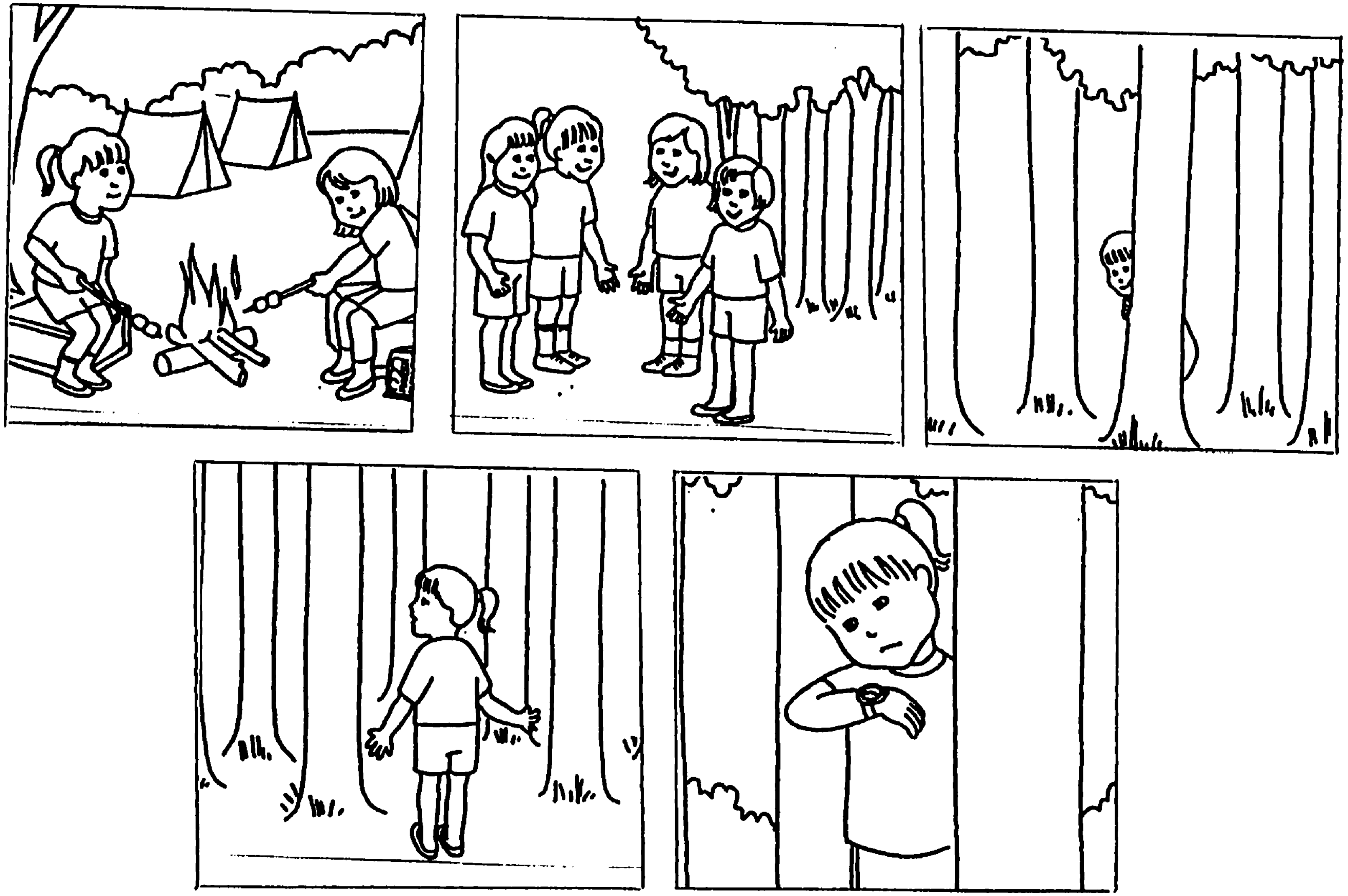
SOCIAL STORY "SNOW BALL"



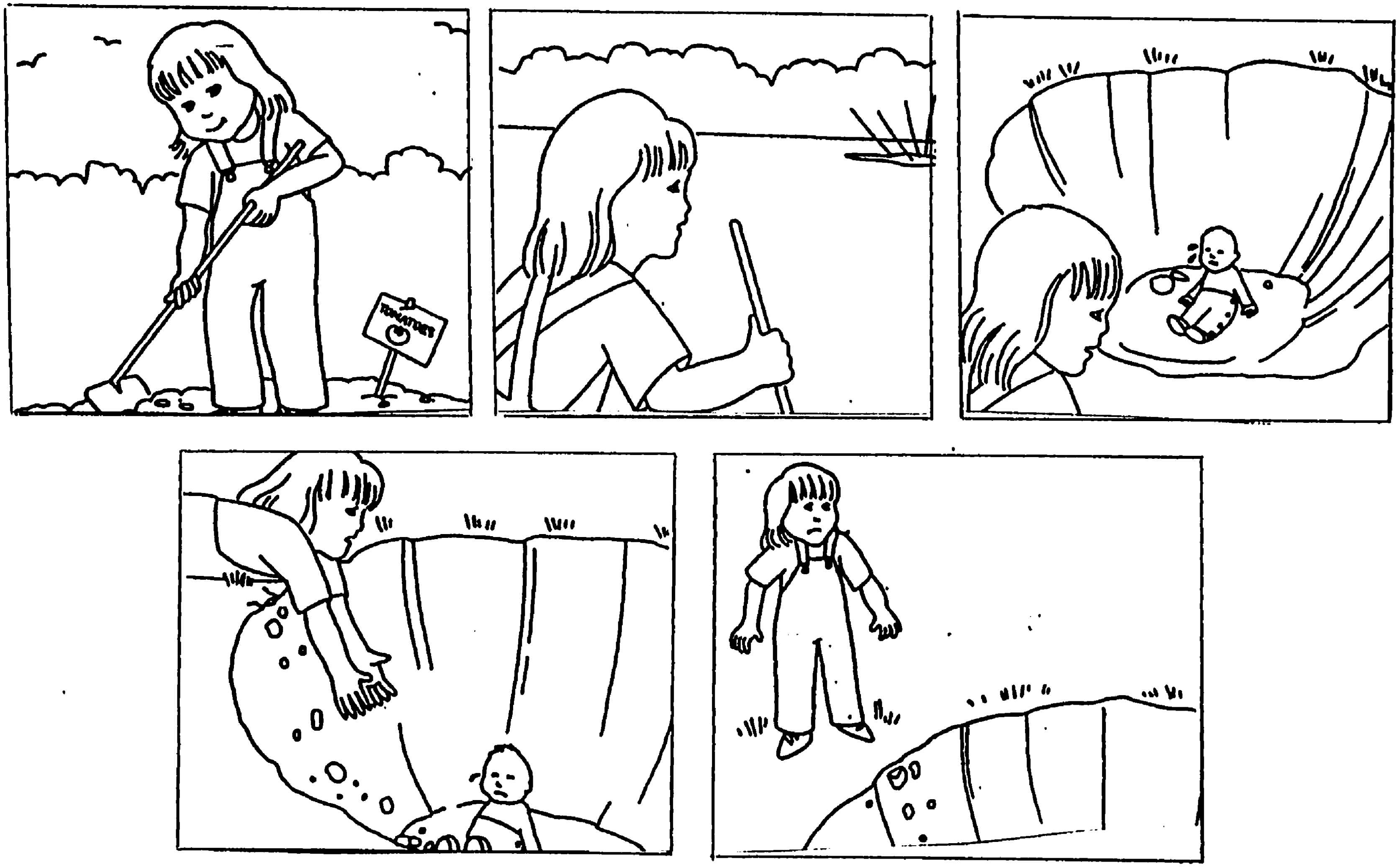
SOCIAL STORY "CARDS"



ACADEMIC STORY "CAMP"



ACADEMIC STORY "GARDENER"



APPENDIX A.3: Unfinished Stories (US)

The following are the four stories for the Unfinished Stories problem solving task. The bracketed and underlined words were presented as blanks to the subjects. The materials for the boys are depicted here, where the characters in the social stories are boys. Identical stories were constructed utilizing girls in the social stories for the female subjects.

The academic stories are "The Crow and the Pitcher" and "The Fox and the Bear".

The social stories are "The New Boy in Town" and "The Boy and the Skateboard".

Academic Stories:

The Crow and the Pitcher

It was a warm summer day. The sun was shining and the sky was blue. There was a crow flying in the forest, who needed <u>(a drink)</u>. He was quite a large crow, all black in color, and a very fast flyer. He looked all around for <u>(water)</u>, but he could not find <u>(any)</u>. At last, he found a big pitcher under a tree. The tree was a big willow tree, with long branches hanging down to the ground. He looked into it and found that there was a little water left. The pitcher was so deep that try as he could the crow could not <u>(reach the water)</u>. It was very quiet in the forest, and you could hear the birds singing clearly. The crow, however, would not give up. After thinking about it for a few minutes, he knew what to do. Near the pitcher there were some stones piled up.

The Fox and the Boat

It was springtime in the forest. Trees were budding and the grass was a lush green color. A fox was standing beside a river and needed <u>(to cross)</u>. The fox had a thick reddish fur coat, and a very long, bushy tail. He tried to find a narrow place to <u>(cross)</u>, but the river was <u>(too wide)</u>. He finally found an old boat beside the river. The area by the river was quite pretty, with lots of colorful flowers and large rocks. He jumped into it and started to row. The heavy boat got stuck, and even though he tried, the fox could not <u>(get out)</u>. The sun was high overhead, and the leaves on the trees were swaying in the wind. But the fox wouldn't stop trying. After thinking about what to do, he came up with an idea. Inside the boat there was a lot of dirt and rocks.

Social Stories:

The New Boy in Town

It has been a great summer this year, with lots of warm, sunny days. Last week a boy moved into town, and he wanted to (make new friends). There were a lot of people outside who were enjoying the good weather. He would smile and say 'hi' to try and (make friends), but nobody would (stop and play). He finally decided to go to the playground near his house. A big playground, it has swings, a baseball diamond, and a large soccer field. He heard many voices and found ten boys his age playing four square. There were so many people that even though he asked, the boys wouldn't let him (play). It was still a long time before he had to be home for supper. The boy however, would not give up. He walked home, thinking about what to do then remembered something. In his toy box, there is lots of sports equipment.

The Boy and the Skateboard

Today was the first day in the past four days that it hasn't been cloudy and cool. There was a boy playing outside, and he wanted to try (skateboarding). It was a perfect day, with clear blue skies, and a warm breeze. He would watch other boys (skateboarding), but nobody would give him (a try). After a while he went closer to talk to the boys. The boys were about his age and seemed to be having a great time. He would run beside them admiring their skateboards. He tried to be friendly and ask nicely, but the boys didn't want to stop (riding). Time was passing by slowly and he didn't feel like going home yet. He thought and thought about what to do then had an idea. He had a new electronic game that was a lot of fun.

APPENDIX A.4: Analogous Situations

The academic story, "Magic Carpet", and the accompanying transfer problem, "Ball Problem", and the social story, "Rabbit's New Friend", and the accompanying transfer problem, "Fight Problem", are presented below.

Academic Story: **Magic Carpet**

Once upon a time there lived a magical genie. He was a very old, wise, and rich genie indeed. One day while he was polishing his home, which was actually a bottle, he decided he would like to find an even bigger and better home to live in. So he began searching far and wide for another bottle. Finally, he found the perfect home. It was larger, prettier, and not too far away from his old bottle. The genie was very excited and began moving his belongings right away. But now the genie had a problem. He had a great many beautiful and very precious jewels in his old home. He had to somehow get all the jewels from his old bottle to the new bottle without dropping or losing a single jewel. After thinking a bit, the genie came up with a wonderful idea.

He searched for his magic carpet. Then he commanded it to roll itself up into a long hollow tube. Next the genie commanded his flying carpet to place one end at his old home and the other end at his new home so that it formed a sort of hollow bridge between the two bottles. Then, the genie very carefully took one jewel from inside his old home and placed it into the opening of his carpet. At once, the jewel began tumbling and rolling through the carpet tube until it reached his new home and plopped safely inside. The genie grinned happily and began rolling all his jewels through the carpet into his new home. In fact, I'm sure you can still find him sitting in his new, bigger and better bottle with all his jewels and smiling contentedly even today.

Transfer Task: **Ball Problem**

A toy company has decided to hire kids to help them design new games. They know that kids are very creative and imaginative, and have a lot of ideas that adults might not think of. You are hired to help them come up with different ideas of how to play a new game.

One part of the game involves getting these ping pong balls from this bowl to the empty bowl. You can't reach the bowl since it is just beyond your reach. The toy company wants you to come up with as many different ways of doing that as you can. You can use anything you can think of, and if these materials on the table are helpful, you can use them, too, in any way you wish. Show me and say exactly what to do. Remember, think up as many different ways to do this as you can.

Social Story: **Rabbit's New Friend**

Once upon a time there was a friendly rabbit who lived in the forest. He was friends with everybody and he loved to throw parties for all the animals he knew. One day he was out in the forest collecting flowers to decorate his home, and lots of tasty vegetables to feed to his friends. He was planning a big party that night and had invited every friend he had. It was going to be great fun. Suddenly, he was stopped in his path by a large menacing monster. The monster looked down at him and snarled in a deep voice, saying that he was going to eat the rabbit for a snack. The rabbit was trembling with fear. Every animal in the forest knew about the monster, but no animal who had ever seen him had lived to tell about it. The rabbit's first thought was that this was the end, but then he had an idea that he hoped would save him.

The rabbit held up his paw and pleaded with the monster to let him say something before the monster ate him. The monster was only a bit hungry, so he agreed. In a very calm, pleasant voice the rabbit started talking to the monster about not wanting to be eaten and that he had lots of tasty vegetables here that the monster could eat instead. The rabbit talked about becoming friends and how much nicer it is to be friends than enemies. He noticed that the monster was listening. The rabbit felt encouraged and told him that he could get enough to eat and not be hungry by eating vegetables, and be happier by having the rabbit as his friend. The rabbit even offered to help him make new friends. The monster thought about what the rabbit said, then thought about how lonely he was without any friends to play with. He bit off a chunk of the rabbit's vegetables, decided that they really were tasty, and gave the rabbit a big smile. In relief, and happy to have a new friend, the rabbit shook hands with the monster and sealed a new friendship. It wasn't long before the monster had as many friends as the rabbit, and was just as happy.

Transfer Task: **Fight Problem**

This boy/girl is not very smart, and is having a lot of trouble in math, and is far behind the class. You are smart and find math really easy. You accidentally ruin this boy's/girl's math homework. He/she thinks it was done on purpose, is really mad and frustrated, and tells you that he/she is going to `get you' after school. The teacher tells the class to get in their seats, and there isn't time for you to explain. You are really scared because the other boy/girl is stronger and bigger than you. It's now the end of school and the boy/girl is waiting for you here [point on board]. I want you to figure out as many ways as possible to get out of this. Show me and say exactly what to do. Remember, think up as many different ways to do this as you can.

APPENDIX A.5
Sorting Task and Scoring Example

The following are the scenarios for the "Biological Principles" and "Potential Peer Conflict" themes. Also included are the Underlying Principles and Surface Features for each theme.

Biological Principles:

The Capricorn Beetle is a type of insect. It has 2 stiff outer wings and 2 wings hidden underneath. If a dangerous animal is near, the Capricorn Beetle opens it's wing to look like a wasp.

UP: visual mimicry SF: description

The Seahorse's head looks like a horse. It has a long snout on it. It can hide from danger because it can match all background colors.
UP: camouflage SF: description

The Arctic Fox is from the dog family. It is most often seen up north in the Arctic. Gray in summer and white in the winter, the Arctic Fox blends into it's surroundings.

UP: camouflage SF: where it lives

The Purple Martin Is a kind of bird. It feeds on mosquitos. In the places where they live, mosquitos are much less of a bother to people.

UP: natural pest control SF: what it feeds on

The Hawkmoth Caterpillar is a long worm-like larva. It is seen most often in South America. It turns over to show marks on its underside that look like a poisonous snake.

UP: visual mimicry SF: where it lives

The Chameleon is a type of lizard. It feeds on insects. It is able to change color, so that it is very hard to see in the shadows of the forest.

UP: camouflage SF: what it feeds on

The Manatee is a large water mammal. It is seen most often in Florida's water ways. The Manatee eats the weeds that clog the river and hinder pleasure boating.

UP: natural pest control SF: where it lives

The Ladybug is part of the beetle family. It's shell has bright colors on it. It kills little white bugs called aphids that grow on and can ruin hops and orange crops.

UP: natural pest control SF: description

The Crested Rat is in the rodent family. It feeds on almost anything that can be eaten. It parts it's hair to show skunk-like markings to protect itself.

UP: visual mimicry SF: what it feeds on

Possible Peer Conflict:

It is recess, and you see your friends at the far end of the playground. You start to walk toward them to join their game. You pass by some other boys kicking a soccer ball. As you walk by, you get hit in the back with the ball.

UP: physical provocation SF: on the playground

You are on the playground waiting for the bell to ring. You just got your hair cut last night. As you walk by two boys in your class playing catch, they both start to laugh.

UP: embarassment SF: on the playground

You are in gym class. Captains are chosen to play baseball and they start to pick team members. The teacher asks the captains to take turns choosing. You are the last one to get picked for a team.

UP: rejection SF: gym class

In language arts class, the teacher is discussing a story with the class. She calls on you to answer an easy question. You did not know the answer. As the teacher is asking someone else to answer, you hear two boys behind you whispering and giggling.

UP: embarassment SF: in class

During science class the teacher tells everyone to split up into small groups to work on a project. You see a lot of boys two rows from you. You go over and ask if you can be in their group. They say "no".

UP: rejection SF: in class

You were out on the playground and a boy suggested that everyone play a game of tag. You were standing nearby, and want to play the game. The boy asks everyone who is standing around to play except you.

UP: rejection SF: on the playground

You were really hot and thirsty from exercising in the gym. You were waiting in line to get a drink of water. A boy comes running up behind you and smashes right into you, knocking you down on the ground.

UP: physical provocation SF: gym class

Everyone in your class is making a poster in art. Your teacher says it is almost time to clean up. One of the boys in your class comes over, reaches for a jar of paint, bumps into you, and spills paint all over your poster.

UP: physical provocation SF: in class

The teacher asked everybody to line up to jump the high jump. With the high jump bar still low, everybody in your gym class clears the bar without trouble. You are the last one to try and you knock the bar off the stands. Lying on the mat, you see a couple of boys making faces.

UP: embarassment SF: gym class

Scoring example of Underlying Principles and Surface Features for the "Biological Principles" theme.

FIRST PILE: Subjects comment: "How it looks dangerous"

The Capricorn Beetle is a type of insect. It has 2 stiff outer wings and 2 wings hidden underneath. If a dangerous animal is near, the Capricorn Beetle opens it's wing to look like a wasp.

The Hawkmoth Caterpillar is a long worm-like larva. It is seen most often in South America. It turns over to show marks on its underside that look like a poisonous snake.

Score: UP - 1 (visual mimicry), SF - 0

SECOND PILE: Subjects comment: "Talking about what it eats"

The Purple Martin Is a kind of bird. It feeds on mosquitos. In the places where they live, mosquitos are much less of a bother to people.

The Chameleon is a type of lizard. It feeds on insects. It is able to change color, so that it is very hard to see in the shadows of the forest.

The Manatee is a large water mammal. It is seen most often in Florida's water ways. The Manatee eats the weeds that clog the river and hinder pleasure boating.

The Ladybug is part of the beetle family. It's shell has bright colors on it. It kills little white bugs called aphids that grow on and can ruin hops and orange crops.

Score: UP - 0, SF - 1 (what it feeds on)

THIRD PILE: Subjects comment: "camouflages"

The Seahorse's head looks like a horse. It has a long snout on it. It can hide from danger because it can match all background colors.

The Arctic Fox is from the dog family. It is most often seen up north in the Arctic. Gray in summer and white in the winter, the Arctic Fox blends into it's surroundings.

The Crested Rat is in the rodent family. It feeds on almost anything that can be eaten. It parts it's hair to show skunk-like markings to protect itself.

Score: UP - 1 (camouflage), SF - 0

TOTAL SCORE: UP - 2, SF - 1

APPENDIX B

Harter's (1982) Teacher and Child Self Report Rating Scales

"Teacher Rating Scale of Child's Actual Behavior" (Harter, 1982)

TEACHER'S RATING SCALE OF CHILD'S ACTUAL BEHAVIOR

(Parallels the self-perception profile for children)

Really True	Sort of True				Sort of True	Really True
☐	☐	This child is really good at his/her school work.	OR	This child can't do the school work assigned.	☐	☐
☐	☐	This child finds it hard to make friends.	OR	For this child it's pretty easy.	☐	☐
☐	☐	This child often forgets what s/he learns.	OR	This child can remember things easily.	☐	☐
☐	☐	This child has a lot of friends.	OR	This child doesn't have many friends.	☐	☐
☐	☐	This child has trouble figuring out the answers in school.	OR	This child almost always can figure out the answers.	☐	☐
☐	☐	This child is popular with others his/her age.	OR	This child is not very popular.	☐	☐

"Self Perception Profile for Children" (Harter, 1982)

SAMPLE SENTENCE

	Really True for me	Sort of True for me				Sort of True for me	Really True for me
(a)	☐	☐	Some kids would rather play outdoors in their spare time	BUT	Other kids would rather watch T.V.	☐	☐
1.	☐	☐	Some kids feel that they are very *good* at their school work	BUT	Other kids *worry* about whether they can do the school work assigned to them.	☐	☐
2.	☐	☐	Some kids find it *hard* to make friends	BUT	Other kids find it's pretty *easy* to make friends.	☐	☐
7.	☐	☐	Some kids feel like they are *just as smart* as as other kids their age	BUT	Other kids aren't so sure and *wonder* if they are as smart.	☐	☐
8.	☐	☐	Some kids have *alot* of friends	BUT	Other kids *don't* have very many friends.	☐	☐
13.	☐	☐	Some kids are pretty *slow* in finishing their school work	BUT	Other kids can do their school work *quickly*.	☐	☐
14.	☐	☐	Some kids would like to have alot more friends	BUT	Other kids have as many friends as they want.	☐	☐
19.	☐	☐	Some kids often *forget* what they learn	BUT	Other kids can remember things *easily*.	☐	☐
20.	☐	☐	Some kids are always doing things with *alot* of kids	BUT	Other kids usually do things *by themselves*.	☐	☐
25.	☐	☐	Some kids do *very well* at their classwork	BUT	Other kids *don't* do very well at their classwork.	☐	☐
26.	☐	☐	Some kids wish that more people their age liked them	BUT	Other kids feel that most people their age *do* like them.	☐	☐
31.	☐	☐	Some kids have *trouble* figuring out the answers in school	BUT	Other kids almost *always* can figure out the answers.	☐	☐
32.	☐	☐	Some kids are *popular* with others their age	BUT	Other kids are *not* very popular.	☐	☐

APPENDIX C
Academic and Social Themes

The following are the 'academic' and 'social' themes used in the sorting task, and the underlying principles (UP) and surface features (SF) created for each theme.

Academic Themes:

1) Biological Principles (descriptive)

2) Environmental Waste Control (descriptive)

3) Arithmetic Word Problems (problem)

4) Water Principles (problem)

Social Themes:

5) Social Skills (descriptive)

6) Rejection Situations (descriptive)

7) Potential Peer Conflict (problem)

8) Unsuccessful Personality Types (problem)

1) Biological Principles:

CARD A: [UP - visual mimicry, SF - physical characteristics]

If a dangerous animal is near, the Capricorn Beetle opens it's wing to look like a wasp. It is a type of insect. It has 2 stiff outer wings and 2 wings hidden underneath.

CARD B: [UP - camouflage, SF - physical characteristics]

The Seahorse's head looks like a horse. It can hide from danger because it can match all background colors. It has a long snout on it.

CARD C: [UP - camouflage, SF - where it lives]

Gray in summer and white in the winter, the Arctic Fox blends into it's surroundings. It is from the dog family. It is most often seen up north in the Arctic.

CARD D: [UP - natural pest control, SF - what it feeds on]

The Purple Martin feeds on mosquitos. In the places where they live, mosquitos are much less of a bother to people. It is a kind of bird.

CARD E: [UP - visual mimicry, SF - where it lives]

The Hawkmoth Caterpillar is a long worm-like larva. It is seen most often in South America. It turns over to show marks on its underside that look like a poisonous snake.

CARD F: [UP - camouflage, SF - what it feeds on]

The Chameleon is a type of lizard. It feeds on insects. It is able to change color, so that it is very hard to see in the shadows of the forest.

CARD G: [UP - natural pest control, SF - where it lives]

The Manatee eats the weeds that clog the river and hinder pleasure boating. It is a large water mammal. It is seen most often in Florida's water ways.

CARD H: [UP - natural pest control, SF - physical characteristics]

The Ladybug is part of the beetle family. It's shell has bright colors on it. It kills little white bugs called aphids that grow on and can ruin hops and orange crops.

CARD I: [UP - visual mimicry, SF - what it feeds on]

The Crested Rat feeds on almost anything that can be eaten. It parts it's hair to show skunk-like markings to protect itself. It is in the rodent family.

2) **Environmental Waste Control**

CARD A: [UP - recycling, SF - containers]

Tin cans keep foods that go bad quickly, tasting good. Tin cans are made of metal, and after they have served their purpose, they can be melted down for more cans. They are a great way to hold and store food for a long time.

CARD B: [UP - landfill waste, SF - common use]

Disposable diapers are very common to use because they can be thrown out. People are starting to use cloth diapers more so we do not fill garbage dumps with disposable diapers. Babies go through many diapers each day.

CARD C: [UP - recycling, SF - containers]

Glass bottles are good to hold and store liquids. People have been using glass bottles for a long time. When a glass bottle is empty it can often be sent back to the company and re-filled.

CARD D: [UP - composting, SF - common use]

People do not like the smell of manure, but still use it on their lawns. Using manure is a common way to help plants grow. Manure comes from animal droppings and is helpful in all kinds of gardens, from a small patch of grass to a large field.

CARD E: [UP - recycling, SF - jobs]

Once a newspaper is not of any use, it can be mixed with water, dried, and made into newsprint. Lots of kids have a job delivering papers. The news helps to keep people in touch with the world around them.

CARD F: [UP - landfill waste, SF - jobs]

Some scientists have the job of studying strong chemicals. Many are part of our daily needs, like the chemical that keeps a fridge cold. Some are so harmful, that once we are done with them, we can not get rid of them.

CARD G: [UP - composting, SF - jobs]

In good weather, a lawn must be cut once a week. Leaving the cut grass where it falls on the lawn is good for the grass, and it makes grass cutting an easier job, too. Lots of kids have a job cutting grass and get paid for each lawn cut.

CARD H: [UP - composting, SF - common use]

Fruit that is left on the ground will rot, and is healthy for the soil. Fruits are a very common part of a good diet. You should not make a mess, but it's okay to throw pieces of fruit (like apple cores) on the ground.

CARD I: [UP - landfill waste, SF - containers]

When plastic containers are thrown out they will stay in one piece and will not rot for years and years. They can hold and you can store most things in them. The containers are cheap to make, and have many uses.

3) Arithmetic Word Problems

CARD A: [UP - addition, SF - number]

John and Kate were both collecting stamps to put in one album. John had 26 and Kate had 35. They wanted to figure out the number of stamps that would be in the album.

CARD B: [UP - addition, SF - hours]

He was trying to decide exactly how long before he could leave. Ken wanted to go and bowl. First, he had to clean the house for 2 hours, jog for 1 hour, and walk the dog for half an hour.

CARD C: [UP - division, SF - number]

He had a box of smarties with 30 smarties in it to give to the kids. He was trying to decide what number of smarties would be fair to give to each kid. Joe was babysitting 3 kids.

CARD D: [UP - division, SF - money]

They wanted to figure out how much money they could get for each bushel of apples picked. Tom picked 2 bushels and Bob picked 3 bushels of apples. They were paid $20.00 altogether.

CARD E: [UP - subtraction, SF - hours]

Ted worked 3, 4, and 2 hours, while Dave worked 4, 1, and 3 hours, during the week. They were trying to figure out who did the most homework. Ted and Bill did homework on three nights.

CARD F: [UP - subtraction, SF - number]

They were trying to decide who had the bigger grocery bill for cat food. Kim has 8 black cats and 5 white cats, and Jack has 7 gray cats and 4 brown cats. All cats eat about the same amount of food.

CARD G: [UP - subtraction, SF - money]

Mary worked for a day on one job and made $9.00. She worked for a day on another job and made $5.00. She wanted to know how much more money she got on the first job.

CARD H: [UP - addition, SF - money]

They put together all of the money. They want to know the total amount that they will give to the charity. Kim raised $110.00 for the charity and Jim raised $95.00 for the charity.

CARD I: [UP - division, SF - hour]

Pat and Sue could wash 3 cars in an hour. There were 24 cars to wash. They wanted to know how long they would have to work until they could go home.

4) Water Principles

CARD A: [UP - displacement of water, SF - man]

A man put a big load of rocks into his wheelbarrow and rolled it to the side of the pond. He wanted to make the pond wider and more shallow. A man had a small but deep pond.

CARD B: [UP - sinking, SF - glass]

A young boy wanted a snack, so he poured some milk into a glass and dropped a cookie on top of the milk. He put away the cookie jar and milk bottle, and cleaned up his mess. When he went to get his glass of milk, the cookie had disappeared.

CARD C: [UP - sinking, SF - man]

A man in a new lake saw some rocks just below the water's surface. He was afraid that other people might not see the rocks and crash their boats into them. He grabbed an empty plastic container and an old rope that were in his boat.

CARD D: [UP - displacement of water, SF - animal]

A thirsty crow found a pitcher with a little water in it. The pitcher was so deep, the crow could not reach the water with his beak. He saw some stones by the pitcher and started picking them up with his beak.

CARD E: [UP - sinking, SF - man]

A man robbed a bank and was chased by police to a river. He found a boat, jumped in, and started to row away. The police wanted to catch him but not hurt him, so they aimed their guns at the bottom of the boat.

CARD F: [UP - displacement of water, SF - glass]

The large glass made it look like there wasn't very much pop in the glass. A boy had poured a drink into a large glass. He walked over to the fridge, opened the ice box and grabbed the ice cubes.

CARD G: [UP - floatation, SF =animal]

The river was wide and the monkey could not swing across between the trees. He saw a big, flat piece of wood caught in some weeds and went to get it. A monkey wanted the big bananas on the other side, but could not swim.

CARD H: [UP - sinking, SF - animal]

The penguin's mother tricked the baby into going on a raft that had holes in it. She knows that penguins must learn how to swim so they can fish and eat. The baby penguin did not like to get wet and could not swim.

CARD I: [UP - floatation, SF - animal]

Somebody was pouring a strong drink in the glass, and the bug could not swim. A small bug had fallen in a glass with a couple of sweet cherries in it. He saw that the cherries were at the top of the water and tried to reach them.

5) Social Skills

CARD A: [UP - sharing/cooperation, SF - computer]

A bunch of your friends are over at your house and everybody wants to play. You just got a new computer game for your birthday. Since only two people can play at a time, you decide to let each person have ten minutes on the computer at a time.

CARD B: [UP - nonverbal communication, SF - lunch hour]

At lunch hour, your friends outside see you in the classroom and are jumping up and down and waving their arms at you. You can't hear what they are saying, only see them. While eating your lunch, you see a bunch of your friends on the playground.

CARD C: [UP - joining, SF - computer]

You have room for one more member, so you invite him to join your group. You see that one boy in your class is not in a group. You have just formed groups to da a project on the computer.

CARD D: [UP - joining, SF - lunch hour]

Neither soccer game has many players. During the lunch hour, you and a few kids are playing soccer, and some other kids are also playing soccer. You talk it over with your friends, then suggest to the other group to play together.

CARD E: [UP - nonverbal communication, SF - four friends]

It is a tough game and you and your 4 friends are playing well. You and four of your friends have been practicing for weeks for this big game. You look over at your coach and he gives you the thumbs up sign.

CARD F: [UP - joining, SF - four friends]

You see 4 of your friends having a lot of fun playing tennis. You would really like to play, but there is no one else around. You ask the four boys if you could be a substitute for their game when somebody needs a rest.

CARD G: [UP - sharing/cooperation, SF - lunch hour]

You did not bring a lunch and are starving by lunch hour. You are working on your homework to forget about eating. A boy near you notices that you don't have a lunch and offers you some of his.

CARD H: [UP - nonverbal communication, SF - computer]

Your best friend is presenting his project about uses of the computer to the class. You are listening carefully and smiling while he talks. Most of the other kids in your class are yawning.

CARD I: [UP - sharing/cooperation, SF - four friends]

The 4 boys see that you do not have a glove and decide to take turns and let you use their gloves. Four of your friends are on the playground practicing. You forgot to bring your baseball glove to school to practice catching.

6) Rejection Situations

CARD A: [UP - accidental, SF - party]

The boy did not ask you because you were behind one kid and he did not see you. You want to go to the games party, but the boy asked everyone to come but you. The boy wants to have a games party and it sounds like fun.

CARD B: [UP - intentional, SF - party]

You want to go to the party, but the boy asks everyone to be there but you. The boy is planning a party. He did not ask you because he knows how much you want to ba a part of the group and is just being mean.

CARD C: [UP - justified, SF - forming a group]

You like to play the drums, but the boy asks everyone to join the band but you. In music class, a boy was talking about forming a group. He did not ask you because you are always making fun of kids when they play their instruments.

CARD D: [UP - intentional, SF - weekend]

At recess, some of the boys are talking about going skating this weekend. You love to go skating, but they ask everyone to go but you. They did not ask you because they thought it would be fun to see how mad you would get.

CARD E: [UP - intentional, SF - forming a group]

The boys did not ask you because they are being nasty and want to make you feel bad. You would like to be in the club, but the boys ask everyone to attend but you. Some boys are talking about forming an "after school" group.

CARD F: [UP - justified, SF - party]

A boy wants everyone to come to his place for a video party. You like to see videos, but the boy asks everyone to go but you. He did not ask you because you did not ask him to your place last weekend.

CARD G: [UP - justified, SF - weekend]

The boy did not ask you because he had a fight with you and you called him some bad names. You would like to go bowling, but he asks everyone to attend but you. The boy was talking to everyone about going bowling this weekend.

CARD H: [UP - accidental, SF - forming a group]

A boy is talking about forming a study group for math. You want to be in the group, but he asks everyone to go but you. He did not ask you because he thought you knew that you were invited, and he did not mean to leave you out.

CARD I: [UP - accidental, SF - weekend]

You like swimming, but the boys ask everyone to join in but you. During gym, some boys are planning to go swimming on the weekend, and it sounds like fun. They did not ask you because you were shaking your head and looked like you could not go.

7) **Possible Peer Conflict**

CARD A: [UP - physical provocation, SF - playground]

You start to walk to your friends, to join their game. It is recess, and you see them at the far end of the playground. You pass by some other boys kicking a soccer ball and as you walk by, you get hit in the back with the ball.

CARD B: [UP - embarassment, SF - playground]

As you walk by two boys in your class playing catch, they both start to laugh. You just got your hair cut last night. You are on the playground waiting for the bell to ring.

CARD C: [UP - rejection, SF - gym class]

Captains are chosen to play baseball and they start to pick team members. You are in gym class and the teacher asks the captains to take turns choosing. You are the last one to get picked for a team.

CARD D: [UP - embarassment, SF - in class]

In language arts class, the teacher is discussing a story with the class. She calls on you to answer an easy question but you did not know the answer. As the teacher is asking someone else to answer, you hear two boys behind you whispering and giggling.

CARD E: [UP - rejection, SF - in class]

During science class the teacher tells everyone to split up into small groups to work on a project. You see a lot of boys two rows from you. You go over and ask if you can be in their group and they say "no".

CARD F: [UP - rejection, SF - playground]

A boy asks everyone who is standing around to play except you. You were out on the playground and the boy suggested that everyone play a game of tag. You were standing nearby, and want to play the game.

CARD G: [UP - physical provocation, SF - gym class]

A boy comes running up behind you and smashes right into you, knocking you down on the ground. You were waiting in line to get a drink of water. You were really hot and thirsty from exercising in the gym.

CARD H: [UP - physical provocation, SF - in class]

Everyone in your class is making a poster in art. Your teacher says it is almost time to clean up. One of the boys in your class comes over, reaches for a jar of paint, bumps into you, and spills paint all over your poster.

CARD I: [UP - embarassment, SF - gym class]

With the high jump bar still low, everybody in your gym class clears the high jump bar without trouble. You are the last one to try and you knock the bar off the stands. Lying on the mat, you see a couple of boys making faces.

8) Unsuccessful Personality Types

CARD A: [UP - bully/aggressive, SF - skating]

You are playing hockey at the skating rink, but you are one man short. Les plays hockey and is at the rink looking for a game to join. You do not know if you should ask him because he always gets into fights.

CARD B: [UP - bully/aggressive, SF - neighborhood]

You wish Chris would not show up to play because he always ends up yelling and swearing. Everybody else is a good sport when you play baseball. You are forming a baseball game with the kids in your neighborhood.

CARD C: [UP - selfish, SF - in class]

You mom asks you to be friends with the son of her friend. He is in your class and does not have a friend. You feel sorry for him, but he does things like keeping the best for himself when handing out stuff in class.

CARD D: [UP - bully/aggressive, SF - in class]

Jess asked if he could be part of your group. You just started a group project in class. You would like Jess to go to another group because he argues a lot and makes people do stuff they do not want to do.

CARD E: [UP - shy/withdrawn, SF - in class]

You do not want to ask Brad to be in your group because he never smiles, and does not hang around with anybody. He is sitting near your group in class. Brad is the only person in your class that has not joined a group to put on a play.

CARD F: [UP - shy/withdrawn, SF - neighborhood]

Pat lives in your neighborhood, but you do not like to play with him. Your teacher asks you to try to involve Pat in games outside of school. You do not want to because he sticks to himself and does not try to talk to other kids.

CARD G: [UP - selfish, SF - skating]

As captain of the team, you have to tell Jim to stop eating most of the pizza. It is fun to talk about skating while eating pizza but Jim never shares. After skating, the coach always orders a pizza.

CARD H: [UP - shy/withdrawn, SF - skating]

Jamie is the one kid that takes lessons who does not have fun. He is in the same skating lessons as you. You feel bad for Jane, but it is hard to be friends because he never joins in the fun and always skates alone.

CARD I: [UP - selfish, SF - neighborhood]

Everybody in your neighborhood hopes that Steve will not be at the playground. Everybody likes to swing on the rope. You wish there was something you could do about him because he always hogs the rope and does not let others try it.

APPENDIX D

Scoring Key for the Underlying Principles and Surface Features for Each Theme, followed by an example of the Categorical and Quantitative Scoring Systems for Two Subjects

Themes were scored according to underlying principles (UP) or surface features (SF). For the categorical scoring method, each pile sorted appropriately according to the scoring key below received a point, with a maximum of 3 points for each theme. For the quantitative scoring method, each scenario categorized in a meaningful fashion according to the scoring key below, received one point, for a maximum score of nine for each theme. Each scenario or card is represented by a letter (from A to I; see Appendix C for each scenario and the corresponding letters).

Scores were based on the letters provided by the subjects and the accompanying comments describing their rationale for grouping the scenarios together. Comments only needed to reflect the 'gist' of the descriptors listed in the scoring key. Every attempt was made not to make scoring dependent on written expressive skills. Thus, relevant written comments resulted in greater ease with scoring, while poorly described or non-existent comments required closer analysis of the letter groupings in order to discern the rationale employed by the subject. The following guidelines were used when responses were not presented in a manner that easily fit into the scoring criterion:

1) If comments were inadequate or nonexistent, but the groupings fell into categories reflected in the scoring key, credit was given.

2) When too many scenarios were grouped together, with several falling into a given category and one or two additional scenarios that did not 'fit', and if half or more of the scenarios were appropriately grouped, those scenarios received credit.

3) When only a few scenarios were grouped together and several more could have been included, and if the grouping fit the scoring criterion, then the scenarios were credited.

4) If only one scenario was presented for one category, this generally did not receive any credit (since no relationship can be discerned), <u>unless</u> the other two categories demonstrated groupings that clearly excluded the individual scenario (thereby, demonstrating a distinctive relationship by exclusion).

5) If a rationale was stated but the cards did not reflect the rationale, nor any similar rationale according to the scoring criterion, then no credit was given.

6) If a rationale was given that was so general that it did not discriminate categories (e.g., stating that a subset of scenarios in the rejection situations reflects rejection, and the grouped scenarios could not be discriminated from the rest), then no credit was given.

7) No credit was given when the comments were incorrect and the grouped scenarios did not 'fit' in any coherent fashion.

In order to be considered an underlying principle, the grouping of scenarios needed to represent information that is not directly stated, but is a concept or underlying theme that ties the scenarios together. A surface feature is a salient detail that is clearly stated in the scenarios. It would include specific objects or actions, or specific words common to the scenarios grouped together. Some information may not be explicitly stated, but refers to a common detail presented in the scenario that does not reflect an understanding of the underlying intent of the scenario. Features that did not relate to the content of the scenarios, but rather to basic syntactic or graphic similarities (e.g, grouping all scenarios that end with an 's'), were not scored. It was felt that, while this type of information could be considered a surface feature, it was qualitatively inferior to surface features referring to story content. These types of categories tended to occur infrequently, and appeared to represent 'groping in the dark' attempts by subjects to come up with some kind of similarity during the second sort. Furthermore, comparing scoring systems with and without the inclusion of this type of information did not yield any significant differences in results.

The following is the scoring key of UP and SF for the various themes. The capital letters identify the specific scenarios. Bracketed groupings of letters refer to more general groupings or an extension of a principle or feature that was considered valid.

ACADEMIC THEMES:

Biological Principles:

Underlying Principles:

visual mimicry (become more dangerous) - AEI
camouflage - BCF
natural pest control - DGH (F)
animals that lay eggs - BDEFH
animals that kill something - DH

Surface Features:

"feeds on"/eats (insects) - DFI (GH)
"most often seen"/lives - CFG
description - ABH (GECI), "looks like" - ABF
colors of animals - BFH (CD)
"family" ("kind of","type of") - CHI (DF)
in water (swim) - BG; "beetle" family - AH
fly (has wings) - ADH; have fur - CGI
on land - ACEFI; four legged - CFGI

Environmental Waste Control:

Underlying Principles:

recycle - ACE / re-use things - ACEI(H)
compost (nature/use for lawns/discard) - DGH
landfill waste (harmful to us/problems) - BFI
containers prolong life of food - ACI
something going bad - AGH; rot/droppings/waste - BD
people don't like them, smell/odor - BDF (GH)

Surface Features:

"containers"/"holdand store" (food) - ACI (F)
"common" use - BDH; "kids"/babies - BEG
job - EFG; lawns and garden / ground - DGH
liquids - CE; food and drink - ACHI
people - BCDE (F)

Arithmetic Word Problems:

Underlying Principles:

summation/add - ABH; must use +(total) - ABEFH
difference/subtract - EFG (B)
division/fractions (multiplication, rate) - CDI
comparing - EFG; working together - ADHI
give something away/sharing/being kind,generous - CH
1 math step - DEF; > 1math step - ABCHI

Surface Features:

number - ACF (I); collecting - ADH
hours / "how long" - BEI; animals - BF
money - DGH (F); "work" (jobs) - EGI (BCD)
objects - AC (I); more/bigger/most - EFG
"trying to decide"/decision making - BCF
"to figure out" - ADE; "want to know" - GHI
"altogether" - DH; how much - DG (H)
to do with food - CDF; boy and girl - AFHI
about 1 person - BCG; about 2 people - ADEFHI
about girls - GI; about boy(s) - BC(DE)

Water Principles

Underlying Principles:

floating - CGI; something floats - EFGI
(will) sink - (D)BEH; they'll get wet - EHI
displacement of water (changing size) - ADF
something heavy in water - ABDF
trying to get food - BGH; disintegrating - BF
concerning safety (accidents) - CEHI
don't want people harmed/ warnings - CE
hurting another person/animal (for own good) - CH
helping/ helping yourself - ADEGI
used rock to get/finish something - AD
try to fix something/do themselves - ACG
teaching a lesson - EGH
intent given but not specified - ADG

Surface Features:

man - ACE; boy - BF; human - ABCEFI
glass, thirsty/drink - BFI (D); container - BCDFI
animal - DGHI; bird - DH; wood - GH
soft drink - BF; "could not swim" - GHI
reach / trying to get something - DI (EG)
man, water and boat - CE; rock/stones - ACD
pond/river/lake - ACEG (H); eating - BGH
water transportation - CEGH; liquid (not H2O) - BFI
uses fridge - BF; "want something" - ABEG
disappeared - BF; trying to cross river - EG (F)
dropping into something - ABDF
couldn't do something - DGI

Social Themes

5) Social Skills

Underlying Principles:

sharing/cooperation - AGI (DF); take turns - AFI
joining - CDF; include another person - CGI
communication - BEH; make a new friend - CG
suggestions - DF; you solve a problem/help others - ACDF
give/offer you something - GI; organize groups - ACD

look for/give approval - EH; miss out on something - BGI
you don't leave a person out (isolated person) - CFGI (B)
playing together as one - DE; helps/kindness - EGI

Surface Features:

computer / indoor activities - ACH; project - CH
4 kids/friends - EFI; forget something - GI
lunch hour (time) - BDG (A); tired - FH
sports/ play outside - DEFI (B); game - ADEFI
at school - BCDGH; out of school - AEFI; inside - ACGH
"practicing" - EI; give you something - EG

6) Rejections Situations

Underlying Principles:

accident - AHI; being misunderstood - HI
intentional, mean on purpose - BDE; revenge - CFG
justified, deserve it - CFG; not physically active - BCFH
you influenced their decision in some way - CGHI

Surface Features:

party - ABF; "wants to go" - ABH
form a group - CEH; "(would) like to" - CFI (EG)
weekend (sports) - DFGI; talking - CDGH
school - CDH (EI); classes - CH
out of school activities - ABDEFI

7) Possible Peer Conflict

Underlying Principles:

embarassment - BDI; make mistakes - DI
rejection (lonely) - CEF; can't do something - DEFI
provocation - AGH; accident - AGHI; get hurt - AGI
feelings hurt by what someone says - BDE
teacher initiated - CDEHI; self initiated - AB
other (peer) initiated - FG; embar't is own fault - DEI
embar't is caused by others - AGH; embar't has no clear cause - BCF

Surface Features:

gym - CGI (B); choosing - CF; laughing - BD
playground - ABF (I); last one - CFI; teacher - CDEHI
class (school) - DEH (CGI); extra curricular - DEGI
playing games - ABCF (G); sports - ABCFI; ball - ABC
"walking" by people - AB; "waiting" - BG (C)
groups - AE (C); you are talking - DE

8) Unsuccessful Personality Types

Underlying Principles:

bully - ABD; not compelled to take action - ABFHI
selfish - CGI; feel compelled to do something - CDFG
shy/withdrawn - EFH; difficulty joining groups - CDEFH
lonely/needs friends/don't hang around with others - CEFH
people who are pitied - CH; ambivalent feelings - ACH
deals with your free time - CFI

Surface Features:

skating - AGH; hope person won't show up - BI
neighborhood/ out of school/ playground - BFI
"groups" at school - CDE; about school - CDEFH
sports - ABGH; games - ABFGHI; "art" - DH;
someone asks you to do something - CDF; fun - GH
you feel bad/sorry for person - CH; pair - CFH
groups - DE (ABFG); "you wish" - BI

An Example of the Categorical and Quantitative Scoring Systems for the FIrst and Both Sorts for two Subjects

The following is an example of how the "Unsuccessful Personality Types" theme was sorted by two subjects on their first and second sorts, and includes their written responses. The categorical and quantitative scoring systems follow the subjects responses.

The first subject identified surface features (SF) correctly for all scenarios during the first sort and no underlying principles (UP). This resulted in categorical scores of 3 for SF and 0 for UP and omission, and quantitative scores of 9 for SF and 0 for UP. On the second sort, the subject identified UP only, resulting in categorical scores of 3 for UP and 0 for SF and omission, and quantitative scores of 9 for UP and 0 for SF. Taken together (i.e., both sorts), this subject received categorical scores of 3 for UP and 3 for SF and 0 for omission, and quantitative scores of 9 for UP and 9 for SF. Thus, subject one was able to identify both UP and SF, and identified the UP after further considerations of the materials, during the second sort.

The second subject focussed on UP in the first sort. All three piles correctly identified UP, resulting in categorical scores of 3 for UP and 0 for SF and omission. Card 'C' in the second pile was incorrectly placed and consequently could not be credited in the quantitative scoring, resulting in quantitative scores of 8 for UP and 0 for SF. During the second sort, the second subject's first and second piles were overlapping and too general, while the third pile correctly contained SF. This resulted in categorical scores of 2 for omission, 1 for SF and 0 for UP. Card 'B' was incorrectly placed in the third pile, resulting in quantitative scores of 3 for SF and 0 for UP. Taken together, both sorts yielded categorical scores of 3 for UP and 1 for SF and 2 for omission, and quantitative scores of 8 for UP and 3 for SF. Thus, the second subject focussed on UP initially, then considered the materials too generally and only grouped scenarios according to one SF in the second sort.

Sorting of the "Unsuccessful Personality Types" theme, and Categorical and Quantitative Scores, for two Subjects.

SUBJECT # 1 - FIRST SORT

Your mom asks you to be friends with the daughter of her friend. She is in your class and does not have a friend. You feel sorry for her, but she does things like keeping the best for herself when handing out stuff in class C	You are playing hockey at the skating rink, but you are one man short. Les plays hockey and is at the rink looking for a game to join. You do not know if you should ask her because she always gets into fights. A	You wish Chris would not show up to play because she always ends up yelling and swearing. Everybody else is a good sport when you play a baseball with the kids in your neighborhood. B
Jess asked if she could be part of your group project in class. You would like Jess to go to another group because she argues a lot and makes people do stuff they do not want to do. D	As captain of the team, you have to tell Kim to stop eating most of the pizza. It is fun to talk about skating while eating pizza but Kim never shares. After skating, the coach always orders a pizza. G	Pat lives in your neighborhood, but you do not like to play with her. Your teacher asks you to try to involve Pat in games outside of school. You do not want to because she sticks to herself and does not try to talk to other kids. F
You do not want to ask Barb to be in your group because she never smiles, and does not hang around with anybody. She is sitting near your group in class. Barb is the only person in your class that has not joined groups to be in a play. E	Jane is the one kid that takes lessons who does not have fun. She is in the same skating lessons as you. You feel bad for Jane, but it is hard to be friends because she never joins in the fun and always skates alone. H	Everybody in your neighborhood hopes that Sue will not be at the playground. Everybody likes to swing on the rope. You wish there was something you could do about her because she always hogs the rope and does not let others try it. I

"It all involves a situation at school."	"They all have skating in them."	"You hope he won't show up to play."

SUBJECT # 1 - SECOND SORT

You are playing hockey at the skating rink, but you are one man short. Les plays hockey and is at the rink looking for a game to join. You do not know if you should ask her because she always gets into fights. A	Your mom asks you to be friends with the daughter of her friend. She is in your class and does not have a friend. You feel sorry for her, but she does things like keeping the best for herself when handing out stuff in class. C	You do not want to ask Barb to be in your group because she never smiles, and does not hang around with anybody. She is sitting near your group in class. Barb is the only person in your class that has not joined groups to be in a play. E
Your wish Chris would not show up to play because she always ends up yelling an swearing. Every body else is a good sport when you play baseball with the kids in your neighborhood. B	As captain of the team, you have to tell Kim to stop eating most of the pizza. It is fun to talk about skating while eating pizza but Kim never shares. After skating, the coach always orders a pizza. G	Pat lives in your neighborhood, but you do not like to play with her. Your teacher asks you to try to involve Pat in games outside of school. You do not want to because she sticks to herself and does not try to talk to other kids. F
Jess asked if she could be part of your group project in class. You would like Jess to go to another group because she argues a lot and makes people do stuff they do not want to do. D	Everybody in your neighborhood hopes that Sue will not be at the playground. Every body likes to swing on the rope. You wish there was something you could do about her because she always hogs the rope and does not let others try it. I	Jane is the one kid that takes lessons who does not have fun. She is in the same skating lessons as you. You feel bad for Jane, but it is hard to be friends because she never joins in the fun and always skates alone. H

"Somebody is doing something bad." "The person always hogs things." "Every person feels alone."

SUBJECT # 2 - FIRST SORT

As captain of the team, you have to tell Kim to stop eating most of the pizza. It is fun to talk about skating while eating pizza but Kim never shares. After skating, the coach always orders a pizza. G	Your mom asks you to be friends with the daughter of her friend. She is in your class and does not have a friend. You feel sorry for her , but she does things like keeping the best for herself when handling out stuff in class. C	You are playing hockey at the skating rink, but you are one man short. Les plays hockey and is at the rink looking for a game to join. You do not know if you should ask her because she always gets into fights. A
Everybody in your neighborhood hopes that Sue will not be at the playground. Every body likes to swing on the rope. You wish there was something you could do about her because she always hogs the rope and does not let others try it. I	You do not want to ask Barb to be in your group because she never smiles, and does not hang around with anybody. She is sitting near your group in class. Barb is the only person in your class that has not joined groups to be in a play. E	You wish Chris would not show up to play because she always ends up yelling and swearing. Everybody else is a good sport when you play baseball with the kids in your neighborhood. B
	Pat lives in your neighborhood, but you do not like to play with her. Your teacher asks you to try to involve Pat in games outside of school. You do not want to because she sticks to herself and does not try to talk to other kids. F	Jess asked if she could be a part of your group project in class. You would like Jess to go to another group because she argues a lot and makes people do stuff they do not want to do. D
	Jane is the one kid that takes lessons who does not have fun. She is in the same skating lessons as you. You feel bad for Jane, but it is hard to be friends because she never joins in the fun and always skates alone. H	

"Kids who don't share and hog things."

"They are left out."

"Everyone is angry and fighting."

SUBJECT # 2 - SECOND SORT

You do not want to ask Barb to be in your group because she never smiles, and does not hang around with anybody. She is sitting near your group in class. Barb is the only person in your class that has not joined groups to be in a play. E	Your mom asks you to be friends with the daughter of her friend. She is in your class and does not have a friend. You feel sorry for her, but she does things like keeping the best for herself when handing out stuff in class. C	Your are playing hockey at the skating rink, but you are one man short. Les plays hockey and is at the rink looking for a game to join. You do not know if you should ask her because she always gets into fights. A
Pat lives in your neighborhood, but you do not like to play with her. Your teacher asks you to try to involve Pat in games outside of school. You do not want to because she sticks to herself and does not try to talk to other kids. F	Jess asked if she could be part of your group project in class. You would like Jess to go to another group because she argues a lot and makes people do stuff they do not want to do. D	You wish Chris would not show up to play because she always ends up yelling and swearing . Everybody else is a good sport. When you play baseball with the kids in your neighborhood. B
	Every body in your neighborhood hopes that Sue will not be at the playground. Every body likes to swing on the rope. You wish there was something you could do about her because she always hogs the rope and does not let others try it. I	As captain of the team, you have to tell Kim to stop eating most of the pizza. It is fun to talk about skating while eating pizza but Kim never shares. After skating, the coach always orders a pizza. G
		Jane is the one kid that takes lessons who does not have fun. She is in the same skating lessons as you. You feel bad for Jane, but it is hard to be friends because she never joins in the fun and always skates alone. H
"They don't want to bother participating."	"They don't let others participate."	"Some thing to do with skating or lessons."

Summary of the Categorical and Quantitative Scoring System

SUBJECT #1

	FIRST SORT	(SECOND SORT)	BOTH SORTS
Categorical Scores:			
UP:	0	3	3
SF:	3	0	3
Omission:	0	0	0
Quantitative Scores:			
UP:	0	9	9
SF:	9	0	9

SUBJECT #2

	FIRST SORT	(SECOND SORT)	BOTH SORTS
Categorical Scores:			
UP:	3	0	3
SF:	0	1	1
Omission:	0	2	2
Quantitative Scores:			
UP:	8	0	8
SF:	0	3	3

APPENDIX E
The Knowledge Test

The following is the knowledge test, given to each subject in order to assess their understanding of the underlying principles presented in each theme. Male and female versions of the test were created that were identical in terms of item content, with the exception that questions focussing on social themes contained same-sex characters. That is, for social themes describing a boy or a girl, males read about a boy, and females read about a girl.

KNOWLEDGE TEST

Please read each question or statement very carefully and circle the letter that best answers the question or completes the statement.

1. Cats chase and often catch and kill mice and rats. We can say:

   a) cats are hungry animals
   b) cats are killers and we should avoid them
   c) mice and rats like to play with cats
   d) people like cats because they help control pests, such as mice and rats

2. We send messages to other people <u>without</u> using any words by:

   a) smiling b) shrugging our shoulders
   c) yawning d) all of the above

3. Which of the following <u>cannot</u> be recycled?

   a) soup tins b) newspapers
   c) broken glass d) plastic bags

4. A boy invites everyone standing around <u>except you</u> to a party after school. He mistakenly thought you said that you had to go to the doctor's after school. He did not invite you because he:

   a) wanted to be mean
   b) accidentally thought you would be busy and couldn't go

c) did not want you to come
d) did not think that you liked parties

5. A farm has 3 horses, 4 cows, 12 chickens, 1 dog, 5 cats, and 6 kittens. How would you figure out how many animals there are on the farm altogether?

a) add (+)   b) subtract (-)
c) multiply (x)   d) divide (-)

6. A boy bumps into you again and again from behind while standing in line, and laughs with his friend every time he does it. This boy:

a) is a very funny person
b) bumped into you accidentally
c) is sorry for bumping into you
d) is bumping into you on purpose

7. If you throw a bunch of rocks into a bucket of water, the level of the water in the bucket will:

a) go down   b) stay the same
c) go up   d) none of the above

8. A boy you know always gives himself the most or best of everything and leaves less or the not-as-nice stuff for others. The best way to describe him is to say that he is:

a) a bully   b) hungry
c) selfish   d) lonely

9. Some animals can make themselves look like a more dangerous animal when they are about to be attacked. They do this to:

a) hide from the attacker
b) try and scare away an attacker
c) be seen easier so other animals will come and save them
d) warn other animals to go and hide

10. Working together as a group to finish a project, means:

a) cooperating with others
b) working alone
c) not getting along with others
d) joining a game

11. Which of the following should not be thrown on the earth in your garden?

a) carrot greens b) apple cores
c) grass clippings d) candy wrappers

12. Some kids knew you really wanted to join their club and thought it was really funny to invite everyone in class except you to join. Which of the following is true?

a) it was accident that you weren't invited
b) they were going to invite you but forgot
c) they didn't ask you on purpose, just to be mean
d) you didn't want to join the club

13. Jessie has a bigger paper route than Pat, and they want to figure out how many more papers Jessie has than Pat. To do this, they need to use:

a) division b) subtraction
c) fractions d) decimals

14. How would most people feel if they made something in art and their classmates said it looked stupid?

a) embarassed b) happy
c) glad d) sorry

15. What happens to a beach ball filled with air if it is at the bottom of an empty pool, and somebody starts filling the pool with water? The ball will:

a) float on the water b) be covered with water
c) burst d) lose it's air

16. How would you best describe a boy that always sits by himself and doesn't try to talk with other kids?

a) happy b) smart
c) lonely d) friendly

17. With some animals, the color of their skin/coat changes to blend in with their surrounding. This is helpful because:

a) they don't like to be only one color
b) they are easier to see
c) it is a part of aging
d) it protects the animals

18. A boy who does not join in a game even when asked, and sits with his back to the game, is someone who is not:

a) smart b) participating
c) understanding d) sad

19. Which of the following should not be put in garbage dumps?

a) dangerous chemicals b) old leaves
c) kitchen scraps d) newspapers

20. A boy having a party doesn't ask you to come because you are always mean to him. Which one of the following is true?

a) it was an accident that you were left out
b) the boy is being mean for no reason
c) you aren't invited because of the unfriendly way you treat that boy
d) the boy is being friendly

21. A man has $150.00 and wants to give it to his five children. He wants them all to have the same amount of money. How would the man do this?

a) add (+) b) subtract (-)
c) multiply (x) d) divide (-)

22. You ask to join a game, but the kids who are playing say "no". From this, you could say that they:

a) are not being very nice
b) need another player
c) like you a lot
d) don't know how to play the game

23. What happens to a heavy rock, when you throw it in a lake?

a) it floats to the surface
b) it goes underwater but won't touch bottom
c) it sinks to the bottom
d) it breaks into small pieces when it hits the water

24. Which kind of person would most people <u>not</u> like to hang around? Somebody who:

a) has a broken leg b) works hard
c) gets into a lot of fights d) talks a lot

The following summarizes the themes and underlying principles tapped by each question of the knowledge test:

Academic Themes:

Biological Principles:

1 d) - natural pest control
9 b) - visual mimicry
17d) - animal camouflage

Environmental Waste Control:

3 d) - recycling
11d) - composting
14a) - landfill waste

Arithmetic Word Problems:

5 a) - summation
13b) - difference
21d) - fractions/division

Water Principles:

7 c) - displacement of water
15a) - floatation
23c) - sinking

Social Themes:

Social Skills:

2 d) - non-verbal communication
10a) - sharing/cooperation
18b) - joining

Rejection Situations:

4 b) - accidental
12c) - intentional
20c) - justified

Possible Peer Conflict:

6 d) - physical provocation
14a) - embarassment
22a) - rejection

Unsuccessful Personality Types:

8 c) - selfish
16c) - withdrawn
24c) - aggressive

APPENDIX F
Descriptive Statistics, Study One.

Variable Name	Grade	Mean	Standard Deviation	Skew	Kurtosis
Competence Tasks:					
Achievement (OLSAT)	6	0.52	0.16	0.09	-0.37
	8	0.72	0.17	-0.80	-0.16
Academic Teacher Ratings	6	0.74	0.24	-0.51	-0.77
	8	0.78	0.20	-0.74	0.12
Academic Self Perception	6	0.74	0.16	-0.34	-0.49
	8	0.75	0.15	-.49	-0.39
Sociometric Ratings	6	3.20	0.80	-0.64	-0.05
	8	3.32	0.81	1.14	2.60
Social Teacher Ratings	6	0.73	0.21	-0.92	0.27
	8	0.75	0.18	-0.15	0.91
Social Self Perception	6	0.78	0.19	-0.98	0.29
	8	0.75	0.15	-0.27	-0.32
Knowledge Test:					
Total Test Items	6	0.91	0.09	-1.30	2.10
	8	0.94	0.07	-2.36	7.39
Academic Test Items	6	0.90	0.12	-1.53	2.04
	8	0.93	0.09	-1.54	2.82
Social Test Items	6	0.92	0.09	-1.89	4.40
	8	0.96	0.07	-2.51	9.00
Problem Solving Task:					
First Sort :					
Theme 1 (Academic)	6	1.74	2.71	1.57	1.26
	8	2.95	3.21	0.82	-0.66
Theme 2 (Academic)	6	3.87	3.16	0.21	-1.18
	8	4.84	3.11	-0.16	-1.29
Theme 3 (Academic)	6	1.91	3.35	1.32	-0.06
	8	2.47	3.63	0.98	-0.83
Theme 4 (Academic)	6	0.20	0.66	3.02	7.72
	8	0.44	1.34	3.00	7.69

APPENDIX F (continued)
Descriptive Statistics, Study One.

Variable Name	Grade	Mean	Standard Deviation	Skew	Kurtosis
Theme 5 (Social)	6	0.56	1.27	2.22	4.01
	8	0.94	1.88	2.17	4.65
Theme 6 (Social)	6	3.04	3.71	0.66	-1.30
	8	3.75	4.09	0.31	-1.75
Theme 7 (Social)	6	1.74	2.60	1.35	0.60
	8	3.88	3.59	0.15	-1.58
Theme 8 (Social)	6	2.69	3.30	0.88	-0.75
	8	3.91	3.58	0.22	-1.51
Academic Themes	6	7.72	6.34	0.65	-0.18
	8	10.70	7.08	0.50	-0.65
Social Themes	6	5.02	6.84	0.76	-0.29
	8	12.47	9.01	0.38	-0.65
Total Themes	6	15.74	11.19	0.83	0.39
	8	23.17	13.01	0.77	0.49
Both Sorts :					
Theme 1 (Academic)	6	2.70	3.21	0.96	-0.40
	8	3.89	3.36	0.30	-1.34
Theme 2 (Academic)	6	5.30	3.15	-0.13	-0.89
	8	6.67	3.32	0.22	-0.34
Theme 3 (Academic)	6	2.26	3.49	1.04	-0.72
	8	2.95	3.73	0.78	-1.08
Theme 4 (Academic)	6	0.57	1.31	2.80	9.16
	8	0.95	1.91	1.90	2.66
Theme 5 (Social)	6	0.87	1.48	1.49	1.12
	8	1.64	2.18	1.27	1.08
Theme 6 (Social)	6	4.50	3.37	0.01	-1.59
	8	5.45	3.68	-0.43	-1.48
Theme 7 (Social)	6	2.70	2.85	0.64	-0.93
	8	4.89	3.44	-0.20	-1.32
Theme 8 (Social)	6	3.67	3.67	0.45	-1.36
	8	4.73	3.54	-0.03	-1.30

APPENDIX F (continued)
Descriptive Statistics, Study One.

Variable Name	Grade	Mean	Standard Deviation	Skew	Kurtosis
Academic Themes	6	10.83	7.01	0.39	-0.33
	8	14.47	7.72	0.73	-0.04
Social Themes	6	11.74	7.31	0.27	-0.70
	8	16.72	8.23	-0.02	-0.85
Total Themes	6	22.57	12.20	0.19	-0.41
	8	31.19	13.64	0.56	0.09

APPENDIX G
t - tests of the Differences Between Means, Study One

APPENDIX G.1: Sex Differences

APPENDIX G.2: Grade Differences

APPENDIX G.3: Individual Themes

...ans, Study One

	Grade 6 df = 53	Value	Grade 8 df = 63
	0.[illegible]		1.29
	-[illegible]		-0.30
			1.15
			0.03
			-0.57
			0.64
			-0.15
			0.33
			-0.68
	[illegible].04		
	1.33		
	-1.06		[illegible]
...s-AR)			
	1.09		[illegible]
	0.43		[illegible]
	0.23		[illegible]
	-0.13		[illegible]
	-0.14		[illegible]
	-1.20		[illegible]
	-0.52		[illegible]
	-1.46		
	0.76		
	-1.83		
	-0.66		
Academ...	-0.50		
(Academ...	0.68		
(Acade...	0.15		
(Acad...	-0.37		
(Soc...	-1.11		
(Sc...	0.19		
6 (S...	-0.17		
7 (S...	-0.87		
8 (...	0.08		
...Themes	-0.6[illegible]		
...hemes	-0.[illegible]		
...hemes			

...001 ** p < .01 * p < .05

APPENDIX G.1
t-tests of the Difference Between Means, Study One
Sex Differences

Comparison	t Value Grade 6 df = 53	t Value Grade 8 df = 63
Competence Tasks:		
Achievement	0.91	1.29
Academic Teacher Ratings	-0.26	-0.30
Academic Self Perception	-0.74	1.15
Sociometric	-0.50	0.03
Social Teacher Ratings	-0.29	-0.57
Social Self Perception	0.77	0.64
Knowledge Test:		
Total Test Items	0.04	-0.15
Academic Test Items	1.33	0.33
Social Test Items	-1.66	-0.68
Problem Solving Themes (Original Scores-AR)		
First Sort:		
Theme 1 (Academic)	1.09	0.06
Theme 2 (Academic)	0.43	1.21
Theme 3 (Academic)	0.23	0.13
Theme 4 (Academic)	-0.13	-0.22
Theme 5 (Social)	-0.14	0.99
Theme 6 (Social)	-1.20	-0.48
Theme 7 (Social)	-0.52	-0.59
Theme 8 (Social)	-1.46	-2.23*
Academic Themes	0.76	0.57
Social Themes	-1.83	-1.11
Total Themes	-0.66	-0.45
Both Sorts:		
Theme 1 (Academic)	-0.50	0.08
Theme 2 (Academic)	0.68	1.16
Theme 3 (Academic)	0.15	0.46
Theme 4 (Academic)	-0.37	-0.04
Theme 5 (Social)	-1.11	0.38
Theme 6 (Social)	0.19	-0.39
Theme 7 (Social)	-0.17	0.15
Theme 8 (Social)	-0.87	-1.22
Academic Themes	0.08	0.74
Social Themes	-0.64	-0.94
Total Themes	-0.33	-0.15

*** $p < .001$ ** $p < .01$ * $p < .05$

(continued...)

APPENDIX G.1
t-tests of the Difference Between Means, Study One
Sex Differences (continued)

Comparison			t Value Grade 6 df = 53	Grade 8 df = 63
Problem Solving Themes (Residual scores, ARr):				
First Sort:				
Theme	1	(Academic)	0.55	0.06
Theme	2	(Academic)	0.48	1.26
Theme	3	(Academic)	-0.23	0.09
Theme	4	(Academic)	-0.17	-0.24
Theme	5	(Social)	-1.37	0.95
Theme	6	(Social)	-0.76	-0.66
Theme	7	(Social)	-0.50	-0.36
Theme	8	(Social)	-1.27	-1.99
Academic Themes			0.34	0.53
Social Themes			-1.56	-1.01
Total Themes			-0.69	-0.43
Both Sorts:				
Theme	1	(Academic)	-1.23	0.07
Theme	2	(Academic)	0.70	1.14
Theme	3	(Academic)	-0.31	0.45
Theme	4	(Academic)	-0.36	-0.06
Theme	5	(Social)	-1.11	0.42
Theme	6	(Social)	0.71	-0.66
Theme	7	(Social)	-0.09	0.31
Theme	8	(Social)	-0.62	-1.86
Academic Themes			-0.38	0.69
Social Themes			-0.26	-0.77
Total Themes			-0.35	-0.10

*** p.< 001 ** p < .01 * p < .05

APPENDIX G.2
t-tests of the Difference Between Means, Study One
Grade Differences

Comparison	t Value df= 117
Competence Tasks:	
Achievement	-6.48***
Academic Teacher Ratings	-0.93
Academic Self Perception	-0.44
Sociometric	-0.82
Social Teacher Ratings	-0.40
Social self Perception	1.00
Knowledge Test:	
Total Test Items	-2.28*
Academic Test Items	-1.51
Social Test Items	-2.47*
Problem Solving Themes (Original Scores-AR)	
First Sort:	
Theme 1 (Academic)	-2.19*
Theme 2 (Academic)	-1.68
Theme 3 (Academic)	-0.87
Theme 4 (Academic)	-1.17
Theme 5 (Social)	-1.27
Theme 6 (Social)	-0.98
Theme 7 (Social)	-3.64***
Theme 8 (Social)	-1.92
Academic Themes	-2.39*
Social Themes	-2.98**
Total Themes	-3.29**
Both Sorts	
Theme 1 (Academic)	-1.95
Theme 2 (Academic)	-2.29*
Theme 3 (Academic)	-1.04
Theme 4 (Academic)	-1.24
Theme 5 (Social)	-2.20*
Theme 6 (Social)	-1.41
Theme 7 (Social)	-3.72***
Theme 8 (Social)	-1.61
Academic Themes	-2.66**
Social Themes	-3.44***
Total Themes	-3.50***

*** p.< 000 ** p < .01 * p < .05

APPENDIX G.2
t-tests of the Difference Between Means, Study One
Grade Differences (continued)

Comparison			t Value N = 116
Problem Solving Themes (Residual Scores-ARr)			
First Sort:			
Theme	1	(Academic)	15.19***
Theme	2	(Academic)	15.13***
Theme	3	(Academic)	15.23***
Theme	4	(Academic)	15.09***
Theme	5	(Social)	15.07***
Theme	6	(Social)	15.28***
Theme	7	(Social)	15.55***
Theme	8	(Social)	15.25***
Academic Themes			15.43***
Social Themes			15.20***
Total Themes			15.48***
Both Sorts			
Theme	1	(Academic)	15.35***
Theme	2	(Academic)	15.05***
Theme	3	(Academic)	15.18***
Theme	4	(Academic)	15.07***
Theme	5	(Social)	15.08***
Theme	6	(Social)	15040***
Theme	7	(Social)	15.39***
Theme	8	(Social)	15.38***
Academic Themes			15.46***
Social Themes			15.50***
Total Themes			15.63***

*** p.< 001 ** p < .01 * p < .05

APPENDIX G.3
t-tests of the Difference Between Means, Study One
Individual Themes

Comparison				t Value Grade 6 df = 53	t Value Grade 8 df = 63
Theme	1	with	Theme 2	-5.05***	-4.86***
Theme	1	with	Theme 3	.73	1.58
Theme	1	with	Theme 4	4.66***	6.47***
Theme	1	with	Theme 5	3.99***	4.63***
Theme	1	with	Theme 6	-3.08**	-3.04**
Theme	1	with	Theme 7	.00	-1.80*
Theme	1	with	Theme 8	-1.60	-1.62
Theme	2	with	Theme 3	5.36***	7.21***
Theme	2	with	Theme 4	9.64***	13.15***
Theme	2	with	Theme 5	8.83***	11.20***
Theme	2	with	Theme 6	1.55	2.41*
Theme	2	with	Theme 7	5.97***	3.28**
Theme	2	with	Theme 8	2.55*	3.40**
Theme	3	with	Theme 4	3.67**	4.28***
Theme	3	with	Theme 5	2.43*	2.69**
Theme	3	with	Theme 6	-3.85***	-3.97***
Theme	3	with	Theme 7	-.85	-3.11**
Theme	3	with	Theme 8	-2.17*	-3.15**
Theme	4	with	Theme 5	-1.06	-2.99**
Theme	4	with	Theme 6	-7.87***	-8.79***
Theme	4	with	Theme 7	-4.93***	-8.33***
Theme	4	with	Theme 8	-6.05***	-8.53***
Theme	5	with	Theme 6	-6.89***	-8.18***
Theme	5	with	Theme 7	*4.35***	-6.89***
Theme	5	with	Theme 8	-5.56***	-6.04***
Theme	6	with	Theme 7	3.22**	1.04
Theme	6	with	Theme 8	1.33	1.20
Theme	7	with	Theme 8	-1.65	.31

*** p.< 001 ** p < .01 * p < .05

APPENDIX H
Pearson Product-Moment Correlations, Study One, Grades 6 and 8, Male and Female Subjects

APPENDIX H.1a: Pearson Product-Moment Correlations Between Academic and Social Competence Tasks, Female Subjects

APPENDIX H.1b: Pearson Product-Moment Correlations Between Academic and Social Competence Tasks, Male Subjects

APPENDIX H.2a: Pearson Product-Moment Correlations Between the Knowledge Test and the Competence Tasks, Female Subjects

APPENDIX H.2b: Pearson Product-Moment Correlations Between the Knowledge Test and the Competence Tasks, Male Subjects

APPENDIX H.3a: Pearson Product-Moment Correlations Between Analogical Reasoning and Competence Tasks, Female Subjects

APPENDIX H.3b: Pearson Product-Moment Correlations Between Analogical Reasoning and Competence Tasks, Male Subjects

APPENDIX H.4a: Pearson Product-Moment Correlations Between Analogical Reasoning and Competence Tasks, Controlling for Knowledge, Female Subjects

APPENDIXH.4b: Pearson Product-Moment Correlations Between Analogical Reasoning and Competence Tasks, Controlling for Knowledge, Male Subjects

APPENDIX H.1a

Pearson Product - Moment Correlations Between Academic and Social Competence Tasks, Study One Grade 6 (above) and Grade 8 (Below), Female Subjects

	1	2	3	4	5	6
1 - Achievement						
2 - Academic Teacher Ratings	.31 .50**					
3 - Academic Self Report	.35 .44*	.69*** .36				
4 - Sociometric	.14 -.18	.11 .01	.21 -.33			
5 - Social Teacher Ratings	-.07 -.36	.26 .04	.44* -.18	.78*** .62***		
6 - Social Self Report	-.29 -.35	-.07 -.44*	.14 .06	.52** .18	.42* .22	

***p < .001, ** p < .01, * p < .05

APPENDIX H.1b

Pearson Product - Moment Correlations Between Academic and Social Competence Tasks, Study One Grade 6 (above) and Grade 8 (Below), Male Subjects

	1	2	3	4	5	6
1 - Achievement						
2 - Academic Teacher Ratings	.64*** .51**					
3 - Academic Self Report	.52** .29	.59*** .41*				
4 - Sociometric	-.01 .13	.27 .39*	.27 -.08			
5 - Social Teacher Ratings	.06 .00	.25 .35*	.18 .02	.63*** .33*		
6 - Social Self Report	-.05 .00	.02 .15	.06 .08	.48** .53*	.51** .48**	

***p < .001, ** p < .01, * p < .05

APPENDIX H.2b

Pearson Product - Moment Correlations Between the Knowledge Test and Competence Tasks, Study One Grade 6 and Grade 8, Male Subjects

	Knowledge Test - Total		Knowledge Test - Academic		Knowledge Test - Social	
	6	8	6	8	6	8
Achievement	.48**	.61***	.34	.54**	.49**	.55***
Teacher Ratings: Academic	.34	.60***	.17	.53**	.42*	.55***
Self Report: Academic	.31	.22	.23	.13	.32	.28
Sociometric	-.21	.10	-.37	.05	-.03	.14
Teacher Ratings: Social	-.10	.19	-.29	.16	.09	.19
Self Report: Social	.18	.01	-.05	-.03	.33	.06

***p < .001, ** p < .01, * p < .05

APPENDIX H.2b
Pearson Product - Moment Correlations Between the Knowledge Test and Competence Tasks, Study One
Grade 6 and Grade 8, Male Subjects

	Knowledge Test - Total		Knowledge Test - Academic		Knowledge Test - Social	
	6	8	6	8	6	8
Achievement	.48**	.61***	.34	.54**	.49**	.55***
Teacher Ratings: Academic	.34	.60***	.17	.53**	.42*	.55***
Self Report: Academic	.31	.22	.23	.13	.32	.28
Sociometric	-.21	.10	-.37	.05	-.03	.14
Teacher Ratings: Social	-.10	.19	-.29	.16	.09	.19
Self Report: Social	.18	.01	-.05	-.03	.33	.06

***p < .001, ** p < .01, * p < .05

APPENDIX H.3a
Pearson Product - Moment Correlations Between the Analogical Reasoning and Competence Tasks, Study One
Grade 6 (above) and Grade 8 (below), Female Subjects

	Analogical Reasoning (AR)		
	Academic Themes	Social Themes	Total Themes
Achievement	.67*** .24	.34 .27	.63*** .32
Academic Teacher Ratings	.40* .42*	.23 .27	.39* .43*
Academic Self Report	.28 .12	.31 .09	.37 .13
Sociometric	.05 -.08	.05 -.07	.06 -.09
Social Teacher Ratings	-.12 .03	.14 .02	.01 .03
Social Self Report	-.18 -.51**	-.19 -.30	-.24 -.51**

***p < .001, ** p < .01, * p < .05

APPENDIX H.3b

Pearson Product - Moment Correlations Between the Analogical Reasoning and Competence Tasks, Study One Grade 6 (above) and Grade 8 (Below), Male Subjects

	Analogical Reasoning (AR)		
	Academic Themes	Social Themes	Total Themes
Achievement	.61*** .32	.41* .48**	.57** .45**
Academic Teacher Ratings	.55** .31	.35 .30	.50** .34*
Academic Self Report	.43* -.12	.17 .10	.33 .00
Sociometric	.06 .02	.11 -.18	.09 -.10
Social Teacher Ratings	.04 .26	.25 .21	.17 .26
Social Self Report	.03 -.13	.16 -.12	.11 -.14

***p< .001, ** p < .01, * p < .05

APPENDIX H.4a

Pearson Product - Moment Correlations Between the Analogical Reasoning and Competence Tasks, Study One Grade 6 (above) and Grade 8 (Below), Controlling for Knowledge, Female Subjects

	Analogical Reasoning (ARr)		
	Academic Themes	Social Themes	Total Themes
Achievement	.52* .21	.29 .23	.50* .26
Academic Teacher Ratings	.28 .38	.19 .26	.30 .37
Academic Self Report	.14 .07	.26 .08	.26 .05
Sociometric	.04 -.02	.04 -.11	.05 -.02
Social Teacher Ratings	-.17 .04	.12 .08	-.02 .09
Social Self Report	-.08 -.52**	-.17 -.27	-.16 -.50**

*** p < .001, ** p < .01 , * p < .05

APPENDIX H.4b

Pearson Product - Moment Correlations Between the Analogical Reasoning and Competence Tasks, Study One Grade 6 (above) and Grade 8 (below) Controlling for Knowledge, Male Subjects

	Analogical Reasoning (ARr)		
	Academic Themes	Social Themes	Total Themes
Achievement	.53** .23	.29 .32	.47** .24
Academic Teacher Ratings	.52** .22	.25 .13	.43* .12
Academic Self Report	.38* -.15	.08 .01	.26 -.10
Sociometric	.16 .01	.12 -.24	.15 -.15
Social Teacher Ratings	.12 .24	.24 .15	.20 .20
Social Self Report	.04 -.13	.08 -.14	.07 -.16

***$p < .001$, ** $p < .01$, * $p < .05$

APPENDIX I
Principal Components Factor Analysis Using a Varimax Rotation on the Correlations Among the Analogical Reasoning Scores for the Individual Themes (Eigen = 1), Study One, Grades 6 and 8

	FACTOR I		FACTOR II		FACTOR III	
	Grade 6	Grade 8	Grade 6	Grade 8	Grade 6	Grade 8
Theme 1	.58	.01	.24	.63	.11	.20
Theme 2	.81	.32	-.25	.04	-.17	.65
Theme 3	.36	.55	-.42	.17	.59	.08
Theme 4	-.14	.87	.03	.12	.85	-.05
Theme 5	.00	.76	.84	-.10	-.19	.32
Theme 6	.57	-.02	.08	.26	.35	.84
Theme 7	.74	.02	.06	.58	-.03	.31
Theme 8	.26	.25	.56	.82	.39	-.17
Percent Variance Explained	26	23	17	19	18	18

APPENDIX J
t-tests of the Differences Between Correlations, Study One, Grades 6 and 8

APPENDIX J.1: t-tests of the Differences Between Correlations of Analogical Reasoning and Competence, Across Competence Tasks (with and without Controlling for Knowledge)

APPENDIX J.2: t-tests of the Differences Between Correlations of Analogical Reasoning and Competence, Comparing with and without Controlling for Knowledge

APPENDIX J.1
t-tests of the Differences Between Correlations of Analogical Reasoning and Competence, Across Competence Tasks, Study One
Grade 6 and Grade 8, with and without Controlling for Knowledge

	Without Controlling Knowledge		Controlling Knowledge	
Comparison	Grade 6	Grade 8	Grade 6	Grade 8
r(ACHT,ARt), r(SPC, ARt)	1.91*	2.73**	1.52	2.01*
r(ACHT,ARa), r(SPC,ARa)	2.34*	2.26*	1.72*	1.93*
r(ACHT,ARs), r(SPC,ARs)	1.01	2.43*	.84	1.80*
r(ACHT,ARt), r(TRC,ARt)	1.14	.26	.80	.24
r(ACHT,ARa), r(TRC,ARa)	1.48	-.34	.83	-.32
r(ACHT,ARs), r(TRC,ARs)	.53	.68	.44	.73
r(TRC,ARt), r(SPC,ARt)	.93	2.51**	.89	1.81*
r(TRC,ARa), r(SPC,ARa)	1.04	2.64*	1.09	2.29*
r(TRC,ARs), r(SPC,ARs)	.61	1.62	.51	1.14

ACHT = achievement, TRC = academic teacher ratings, SPC = academic self report
ARt ; Ara, Ars = Analogical Reasoning Scores for the total, academic, and social themes
*** p<.000, ** p<.01, * p<.05

APPENDIX J.2
t-tests of the Differences Between Correlations of Analogical Reasoning and Competence, Comparing with and without Controlling for Knowledge, Study One, Grades 6 and 8

Comparison	Grade 6	Grade 8
r(ACHT, ARt), r(ACHT, ARt(r))	4.45***	4.37***
r(ACHT, ARa), r(ACHT, ARa(r))	3.35***	4.67***
r(ACHT, ARs), r(ACHT, ARs(r))	3.01**	3.53***
r(TRC, ARt), r(TRC, ARt(r))	2.74**	4.31***
r(TRC,ARa), r(TRC,ARa(r))	1.41	4.75***
r(TRC, ARs), r(TRC, ARs(r))	2.57**	3.80***
r(SPC, ARt), r(SPC, ARt(r))	2.61**	1.85*
r(SPC, ARa), r(SPC, ARa(r))	1.56	1.70*
r(SPC, ARs), r(SPC, ARs(r))	2.18*	1.70*

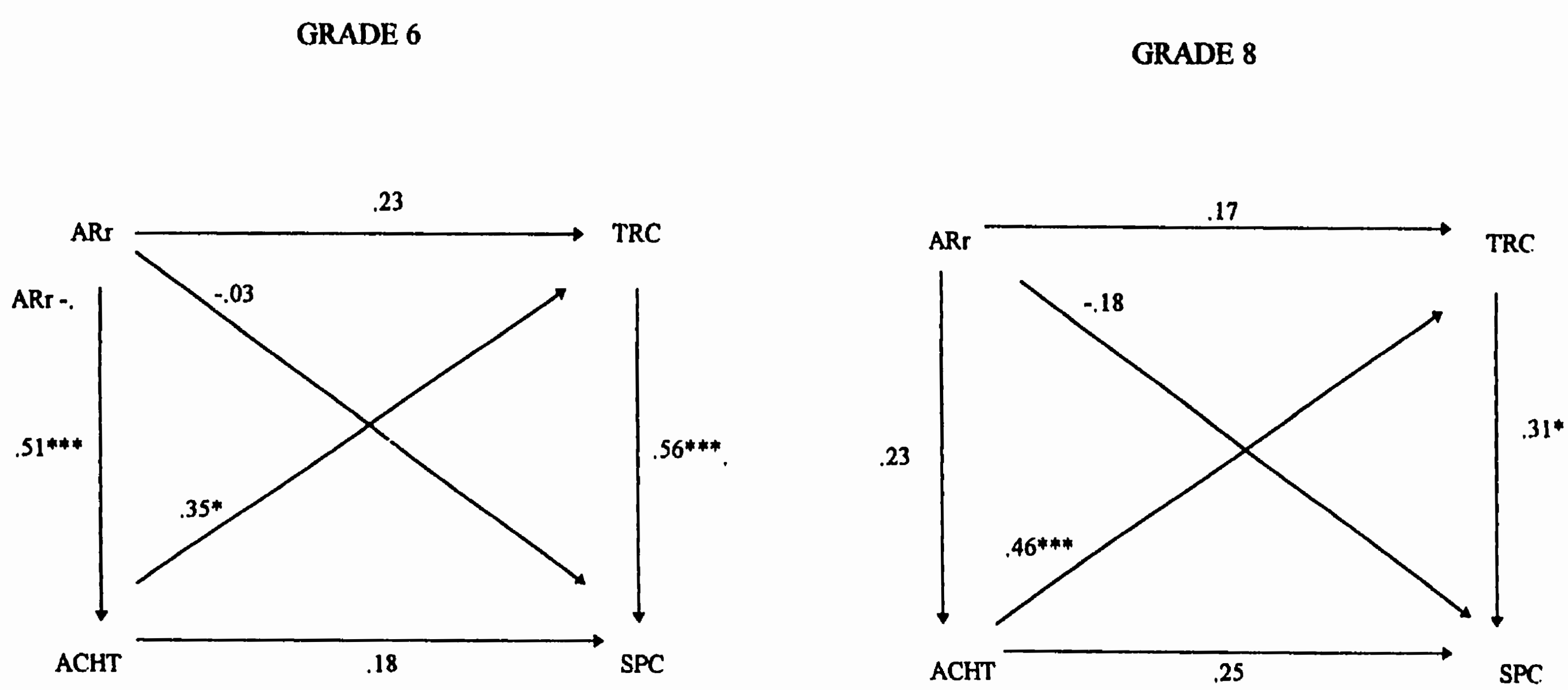
ACHT = achievement, TRC = academic teacher ratings, SPC = academic self report
ARt,ARa,ARs = Analogical Reasoning Scores for the total, academic and social themes, without controlling for knowledge
ARt(r),ARa(r),ARs(r) = Analogical Reasoning Scores for the total, academic, and social themes, controlling for knowledge
*** $p<.000$, ** $p<.01$, * $p<.05$

APPENDIX K
Academic Causal Model, Using 4 Academic and 4 Social Themes, Study One

APPENDIX K.1: Academic Causal Model, Using 4 Academic Themes

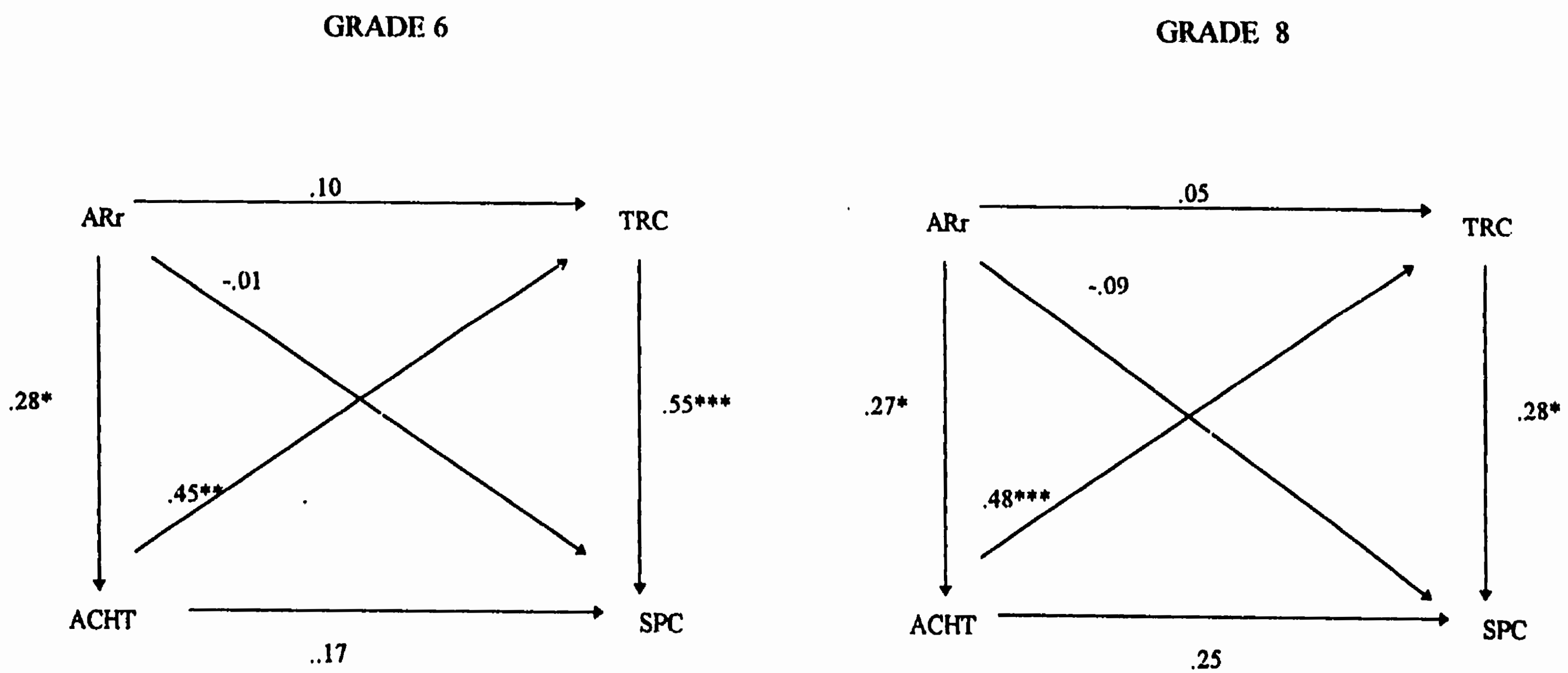
APPENDIX K.2: Academic Causal Model, Using 4 Social Themes

APPENDIX K.1
Academic Causal Model (Using 4 Academic Themes), Study One



ARr = Analogical Reasoning (ARr), using 4 Academic Themes, TRC = academic teacher ratings, ACHT = achievement, SPC = academic self report
*** p.< 001 ** p < .01 * p < .05

APPENDIX K.2
Academic Causal Model (Using 4 Social Themes), Study One



ARr = Analogical Reasoning (ARr), using 4 Social Themes, TRC = academic teacher ratings, ACHT = achievement, SPC = academic self report
*** p.< 001 ** p < .01 * p < .05

APPENDIX L: Extended Analyses from Study Two

APPENDIX L.1: Descriptive Statistics, Study Two

APPENDIX L.2: Pearson Product-Moment Correlations among Competence Tasks

APPENDIX L.3: Principal Components Factor Analyses using a Varimax Rotation for the Individual Themes

APPENDIX L.4: Pearson Product-Moment Correlations between Individual Themes

APPENDIX L.5: Pearson Product-Moment Correlations between Competence Tasks and Knowledge Test

APPENDIX L.1: Descriptive Statistics, Study Two

Variable	Grade	Mean	Standard Deviation
Competence Tasks:			
Achievement	6	.61	.16
	8	.73	.15
TR: Academic	6	.81	.20
	8	.84	.22
SP: Academic	6	.76	.16
	8	.75	.16
Sociometric	6	3.48	.73
	8	3.47	.59
TR: Social	6	.77	.20
	8	.76	.21
SP: Social	6	.74	.19
	8	.77	.15
Knowledge Test			
Total test itmes	6	.90	.11
	8	.94	.10
Academic items	6	.91	.11
	8	.92	.12
Social items	6	.89	.16
	8	.94	.10
AR Task - Both Sorts			
Theme 1	6	2.93_	2.81
	8	3.85	3.09

Variable	Grade	Mean	Standard Deviation
Theme 2	6	5.51	2.97
	8	7.16	3.19
Theme 3	6	2.84	3.61
	8	3.30	3.94
Theme 4	6	.67	1.56
	8	1.39	2.40
Theme 5	6	1.28	1.77
	8	2.46	2.80
Theme 6	6	4.18	3.98
	8	6.14	3.53
Theme 7	6	3.48	3.41
	8	5.29	3.01
Theme 8	6	4.19	3.63
	8	6.32	3.10
Academic Themes	6	3.57	4.26
	8	4.69	5.20
Social Themes	6	5.46	4.87
	8	8.59	5.17
Total Themes	6	8.44	4.40
	8	11.01	4.96

APPENDIX L.2: Pearson Product-Moment Correlations Among Competence Tasks, Study Two - Grade 6 (above) and Grade 8 (below)

	ACHT	TRC	SPC	SOCIO	TRS	SPS
ACHT						
TRC	.72***					
	.53***					
SPC	.44***	.53***				
	.43***	.64***				
SOCIO	-.01	.14	.23*			
	-.05	-.10	-.03			
TRS	.25	.43***	.26*	.10		
	.20	.45***	.33**	-.18		
SPS	-.08	.04	.30**	.09	.39***	
	-.12	.01	.16	-.09	.41***	

*** p<.001, ** p<.01, * p<.05

APPENDIX L.3: Principal Components Factor Analyses using a Varimax Rotation (Eigen = 1) for the Individual Themes

Study Two, Grade 6 and Grade 8

Grade 6		**Grade 8**		
Theme	Factor I	Theme	Factor I	Factor II
1	.60	1	.49	.28
2	.35	2	.64	-.03
3	.65	3	-.03	.77
4	.61	4	.03	.69
5	.45	5	.30	.54
6	.72	6	.72	.31
7	.54	7	.72	-.04
8	.64	8	.42	.41
% Variance Explained:	34%		24%	21%

APPENDIX L.4: Pearson Product Moment Correlations between Individual Themes, Study Two, Gr. 6 & 8 (above & below)

	1	2	3	4	5	6	7	8
Theme 1								
Theme 2	.16							
	.25*							
Theme 3	.35**	.13						
	.19	.05						
Theme 4	.33**	.15	.25*					
	.07	.10	.31**					
Theme 5	.20	.12	.19	.16				
	.28**	.15	.20	.21*				
Theme 6	.27**	.14	.37***	.33**	.33**			
	.29**	.31**	.24*	.20	.33**			
Theme 7	.16	.08	.20	.21*	.16	.38***		
	.14	.20*	.03	.12	.08	.43***		
Theme 8	.25*	.18	.37***	.31**	.09	.33**	.28**	
	.21*	.12	.19	.21*	.24*	.30**	.28**	

APPENDIX L.5: Pearson Product-Moment Correlations between Competence Tasks and Knowledge Test, Study Two - Grade 6 and Grade 8

	Knowledge Test - Total		Knowledge Test - Academic		Knowledge Test - Social	
	Gr. 6	Gr. 8	Gr. 6	Gr. 8	Gr. 6	Gr. 8
Achievement	.60***	.49***	.50***	.52***	.49***	.43***
Teacher Rating - Academic	.51***	.48***	.40***	.40***	.46***	.49***
Self Perception - Academic	.21*	.35**	.22*	.29*	.20	.37***
Sociometric	.02	.09	.03	.10	.04	.02
Teacher Ratings - Social	.13	.24*	.05	.19	.12	.27*
Self Perception - Social	-.07	-.10	-.10	-.08	-.02	-.04

[Note: *** p<.001; ** p<.01; * p<.05]

APPENDIX M
Pearson Product-Moment Correlations Between Analogical Reasoning and Competence, Study Two, Grades 6 and 8, Male and Female Subjects

APPENDIX M.1: Pearson Product-Moment Correlations Between Analogical Reasoning and Competence - without Controlling for Knowledge

APPENDIX M.2: Pearson Product-Moment Correlations Between Analogical Reasoning and Competence - Controlling for Knoweldge

APPENDIX M.1

Pearson Product - Moment Correlations Between Analogical Reasoning and Competence, Male and Female Subjects, Grade 6 (above) and Grade 8 (Below), Study Two Without Controlling for Knowledge

	Analogical Reasoning (AR)					
	Academic Themes		Social Themes		Total Themes	
	Males	Females	Males	Females	Males	Females
Achievement	.44**	.55***	.42**	.45**	.35*	.39*
	.62***	.41***	.40**	.35*	.40**	.21
Academic Teacher Ratings	.36**	.41*	.28*	.29	.21	.41*
	.50***	.24	.18	.20	.51***	.11
Academic Self Report	.24	.57***	.24	.38*	.10	.22
	.61***	.18	.16	.02	.48**	.17
Sociometric	-.14	.20	-.22	.13	.11	.08
	.06	.05	.12	.16	-.20	.04
Social Teacher Ratings	-.00	.22	-.12	.46**	-.12	.20
	.34*	.00	.04	-.12	.26	.34*
Social Self Report	-.08	.30	-.16	.28	-.17	.26
	.01	-.06	-.09	.22	-.10	.22

***p < .001, ** p < .01, * p < .05

APPENDIX M.2

Pearson Product - Moment Correlations Between the Analogical Reasoning and Competence, Male and Female Subjects, Grade 6 (above) and Grade 8 (below), Study Two Controlling for Knowledge

	Analogical Reasoning					
	Academic Themes		Social Themes		Total Themes	
	Males	Females	Males	Females	Males	Females
Achievement	.42** .36*	.48** .27	.28* .21	.36* .14	.29* .30*	.44** .26
Academic Teacher Ratings	.29* .26	.34* .17	.13 .23	.38* .05	..13 .30*	.41* .15
Academic Self Report	.27* .35*	.46** .15	.14 .33*	.26 .20	.21 .40**	.40* .22
Sociometric	-.18 .11	.11 .15	.12 -.21	-.12 .16	-.00 -.12	-.05 .18
Social Teacher Ratings	-.11 .17	.42* -.15	-.13 .00	.23 .25	-.14 .09	.36* .05
Social Self Report	-.10 .02	.33* -.10	-.29* -.23	.27 .30*	-.19 -.14	.34* .15

***p < .001, ** p < .01, * p < .05

APPENDIX N
t-tests of the Differences Between Correlations, Study Two, Grades 6 and 8

APPENDIX N.1: t-tests of the Differences Between Correlations of Analogical Reasoning and Competence, Across Competence Tasks (with and without Controlling for Knowledge)

APPENDIX N.2: t-tests of the Differences Between Correlations of Analogical Reasoning and Competence, Comparing with and without Controlling for Knowledge

APPENDIX N.1
t-tests of the Differences Between Correlations of Analogical Reasoning and Competence, Across Competence Tasks, Study Two Grade 6 and Grade 8, with and without Controlling for Knowledge

	Without Controlling Knowledge		Controlling Knowledge	
Comparison	Grade 6	Grade 8	Grade 6	Grade 8
r(ACHT,ARt), r(SPC, ARt)	1.94*	.99	.39	-.59
r(ACHT,ARa), r(SPC,ARa)	1.55	2.81**	.82	.48
r(ACHT,ARs), r(SPC,ARs)	1.77*	-.71	.94	-1.04
r(ACHT,ARt), r(TRC,ARt)	1.51	1.07	1.08	.10
r(ACHT,ARa), r(TRC,ARa)	2.44**	2.57**	1.99*	.84
r(ACHT,ARs), r(TRC,ARs)	.56	-.32	.40	-.31
r(TRC,ARt), r(SPC,ARt)	.88	.00	-.41	-.84
r(TRC,ARa), r(SPC,ARa)	-.22	.49	-.63	-.35
r(TRC,ARs), r(SPC,ARs)	1.48	-.50	.71	-.95

ACHT = achievement, TRC = academic teacher ratings, SPC = academic self report
ARt ; Ara, Ars = Analogical Reasoning Scores for the total, academic, and social themes
*** p<.000, ** p<.01, * p<.05

APPENDIX N.2
t-tests of the Differences Between Correlations of Analogical Reasoning and Competence, Comparing with and without Controlling for Knowledge, Study Two, Grades 6 and 8

Comparison	Grade 6	Grade 8
r(ACHT, ARt), r(ACHT, ARt(r))	2.73**	3.76***
r(ACHT, ARa), r(ACHT, ARa(r))	1.99*	3.90***
r(ACHT, ARs), r(ACHT, ARs(r))	1.18	1.34
r(TRC, ARt), r(TRC, ARt(r))	2.31*	2.39**
r(TRC,ARa), r(TRC,ARa(r))	1.47	1.76*
r(TRC, ARs), r(TRC, ARs(r))	1.06	1.36
r(SPC, ARt), r(SPC, ARt(r))	.74	1.40
r(SPC, ARa), r(SPC, ARa(r))	.83	.87
r(SPC, ARs), r(SPC, ARs(r))	.37	1.05

ACHT = achievement, TRC = academic teacher ratings, SPC = academic self report
ARt,ARa,ARs = Analogical Reasoning Scores for the total, academic and social themes, without controlling for knowledge
ARt(r),ARa(r),ARs(r) = Analogical Reasoning Scores for the total, academic, and social themes, controlling for knowledge
*** $p<.000$, ** $p<.01$, * $p<.05$