

California State University, San Bernardino

CSUSB ScholarWorks

Theses Digitization Project

John M. Pfau Library

2005

The relationship between epistemological beliefs and academic achievement goals in middle school children

Sara Elizabeth Schuyten Pierce

Follow this and additional works at: <https://scholarworks.lib.csusb.edu/etd-project>



Part of the [Educational Psychology Commons](#)

Recommended Citation

Schuyten Pierce, Sara Elizabeth, "The relationship between epistemological beliefs and academic achievement goals in middle school children" (2005). *Theses Digitization Project*. 2738.

<https://scholarworks.lib.csusb.edu/etd-project/2738>

This Thesis is brought to you for free and open access by the John M. Pfau Library at CSUSB ScholarWorks. It has been accepted for inclusion in Theses Digitization Project by an authorized administrator of CSUSB ScholarWorks. For more information, please contact scholarworks@csusb.edu.

THE RELATIONSHIP BETWEEN EPISTEMOLOGICAL BELIEFS
AND ACADEMIC ACHIEVEMENT GOALS IN
MIDDLE SCHOOL CHILDREN

A Thesis
Presented to the
Faculty of
California State University,
San Bernardino

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts
in
Psychology:
Child Development

by
Sara Elizabeth Schuyten Pierce

December 2005

THE RELATIONSHIP BETWEEN EPISTEMOLOGICAL BELIEFS
AND ACADEMIC ACHIEVEMENT GOALS IN
MIDDLE SCHOOL CHILDREN

A Thesis
Presented to the
Faculty of
California State University,
San Bernardino

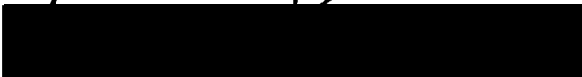
by
Sara Elizabeth Schuyten Pierce

December 2005

Approved by:



Dr. Robert Ricco, Chair, Psychology



Dr. Laura Kamptner



Dr. David Chavez

October 18 2005

Date

ABSTRACT

This study examined relationships among epistemic beliefs, achievement goals, self-regulated learning, cognitive strategy use, and academic performance for 131 sixth graders and 100 eighth graders. A self-report measure of student achievement goals, epistemic beliefs, self-regulation, and use of cognitive strategies was administered. Each students' current grade in science class was utilized as a measure of academic performance. Students adopting learning goals also held more complex beliefs about learning and the validation of knowledge but viewed authority figures uncritically as sources of knowledge and believed scientific truths to be immutable. In addition, self-regulated learning and cognitive strategy use were positively related to the adoption of learning goals, sophisticated beliefs about the justification process in science, and the belief that learning can be increased through effort. Little evidence that epistemic beliefs develop significantly across the middle school years was found. Implications for individual differences in goal orientation, self-regulation, and cognitive strategy use in the classroom are discussed.

ACKNOWLEDGMENTS

I would like to extend my thanks and gratitude to Dr. Robert Ricco for his direction, assistance and dedication to this project. He has been an on going source of support, guidance and encouragement throughout my undergraduate and post-graduate college career.

Additionally, I would like to acknowledge Dr. Kamptner and Dr. Chavez for their mentorship and support.

I would also like to recognize and thank all of the countless teachers, parents, students and others who assisted with and participated in this study.

Finally, I must give special thanks to my family and friends who have helped me in many different ways as I worked on this project. Words alone cannot express the gratitude that I owe to my husband, David Pierce, for his encouragement, support and assistance.

DEDICATION

Dedicated in loving memory to my father, Marc David Schuyten. The principles and beliefs that you guided me to in my youth will always be my source of strength and inspiration. Thank-you for being the first person to inspire me to write about psychology. I know that you are rejoicing in spirit and in my heart as I celebrate this accomplishment.

TABLE OF CONTENTS

ABSTRACT	iii
ACKNOWLEDGMENTS	iv
LIST OF TABLES	vi
CHAPTER ONE: INTRODUCTION	1
Epistemological Beliefs	2
Personal Epistemology and Academic Achievement Goals	10
Purpose of Study	16
CHAPTER TWO: METHOD	
Participants	19
Measures	19
Epistemic Beliefs Questionnaire	20
Epistemic Beliefs About Science	22
Implicit Learning Questionnaire	23
Academic Achievement Goals Inventory	24
Self-Regulated Learning Scale	25
Cognitive Strategy Use Scale	26
Academic Performance	26
Procedure	27
CHAPTER THREE: RESULTS	29
CHAPTER FOUR: DISCUSSION	38
APPENDIX: QUESTIONNAIRES	54
REFERENCES	66

LIST OF TABLES

Table 1. Loadings of Epistemic Beliefs Questionnaire Items on the Ability to Learn (AbL) and Stability of Knowledge (SK) factors	31
Table 2. Mean Scores of Sixth and Eighth Grade Students on Epistemic Beliefs Variables, Self-Regulation, and Cognitive Strategy Use	33

CHAPTER ONE

INTRODUCTION

Epistemology is a sub-discipline of philosophy that is concerned with the origin, nature, limits, and justification of human knowledge (Hofer, 2002). Within the fields of psychology and education in recent decades, we have seen a growing recognition that lay individuals develop interrelated sets of beliefs about these issues which might be called a naïve theory of epistemology or a personal epistemology. The study of personal epistemology concerns how an individual develops such conceptions of knowledge and knowing and utilizes them in developing an understanding of the world (Hofer, 2002). A person's epistemological beliefs can influence their ability to understand and make sense of information. For example, when we read newspaper articles or watch television commercials we may make judgments as to the truth of the claims being made and these judgments carry epistemological assumptions about what constitutes valid evidence and valid sources of knowledge (Hofer, 2002). In classrooms, students approach learning differently depending on their own beliefs about how knowledge is acquired (Hofer, 2002).

Epistemological Beliefs

The study of personal epistemology originally began with the work of William Perry in the late 1960's. Perry (1968) and his research staff conducted lengthy interviews with Harvard undergraduate students over their four-year college experience, compiling detailed student responses and descriptive stage schemes of epistemological development. Perry hypothesized that there are nine developmental stages that one goes through on their path from being a dualistic thinker, as a freshman, to becoming a relativistic thinker by the end of their four-year college experience. From his research Perry concluded that many first year students believe that all-knowing persons of authority pass down simple, certain, unchangeable facts. However, four years later, students believe that complex, tentative knowledge is derived from empirical inquiry and reason (Schommer-Aikins, 2004).

Many researchers have continued to use cumbersome interviews to study personal epistemology (Baxter Magolda, 1992, 1998; Belenky, Clinchy, Goldberger, & Tarule, 1986; King & Kitchener, 1994). However, Schommer (1990) contends that epistemic beliefs could be accessed reliably through self-report measures. She also suggests that personal epistemology might be too complex to be captured by a

stage theory. Schommer hypothesized that personal epistemology should be thought of as a system of distinct but interrelated beliefs. In her original theoretical model, Schommer posits five beliefs, some of which concern the nature of knowledge while others concern the nature of learning (Schommer, 1994).

Empirical research has provided modest support for self-report assessments of personal epistemology, and factor analyses have confirmed the validity of four epistemological belief factors similar in interpretation to those in Schommer's original model (Schommer-Aikins, Mau, Brookhart, & Hutter, 2000). Two factors concern learning (learning ability and speed of learning) while the other two concern knowledge (structure and stability of knowledge). With respect to learning, there are significant individual differences in adults' beliefs about their *ability to learn*. Some individuals see this ability as relatively fixed while others believe it to be malleable through effort. Individual differences are also evident concerning beliefs about the *speed* with which learning takes place. Some individuals believe learning to be relatively immediate and an all or nothing at all process while others see it as more gradual and cumulative in nature. With respect to knowledge, adults differ in

their beliefs about the *structure of knowledge*. Some individuals consider knowledge to be organized as discrete pieces of information while others see knowledge as theoretical, complex, and consisting of interrelated concepts. Differences are also apparent for beliefs about the *stability of knowledge*. Some individuals consider knowledge to be largely unchanging while others see it as constantly evolving and subject to revision. This four-factor structure has been obtained with college students (Dunkle, Schraw, & Benixen, 1993; Schommer, Course, & Rhodes, 1992) and high school students (Schommer, 1993).

Arguing against a strict stage notion, Schommer (1990) discovered that students' epistemic beliefs exist at different levels of development. For example, students can believe that knowledge is unchanging, and also believe that it is complex in structure (Schommer, 1994). Schommer (1994) theorized that the four belief factors identified above, and the relationships among those factors, undergo development. She maintains that in the early school years, children's epistemic beliefs are largely undifferentiated and relatively undeveloped. In the pre-adolescent and early adolescent years, the beliefs begin to differentiate but there may be substantial differences in developmental

level across beliefs. In late adolescence and early adulthood, epistemological beliefs become more integrated, with similar levels of development in evidence across beliefs (Schommer-Aikins et al., 2000).

In two previous studies with middle school students (Schommer-Aikins et al., 2000; Schommer-Aikins, Duell, & Hutter, 2005) Schommer-Aikins found that early adolescents' epistemological beliefs appear to be multidimensional, but have a simpler structure than found among high school and college students (Schommer, 1990, 1993, 1998). Further analysis revealed that the four-factor model that was obtained with older individuals (Schommer, 1990, 1994) did not fit the data obtained from the middle school samples. In the first of these studies, a three-factor model, including beliefs about the ability to learn, speed of learning, and stability of knowledge, did fit the data. Additionally, it was found that middle school students' beliefs about learning appeared to be better developed than their beliefs about knowledge. This finding may mean that beliefs about learning precede the development of knowledge beliefs (Schommer-Aikins et al., 2000) and represent an important precondition for the latter. Epistemological research with adults is consistent with that claim (Schommer-Aikins et al., 2000). In her

1998 study, Schommer interviewed more than 400 adults. After statistically controlling for education, Schommer (1998) found that age predicted growth in beliefs about learning. After statistically controlling for age, level of education predicted growth in beliefs about knowledge. The results suggest that maturation is critical in the development of beliefs about learning, but that without certain formal educational experiences, beliefs about knowledge may be less likely to advance (Schommer-Aikins et al., 2000). However, in the second study with middle school students, Schommer-Aikins et al. (2005) found a two factor structure. One factor combined items from the two original beliefs about learning factors (speed of learning and ability to learn) while the other factor combined ability to learn and stability of knowledge items. Although this is a different factor structure, the results again suggest that epistemic beliefs about learning may precede those about knowledge and knowing. They also support the claim that the beliefs of older children are more differentiated.

Beliefs about the nature of knowledge and learning seem to have an important impact on academic performance regardless of age (Hofer & Pintrich, 1997; Kardash & Scholes, 1996; Schommer, 1990, 1998; Solomon, Duveen, &

Scott, 1994). Dweck and Bempechat (1983) found that children who believe the ability to learn is fixed at birth will display helpless behavior in the face of a difficult academic task. Children who believe the ability to learn can actually improve over time will persist on the task and try various paths towards a solution (Schommer-Aikins, 2004). Schoenfeld (1983) studied the mathematical beliefs of high school students. He concluded that many high school students believe that mathematicians are born with an ability to do mathematics and that math problems should be solved in 12 minutes or less. Schoenfeld (1983) found other common beliefs held by the students. Some believed that only gifted authority figures can understand mathematics, that mathematical problem solving should happen quickly or it will not happen at all, and that mathematical proofs are determined by omniscient authority figures (Schommer-Aikins, 2004). Additionally, Schoenfeld's (1988) study of high school mathematics classrooms led him to conclude that students developed perspectives about the nature of mathematics that were not only inaccurate, but were likely to impede their use of other mathematical knowledge and possibly hinder their performance (Hofer & Pintrich, 1997). In one of Schommer's (1990) initial studies it was found that

belief in quick learning predicted oversimplified conclusions, poor performance on tests, and overconfidence in test performance (Hofer & Pintrich, 1997). Schommer has demonstrated that belief in quick learning is associated with lower GPA among middle school students and high school students (Schommer, 1993); while belief in complex knowledge is associated with better performance in college students (Schommer, Course, & Rhodes, 1992). Additionally, the less college students believe in quick learning and simple knowledge, the better they comprehend complex academic text (Schommer, 1990; Schommer et al., 1992; Schommer-Aikins et al., 2000).

Although the Schommer-Aikins measure of epistemic beliefs can be worded so as to apply to a particular domain or subject area, it was developed as a domain-general measure. By contrast, some epistemic assessments are domain-specific. Conley, Pintrich, Vekiri, and Harrison (2004), and Chan and Sachs (2001) have developed measures of epistemic beliefs in *science*. Conley et al. (2004) employed a model that differs somewhat from that of Schommer and includes four distinct types of epistemic beliefs. These are source, certainty, development, and justification - of knowledge. The source and justification dimensions reflect beliefs about the

nature of *knowing*. Source of knowledge refers to an individual's beliefs about external authorities (e.g., teachers, textbooks, or family members) as valid sources of knowledge. Justification of knowledge involves beliefs about the ways in which individuals use evidence to evaluate claims. The certainty and development dimensions reflect an individual's beliefs about the nature of *knowledge*. Certainty of knowledge refers to the extent to which an individual believes there may be more than one answer to complex problems. The development dimension is similar to Schommer's stability of knowledge factor and assesses an individual's belief in how knowledge about science has developed over time. An individual with a more sophisticated view about the development of knowledge would view science as an evolving domain with ideas changing as new discoveries or insights are achieved.

Conley et al. (2004) found evidence that fifth graders' epistemological beliefs about science changed over time during an instructional unit. Even though the change was not large, it was found that students became more sophisticated in their beliefs about the source and certainty of knowledge over the nine-week unit. Additionally, the results suggested that there are SES differences in how students think about knowledge and

knowing. It was found that lower SES students are more likely to believe that scientific knowledge is certain and relatively fixed, and that persons in positions of authority are the ones with the knowledge. Differences in achievement levels were also found; higher achieving students demonstrated more sophisticated epistemological beliefs. These results support the work of Hofer and Pintrich (1997) linking higher levels of learning with more sophisticated epistemological beliefs (Conley et al., 2004). Chan and Sachs (2001) looked at school-age children's beliefs about science learning and the influence of such beliefs on understanding of science texts. They found evidence of an increase across the school years in the propensity to hold constructivist views of science learning. Such views were also more likely to be associated with in-depth processing of science texts.

Personal Epistemology and Academic Achievement Goals

In addition to epistemological beliefs, it is now clear that learning is also influenced by a person's academic achievement goals. Achievement goal theory was first developed in the late 1970s and early 1980s by Dweck (1986), Nicholls (1984), and Ames (1984). Originally, two

types of goals were defined: performance goals and learning or mastery goals (Diener & Dweck, 1980; Dweck, 1975; Dweck & Leggett, 1988; Dweck & Reppucci, 1973; Elliot & Church, 1997; Nicholls, 1984). Dweck and Leggett (1988) found that children who shy away from challenge are often equal in ability to those children who seek challenging experiences and strive to learn. They then sought to understand why children possessing similar abilities would respond to difficult tasks in such different ways. Dweck and Leggett (1988) looked towards individual goals as a possible answer. They identified two types of goals: learning goals and performance goals. Individuals who pursue learning goals are concerned with trying to increase their competence whereas a performance goal orientation involves seeking favorable judgments about one's competence or ability. Dweck and Leggett (1988) maintain that different theories about the nature of intelligence (analogous to Schommer's learning ability factor) determine which goal one might strive for. Dweck and Leggett (1988) showed that individuals who felt their intelligence was a fixed entity which could not be changed through effort tended to adopt performance goals, while those who felt intelligence was not fixed and had a malleable quality tended to adopt learning goals and to

display a mastery pattern (Bandura & Dweck, 1985; Dweck, Tenney, & Dinces, 1982).

Learning or mastery goals have been linked to numerous adaptive outcomes, including high task value, interest, effort and persistence, positive affect, higher levels of efficacy, the use of more cognitive strategies, and better performance (Pintrich, 2000). Performance goals are usually seen as less adaptive in terms of task value, motivation, affect, cognitive strategy use, and performance on tasks (Ames, 1992; Dweck & Leggett, 1988; Pintrich, 2000). However, some researchers have shown that performance goals may not be maladaptive. Research by Elliot and colleagues indicates that performance goals can result in better performance and achievement (Elliot, 1997; Elliot & Church, 1997; Elliot & Harackiewicz, 1996). As a result, a revised goal theory makes a distinction between performance-approach goals and performance-avoidance goals (Elliot, 1997; Elliot & Church, 1997; Middleton & Midgley, 1997). Students with performance-approach goals focus on doing better than others and on demonstrating their ability or competence. As Pintrich (2000) suggests, these students approach tasks in terms of trying to outperform others. Students with a performance-avoidance orientation are attempting to avoid

looking incompetent, leading them to avoid challenging or difficult tasks.

While much research has been conducted in the areas of epistemic beliefs and academic achievement goal orientation, very little research has studied the relationship between the two. Braten and Stromso (2004) examined the relative contribution of epistemological beliefs and implicit theories of intelligence to the adoption of academic achievement goals among student teachers in Norway. They utilized Schommer's Epistemological Beliefs Questionnaire to assess the students' epistemological beliefs. Dweck's (1999) Theories of Abilities Questionnaire (TAQ) was used to assess students' entity and incremental beliefs about intelligence. To assess academic achievement goals, Braten and Stromso used measures adapted from Midgley et al. (1998).

Braten and Stromso's (2004) study provides preliminary evidence regarding the contribution of epistemological beliefs and theories of intelligence to the development of academic achievement goals. The study revealed that students who believed that learning happened quickly or not at all were more likely to adopt performance-avoidance goals and less likely to adopt

mastery goals. In their explanation for this finding, the authors suggest that those students who believe that learning is a quick, all or nothing process may consider it a waste of time to strive to increase their competence and master challenging, time-consuming tasks. Further, students who believe in quick learning may be concerned with incompetence in relation to others and view persistent effort as proof of their inability to learn (Braten & Stromso, 2004). Students who thought of knowledge as stable and unchanging were less likely to adopt mastery goals. Belief in quick, all or nothing learning and belief that knowledge is stable and unchanging may have oriented students away from mastery goals and gradual self-improvement. It was also found that gender predicted achievement goals, with females being more likely to report mastery goals and males more likely to report performance-approach and performance-avoidance goals (Braten & Stromso, 2004).

While Braten and Stromso's (2004) study sheds light on the relationship between epistemological beliefs and academic achievement goals, they were not able to draw conclusions about causality. Their favored explanations for the relationship imply that personal epistemology gives rise to specific academic achievement goals.

However, it is also possible that an individual's goals may influence their beliefs about learning and knowledge. For example, ample experience pursuing learning or mastery goals may lead the individual to develop a sophisticated appreciation of both the learning process and the nature of knowledge. Supporting a claim that goals influence epistemic beliefs is the fact that achievement goals appear to emerge earlier than a personal epistemology (Schommer-Aikins et al., 2000). Another related question left unanswered by the Braten and Stromso study concerns the origins and developmental course of the relationship between epistemological beliefs and achievement goals. Does the relationship obtain in middle school, for example? Findings that academic achievement goals are already influencing performance in the early school years while epistemic beliefs may still be poorly differentiated (Schommer-Aikins et al., 2000) makes it unclear at what point the relationship emerges. Nonetheless, prior evidence that limited epistemic beliefs are operating in middle school suggests that the relationship between achievement goals and epistemological beliefs found in the college years emerges during or shortly before the middle school years.

Previous research has shown that academic achievement goals are present in children and young adults. Current research with middle school students has demonstrated the presence of epistemic beliefs in the areas of learning and knowing. There is a clear need for an exploration of the relationship between epistemic beliefs and academic achievement goals among children in the middle school grades.

Purpose of Study

The focus of the present study is middle school students' epistemological belief systems and achievement goals. While research in these two areas has been conducted with middle school students previously, the existing literature has not demonstrated a clear link between achievement goals and epistemic beliefs among middle school students. The current study attempts to find evidence for such a link. It is hypothesized that sixth and eighth grade students who have more sophisticated epistemological beliefs (i.e., ability to learn can be acquired, knowledge is a complex set of interrelated pieces of information, learning is a gradual process, knowledge is always evolving and changing, knowledge is a construction, authority is not an adequate validation for

knowledge) will be more likely to adopt mastery or learning goals. Students from these grades who have less sophisticated or more naïve epistemological beliefs (i.e., knowledge is organized into simple, separate pieces of information, learning will either happen quickly or it will not happen at all, knowledge is set, structured, and unchanging, and valid knowledge derives from authority figures) will be more likely to adopt performance avoidance goals. It is possible that this relationship may be clearer in later middle school than in early middle school.

We utilized multiple measures to assess 6th and 8th grade middle school students' epistemological beliefs and academic achievement motivation. We instructed students to consider one academic subject (science) as they participated in this study, as it is easier for students to think about issues involved in one particular domain. To assess students' beliefs about learning and knowledge we used the Epistemic Beliefs Questionnaire [EBQ] (Schommer-Aikins et al., 2000), the Epistemic Beliefs About Science (EBS) measure (Conley et al., 2004), and the Implicit Learning Questionnaire [ILQ] (Chan & Sachs, 2001). This battery of measures includes standard

categories of epistemic beliefs as well as some categories that may be unique to science.

In order to assess students' academic achievement goals, we used the Academic Achievement Goals Inventory [AAGI] (Midgley et al., 1998), which measures the extent to which students adopt learning or performance goals in science. In addition, two measures of outcome or performance were employed to determine whether academic goals and epistemic beliefs differ in their effectiveness as predictors of children's academic outcomes. These outcome measures were student grades in science and responses on the MSLQ subscales assessing self-regulated learning skills and the use of cognitive strategies (Pintrich & DeGroot, 1990). Both children's epistemic beliefs and their achievement goals were expected to be associated with grades and degree of self-regulated learning. Students completed these measures across three sessions in their social science classes.

CHAPTER TWO

METHOD

Participants

Participants were 131 6th grade students (mean age = 12.20 years; *SD* = .74) and 100 8th grade students (mean age = 14.10 years; *SD* = .50) from an urban middle school in Southern California serving primarily low-income families. Approximately 63% of students' families reported a family income below 30K and only 40% of parents had completed high school. Students were approximately equal in representation by gender (boys, *n* = 102; girls, *n* = 129). The sample was ethnically diverse (67% Hispanic American, 20% African American, 8% Caucasian, 3% Asian American). The 6th grade participants were drawn from six social science classes, the 8th grade participants were also sampled from six social studies classrooms. Letters were sent home in both English and Spanish to obtain permission from parents for their child to participate in the study. The sample of students included a range of academic achievement levels.

Measures

Students responded to several measures designed to assess their epistemic beliefs and academic achievement

motivation, along with other variables. Each measure requires responses on a Likert-type scale and was administered as part of a questionnaire. Participant's epistemic beliefs were assessed by way of the Epistemic Beliefs Questionnaire (Schommer-Aikins et al., 2000), the Epistemic Beliefs About Science Scale (Conley et al., 2004), and the Implicit Learning Questionnaire (Chan & Sachs, 2001). Academic achievement motivation was assessed using the Academic Achievement Goals Inventory (Midgley et al., 1998). In addition, three measures of academic performance were employed. These were the Self-Regulated Learning Scale, the Cognitive Strategy Use Scale, and students' most recent teacher-assigned grade in Science. Each measure is described in turn below.

Epistemic Beliefs Questionnaire

Epistemic Beliefs Questionnaire [EBQ]
(Schommer-Aikins et al., 2000). This is a 29-item inventory designed to assess four epistemic beliefs in middle school populations. Alpha coefficients across the four subscales measuring these beliefs range from .55 to .71. For each of the four beliefs, statements describe the less sophisticated or more simplistic position. Children's beliefs about their *ability to learn* (fixed and unchangeable as opposed to malleable and under personal

control) are assessed via 9 items (e.g., 1. Some people are just born smart, others are born dumb. 2. An expert is someone who was born smart in something.) and their beliefs about *speed of learning* (quick and automatic as opposed to gradual and effortful) are assessed via 7 items (e.g., 1. You cannot learn anything more from a textbook by reading it twice. 2. If I cannot understand something quickly, it usually means I will never understand it.). Children's beliefs about the *stability of knowledge* (unchanging as opposed to evolving and subject to revision) will be assessed with 4 items (e.g., 1. If scientists try hard enough, they can find the truth to just about anything. 2. I can depend on facts written in my school books for the rest of my life.) and their beliefs about the *complexity of knowledge* (simple and factual as opposed to complex and theoretical) will be assessed by way of 9 items (e.g., 1. The best thing about a science course is that most problems have only one right answer. 2. Most words have one clear meaning.).

Participants will be instructed to think about and consider only their science class when responding to each statement. Participants indicate the extent to which they agree with each statement by way of a 5-point scale ranging from 'not at all' (1) to 'very much' (5). Higher

scores indicate a less sophisticated or more simplistic epistemic position.

Epistemic Beliefs About Science

Epistemic Beliefs About Science [EBS] (Conley et al., 2004). This 26-item measure is designed to assess four epistemic beliefs concerning knowledge in science. Each belief is assessed via a distinct subscale. Alpha coefficients across the four scales range from .44 to .76. The *source of knowledge* subscale consists of 5 items and assesses the extent to which children perceive scientific knowledge as deriving from the pronouncements of authority figures (e.g., 1. Whatever the teacher says in science class is true. 2. Only scientists know for sure what is true in science.). The *certainty of knowledge* subscale consists of 6 items and measures the extent to which children believe scientific findings to be certain (e.g., 1. Scientific knowledge is always true. 2. Scientists pretty much know everything about science; there is not much more to know.). The *development of knowledge* subscale has 6-items and assesses children's belief that scientific knowledge evolves and undergoes revision (e.g., 1. Ideas in science sometimes change. 2. New discoveries can change what scientists think is true.). The *justification of knowledge* subscale utilizes 9-items to assess beliefs

about the importance of observation, manipulation, evidence-gathering, and other forms of justification processes to arriving at valid knowledge (e.g., 1. It is good to try experiments more than once to make sure of your findings. 2. Good answers are based on evidence from many different experiments.). Participants indicate the extent to which they agree with each statement by way of a 5-point scale ranging from 'not at all' (1) to 'very much' (5). Higher scores indicate stronger endorsement of the type of beliefs assessed in the statement. Care must be taken in interpreting the four scales of the measure because they differ in direction. Thus, *higher* scores on the Source and Certainty scales and *lower* scores on the Development and Justification scales indicate *less* sophisticated epistemic positions.

Implicit Learning Questionnaire

Implicit Learning Questionnaire (Chan & Sachs, 2001). This is a nine-item, forced-choice measure ($\alpha = .52$) of whether children view science learning as a constructive process of problem solving or as completion of known routines. Each item is accompanied by three choice options, two of which represent a shallow view of learning and one of which represents the deeper, constructivist view. Participants will be instructed to think about and

consider only their science class when responding to each item. Higher scores indicate a more constructivist account of science learning.

Academic Achievement Goals Inventory

Academic Achievement Goals Inventory [AAGI] (Midgley et al., 1998). This is an 18-item measure of students' academic goals for science content. It identifies three types of academic goals- learning or mastery, performance-approach, and performance-avoidance. Each goal type is measured via 6 items. Alpha coefficients across the three scales range from .82 to .84. Learning goals stress increasing one's knowledge or competence in the domain of science (e.g., 1. I like to do science problems that I'll learn from. Even if I make a lot of mistakes. 2. An important reason why I do my work in science is because I want to get better at it.) Performance- approach goals stress the importance of obtaining tangible indicators of competence or ability in science such as good grades or test scores (1. I want to do better than the other students in my class on my science homework. 2. I would feel successful in school if I did better on my science assignments than most of the other students.) Performance-avoidance goals are oriented toward avoiding evidence of low competence or ability in science (1. One

of my main goals during science lessons is to avoid looking like I can't do my work. 2. The reason I do my work during science is so my teachers don't think I know less than others.) Participants indicate the extent to which they agree with each statement by way of a 5-point scale ranging from 'not at all' (1) to 'very much' (5). Higher scores indicate stronger endorsement of the type of goal assessed in the statement.

Self-Regulated Learning Scale

Self-Regulated Learning Scale (SRLS) of the Motivated Strategies for Learning Questionnaire (Pintrich & DeGroot, 1990). This 8-item measure ($\alpha = .74$) assesses the extent to which a student understands, and can regulate, her own learning processes (e.g., 1. When reading I try to connect things I am reading about with what I already know. 2. Before I begin studying I think about the things I will need to do to learn.) Participants will be instructed to think about and consider only their science class when responding to each statement. Participants indicate the extent to which they agree with each statement by way of a 5-point scale ranging from 'not at all' (1) to 'very much' (5). Higher scores indicate greater control over learning.

Cognitive Strategy Use Scale

Cognitive Strategy Use Scale (CSUS) of the Motivated Strategies for Learning Questionnaire (Pintrich & DeGroot, 1990). This is a 13-item measure ($\alpha = .83$) which assesses the use of rehearsal strategies (e.g., "When I read material for this class, I say the words over and over to myself to help me remember"), elaboration strategies such as summarizing and paraphrasing (e.g., "When I study I put important ideas into my own words"), and organizational strategies (e.g., "I outline the chapters in my book to help me study"). Participants will be instructed to think about and consider only their science class when responding to each statement. Participants indicate the extent to which they agree with each statement by way of a 5-point scale ranging from 'not at all' (1) to 'very much' (5). Higher scores indicate a greater use of cognitive strategies.

Academic Performance

Participants' achievement grades in science class will be utilized as a general indicator of academic performance in this subject. Academic grades measure a student's understanding of science content and concepts. Student's academic achievement grades reflect the student's ability to demonstrate their knowledge of the

science content or standards. These grades are a culmination of assessments designed to measure the student's understanding and comprehension of science standards as determined by the State of California Department of Education. Participant's academic achievement grade for science will be obtained from their individual science teachers.

Procedure

Participants responded to the questionnaires during their social studies class. All questionnaires were administered during three separate testing sessions over the course of a two-week time period. Each session lasted approximately 45 minutes. All questionnaires were presented in a random but fixed order. For the 6th grade participants, each questionnaire was explained and read out loud by trained research assistants. This was done to ensure that each participant understands the statement so that they may accurately respond on the Likert-type scale. For the 8th grade participants, the reading of each measure was not necessary. All participants were trained on the use of a Likert-type scale before the survey sessions began. The scale was explained and then statements unrelated to this study were given to the

students so that they were able to practice using this scale to respond with their degree of agreement.

Researchers were present to answer any questions the participants had.

CHAPTER THREE

RESULTS

An exploratory factor analysis conducted on the Epistemological Beliefs Questionnaire revealed a factor structure much closer to that identified in Schommer-Aikins' most recent research with middle schoolers (Schommer-Aikins et al., 2005) rather than her original work with this population (Schommer-Aikins et al., 2000). Two primary components emerged with eigenvalues of 3.56 and 2.40, respectively, accounting for a total of 21% of the variance. Several smaller components were extracted with eigenvalues closer to 1.0 and falling below the natural break in the scree plot. Therefore, a second factor analysis was conducted forcing a two-factor solution under a varimax rotation. An *ability to learn* factor (8 items; $\alpha = .63$) emerged consisting primarily of items from the original Schommer-Aikins et al. (2000) ability to learn scale but also included some of the speed of learning items - thus combining the two categories of beliefs about learning assessed by the EBQ. The items loading on this factor stressed a view of learning as outside the control of the learner and as a quick, straightforward, and automatic process. A *stability of*

knowledge factor (6 items; $\alpha = .56$) emerged featuring three of the four items from the original Schommer-Aikins et al. (2000) stability of knowledge scale as well as three of the items from her original ability to learn scale. This second factor stressed the belief that scientists were capable of arriving at the truth and that scientific truths were unchanging. It also involved the belief that learning about science requires study skills which can be acquired through effort. Table 1 contains a listing of the 14 items comprising these two scales and the loadings of each item on the two factors. These two factors are very similar to those reported in the Schommer-Aikins et al. (2005) recent middle school study.

In order to compare the sixth and eighth grade samples with respect to their beliefs about learning and knowledge, a series of t-tests was performed comparing the two age groups on each of the epistemic belief variables employed in the study. These variables were, *certainty of knowledge*, *source of knowledge*, *knowledge development*, and *knowledge justification*, from the EBAS, *ability to learn* and *stability of knowledge* from the EBQ, and

Table 1. Loadings of Epistemic Beliefs Questionnaire Items on the Ability to Learn (AbL) and Stability of Knowledge (SK) factors

Component	Component	
	AbL	SK
Ability to Learn		
Some people are born smart, others are born dumb.	.52	-.20
Working hard on a difficult problem pays off only for the really smart students.	.65	.04
An expert is someone who was born smart at something.	.57	-.11
The really smart students don't have to work hard to do well in school.	.48	.08
You will get mixed up if you try to combine new ideas in a textbook with what you already know.	.44	.06
If I cannot understand something quickly, it usually means I will never understand it.	.56	-.10
You cannot learn anything more from a textbook by reading it twice.	.34	.10
Students who are average in school will remain "average" for the rest of their lives.	.44	-.02
Stability of Knowledge		
I can depend on facts written in my schoolbooks for the rest of my life.	.01	.52
What students learn from a textbook depends on how they study it.	-.22	.50
A class in study skills would probably help students who are slow learners.	.01	.50
The knowledge of how to study is generally learned as we grow older.	-.05	.48
Scientists can get the truth if they just keep on searching for it.	.02	.47
If scientists try hard enough, they can find the truth to almost everything.	-.02	.51

constructivism assessed by the ILQ. In addition, the age groups were compared with respect to *self-regulation* and *cognitive strategy* use. Table 2 contains the relevant means and standard deviations. All means for both age groups differ significantly from the mid-point (3.0) of the scale indicating that even the sixth graders held epistemic beliefs that were more likely to be complex than simple. Results of the grade comparisons indicated that eighth graders were more likely than sixth graders to believe that there is only one right answer to complex problems in science, $t(228) = 2.39, p < .018$. In addition, eighth graders were more likely than sixth graders to take a constructivist view of learning, $t(226) = 3.44, p < .001$. Finally, and unexpectedly, sixth graders reported higher levels of self-regulation in learning than eighth graders, $t(227) = 2.16, p < .032$. The age groups did not differ on any of the other epistemic variables. Because there were so few grade effects, all remaining analyses combined the sixth and eighth grade samples, though grade was included as a predictor in some of the multiple regressions.

Table 2. Mean Scores of Sixth and Eighth Grade Students on Epistemic Beliefs Variables, Self-Regulation, and Cognitive Strategy Use

	6 th Graders M (SD)	8 th Graders M (SD)
Source (skepticism toward text, teachers, experts.)	3.69 (.80)	3.80 (.67)
Certainty ^a (problems have more than one answer.)	3.40 (.71)	3.61 (.63)
Development (knowledge as evolving, revisable.)	3.82 (.52)	3.91 (.51)
Justification (importance of scientific method in validating scientific knowledge.)	3.93 (.55)	4.04 (.47)
Stability of Knowledge (scientific truths as accessible, unchanging, and learnable through study.)	3.62 (.54)	3.61 (.53)
Ability to Learn (learning process as gradual; controlled by learner.)	3.76 (.59)	3.83 (.63)
Constructivism (knowledge acquisition is an active process.)	.37 (.18)	.45 (.19)
Self Regulation (understanding of, and ability to control, learning)	3.20 (.67)	3.01 (.63)
Cognitive Strategy (strategies that support learning.)	3.46 (.59)	3.45 (.58)

Note. The scales have been adjusted so that for each variable higher scores indicate a more sophisticated belief or self-reported competence. With the exception of constructivism, the midpoint of the scale for each variable is 3.0.

^aVariables on which there was a significant grade effect are in bold.

as straightforward or out of the students' control. Results for the regression on performance approach goals indicated that certainty of knowledge, $\beta = .37$, $p < .001$, and knowledge justification, $\beta = .21$, $p < .001$, were both positively related to performance-approach goals, $R^2 = .19$, $F(2, 212) = 24.29$, $p < .001$. Students with more of a performance-approach orientation were more likely to believe that complex problems had only one correct answer. They were also more likely to value the importance of justification in science. Results for the regression on performance-avoidance goals indicated that certainty of knowledge, $\beta = .21$, $p < .004$, and stability of knowledge, $\beta = .20$, $p < .005$, were positively related to performance-avoidance goals. In addition, child grade, $\beta = -.13$, $p < .047$, was negatively related to performance-avoidance goals, $R^2 = .14$, $F(3, 215) = 11.45$, $p < .001$. Thus students with more of a performance-avoidance orientation were more likely to believe that complex problems have only one right answer and more likely to see scientific truths as unchanging and learnable through good study habits. In addition, eighth graders were less likely than sixth graders to endorse avoidance goals.

A final set of regressions was conducted to determine whether or not the epistemic belief variables and achievement goal variables were related to student outcome or performance and which of these predictors might best account for the outcome variables. Regressions were conducted on students' science grades, their self-regulated learning scores, and their cognitive strategy use scores. Results of the regression on science grade indicated that family income, $\beta = .17$, $p < .037$, and development of knowledge, $\beta = .17$, $p < .038$, were positively related to students' science grades, $R^2 = .06$, $F(2, 149) = 4.96$, $p < .008$. Students who viewed the development of knowledge as evolving with new discoveries and who came from families with higher incomes tended to have higher grades. Results for the regression on self-regulated learning indicated that learning goals, $\beta = .52$, $p < .001$, were positively related to self-regulation while constructivism, $\beta = -.16$, $p < .007$, ability to learn, $\beta = -.17$, $p < .003$, and child grade, $\beta = -.13$, $p < .031$, were negatively related to self-regulation, $R^2 = .34$, $F(4, 205) = 26.79$, $p < .001$. Students demonstrating more self-regulated learning were more likely to adopt learning goals and less likely to view learning as straightforward and out of the learner's

control. Surprisingly, self-regulation was also associated with less of a constructivist view of knowledge. In addition, sixth graders were more likely to be self-regulated than eighth graders were. Results for the regression on cognitive strategy use indicated that learning goals, $\beta = .50$, $p < .001$, and knowledge justification, $\beta = .28$, $p < .001$, were both positively related while constructivism, $\beta = -.12$, $p < .028$, was negatively related to strategy use, $R^2 = .42$, $F(3, 206) = 48.81$, $p < .001$. Students reporting the use of cognitive strategies were more likely to adopt learning goals and to value the importance of justification in arriving at valid knowledge. Additionally, they were more likely to have a passive rather than active, constructivist view of knowledge.

CHAPTER FOUR

DISCUSSION

This study adds to the current body of research on the development of epistemic beliefs and achievement goals during the middle school years. When we explored the factor structure of middle school students' epistemological beliefs, we found a two-factor solution that supports Schommer-Aikins' recent results with middle school students (Schommer-Aikins et al., 2005), even though the present study employs a sample that is lower in SES and more minority-based than that used by Schommer-Aikins. The *ability to learn* factor which emerged for our sample of middle schoolers combined the notion of learning as a fixed, innate ability that is outside the control of the learner with the notion of learning as quick and automatic. Although these aspects of learning are differentiated in older students (Dunkle, Schraw, & Bendixen, 1993; Schommer et al., 1992; Schommer, 1993), they appear to be relatively undifferentiated in middle school. Beliefs about learning have been shown to be related to academic performance. For example, previous research has shown that belief in quick learning has a negative influence on academic achievement

(Schommer-Aikins et al., 2005). The more high school students believe in quick learning, the lower grade point average they earn (Schommer, 1993). The more college students believe in quick learning, the more poorly they comprehend (Schommer, 1990). Although the ability to learn factor was not related to academic grades in the present study, it did predict self-regulated learning. The *structure of knowledge* factor which emerged, not only in the present study, but in previous research with middle schoolers, combined the notion that scientific inquiry reveals fundamental truths and that these truths are unchanging with the notion that learning about scientific findings requires study skills which can be increased through effort. These notions are, again, distinguished in older populations. Though the notions combined in this factor may seem to have little in common, the underlying theme may be one of control - the control over our lives that scientific inquiry provides (via discovery of enduring, objective truths) and the control over individual learning that is provided by strategic processing such as the use of study skills.

This new evidence provides further support for Schommer-Aikins et al. (2000) claim that in middle childhood, children's personal epistemology will be

undifferentiated and less developed. In early adolescence, children's epistemological beliefs will begin to differentiate and vary in their development (Schommer-Aikins et al., 2000). Additionally, these new findings with middle school students may also reflect a developmental trend from undifferentiated to differentiated thinking that is consistent with Wellman's (1990) notion of children's theory of the mind. Wellman suggested that young children have a global theory of the mind. Adults, however, conceptualize the mind as composed of distinct processes and components (Montgomery, 1992).

Some limited evidence that epistemic beliefs develop within the relatively narrow span of middle school comes from our comparison of 6th and 8th grade students. We found that 8th graders were more sophisticated in their beliefs about the certainty of knowledge. The older students were less likely to believe that there is only one correct answer to a complex science problem. Additionally, the older students were more likely to have a constructivist view of learning than the 6th graders. These findings provide some support of the previous research showing that epistemological beliefs are developmental in nature (Kitchener & King, 1989; Perry, 1968), and that students' beliefs become more sophisticated with age and experience.

Previous studies have also revealed that age and level of education predict growth in beliefs about learning and knowledge (Schommer-Aikins et al., 2000). The results from this study demonstrate the maturation of some epistemic beliefs as children proceed through the middle school years. Nonetheless, most of the epistemic belief variables did not show any age effects. It is unclear whether this indicates that significant development in this area occurs later in adolescence or whether these findings are unique to low-income populations.

The principal hypothesis of the study concerns the relationship between epistemic beliefs and achievement goals in middle school. It had been predicted that more sophisticated beliefs would be associated with learning goals while less sophisticated beliefs would be associated with performance-avoidance goals. The present findings, while providing significant support for these expectations, also seem to indicate that relations between beliefs and goals may be more complex than anticipated because early beliefs about knowledge, even in learning-oriented students, may be markedly different from those of high school and college students. First, as expected, learning oriented students were *less* likely to view learning as quick and straightforward and as outside

the control of the learner. They were also more likely to believe that the use of study skills and good study habits would help them increase their ability to learn science. These findings provide further support for Dweck's previous work with children (Dweck, 1986; Dweck & Leggett, 1988) in which she found that learning oriented students were more likely to view intelligence as malleable and changeable through effort (Braten & Stromso, 2004; Dweck, 1986; Dweck & Leggett, 1988).

Also consistent with expectations is the finding that learning-oriented students were more likely to value the role of justification in arriving at valid knowledge in science. Learning-oriented students are more likely to hold an appreciation of the process of science wherein scientific knowledge is validated through the use of experiments, testing, and research. At the same time, however, learning-oriented students were more likely to uncritically trust teachers and textbooks as valid sources of scientific knowledge and they were more likely to believe that science yields objective truths that are unchanging. From an adult perspective, these are less sophisticated epistemic positions. Why would they be associated with learning goals in middle school? One possibility is that the early positive experiences with

scientific inquiry that learning goal students are likely to have, combined with the emergence of powerful analytical thinking skills (Inhelder & Piaget, 1958), may give rise to a naïve confidence in the progress of science and the immutability of scientific findings as well as the trustworthiness of texts, teachers, and experts in reporting these findings.

The findings for performance avoidance goals were generally consistent with expectations. Certainty and stability of knowledge were both positively related to performance-avoidance goals. Students with a performance-avoidance orientation were more likely to believe that there is one correct answer to complex problems in science and more likely to see scientific truths as unchanging. Previous research (Ravindran, Greene, & DeBacker, 2005) has indicated that students who believed knowledge to be certain and that persons in positions of authority (teachers, textbooks) were the ones with privileged access to knowledge tended to also engage in shallow processing when trying to study or learn. These findings provide continued support for the notion that performance-avoidance goals are associated with maladaptive outcomes in regards to both poor academic performance and less motivation or interest (Elliot &

Church, 1997; Middleton & Midgley, 1997; Braten & Stromso, 2004). It is possible that students with more of a performance-avoidance orientation hold these naïve views of knowledge because they may not have had successful learning experiences in school that lead to the development of more sophisticated epistemic beliefs. Additionally, our sample groups differed by grade level, with 8th graders being less likely to report performance-avoidance goals. The notion of maturation may also explain this change. As students' progress through the middle school years they may learn that avoiding a challenging or difficult assignment does not make them more successful in school, they do not earn good grades by completing only the tasks in which they feel they can be successful. As students progress through the school years they may come to understand the necessity to complete all tasks and therefore be less likely to report a performance avoidance approach to learning.

No specific predictions had been made about performance approach goals in the present study. Nonetheless, the results are of interest here. Regression analysis on performance approach goals revealed that certainty of knowledge and justification of knowledge were both positively related to performance approach goals.

Students with more of a performance approach orientation were more likely to believe that complex problems in science have only one correct answer. They were also more likely to value the importance of justifying knowledge in science. This is consistent with the findings from a previous study (Ravindran et al., 2005) conducted with preservice teachers, which found that students who reported a more performance goal orientation also reported belief in simple knowledge. However, students who reported more of a performance approach orientation also seem to hold an appreciation for the process of science and how scientific knowledge is proven valid through the use of experiments, testing, and research. The findings for both learning-oriented and performance-oriented students, linking sophisticated views of justification with unsophisticated views of scientific facts may reflect a basic belief in the power of the scientific method. As more learning- or achievement-oriented middle schoolers see it, once a scientific finding has been established through an appropriate justification process, it can be taken as certain, true, and superior to other possible accounts. Further, if it appears in a science text, it must have gone through this justification process and can be accepted and trusted.

An additional concern of the present study was to determine the relative importance of epistemic beliefs and achievement goals for student outcomes in middle school. Results of the regression on science grade indicated that family income and the development of knowledge factor were positively related to students' science grade. Students who recognize that not all scientists agree on what is true and who view science as an evolving discipline wherein new discoveries can change what scientists believe, tended to have high grades in science. Overall, however, it is surprising that most of the epistemic and goal variables were unrelated to students' science grades. There are a few possible explanations for these non-findings. The measure of academic achievement in science was a cumulative trimester grade. This measure may have had significant inherent variance because it only reflects current performance and because so many different science teachers contributed these grades. Further, the school used in the study was in the process of changing their grading policies and practices, again offering the possibility of variance in the manner in which students' science grades were determined by individual teachers. Future researchers may want to consider alternate measures of science achievement (i.e., using a grade that was

cumulative for the school year, results on a specific scientific task, or possibly the students overall grade point average). It was also found that students who come from families with higher income levels tended to have higher grades. One possible explanation for this finding is that children who come from high-income families probably have parents with higher levels of education. These parents have greater academic experiences and knowledge, and thus maybe more able to help and assist their child in learning. This may help explain the higher achievement grades of students who come from families with higher income levels.

The analysis on self-regulated learning showed that learning goals were positively related to self-regulated learning. Students who reported higher levels of self-regulation in their learning were more likely to adopt learning goals. Also, learning goals and justification of knowledge were also positively related to cognitive strategy use. Students reporting the use of more cognitive strategies in their learning also were more likely to adopt learning goals and to value the importance of justification in arriving at valid knowledge. Results showed that constructivism, ability to learn, and grade level were all negatively related to self-regulated

learning while constructivism was also negatively related to the use of cognitive strategies. Students who demonstrated more self-regulated learning were less likely to view learning as straightforward and out of the learner's control. Students demonstrating more self-regulation in their own learning believe that their ability to learn can be increased through effort. Students reporting greater use of cognitive strategies were also more likely to hold an incremental theory of intelligence, believing that their ability to learn can be increased through effort and study. These findings are consistent with previous research that has demonstrated a positive relationship between self-regulation and learning goals (Ames & Archer, 1988; Greene & Miller, 1996; Ravindran, Greene, & DeBacker, 2005). The one surprising finding here is that students who report more self-regulation in their learning and who use more cognitive strategies were less likely to have a constructivist view of knowledge. There are some possible explanations for this finding. This may reflect the general absence of a constructivist perspective in middle school. Students at the middle school level may not yet appreciate the active control and influence they have over their own learning. On the other hand, it may be that students responded to the Implicit

Learning Questionnaire by reflecting on practices that have proven successful for them in the past. For example, reading correctly, listening carefully to what the teacher says, remembering facts, and repetition were options that were scored as non-constructivist views. Nonetheless, these habits may well be associated with school success for many middle school students and might have been chosen for that reason. Finally, the Implicit Learning Questionnaire had a low reliability score in our study ($\alpha = .37$), and it is certainly possible that adjustments to the scale might result in different findings.

Our findings hold some practical implications for teachers and parents. Middle school students who have less mature beliefs about the ability to learn and speed of learning may assume that all assignments should be completed quickly. When working on a more challenging task, students who believe that learning should happen quickly, may give up after a set amount of time has passed. Additionally, they may feel as though effort is of limited utility if a basic natural ability is not present. For teachers, this means that they may have to warn their students when a task will be time-consuming and difficult. Some students may need extra help and encouragement so that they do not give up after a set amount of time or

effort is expended, and, instead, continue and persist in the task until finished completely and correctly. Additionally, some researchers have argued that having sophisticated epistemic beliefs is necessary for the development of critical thinking (Keating & Sasse, 1996; Moshman, 1999). If a student believes that knowledge is simple and certain and will not change, they may be less likely to engage in critical thinking or reflection (Ravindran et al., 2005). Teachers need to ensure that their students have ways of approaching learning other than through the use of shallow processing. It is important for teachers to be aware of and challenge the naïve epistemic beliefs that support shallow processing strategies and lower levels of engagement. Parents can also assist and encourage their children from home. When children are working on homework assignments, projects, or studying, parents should support and encourage their children to take their time and think things through. Parents can help their student understand that learning does take time, that effort and persistence are important attributes, and that earlier failures may lead to later successes. Both parents and teachers can help support and encourage students to challenge their existing beliefs and guide them towards more sophisticated beliefs about

knowledge and learning. Clearly teachers have an impact on their students' learning and understanding. Future research is needed to understand how less sophisticated or naive epistemic beliefs evolve and how they can be changed through specific instructional interventions. If we better understand how these beliefs develop, we will be better prepared to help teachers recognize strategies that can be used to help modify and develop those beliefs, and facilitate successful learning in their students.

The present findings provide insight into middle school students' epistemic beliefs and the relationship between these beliefs and students' achievement goals. Students who hold a learning or mastery approach to school are less likely to view learning as a quick, all-or-nothing process, more likely to believe that the use of study skills and good study habits can increase their ability to learn, and more likely to have an appreciation for the justification process in science. However, they are also more likely to trust, naively, in authority figures as sources of scientific knowledge and more likely to view scientific findings as not subject to revision. Students who hold a performance goal orientation (approach or avoidance) were more likely to believe that complex problems in science have only one solution.

Performance-approach students resemble learning-oriented students in their beliefs about the justification process in science but performance-avoidance students resemble learning-oriented students in their belief in the unchanging nature of scientific findings. Both academic achievement goals and epistemic beliefs seem to be valuable in predicting self-regulated learning and the use of cognitive strategies.

Some findings appear generalizable beyond the conditions of this study. For example, the Schommer-Aikins et al., (2005) study was conducted among middle school students in the Midwest with a predominately white (86% European American) and middle class (23% receiving free or reduced-price lunch) population. The sample used in our study, while more culturally diverse, was predominately Hispanic American (67%) and lower income, with 90% of the students receiving free or reduced-price lunch. In spite of these sampling differences, both studies identified the same factor structure to the EBQ, suggesting that these factors reflect something about the developmental status of middle schoolers. On the other hand, it remains for future research to determine whether the specific relationships between epistemic beliefs and achievement goals found in the present study accurately describe early

adolescent thinking, rather than the correlates of SES. Future research should strive to directly compare minority and Caucasian groups as well as students who come from families with higher and lower socioeconomic status. Additionally, more research is needed that delves deep into the relationship between epistemic beliefs and achievement goals. Which develops first? At what stage do they become clearly defined? What causal pathways define their interrelationship? Another suggestion for future research would be to include high school students; this may reveal more clearly the developmental course of epistemic beliefs and achievement goals. It may also allow for greater understanding of the relationship between epistemic beliefs and learning goals at various stages of a students' development.

APPENDIX
QUESTIONNAIRES

Demographic Information

Our research will be more effective if we have some general information about the children participating. If you consent to include your child in this research study, please provide the following information and return this sheet to school along with the consent form. Be assured that neither your name nor that of your child will be reported along with this information. We are using a code which appears in the upper right hand corner of this sheet instead of a name for our records.

1. Please indicate your child's **ethnicity** below. Put a check next to the ethnic group to which your child belongs. (check one):
 African American/Black Middle Eastern/Arab
 White/Caucasian/European American Latino/Hispanic/Chicano
 Native American/American Indian Asian American/Pacific
Islander/Indian
 Multiethnic/Other ethnic background (Please indicate: _____)

2. What was your total family **income** last year (from all sources, before taxes)? This refers to the summed incomes of all individuals living in your home:
 less than 15,999 \$50,000 to \$59,999
 \$15,999 to \$19,999 \$60,000 to \$69,999
 \$20,000 to \$29,999 \$70,000 to \$79,999
 \$30,000 to \$39,999 \$80,000 to \$89,999
 \$40,000 to \$49,999 \$90,000 or more

3. What is the highest level of **education** that YOU completed?
 Grade 5 or below. Some college.
 Between grade 5 and 8. Completed college degree.
 Some high school but didn't finish. Graduate degree.
 Completed high school degree.

4. What is the highest level of **education** that your SPOUSE completed?
 Grade 5 or below. Some college.
 Between grade 5 and 8. Completed college degree.
 Some high school but didn't finish. Graduate degree.
 Completed high school degree.

Participant Number _____

EBQ

Below are a number of statements concerning learning and the nature of knowledge in **SCIENCE**. Please use the following scale to indicate **HOW MUCH YOU AGREE** with each statement. In answering, try to apply these statements to your **SCIENCE** class, rather than your other classes.

Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree
1	2	3	4	5

- ___ 1. Some people are just born smart, others are born dumb.
- ___ 2. If I can't understand something right away, I will keep on trying.
- ___ 3. I can depend on facts written in my school books for the rest of my life.
- ___ 4. It is hard to learn anything from textbooks unless you start at the beginning and learn one chapter at a time.
- ___ 5. What students learn from a textbook depends on how they study it.
- ___ 6. You cannot learn anything more from a textbook by reading it twice.
- ___ 7. Scientists can get the truth if they just keep on searching for it.
- ___ 8. The best thing about a science course is that most problems have only one right answer.
- ___ 9. A class in study skills would probably help students who are slow learners.
- ___ 10. Learning something really well takes a long time.
- ___ 11. You will get mixed up if you try to combine new ideas in a textbook with what you already know.
- ___ 12. Working hard on a difficult problem pays off only for the really smart students.
- ___ 13. Successful students understand things quickly.
- ___ 14. I like it when experts disagree.
- ___ 15. Being a good student generally involves memorizing facts.
- ___ 16. Today's facts may be tomorrow's fiction.

**Strongly
Disagree**
1

Disagree
2

Unsure
3

Agree
4

**Strongly
Agree**
5

- ___ 17. If I cannot understand something quickly, it usually means I will never understand it.
- ___ 18. An expert is someone who was born smart in something.
- ___ 19. If I am ever going to be able to understand something, it will make sense to me the first time I hear it.
- ___ 20. The really smart students don't have to work hard to do well in school.
- ___ 21. Thinking about what a textbook says is more important than memorizing what a textbook says.
- ___ 22. Students who are average in school will remain "average" for the rest of their lives.
- ___ 23. If I find the time to re-read a textbook chapter, I get a lot more out of it the second time.
- ___ 24. If scientists try hard enough, they can find the truth to almost everything.
- ___ 25. I really do not like listening to teachers who cannot seem to make up their minds as to what they really believe.
- ___ 26. The knowledge of how to study is usually learned as we grow older.
- ___ 27. Most words have one clear meaning.
- ___ 28. To me, studying means getting the big ideas from the textbook, rather than the details.
- ___ 29. Getting ahead takes a lot of work.

EBAS

Below are a number of statements concerning your science class. Please use the following scale to indicate **HOW MUCH YOU AGREE** with each statement.

Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree
1	2	3	4	5

- ___ 1. Everybody has to believe what scientists say.
- ___ 2. All questions in science have one right answer.
- ___ 3. Some ideas in science today are different that what scientists used to think.
- ___ 4. Ideas about science experiments come from being curious and thinking about how things work.
- ___ 5. In science, you have to believe what the science books say about stuff.
- ___ 6. The most important part of doing science is coming up with the right answer.
- ___ 7. The ideas in science books sometimes change.
- ___ 8. In science, there can be more than one way for scientists to test their ideas.
- ___ 9. Whatever the teacher says in science class is true.
- ___ 10. Scientists pretty much know everything about science; there is not much more to know.
- ___ 11. There are some questions that even scientists cannot answer.
- ___ 12. One important part of science is doing experiments to come up with new ideas about how things work.
- ___ 13. If you read something in a science book, you can be sure it's true.
- ___ 14. Scientific knowledge is always true.
- ___ 15. Ideas in science sometimes change.
- ___ 16. It is good to try experiments more than once to make sure of your findings.
- ___ 17. Good ideas in science can come from anybody, not just from scientists.
- ___ 18. New discoveries can change what scientists think is true.

**Strongly
Disagree
1**

**Disagree
2**

**Unsure
3**

**Agree
4**

**Strongly
Agree
5**

- ___ 19. Once scientists have a result from an experiment, that is the only answer.
- ___ 20. A good way to know if something is true is to do an experiment.
- ___ 21. Sometimes scientists change their minds about what is true in science.
- ___ 22. Good answers are based on evidence from many different experiments.
- ___ 23. Scientists always agree about what is true in science.
- ___ 24. Ideas in science can come from your own questions and experiments.
- ___ 25. Only scientists know for sure what is true in science.
- ___ 26. It is good to have an idea before you start an experiment.

MSLQ

Below are a number of statements that concern your **SCIENCE** class. Please use the following scale to indicate **HOW MUCH YOU AGREE** with each statement. In responding to the statements, please think **ONLY** about your **SCIENCE** class. Do not consider your other classes at school.

Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree
1	2	3	4	5

- ___ 1. Compared with other students in this class I expect to do well.
- ___ 2. When I study for a test, I try to put together the information from class and from the book.
- ___ 3. I prefer class work that is challenging so I can learn new things.
- ___ 4. When I do homework, I try to remember what the teacher said in class so I can answer the questions correctly.
- ___ 5. I'm certain I can understand the ideas taught in this course.
- ___ 6. It is important for me to learn what is being taught in this class.
- ___ 7. It is hard for me to decide what the main ideas are in what I read.
- ___ 8. Even when study materials are dull and uninteresting, I keep working until I finish.
- ___ 9. I expect to do very well in this class.
- ___ 10. When I study I put important ideas into my own words.
- ___ 11. I ask myself questions to make sure I know the material I have been studying.
- ___ 12. I outline the chapters in my book to help me study.
- ___ 13. When reading I try to connect things I am reading about with what I already know.
- ___ 14. Compared with other students in this class, I think I'm a good student.
- ___ 15. I always try to understand what the teacher is saying even if it doesn't make sense.
- ___ 16. When I study for a test I try to remember as many facts as I can.
- ___ 17. When work is hard I either give up or study only the easy parts.
- ___ 18. I like what I am learning in this class.

Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree
1	2	3	4	5

- ___ 19. When studying, I copy my notes over to help me remember the material.
- ___ 20. When I am studying a topic, I try to make everything fit together.
- ___ 21. Before I begin studying I think about the things I will need to do to learn.
- ___ 22. I am sure I can do an excellent job on the problems and tasks assigned for this class.
- ___ 23. I use what I have learned from old homework assignments and the textbook to do new assignments.
- ___ 24. I often find that I have been reading for class but don't know what it is all about.
- ___ 25. I find that when the teacher is talking I think of other things and don't really listen to what is being said.
- ___ 26. I think I will receive a good grade in this class.
- ___ 27. My study skills are excellent compared with others in this class.
- ___ 28. Compared with other students in this class I think I know a great deal about the subject.
- ___ 29. I know that I will be able to learn the material for this class.
- ___ 30. I think I will be able to use what I learn in this class in other classes.
- ___ 31. I work on practice exercises and answer end of chapter questions even when I don't have to.
- ___ 32. I think that what we are learning in this class is interesting.
- ___ 33. Understanding this subject is important to me.
- ___ 34. When I study for a test I practice saying the important facts over and over to myself.
- ___ 35. Even when I do poorly on a test I try to learn from my mistakes.
- ___ 36. I think that what I am learning in this class is useful for me to know.
- ___ 37. When I read material for this class, I say the words over and over to myself to help me remember.
- ___ 38. When I am reading I stop once in a while and go over what I have read.

AAGI

The following questions ask you to think about how you feel about schoolwork. We want you to tell us HOW MUCH YOU AGREE with each of the following statements:

- | Strongly
Disagree | Disagree | Unsure | Agree | Strongly
Agree |
|------------------------------|-----------------|---------------|--------------|---------------------------|
| 1 | 2 | 3 | 4 | 5 |
-
- ___ 1. I like to do SCIENCE problems that I'll learn from. Even if I make a lot of mistakes.
 - ___ 2. I would feel really good if I were the only one who could answer the teachers' questions during SCIENCE.
 - ___ 3. It's very important to me that I don't look stupid during the SCIENCE lesson.
 - ___ 4. An important reason why I do my work during SCIENCE is because I like to learn new things.
 - ___ 5. I want to do better than the other students in my class on my SCIENCE homework.
 - ___ 6. An important reason why I do my work during SCIENCE is so that I don't embarrass myself.
 - ___ 7. I like the SCIENCE lesson and homework best when it really makes me think.
 - ___ 8. It's important to me that the other students in my class think that I am good at SCIENCE.
 - ___ 9. The reason I do my work during SCIENCE is so my teachers don't think I know less than others.
 - ___ 10. An important reason why I do my work in SCIENCE is because I want to get better at it.
 - ___ 11. I would feel successful in school if I did better on my SCIENCE assignments than most of the other students.
 - ___ 12. One reason I would not raise my hand during the SCIENCE lesson is to avoid looking stupid.
 - ___ 13. I do my SCIENCE homework because I am interested in it.

**Strongly
Disagree**
1

Disagree
2

Unsure
3

Agree
4

**Strongly
Agree**
5

- ___ 14. I'd like to show my teachers that I'm smarter at SCIENCE than the other students in my class.
- ___ 15. The reason I do my work in SCIENCE is so others won't think I'm dumb.
- ___ 16. An important reason I do my SCIENCE assignments is because I enjoy it.
- ___ 17. Doing better than other students on my SCIENCE assignments is important to me.
- ___ 18. One of my main goals during SCIENCE lessons is to avoid looking like I can't do my work.

ILQ

Below are nine multiple-choice items. Each item consists of a question or statement followed by three alternatives (a, b, and c) from which to choose. Please circle the letter corresponding to the alternative that **best** answers the question or completes the statement.

1. The most important thing in learning science is:
 - a. to remember what the teacher has taught you.
 - b. to practice on lots of problems.
 - c. to understand the problems you work on.
2. The most important thing you can do when you are trying to learn science is:
 - a. faithfully do the work the teacher tells you to do.
 - b. try to see how the explanation makes sense.
 - c. try to remember everything you are supposed to know.
3. In order to learn the most you can from a science book, you have to try to:
 - a. read correctly what the book says.
 - b. remember what the book says.
 - c. think deeply about what the book says.
4. When you are learning something new in science, the most important thing to do is:
 - a. to figure out how it fits or doesn't fit with what you already know.
 - b. to get all the facts you can about it.
 - c. to write down what you have learned so you won't forget it.
5. In science, the way you learn the most is by:
 - a. listening to the teacher.
 - b. working by yourself.
 - c. working with other students.
6. If you studied something like science or art really hard for a whole year, at the end of the time how much would you know about it?
 - a. I'd probably run out of things to study before the year was up.
 - b. I'd probably know some things, but there would still be a lot to learn.
 - c. I'd know almost as much as an expert in the area.
7. If you wanted learn everything there is to know about something in science, say animals, how long would you have to study it?
 - a. Less than a year, if you study hard.
 - b. About one or two years.
 - c. Forever.

8. As you learn more and more about something in science:
 - a. the questions get more and more complex.
 - b. the questions get easier and easier.
 - c. the questions all get answered.

9. After you have studied something in science for a while, how can you tell if you've learned anything?
 - a. If I still had a lot of questions, then I know I haven't learned very much.
 - b. If I understand something that I didn't know before, then I know that I have learned something.
 - c. If I get good marks on the test, then I know I've learned a lot.

REFERENCES

- Ames, C. (1984). Achievement attributions and self-instructions under competitive and individualistic goal structures. *Journal of Educational Psychology, 76*, 478-487.
- Ames, C. (1992). Classrooms: Goals, structure, and student motivation. *Journal of Educational Psychology, 84*(3), 261-271.
- Ames, C., & Archer, J. (1988). Achievement goals in the classroom: Students' learning strategies and motivation processes. *Journal of Educational Psychology, 80*, 260-267.
- Bandura, M., & Dweck, C. S. (1985). The relationship of conceptions of intelligence and achievement goals to achievement-related cognition, affect, and behavior. Manuscript submitted for publication.
- Baxter Magolda, M. B. (1992). Students' epistemologies and academic experiences: Implications for pedagogy. *Review of Higher Education, 15*, 265-287.
- Baxter Magolda, M. B. (1998). Learning and gender: Complexity and possibility. *Higher Education, 35*, 351-355.

- Belenky, M. F., Clinchy, B. M., Goldberger, N. R., & Tarule, J. M. (1986). *Women's ways of knowing*. New York: Basic Books.
- Braten, I., & Stromso, H. I. (2004). Epistemological beliefs and implicit theories of intelligence as predictors of achievement goals. *Contemporary Educational Psychology, 29*, 371-388.
- Chan, C. K., & Sachs, J. (2001). Beliefs about learning in children's understanding of science texts. *Contemporary Educational Psychology, 26*, 192-210.
- Conley, A. M., Pintrich, P. R., Vekiri, I., & Harrison, D. (2004). Changes in epistemological beliefs in elementary science students. *Contemporary Educational Psychology, 29*, 186-204.
- Diener, C. I., & Dweck, C. S. (1980). An analysis of learned helplessness II. The processing of success. *Journal of Personality and Social Psychology, 39*, 940-952.
- Dunkle, M. F., Schraw, G. J., & Bendixen, L. (1993, April). The relationship between epistemological beliefs, casual attributions, and reflective judgment. Paper presented at the annual meeting of the American Educational Research Association, Atlanta, GA.

- Dweck, C. S. (1975). The role of expectations and attributions in the alleviation of learned helplessness. *Journal of Personality and Social Psychology, 31*, 674-685.
- Dweck, C. S. (1986). Motivational processes affecting learning. *American Psychologist, 41*, 1040-1048.
- Dweck, C. S. (1999). *Self-Theories: Their role in motivation, personality, and development*. Philadelphia: Psychology Press.
- Dweck, C. S., & Bempechat, J. (1983). Children's theories of intelligence: Consequences for learning. In S. G. Paris, G. M. Olson, & H. W. Stevenson (Eds.), *Learning and motivation in the classroom* (pp. 239-256). Hillsdale, NJ: Erlbaum.
- Dweck, C. S., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. *Psychological Review, 95*, 256-272.
- Dweck, C. S., & Reppucci, N. D. (1973). Learned helplessness and reinforcement Responsibility in children. *Journal of Personality and Social Psychology, 25*, 109-116.
- Dweck, C. S., Tenney, Y., & Dinces, N. (1982). [Implicit theories of intelligence as Determinants of achievement in goal choice]. Unpublished raw data.

- Elliot, A. J. (1997). Integrating the "classic" and "contemporary" approaches to achievement motivation: A hierarchical model of approach and avoidance achievement motivation. In M. L. Maehr, & P. R. Pintrich (Eds.), *Advances in motivation and achievement* (Vol. 10, pp. 143-179). Greenwich, CT: JAI Press.
- Elliot, A. J., & Church, M. A. (1997). A hierarchical model of approach and avoidance achievement motivation. *Journal of Personality and Social Psychology, 72*, 218-232.
- Elliot, A. J., & Harackiewicz, J. M. (1996). Approach and avoidance achievement goals and intrinsic motivation: A mediational analysis. *Journal of Personality and Social Psychology, 70*, 461-476.
- Greene, B. A., & Miller, R. B. (1996). Influences on course achievement: Goals, perceived ability, and cognitive engagement. *Contemporary Educational Psychology, 21*, 181-192.

- Hofer, B. K. (2002). Personal Epistemology as a Psychological and Educational Construct: An Introduction. In B. K. Hofer, & P. R. Pintrich (Ed.), *Personal Epistemology: The psychology of beliefs about knowledge and knowing* (pp. 3-14). Mahwah, NJ, USA Lawrence Erlbaum Associates.
- Hofer, B. K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Journal of Educational Psychology, 67*, 88-140.
- Inhelder, B., & Piaget, J. (1958). *The growth of logical thinking from childhood to adolescence*. New York: Basic Books.
- Kardash, C., & Scholes, R. J. (1996). Effects of preexisting beliefs, epistemological beliefs, and need for cognition on interpretation of controversial issues. *Journal of Educational Psychology, 88*, 260-271.

- Keating, D. P., & Sasse, D. K. (1996). Cognitive socialization in adolescence: Critical period for a critical habit of mind. In G. R. Adams, R. Montemayor, & T. P. Gullota (Eds.), *Psychosocial development during adolescence: Progress in developmental contextualism* (pp. 232-258). Thousand Oaks, CA: Sage.
- King, P. M., & Kitchener, K. S. (1994). *Developing reflexive judgment*. San Francisco: Jossey-Bass.
- Kitchener, K. S., & King, P. M. (1989). The reflective judgment model: Ten years of research. In M. L. Commons, C. Armon, L. Kohlberg, F. A. Richards, T. A. Grotzer, & J. D. Sinot (Eds.), *Adult development 2: Models and methods in the study of adolescent and adult thought* (pp. 63-78). New York: Praeger.
- Middleton, M. J., & Midgley, C. (1997). Avoiding the demonstration of lack of ability: An underexplored aspect of goal theory. *Journal of Educational Psychology, 89*(4), 710-719.
- Midgley, C., Kaplan, A., Middleton, M., Maehr, M. L., Urdan, T., Anderman, L. H., Anderman, E., & Roeser, R. (1998). The development and validation of scales assessing students' achievement goal orientations. *Contemporary Educational Psychology, 23*, 113-131.

- Montgomery, D. E. (1992). Young children's theory of knowing: The development of a folk epistemology. *Developmental Review*, 12, 410-430.
- Moshman, D. (1999). *Adolescent psychological development: Rationality, morality, and identity*. Hillsdale, NJ: Erlbaum.
- Nicholls, J. G. (1984). Conceptions of ability and achievement motivation. In R. Ames & C. Ames (Eds). *Research on motivation in education: Student motivation* (Vol. 1, pp. 39-73). New York: Academic Press.
- Perry, W. G. Jr. (1968). *Patterns of development of thought and values of students in a liberal arts college: A validation of a scheme*. Cambridge, MA: Bureau of Study Counsel, Harvard University. (ERIC Document Reproduction Service No. ED 024315)
- Pintrich, P. R. (2000). Multiple goals, multiple pathways: The role of goal orientation in learning and achievement. *Journal of Educational Psychology*, 92(3), 544-555.
- Pintrich, P. R., & DeGroot, E. V., (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology*, 82, 33-40.

- Ravindran, B., Greene, B. A., & DeBacker, T. K. (2005). Predicting preservice teachers' cognitive engagement with goals and epistemological beliefs. *The Journal of Educational Research*, 98(4), 222-232.
- Schoenfeld, A. H. (1983). Beyond the purely cognitive: Beliefs systems, social conditions, and metacognitions as driving forces in intellectual performance. *Cognitive Science*, 7, 329-363.
- Schoenfeld, A. H. (1988). When good teaching leads to bad results: The disasters of "well taught" mathematics classes. *Educational Psychologist*, 23, 145-166.
- Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology*, 82, 498-504.
- Schommer, M. (1993). Epistemological development and academic performance among secondary students. *Journal of Educational Psychology*, 85, 1-6.
- Schommer, M. (1994). An emerging conceptualization of epistemological beliefs and their role in learning. In R. Garner & P. Alexander (Eds.), *Beliefs about text and about text instruction* (pp. 25-39). Hillsdale, NJ: Erlbaum.

- Schommer, M. (1998). The influence of age and education on epistemological beliefs. *The British Journal of Educational Psychology, 68*, 551-562.
- Schommer, M., Course, A., & Rhodes, N. (1992). Epistemological beliefs and mathematical text comprehension: Believing it is simple does not make it so. *Journal of Educational Psychology, 84*, 435-443.
- Schommer-Aikins, M. (2004). Explaining the epistemological belief system: Introducing the embedded systemic model and coordinated research approach. *Educational Psychologist, 39*(1), 19-29.
- Schommer-Aikins, M., Duell, O. K., Hutter, R. (2005). Epistemological beliefs, mathematical problem-solving beliefs, and academic performance of middle school students. *The Elementary School Journal, 105*(3), 289-303.
- Schommer-Aikins, M., Mau, W. C., Brookhart, S., Hutter, R. (2000). Understanding middle students' beliefs about knowledge and learning using a multidimensional paradigm. *Journal of Educational Research, 94*(2), 120-127.

- Solomon, J., Duveen, J., & Scott, L. (1994). Pupils' images of scientific epistemology. *International Journal of Science Education*, 16(3), 361-373.
- Wellman, H. M. (1990). *Child's theory of mind*. Cambridge, MA: Bradford/MIT Press.