CHANGES IN TEACHER EFFICACY AND BELIEFS DURING A ONE-YEAR TEACHER PREPARATION PROGRAM

DISSERTATION

Presented in Partial Fulfillment of the Requirements for

the Degree Doctor of Philosophy in the Graduate

School of The Ohio State University

By
Alison Schirmer Lockman, M.A.

* * * * *

The Ohio State University
2006

Dissertation Committee:

Professor Anita Roychoudhury, Adviser

Professor David Haury

Professor Anita Woolfolk Hoy

Approved by

Anita Roychoudhury

Adviser
College of Education

ABSTRACT

This study addressed inadequacies in current understanding of the teacher efficacy beliefs, beliefs about students, and beliefs about the role of the teacher of secondary science preservice teachers. It had an overall goal of determining in what situations teacher education makes a difference in teacher beliefs, what aspects of teacher education impact teacher beliefs, and why that might be. A mixed quantitative and qualitative methodology was utilized in order to track participants' beliefs both broadly and in depth throughout a one-year teacher preparation program.

Results from this analysis revealed that preservice teachers at the end of the program had significantly higher personal science teaching efficacy beliefs than those at the beginning of the program. No significant difference in science teaching outcome expectancy beliefs was found,; these beliefs tended to shift more erratically. Teacher efficacy beliefs were directly affected by three of Bandura's four sources of self-efficacy beliefs—Mastery experiences, vicarious experiences, and verbal persuasion—and were facilitated through the process of personal reflection. The most powerful mastery experiences resulted from teaching students and obtaining an unexpected result, the most powerful vicarious experiences involved observing course professors and mentor teachers teach both successfully and unsuccessfully, and the most powerful verbal persuasive elements came from mentor teachers. No evidence was found that affective states by

itself had resulted in belief changes, although many of the mastery experiences, vicarious experiences, and verbal persuasive experiences were more powerful because they were accompanied by an emotional incident. Additionally, the influence of each source of self-efficacy information appeared to change during the course of the teacher preparation program. The preservice teachers relied more strongly on mastery teaching experiences as the year progressed. Vicarious experiences appeared to be most powerful during the quarter in which participants were engaged in their first field experience. Verbal persuasive experiences accounted for a steady but relatively minor proportion of influences on self-efficacy beliefs throughout the year; however, for several individual participants, the verbal persuasion and support of their mentor teachers made an important impact on their teacher efficacy beliefs. Most notably, preservice teachers with unsupportive mentors during their field placements in urban schools developed rather negative teacher efficacy beliefs.

Most preservice teachers in this study underwent a change in belief about their roles as teachers, from more traditional expository beliefs to constructivist and social constructivist beliefs. Teaching practices of participants in the sub-sample developed in the opposite direction as beliefs, progressing from more constructivist practices at the beginning of the teacher preparation program to more expository practices by the end of the program. Seven major categories of change instigators emerged from the data: direct teaching experiences, pressures outside the classroom, student expectations, theoretical

knowledge obtained, vicarious experiences, personal reflection, and verbal persuasive experiences. Direct teaching experiences made by far the greatest impact on participants' beliefs about the role of the teacher, which in some cases appeared due to a conceptual change process.

Preservice teachers in this study expressed in common five beliefs about students and why they tend to perform well or not so well in their science classes. Participants generally believed that all students were able to learn, and that differences in student performances were due to factors such as parental influence, peer pressure, societal expectations, educational background, priorities of other parts of student lives such as athletics, jobs, and taking care of family members, and intrinsic student motivation. Participants also believed that students were intrinsically lazy, that students would not naturally like science and/or that they would feel that science was difficult to learn, that there were differences in student capabilities based on gender, socioeconomic status, and age, and that individualized instruction for all students was important. Few systematic changes in these beliefs were noted during the course of the teacher preparation program; instead, individual preservice teachers tended to wobble rather than permanently change their beliefs. Changes in the preservice teachers' beliefs about students were attributed overwhelmingly to personal teaching experiences, but also to the opinions of other teachers, observations of other teachers, personal experiences as students themselves, and media portrayals of students.

Dedicated to my parents,
who are my greatest teachers

ACKNOWLEDGMENTS

This work would not have been possible without so many people who gave selflessly of themselves. First, thanks to all members of my dissertation committee. I wish to thank my adviser, Anita Roychoudhury, for pushing me to start this project, for encouragement and guidance throughout the process of completing this research and writing this document, and for being so flexible and helpful as I finished the project from a distance. I thank Anita Hoy for introducing me to the constructs of teacher efficacy and teacher beliefs, without which this project never would have existed. I also appreciate her critical eye and constant reminder of basing research in theory. I thank David Haury for helping me to tie together so much of teacher education and science teaching, and for keeping me focused on the "big picture" of teacher education and teacher beliefs.

Next, many thanks to the preservice teachers who were willing to give up their time and energy to participate in this research. You are the heart and soul of this project, and I cannot thank you enough for willingly and honestly sharing your thoughts and experiences throughout an entire year.

I also would like to thank my fellow graduate students. I thank Missy Schen for emotional support, stimulating my thought-processes about research issues (quantitative researcher that she is!), and for facilitating my gathering of data from a distance. I thank

Tim McKeny and Mary LeFever for inspiring me to consider teacher education as a field of research, and for general emotional support throughout this process. I thank Liesl Hohenshell and Michael Meagher for constantly pushing me to do research, and for always sharing their sense of humor.

I would like to thank my friends Elizabeth, Laura, Becky, Amy, Stacey, Rachel, Debra, and Danielle, who often sympathized when I needed to vent my frustrations, and who were constantly enthusiastic about what I was doing and learning. I would also like to thank my own former teachers (good and bad) and the teachers with whom I worked at Westminster School, who initially inspired me to pursue this degree.

Finally, I would like to thank my family, who dealt with the brunt of my frustrations, anxieties, confusions, and successes. Thanks to my parents, who constantly push me to do more and do better, and who motivated the two aspects of my doctoral study—science and teaching. Thanks to Todd and Karen, with whom I have been able to share the joys and difficulties of completing this degree. Thanks to Christine, Susie, and Steve, for keeping me grounded and for being constant sources of good humor. Thanks to Deena and Stuart, who provided love, support, and encouragement throughout this process. Finally, many thanks to my husband, Jeff. Jeff not only provided emotional support and kept me focused on completing this project, but often acted as a sounding-board for my ideas, and he spent many, many hours editing this document.

VITA

December 19.1974............................. Born—Norwood, Massachusetts

1997 .... B.A., Astrophysics, Swarthmore College

1997—1999 ....Instructor/Teaching Assistant
University of Virginia

1999 .... M.A., Astronomy, University of Virginia.

1999—2003 ....Science Teacher
Westminster School

2003—2005 ....Teaching Assistant
The Ohio State University

2006—present .... Associate Instructor
Westminster College

PUBLICATIONS

1. Schirmer, B.R., Bailey, J., & Lockman, A.S. (2004). What verbal protocols reveal about the reading strategies of deaf students: A replication study. *American Annals of the Deaf. 149*(1) 5-16.

2. Schirmer, B.R. & Lockman, A.S. (2001). How do I find a book to read? Middle and high school students use a rubric for self-selecting material for independent reading. *Teaching Exceptional Children, 34*, 36-42.

3. Wehrle, A.E., et al. (1998). Multiwavelength observations of a dramatic high-energy flare in the blazar 3C 279. *Astrophysical Journal, 497*, 178-187.

4. Wehrle, A.E., et al. (1997). Multiwavelength observations of the February 1996 high-energy flare in the blazar 3C 279. *Proceedings of the Fourth Compton Symposium, Williamsburg, VA*

5. Schirmer, A.F. (1996). Optical variability of the BL Lac object 1418+546. *Proceedings of the 1996 Undergraduate Symposium on Research in Astronomy, held at Wellesley College, Wellesley, MA.*

FIELDS OF STUDY

Major Field: Education
Area of Emphasis: Science Education

TABLE OF CONTENTS

Page
Abstract ……………………………………………………………………………...ii
Dedication ……………………………………………………………………………...v
Acknowledgments ………………………………………………………………………vi
Vita ……………………………………………………………………………….viii
List of Tables …………………………………………………………………...xiv
List of Figures ………………………………………………………………….…xvi

Chapters:

1. Introduction and conceptual framework ……………………………………….....1

Teacher efficacy beliefs ………………………………………………………..3
Beliefs about students ………………………………………………………….5
Beliefs about the role of the teacher ……………………………………………...7
Relationships between teacher efficacy and beliefs ………………………………7
Teacher efficacy beliefs and beliefs about students …………………….....8
Teacher efficacy beliefs and beliefs about the teacher's role …………....10
Relationships between teacher beliefs and practices …………………………....12
Some history …………………………………………………………......12
Psychology research ……………………………………………13
Philosophy research ……………………………………………..…17
A conceptual framework of teacher beliefs ……………………………..…19
Summary of teacher beliefs ……………………………………………………..22
Development of teacher beliefs ………………………………………………....23
Rokeach's theory of beliefs ……………………………………………..23
Theories of belief change ……………………………………………….…26
Cognitive dissonance theory ……………………………….…26
Conceptual change model ………………………………………29
Dual-process model …………………………………………….…32
Summary …………………………………………………………………..35
Problem Statement ……………………………………………………………....35

2. A review of the literature ……………………………………………………….37

Introduction ………………………………………………………………………...37
Teacher efficacy beliefs ………………………………………………………39
Teacher characteristics …………………………………………………..39
School characteristics ……………………………………………………...42

Student characteristics 45
Beliefs about students 45
Teacher characteristics 47
School characteristics 48
Student characteristics 50
Beliefs about the role of the teacher 50
Teacher characteristics 52
School characteristics 54
Summary of teacher beliefs 56
Relationship between teacher beliefs and practices 56
Development of teacher beliefs 59
Beliefs about the role of the teacher 62
Beliefs about students 65
Teacher efficacy beliefs 68
General belief change 71
Summary 73

3. Research methods 74

Participants and program description 74
Data collection and analysis 78
Research questions 78
Data sources 79
Instruments 83
Data analysis 85
Trustworthiness 88

4. Findings: Teacher efficacy beliefs 90

Overall trends: Quantitative results 91
Overall trends: Qualitative results 95
Personal teacher efficacy beliefs 95
Outcome expectancy beliefs 101
Influences on teacher efficacy beliefs 116
Summer 117
Autumn 121
Winter 126
Spring 134
Summary 140
Synopsis 142

5. Findings: Beliefs about the role of the teacher……………………………………...146

Characteristics of effective science teachers ………………………………..147
Content knowledge …………………………………………………147
Knowledge of teaching ……………………………………………...148
Knowledge of students ……………………………………………149
External influences …………………………………………………150
Personal characteristics ……………………………………………...151
Development of beliefs about effective teachers ……………………………152
The role of the science teacher ………………………………………………157
Expository teachers ………………………………………………158
Constructivist teachers ……………………………………………159
Social constructivist teachers ………………………………………..160
Empathizer teachers ………………………………………………161
Maturationist teachers ……………………………………………162
Development in beliefs about the role of the science teacher …………………162
Comparison of beliefs and practices ………………………………………...173
Influences on beliefs about the role of the science teacher ……………………180
Direct teaching experiences ………………………………………182
Vicarious experiences ……………………………………………184
Theoretical knowledge obtained …………………………………186
Verbal persuasion by authority ……………………………………...190
Student expectations ………………………………………………...191
Personal reflection …………………………………………………..193
Pressures outside the classroom ……………………………………..194
Changes over time …………………………………………………...196
Summary ………………………………………………………………197
Synopsis ……………………………………………………………………..198

6. Findings: Beliefs about students ………………………………………………202

Beliefs about students ………………………………………………………203
All students can learn ………………………………………………..203
Students are intrinsically lazy …………………………………………210
Students don't like science ……………………………………………..212
Some types of students are more/less successful ………………………213
Students learn differently? ……………………………………………..217
Changes in beliefs about students …………………………………………...220
Influences on beliefs about students …………………………………………...222

Synopsis 230

7. Discussion and implications 233

Research question 1 234
Teacher efficacy beliefs 234
Beliefs about the role of the teacher 236
Beliefs about students 238
Research question 2 240
Teacher efficacy beliefs 241
Beliefs about the role of the teacher 244
Beliefs about students 250
Research question 3 252
Importance of beliefs about the role of the teacher 254
Importance of beliefs about students 258
Importance of mastery experiences 260
Importance of content knowledge 262
Confirming the proposed model 264
Summary: Profiles of high and low efficacy preservice teachers 266
Implications for teacher education 268
Implications for future research 276
Conclusion 278

Appendices:

Appendix A M.Ed. course requirements 279
Appendix B Science Teaching Efficacy Belief Instrument 281
Appendix C Reformed Teaching Observation Protocol 284
Appendix D Semi-structured interview prompts 288
Appendix E Weekly reflection prompts 291
Appendix F Matrix of effective teacher characteristics 302

List of References 306

LIST OF TABLES

Table Page

2.1 Summary of research on teacher beliefs and practices 57

2.2 Some recent empirical research on the malleability of teacher beliefs 61

3.1 Research participants 76

3.2 Data sources 82

3.3 Changes to *Science Teaching Efficacy Belief Instrument* 84

4.1 Comparison of PSTE and STOE scores by cohort 91

4.2 Comparison of PSTE and STOE scores for entire group 91

4.3 Summary of the analysis of variance for PSTE scores 93

4.4 Summary of the analysis of variance for STOE scores 94

4.5 STEBI-A PSTE scores for individual participants 100

4.6 STEBI-A STOE scores for individual participants 115

4.7 Type of influence as changed with time 141

5.1 Development of beliefs about effective teachers 152

5.2 Categories for role of teacher 158

5.3 Categories for role of teacher 164

5.4 Comparison between beliefs and practices 174

5.5 Comparison of constructivist teaching practices at urban and suburban schools 179

5.6 Comparison of constructivist teaching practices at middle and high schools …………………………..…………………….…………………..180

5.7 Factors influencing changes in preservice teacher beliefs about the role of the teacher …………………………………………………………………...181

5.8 Factors influencing changes in preservice teacher beliefs about the role of the teacher …………………………………………………………………...197

6.1 Development of beliefs about students ……………………………………...220

7.1 Comparison of PSTE and STOE Scores ……………………………………….235

7.2 STEBI-A scores for individual participants ……………………………………256

7.3 Correlations between teaching practices and teacher efficacy beliefs …………257

7.4 Type of influence as changed with time ……………………………………….261

LIST OF FIGURES

Figure Page

1.1 Tschannen-Moran et al., 1998 integrated model of self-efficacy ……………….16

1.2 Model of science teacher efficacy ……………………………………………21

2.1 Factors influencing teacher beliefs …………………………………………...38

3.1 Timeline of data collection 89

4.1 Map of factors impacting and changes in teacher efficacy beliefs ……………...90

4.2 STEBI-A PSTE scores for individual participants …………………………….101

4.3 STEBI-A STOE scores for individual participants …………………………….116

5.1 Map of beliefs about teaching and changes in beliefs about teaching …………146

5.2 Changes in beliefs about teaching …………………………………………..171

5.3 Changes in teaching practices ……………………………………………….177

6.1 Map of beliefs about students and changes in beliefs about students …………202

7.1 Model of science teacher efficacy …………………………………………...254

7.2 Influences on teacher efficacy throughout teacher preparation program ……....261

7.3 Experiences and outcomes of low and high efficacy preservice teachers.……..266

CHAPTER 1

INTRODUCTION AND CONCEPTUAL FRAMEWORK

A current national education goal is that all students should have the opportunity to learn and do science, regardless of gender, ethnicity, or cultural background (Barton, 2000; Bianchini, Johnston, Oram, & Cavazos, 2003). Teachers who fail to follow through with this ideal fail to provide their students with equitable access to scientific literacy and to future employment opportunities in an increasingly technological world (Bryan & Atwater, 2002; Bullock, 1997). Furthermore, aside from parents, teachers may have the largest influence on students' achievement, future plans, and perseverance to reach their goals (Brand, Glasson, & Green, 2006; Rascoe & Atwater, 2005; Russell & Atwater, 2005).

It is generally agreed that teachers who have confidence in their own teaching abilities and who believe that effective teaching can influence student learning persist in teaching for longer careers, concentrate more on academics in the classroom, provide students who encounter difficulties with the guidance they need to succeed, and praise student academic accomplishments (Gibson & Dembo, 1984; Hoy & Davis, 2005). They view all students as reachable and teachable, take personal responsibility for student learning (Ashton, 1984), and rely on persuasion rather than authority to manage their classrooms (Ashton & Webb, 1986). Most importantly, teachers who possess and express high expectations for themselves and their students produce students with higher levels of academic achievement (Ashton & Webb, 1986; Fuchs, Fuchs, & Phillips, 1994; Hoy & Davis, 2005; Ross, 1998; Wigfield, Galper, Denton, & Seefeldt, 1999) and more confidence in their academic competence (Czerniak & Chiarelott, 1990; Stipek, Givvin, Salmon, & MacGyvers, 2001). On the other hand, teachers who possess negative teacher efficacy beliefs spend more time on nonacademic activities, give up on students when they do not get quick results, and criticize students for their failures (Gibson & Dembo, 1984). They also favor controlling classrooms through strict rules and rely on extrinsic inducements in order to get students to work (Ashton & Webb, 1986).

Unfortunately, many preservice and novice teachers express extremely low confidence in their abilities to teach and help students learn. Such low confidence in science teachers has usually resulted in science being taught as an afterthought or not at all, and to be taught by transmission methods instead of through inquiry or discovery (Plourde, 2002b; Tosun, 2000). Furthermore, it has been theorized that a teacher's sense of efficacy may be most malleable early in his/her process of learning to teach (Hoy & Spero, 2005). Hence, teacher educators should be keenly aware that the courses and experiences in which preservice teachers engage during their teacher preparation programs may make a significant and permanent impact on their sense of efficacy as professional teachers.

It is important for all children to have successful experiences in science. Science education helps children develop the knowledge, problem solving skills, and critical thinking skills that are necessary in our rapidly changing technological society. Developing the confidence and positive attitude of teachers toward teaching science to all students is, therefore, of utmost importance. It may be even more vital than training future teachers to reach specific competencies:

> After decades in which "the person" was largely absent from the theory on how best to educate teachers, we are now witnessing a surge of interest in the question of how beginning teachers think about themselves and how they undergo the substantial personal transformation they pass through as they become teachers. (Korthagen, 2004)
>
> Knowing that there are variations among teachers and students without any information about why, how, for whom, under what conditions, and to what ends may allow us to group teachers into segments from highest- to lowest-performing, but it does not go very far toward improving teacher preparation or schooling. (Cochran-Smith, 2005)

Teacher Efficacy Beliefs

Teacher efficacy stems from Bandura's (1997) social cognitive theory of self-efficacy. According to Bandura, self-efficacy beliefs are an assessment of one's personal capabilities—to take action, produce results, and have control over a given situation. For example, when people with positive and negative senses of self-efficacy succeed, they both attribute that success to ability; however, when both fail, a person with a positive sense of self-efficacy attributes the failure to insufficient effort, while a person with a negative sense of self-efficacy attributes the failure to lack of ability (Gist & Mitchell, 1992). Not all researchers agree that possession of a positive sense of teacher efficacy is necessary in order to be a successful teacher. It is possible that teachers who have doubts in their efficacy beliefs may actually be spurred to be more innovative, whereas teachers who have a very positive sense of efficacy will feel that their teaching needs no improvement (Wheatley, 2002).

According to most researchers, there are two major of aspects of self-efficacy: personal efficacy and outcome expectancy. Personal efficacy is the belief in one's ability to plan, organize, and execute a course of action toward a specific goal. In relation to teaching, personal efficacy translates into teacher efficacy and is the belief that one can develop strategies to overcome obstacles to student learning and be an effective teacher for all students. According to Bandura, teachers who possess positive teacher efficacy beliefs will expend a great amount of effort to achieve their goals, will persist longer toward accomplishing those goals, and will rebound quickly from setbacks. In relation to teaching, outcome expectancy translates into teacher outcome expectancy. Teacher outcome expectancy is the belief that student learning can be influenced by effective teaching. According to Bandura, teachers who have positive teacher outcome expectancy beliefs believe that they have a large influence over student motivation and performance, regardless of home or environmental problems. There is some debate over the components of self-efficacy beliefs. While the personal efficacy and outcome expectancy components have been utilized for many years in studies of efficacy beliefs, some researchers believe, instead, the distinction between components of self-efficacy beliefs is between internal and external factors. In this case, the internal factor includes perceptions of personal influence and power in teaching and learning situations. The external factor includes perceptions of the teacher's influence on elements that lie outside the classroom (Guskey & Passaro, 1994).

Bandura (1997) defines four sources of teacher efficacy information: mastery experiences, vicarious experiences, verbal persuasion, and affective states. Engaging in a mastery experience produces a teacher's perception that a teaching performance has been successful, and is the source for one's belief that later teaching performances of the same type will be equally successful. Engaging in a vicarious experience involves viewing a successful teaching performance that is modeled by someone else. If one can identify with the model, one will feel that he or she can also be successful at the specific teaching behavior or task. Verbal persuasion is when others express faith in one's capabilities to successfully engage in a specific teaching performance. When one is verbally persuaded, he or she is more likely to try harder and see a teaching performance through to a successful finish, although Bandura notes that this is somewhat dependent on the expectation being a reasonable one; otherwise, it could have the opposite effect and cause one to try less hard. Experience of a affective state (such as anxiety or excitement) during a mastery performance, verbal persuasion, or vicarious experience adds to the feeling of mastery or incompetence, and so may enhance or impair one's sense of teacher efficacy.

Beliefs About Students

Many teachers possess powerful stereotypes with regard to children of certain ethnic background, socioeconomic status, and gender (Delpit, 1995; Norman, Ault, Bentz, & Meskimen, 2001; Roger & Duffield, 2000). Possibly due to the historical lack of representation of certain minorities in science, teachers of science are especially prone to these stereotypes. As a result, children in stigmatized groups are prone to more adverse expectations by teachers and are therefore more likely to have such expectations lead to self-fulfilling prophecies of poor academic performance (Gill & Reynolds, 1999; Kahle, Parker, Rennie, & Riley, 1993; Rascoe & Atwater, 2005). For example, a teacher who believes that girls are less capable science students will treat them as such, and tend to do things for them and/or have them work with male students who will do things for them (Sadker & Sadker, 1995). Consequently, girls do not learn science as well as boys and absorb the belief that they cannot learn science. Alternately, high expectations of teachers and strong student-teacher relationships have been associated with persistence and success of minority students in the sciences (Rascoe & Atwater, 2005; Russell & Atwater, 2005).

Unconscious discriminatory beliefs ultimately may be even more powerful. It has been suggested that preservice teachers possess three general types of beliefs about students (Causey, Thomas, & Armento, 2000). First, they believe that hard work by students will always result in triumph over any obstacle. Second, they believe that good teaching is equally effective for all students. Third, they believe that every person is equal and should be treated the same as every other. In accordance with these three beliefs, teachers may tend to overlook advantages and disadvantages received by certain groups of students that are only due to skin color, gender, or socioeconomic status. They may also ignore individual student learning differences. Hence, they may unconsciously victimize certain students.

Beliefs About the Role of the Teacher

Teachers' beliefs about the role of the teacher are often placed on a continuum anchored by traditional expository beliefs on one end and constructivist beliefs on the other end (Arends, Winitzky, & Tannenbaum, 2001; Sadker & Sadker, 2000). Teachers possessing expository philosophies of teaching and learning tend to believe in teacher-centered instructional roles, where students are expected to absorb information. Such instruction involves the more traditional methods of lecture, verification labs, and teacher-designed worksheets and assignments. Teachers possessing a constructivist philosophy of teaching and learning tend to believe that students construct their own meanings through interaction with information and people (Dewey, 1963; Piaget, 1973), and believe in student-centered instruction. Such instruction includes the less traditional methods of authentic inquiry and student-created questions that are currently taught in most colleges of education.

Relationships Between Teacher Efficacy and Beliefs

Much research has gone into determining which factors affect teacher efficacy beliefs, which experiences during teacher education and professional development programs result in teachers being more receptive to teaching science to all students, and which experiences result in teachers being more open to more progressive methods of teaching. Little research has revealed specifically how teachers with positive teacher efficacy beliefs behave differently than teachers with more negative teacher efficacy beliefs with regard to teaching science to all students and innovative teaching strategies, but I contend that there is a connection between teacher efficacy beliefs, teacher beliefs about students in science, and teacher beliefs about the role of the science teacher.

Teacher Efficacy Beliefs and Beliefs About Students

Teachers' beliefs about students may significantly interact with teacher efficacy beliefs and ultimately, to teacher behaviors and student achievement. Ashton and Webb (1986) suggest that perceived student abilities are the single most influential student characteristic affecting teacher behaviors. For example, teachers have been socialized to view girls as less capable in the sciences, so teachers may have lowered expectations; as a result, teachers tend to challenge girls less and do things for them (Tobin & Gallagher, 2003). Similarly, teachers who do not share a culture with students of color or different socioeconomic backgrounds may misinterpret these groups' behavior, discourse style, and abilities, resulting in lowered expectations, lowered effort in teaching, and lowered collective efficacy of the school community (Delpit, 1995; Goddard, Logerfo, & Hoy, 2004; Hauser-Cram, Sirin, & Stipek, 2003). A strong sense of teacher efficacy may help teachers to move beyond what they do not understand and cannot control about their students and to focus on caring for their students and helping them to learn (Hoy & Davis, 2005). One set of researchers noted the connection between beliefs about students of minority ethnicity and the development of the teacher's sense of efficacy: "A program that challenges and expands teachers' beliefs as related to racial and ethnic identities is crucial to promoting self-efficacy as well as an awareness of the impact beliefs have on science teaching." (Brand & Glasson, 2004 p. 140)

Some beginning teachers are quite receptive to the idea of teaching all students in science. Aside from personal characteristics such as being generally receptive to new ideas, possessing a willingness to critically examine their own belief systems, and being committed to social justice (Garmon, 2004), these teachers share several behavioral characteristics that clearly reveal their high level of teacher self-efficacy. First, they focus on student learning as opposed to teacher behavior. For instance, they teach a smaller number of concepts in a single lesson, using the extra time to facilitate student discussion, wait longer after asking questions, and ask for a larger number of student responses per question (Yerrick & Hoving, 2003). They communicate high expectations and the importance of learning to students, exhibit "withitness", keep all students on task, and praise students often (Ashton & Webb, 1986). They utilize their understanding of student prior experiences and knowledge as they design and facilitate each lesson (Barton, 2000; Tobin, Roth, & Zimmermann, 2001; Yerrick & Hoving, 2003). Further, they use student academic and behavioral challenges to think more broadly about their role as future teachers and about their students as individuals and as members of specific cultural groups (Tobin et al., 2001; Yerrick & Hoving, 2003).

Many teachers believe that not all students are able to learn science and/or that they will not be able to teach science to some students. In general, teachers who believe that not all students can learn science from them share several characteristics that reveal low levels of teacher self-efficacy. They attribute student academic difficulties as due to a lack of discipline, laziness, or a bad attitude (Thompson, Warren, & Carter, 2004; Yerrick & Hoving, 2003). They also believe that some students simply cannot learn, no matter what they as teachers will try (Brown, Anfara, & Roney, 2004; Gilbert & Yerrick, 2001). As a result, they spend less time teaching low achieving students than high achieving students, tend to categorize students by innate "ability" rather than achievement, call on low achieving students less often, and do not push low achieving students beyond their current state (Ashton & Webb, 1986; Gibson & Dembo, 1984).

Teacher Efficacy Beliefs and Beliefs About the Teacher's Role

Teachers' beliefs about the role of the teacher may also tie in to teacher efficacy beliefs. Because teachers with positive teacher efficacy beliefs are confident in their own teaching abilities and confident that they can facilitate student learning. They are more likely to try out new types of teaching methods in order to better help students, and are more likely to expend greater effort in planning and organizing, and to be more persistent and resilient in the face of setbacks (Tschannen-Moran, Hoy, & Hoy, 1998).

Several researchers have found a connection between teacher efficacy beliefs and beliefs about the role of the science teacher, with more positive teacher efficacy beliefs almost exclusively associated with a willingness to use more student-centered and innovative teaching methods. Teachers with more positive teacher efficacy beliefs tend to use more activity-based science instruction and do less seat work, encourage students to answer questions rather than answering questions themselves, and spend more class time teaching science (at the elementary level) than teachers with more negative teacher efficacy beliefs (Ashton & Webb, 1986; Enochs & Riggs, 1990; Mulholland & Wallace, 2001; Ramey-Gassert, Shroyer, & Staver, 1996; Riggs & Enochs, 1990). They also provide opportunities for students to engage in real science explorations, including asking questions, solving problems, collecting and analyzing data, and discussing with collaborators (Barton, 2000; Luft, 1999; Yerrick & Hoving, 2003).

Teachers with a more positive sense of efficacy reported the use of additional progressive techniques such as differentiated instruction and diagnostic teaching, as well as communicating more frequently with parents, school professionals, principals, and students than did teachers with lower teacher efficacy beliefs (Wertheim & Leyser, 2002). Teachers with more positive efficacy beliefs also tend to rate instructional innovation as more important to implement than teachers with lower efficacy beliefs (Ghaith & Yaghi, 1997). In general, these teachers constantly question and challenge their prior beliefs about science teaching and typically use student-centered pedagogical strategies learned in university methods courses (Barton, 2000; Luft, 1999; Tobin et al., 2001; Yerrick & Hoving, 2003).

In contrast, teachers possessing more negative teacher efficacy beliefs tend to avoid progressive, student-centered instructional methods and to almost exclusively utilize teacher-centered instruction. These teachers focus on their own behaviors, such as needing to perform for students and keep control of the class as opposed to examining and promoting student learning (Brighton, 2003; Carlone, 2003; Mulholland & Wallace, 2001; Stipek et al., 2001; Yerrick & Hoving, 2003). They also rarely question their own prior knowledge about teaching and tend to rely on pedagogical strategies learned outside of their teacher preparation program (Yerrick & Hoving, 2003). Many beginning teachers, particularly those with a weak sense of efficacy, are concerned with classroom management issues, feel unprepared to handle the everyday administration of a classroom (Kagan, 1992b), and so feel that initiating innovative teaching methods such as inquiry science, which emphasizes the contributions of all students, might be risky with certain types of children (Yerrick & Hoving, 2003). Instead, it is more comfortable to use whole-class instructional techniques, teacher-centered lessons, and rigidly structured laboratory activities (Mulholland & Wallace, 2001; Stipek et al., 2001; Yerrick & Hoving, 2003).

Relationship Between Teacher Beliefs and Practices

Researchers throughout the last century in the fields of education, psychology, and philosophy have examined the relationship between beliefs and practices. In this section, I will recount some of the history and theory behind the concept of "teacher beliefs" as it has been related to practices.

Some History

The construct of "teacher beliefs" appears to have two main sources of origin in two rather different fields of study: Edward Tolman in the field of psychology and David Hume in the field of philosophy. Tolman was interested in the effects of expectancies, which dealt with perceptions of properties of individuals or groups of individuals (Zuroff

& Rotter, 1985). Hume, on the other hand, was concerned with a philosophical definition of beliefs (Ginsberg, 1972). The research interests of Tolman lead to a large variety of studies on expectancies, motivation, perceptions, self-efficacy, and self-regulation. The theoretical interests of Hume lead to a continuing struggle to define the concept "belief" and to develop theories of human beliefs, thought, emotion, and action. This section will discuss the line of research following Tolman's psychology research, and then the line of research following Hume's original philosophical definition of belief.

Psychology research.

It is believed that Tolman was the first to invent the expectancy construct, motivated by his experiments on the conditioning of rats in mazes (Zuroff & Rotter, 1985). There are references back to 1885 that note unconscious experimenter bias in psychological experiments (for example, rats act smarter when the researchers expect them to do so), but Tolman was the first to define the construct and to create a theory around it (Rosenthal, 1985). Tolman defined expectancy as the expectation that a characteristic of an object of interest will be better or worse for achieving a specific purpose; this definition has been criticized for being too loose and therefore impractical for research verification, and so early successors of Tolman spent much effort tying the construct to more empirically observable concepts (Zuroff & Rotter, 1985).

In the 1930s, Lewin developed expectancy theory by using the concept of goal-seeking; he believed humans were goal-seeking organisms and that human behavior was determined by a person's goals and knowledge of paths toward those goals (Zuroff &

Rotter, 1985). Rotter redefined expectancy more usefully for empirical researchers in the 1950s as the probability held by a person that reinforcement would occur as a result of certain behaviors in a particular situation. Furthermore, he defined two types of expectancies: generalized and specific. Specific expectancies were based on a person's past, overall similar experiences with behaviors, reinforcements, and contexts. Generalized expectancies were based on a person's past experiences in which he or she received the same reinforcements for the same behaviors, but the context did not have to be the same. Such expectancies were thought to affect human behavior in important ways (Zuroff & Rotter, 1985).

Working between 1950 and 1980, Mischel pinned down expectancy theory further by examining how different situations affect expectancies, how a person's psychological state impacts his or her expectancies and behaviors, and how expectancies affect delay of gratification (Zuroff & Rotter, 1985). Bandura further distinguished generalized expectancies in terms of two types of expectations: outcome expectations and efficacy expectations (Bandura, 1997). He later developed a theory of self-efficacy beliefs that explained how the four sources of efficacy information (mastery experiences, vicarious experiences, verbal persuasion, and physiological arousal) establish a person's sense of self-efficacy, and how a person's self-efficacy beliefs then determine his/her thought-processes and emotions, which determine effort spent, persistence, and resilience in the pursuit of goals (Bandura, 1997).

Additionally, several psychologists in the 1950s worked with a theory of motivation to determine the relationship between expectancy, motivation, and incentive.

While Rotter's theory of expectancy assumed that people held relatively stable expectancies that differed only in different situations, motivation theory reversed this original notion and emphasized the idea that situation alone determined expectancies (Zuroff & Rotter, 1985).

Decades later, Tschannen-Moran, Woolfolk Hoy, and Hoy (1998) developed an integrated model of self-efficacy based on Bandura's (1997) theory as well as research on the context-dependence of such beliefs (See Figure 1.1). They added a cognitive processing piece to Bandura's original four sources of self-efficacy information, in which the self-efficacy information is reflected on, interpreted, and evaluated. This information is then compared and assessed against two different aspects of what the teacher has been asked to do: (a) What will be required of him/her in the teaching task itself, including information about student abilities and interests, required materials, physical conditions of the classroom, and support of administration and other teachers; and (b) How the teacher perceives himself/herself as a functioning teacher, as competent or incompetent (Tschannen-Moran et al., 1998). Judgment of these different personal elements against a specific teaching task determines the teacher efficacy. The model also accounts for the cyclical nature of self-efficacy beliefs. Having positive self-efficacy beliefs promotes constructive characteristics such as persistence, effort, and innovation when teaching (Tschannen-Moran et al., 1998). These characteristics then usually result in positive teaching experiences, adding to Bandura's (1997) sources of self-efficacy and resulting in continually high teacher efficacy beliefs. Furthermore, the depth of cognitive processing may differentially impact self-efficacy beliefs. Novelty, unexpected failure, and major changes in task expectations can prompt a more rigorous cognitive processing, which then may more significantly impact self-efficacy beliefs (Gist & Mitchell, 1992).

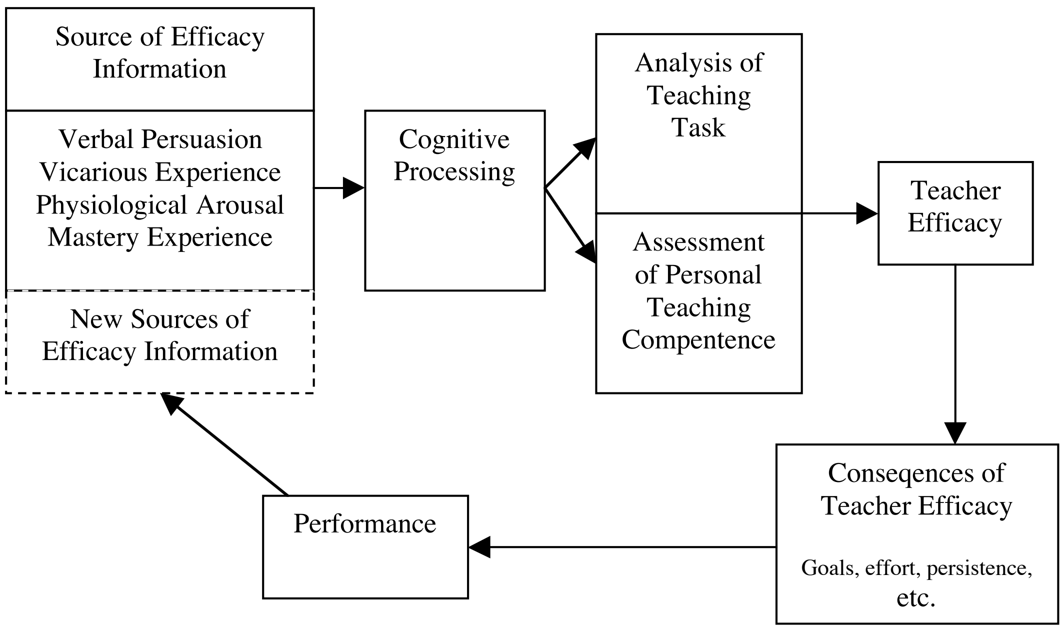

Figure 1.1: Tschannen-Moran et al., 1998 integrated model of self-efficacy

Expectancy theory was first applied to teachers in Rosenthal and Jacobson's (1968) study *Pygmalion in the Classroom*, in which researchers planted false information about student academic potential in teachers' minds. They discovered that the false information lead to teachers having differing expectations for these students, which lead to certain judgments of academic potential, specific actions toward different students, and disparate academic performances by students by the end of the school year. Rosenthal and Jacobson's study gave rise to a huge amount of criticism as well as new areas of research, including how teachers form expectancies, how teacher expectancies are communicated to students, and theories connecting student characteristics to expectancies and expectancies to teacher behaviors (Brophy & Evertson, 1981; Dusek, 1985; Good & Brophy, 1984; Wigfield, Galper, Denton, & Seefeldt, 1999).

Philosophy research.

As has been noted by many researchers, deciding on a useful definition of "belief" has not been an easy process (Kagan, 1992a; Nespor, 1987; Pajares, 1992). Hume originally defined belief as something given or presented to a thinking entity, such as a sensation or a mental picture. According to Hume, a person can distinguish between something believed and something simply imagined by examining the clarity of the mental picture or sensation—very clear sensations and mental pictures are created by beliefs (Ginsberg, 1972). While this definition was understandable and identifiable, it lacked a certain rigor that later philosophers and researchers attempted to remedy. It also lacked any connection to behaviors or actions. Braithwaite, in the 1930s, added to Hume's position by differentiating between a belief and the having of a belief. According to him, having a belief consisted of two parts: first, having thought about the belief at some time; second, acting in an appropriate manner to the belief's being true (Ginsberg, 1972). For Braithwaite, the having a belief inherently involved a disposition to act. Subsequent philosophers such as James suggested that a belief was an act in itself, although this idea was somewhat unpopular (Ginsberg, 1972).

Decades later, Rokeach (1968) developed a theoretical description of belief that clarified the relationship between beliefs and actions. According to Rokeach, every belief has three components: a cognitive component, which represents a person's knowledge; an affective component, because a belief is able to arouse emotion; and a behavioral component, because a belief must lead to action when activated. Rokeach felt so strongly about the determinant relationship between beliefs and actions that he suggested that beliefs could not ever be directly observed or measured. Beliefs could only be inferred through an analysis of what people do and say. Most current studies of teacher beliefs ignore Rokeach's proposal that beliefs must be inferred from actions (see Ritchie, 1999 for an exception), but he developed a theory that describes how beliefs might change over time and experience that has been highly utilized in recent studies (Bryan & Atwater, 2002; Simmons et al., 1999).

Nespor (1987) was the first to create a theoretical model of belief systems specific to the practice of teaching. In this model, beliefs work at the outermost level of individual thinking, in conjunction with microscopic level cognition, applicable knowledge, and metacognition. Beliefs serve three major purposes: they help define tasks or problems, they facilitate memory storage and retrieval, and they are used when dealing with ill-structured problems (as many teaching tasks are). As such, beliefs shape the ways that teachers interpret classroom events, understand the nature of knowledge, and set goals for themselves and students. Nespor did not draw a definite causal relationship between beliefs and practices, however, choosing instead to define practices as impacted but not necessarily determined by beliefs. Other factors affecting practices might include research-based knowledge or academic theory, depending on the specific context.

A Conceptual Framework of Teacher Beliefs

To better synthesize the relationships between teacher efficacy beliefs, beliefs about students, beliefs about the role of the teacher, and teacher practices, I propose the following model of science teacher efficacy (see Figure 1.2) based on the integrated and cyclical model of Tschannen-Moran, Hoy, and Hoy (1998) (See Figure 1). As stated previously, Tschannen-Moran et al. (1998) added a cognitive processing stage to Bandura's original four influences on self-efficacy, a step during which the self-efficacy information is reflected on, interpreted, and evaluated. I suggest that this information is then compared and assessed against five different aspects of what the teacher has been asked to do:

(a) What will be required in the teaching task itself, including information about required materials, physical conditions of the classroom, and support of administration and other teachers

(b) What will be required of him/her in terms of science content knowledge and pedagogical science content knowledge

(c) How the teacher perceives himself/herself as a functioning teacher, as competent or incompetent

(d) What the teacher perceives as his/her role as a science teacher

(e) How the teacher perceives students, including characteristics, interests, and abilities.

The original model of Tschannen-Moran, Hoy, and Hoy utilized (a) and (c) alone and incorporated (e) student characteristics into the teaching task. As I wish to emphasize the importance of the student characteristics factor, I gave it its own category. I also added the categories of (b) science content knowledge and pedagogical content knowledge, and (d) the perceived role of the teacher, which I argue have an impact on teacher efficacy beliefs. The appraisal of these different personal assessment elements in conjunction with a specific science-teaching task determines the science teacher efficacy beliefs (Bandura, 1997). The other change I made was to emphasize the importance of mastery experiences over vicarious experiences and verbal persuasive experiences, and to describe affective states as intensifying these other experiences but not impacting teacher efficacy beliefs independently.

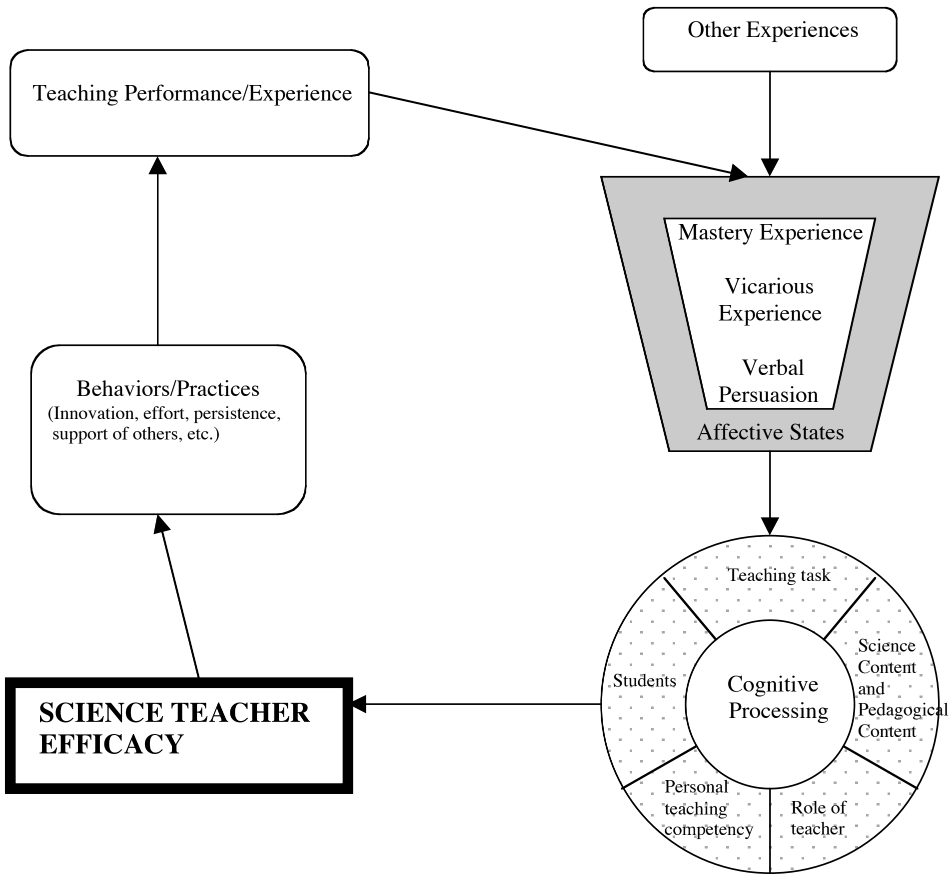

Figure 1.2: Model of science teacher efficacy

As noted in the model, science teacher efficacy beliefs are cyclical in nature. Having positive teacher efficacy beliefs encourages productive behaviors such as perseverance, effort, and innovation when teaching all students (Tschannen-Moran et al., 1998). These behaviors then generally lead to positive experiences in teaching science to all students, adding to Bandura's (1997) sources of self-efficacy and resulting in continually positive teacher efficacy beliefs and positive beliefs toward the teaching of all students. Similarly, possessing negative teacher efficacy beliefs promotes tendencies to have low expectations for certain students, to not to try hard to teach those students, to give up easily when teaching those students, and leading to negative experiences in teaching science; this then further takes away from teacher efficacy beliefs.

Summary of Teacher Beliefs

Altogether, teacher efficacy beliefs, beliefs about students, and beliefs about the role of the teacher are cyclically intertwined. These beliefs also impact teacher behaviors and practices, although they do so through a cognitive process that takes into account a large variety of additional internal and external variables including required materials for a specific teaching task, physical conditions of the classroom, support of the administration and other teacher, what will be required in terms of science content knowledge and pedagogical science content knowledge, and how the teacher perceives himself/herself as a functioning teacher. If researchers can account for all of these factors, the direct and reciprocal relationship between beliefs and practices should become much more clear.

Development of Teacher Beliefs

Although many researchers complain that teacher beliefs are quite resistant to efforts to permanently alter them, the majority of researchers admit that beliefs are ultimately malleable. Because teacher education and professional development programs hope to impress reform-based teaching messages on participants (Errington, 2004; Harcombe, 2001; Schneider, Krajcik, & Blumenfeld, 2005), and because the development of positive teacher efficacy beliefs has shown to be so beneficial in terms of teacher behaviors and persistence as well as student achievement, much effort has gone into determining how to change teacher beliefs. In this section, I will discuss a theory of beliefs that explain why some beliefs are so resistant to change, along with its implications for teacher education and professional development programs. Second, I will discuss three theories that may account for significant changes in belief: cognitive dissonance theory, conceptual change theory, and dual-process theory, along with their implications for teacher education and professional development programs.

Rokeach's Theory of Beliefs

In order to gain a more full understanding of why some beliefs are so readily changed while others appear extremely resistant, it is important to examine the nature of beliefs and belief systems. Toward that end, Rokeach's (1968) model of beliefs is an important one currently utilized in the field of education. According to Rokeach, one's belief system is organized according to centrality. Beliefs that are more connected with other beliefs are more central, and therefore more resistant to change. Additionally, more central beliefs touch on a person's identity and are shared with others. Rokeach visualized the most central part of one's entire belief system as self-concept, surrounded in concentric but overlapping circles by beliefs, values, and then attitudes. As such, attitudes and values are the most malleable while self-concept and beliefs are the most resistant to change of these characteristics. When fundamental, central beliefs are challenged, the challenge may be taken as an attack on one's self-concept. As a result, the person tends to shore up his/her belief system, making changes in beliefs more difficult (Bullough & Baughman, 1997).

Rokeach (1968) discriminated between derived and underived beliefs. Derived beliefs are learned from others and so do not operate as connectedly or centrally as underived beliefs. They are therefore easier to modify, but altering them may not result in significant or lasting changes in beliefs or ensuing behaviors. Underived beliefs are learned through direct experience, and so result in more connections and are more likely to be directly connected to one's sense of self. These would therefore be much more difficult to modify, but altering them could potentially have lasting effects on both beliefs and behaviors. There is a connection between Rokeach's sources of derived versus underived beliefs and Bandura's (1997) sources of self-efficacy information that helps to give credence to both theories. Bandura notes that the most powerful source of self-efficacy information is mastery experience, which is quite similar to Rokeach's source of underived belief. Lesser sources of self-efficacy information include verbal persuasion and vicarious experience, which are similar to Rokeach's sources of derived belief.

I venture to say that much of traditional teacher education coursework focuses on derived beliefs, as preservice teachers learn from professors, textbooks, and their peers about teaching. On the other hand, teaching practica and perhaps microteaching episodes within teacher education courses offer more of a "hands on" approach, which could potentially stimulate the development of underived beliefs. If teacher educators hope that teachers and preservice teachers create lasting beliefs that align with the goals of their programs, it seems important for them to utilize as many as possible actual teaching experiences and actual experiences with students. Many other researchers have recommended such extended practical experiences as an important step in teachers understanding their initial beliefs and developing new ones (Bryan & Atwater, 2002; Bullock, 1997; Kagan, 1992b; Luft, 1999).

Finally, Rokeach (1968) notes the effect of time on beliefs. The earlier a belief is incorporated in a person's belief system, the more resistant it is to change; as a consequence, newly formed beliefs are the most easy to alter. Similarly, beliefs of adults are more difficult to change than beliefs of younger people. Only major events will be able to significantly and permanently impact the beliefs of adults. This characteristic of beliefs has major implications for teacher education and professional development of teachers, most of whom may be considered adults. Teacher educators need to understand and take into account the fact that their students are adults, that these adults possess beliefs that may be extraordinarily resistant to change, and to adjust their expectations and requirements accordingly (Kagan, 1992a).

Theories of Belief Change

Knowing how beliefs are established and why they are so difficult to alter has been the first step. Learning more about the individual experiences that can change teacher beliefs as well as exactly how they do so is the next one. In order to better understand belief change, three main theories of belief change are considered next.

Cognitive dissonance theory.

Festinger's (1957) theory of cognitive dissonance is one way by which belief change or lack thereof may be explained. Dissonance between elements in a person's cognition creates a psychologically uncomfortable situation, thereby motivating the person to reduce the dissonance. This is particularly important for teachers because teachers make many decisions in any given day, and each decision can result in dissonance.

Dissonance can be created through a variety of means (Festinger, 1957). First, a person may recognize a logical inconsistency in his or her belief system. Festinger gives the following example to illustrate: A person believes that someone will stand on the moon in the near future as well as that humankind will not be able to build a device to leave Earth's atmosphere. The two beliefs are logically inconsistent, and thus dissonant. Another way to achieve dissonance is through a non-alignment between personal behavior and societal customs; for example, when a person throws mashed potatoes at his/her friend when attending a fancy dinner. A third cause of dissonance is when there is a disagreement between the holding of a specific opinion which is normally embedded in a more general opinion. A Democrat who prefers a Republican candidate in an election feels cognitive dissonance. A final cause of cognitive dissonance is through a conflict between a current experience and expectations based on a past experience. For example, a person has experienced that when it is hot, he/she sweats. If he/she were to then stand outside on a hot day and not sweat, he/she would experience cognitive dissonance.

One reaction to cognitive dissonance is to reduce the magnitude of the dissonance. Such pressure to reduce the cognitive dissonance is directly related to the magnitude of the dissonance, which is a function of the importance and number of the elements that are at odds (Festinger, 1957). Reduction of dissonance happens through three major strategies: changing behavior, changing environment, and adding cognitive elements. A person may work to change her/his behavior or feelings in agreement with (or in opposition to) information that caused the dissonance to occur. Festinger's example is of the person who stops smoking when he/she hears that smoking is unhealthy. A person may also work to change her/his physical or social environment to lesson the amount of dissonance. For example, a reading teacher who teaches whole language reading may only surround herself/himself with other teachers who teach using whole language reading. Similarly, a person may seek out information that supports only one element that caused the dissonance. For example, the whole language reading teacher may only read articles that support whole language teaching and avoid any articles supporting the teaching of phonics.

Of course, circumstances may make it difficult to make some of these changes. Changing one's behavior may be physically or emotionally painful, or involve some sort of loss. The present behavior may be satisfying, aside from that it causes cognitive dissonance. Additionally, some behaviors (the feeling of fear, for example) and some environments (particularly the physical environment) cannot be easily controlled or changed. Finally, there are many situations where the dissonant element is related to other elements that are not dissonant, and the expulsion of the dissonant element would result in the expulsion of these elements that are not dissonant (Festinger, 1957).

Another reaction to cognitive dissonance is the future avoidance of it. Even people who do not experience dissonance in the immediate present may avoid it by keeping away from all possible sources of dissonance. For example, a teacher who prefers to teach through lecture may only talk to people and read books and articles that support teaching through lecturing. Even if this person has never read an article about different types of teaching (which would cause dissonance), s/he may unconsciously only interact with material that supports that person's opinion. Similarly, people who have experienced dissonance in the past may be fearful of future dissonant experiences; as a result, they may prevent themselves from acquiring new knowledge or they may be reluctant to commit their own opinions and behaviors (Festinger, 1957).

Teacher educators may use cognitive dissonance theory when planning microteaching episodes or even field experiences, with the goal of constructing a situation where preservice or inservice teachers would have to problematize their beliefs about teaching and/or teaching practices. Cognitive dissonance would be the result, whereby the teachers should be inclined to change their initial beliefs. For example, in one study (Mulholland & Wallace, 2001), an elementary teacher initially believed that students would be out of control during an inquiry-oriented science lesson, and so she tended to teach science using mostly traditional, teacher-directed instructional methods. However, she eventually attempted a few inquiry-oriented lessons and was surprised by the positive reaction by students. This positive reaction appears to have created cognitive dissonance, as she had expected that not all students would understand the inquiry lesson and that students would be out of control if she gave them too much freedom. As a result, the teacher changed her beliefs about the role of the teacher to incorporate more student-centered learning. The example presented happened in the course of normal teaching experience, but teacher educators could purposefully create situations that would challenge teachers' initial beliefs, create cognitive dissonance, and eventually change teachers' beliefs.

Cognitive dissonance theory has been criticized on several grounds. It does not account for changes in thinking that occur under non-aversive conditions. It also does not explicate the role of prior conceptions, beliefs, or attitudes (Gregoire, 2003). The latter of these issues is taken into consideration by the conceptual change model.

Conceptual change model.

Posner, Strike, Hewson, and Gertzog (1982) theorized a second way in which beliefs may be changed, known as the conceptual change model. Inspired by study of the philosophy of science, conceptual change is composed of two phases: assimilation and accommodation. Assimilation involves the use of existing concepts in order to deal with new information. This happens when someone learns new information that is easily organized into the person's existing schema. Accommodation occurs when the existing schema are not sufficient to deal with new information; as a result, existing concepts must be reorganized or replaced.

Posner et al. (1982) suggest four conditions without which accommodation is not likely to occur. First, a person must feel dissatisfied to the point that he/she is willing to give up on existing conceptions. Second, the new conception must help the person structure future observations of phenomena and to make them more meaningful and intelligible. Third, the new conception must be useful and plausible for explaining the phenomena that originally instigated the accommodation. Finally, the new concept must be able to open up new areas of understanding and inquiry. More specifically, two features of an individual's conceptual ecology have been shown to aid in the process of accommodation: anomalies and fundamental assumptions about knowledge. Similar to Festinger's (1957) theory of cognitive dissonance, anomalies provide a state of cognitive conflict or crisis that allows for easier accommodation of new concepts. And a person's epistemological beliefs are the basis on which new knowledge is judged; if a person does not possess the prerequisite standards of judgment in order to make a conceptual change, they will either reject the new knowledge or else accept it irrationally.

Several recommendations have been made for teachers in order to facilitate accommodation rather than recall or assimilation in their students. Although these suggestions were intended for teachers of science students, they appear equally applicable to educators of future science teachers. Teacher educators can use instructional strategies that promote cognitive conflicts in teachers (Posner, Strike, Hewson, & Gertzog, 1982). This can be accomplished through the use of experiences that force teachers to confront anomalies. An example of an anomalous situation was presented in the preceding section, about the elementary science teacher who realized that an inquiry lesson was a useful and positive experience for students. Teacher educators can also use multiple representations of content and force teachers to translate from one form to another (Posner et al., 1982). A practical example of this might involve asking preservice teachers to connect learning theories into specific lesson plans or dealings with students. Teacher educators can organize instructional time so that they can spend much of that time diagnosing and contending with misconceptions. Similarly, they can develop strategies to help identify and deal with misconceptions, and to track changes in thinking over time (Posner et al., 1982). Teacher educators might implement this suggestion by actively working to help teachers recognize, closely examine, and then challenge their initial beliefs. Finally, the teacher educator must model qualities of scientific thinking, such as being skeptical of theories and empirical data while demanding consistency between beliefs, theory, and empirical evidence (Posner et al., 1982). They might also model their own conceptual change process and provide a safe environment for reflection, experimentation, and debate (Hashweh, 2003). Regardless of the approach, the conceptual change model emphasizes the importance that the new concept must be intelligible, plausible, and fruitful. Teacher educators must keep these characteristics in mind when presenting new ideas to teachers, and perhaps assist in teachers making sense of them, seeing them as reasonable, and showing them how they would be useful to them in their careers.

Conceptual change has been criticized on several grounds. First, the model treats thinking and feeling as entirely separate processes, and it values thinking over feeling (Brickhouse, 2001; Gregoire, 2003). If we are to utilize Rokeach's (1968) theory of belief systems, it is not necessarily appropriate to separate cognition from affect in determining belief change, since Rokeach suggests that beliefs are composed of cognitive, affective, and behavioral elements. In fact, it has been suggested that emotional incidents associated with specific situations trigger belief change more powerfully than cognitive reasoning (Bullough & Baughman, 1997). Additionally, the model does not specify what instigates the conceptual change process other than dissatisfaction with an existing conception (Gregoire, 2003). Both of these issues are taken into consideration by the dual-process model, which will be presented next.

Dual-process model.

Social psychologists in the between 1960 and 1980 created models of belief change based on empirical research on persuasion (see Dole & Sinatra, 1998; Gregoire, 2003 for reviews). So-called process models were essentially qualitative descriptions of how individuals come to accept new information. A large number of empirical studies in this field revealed two major processes to belief or attitude change: a deep and thoughtful consideration of new information (named the central route), and a more surface assessment of new information (named the peripheral route). A variety of dual-process models were thus created to account for the influence of both of these processes on belief change.

Dual-process models share significant commonalities with Rokeach's (1968) theory of beliefs. Much as Rokeach defined derived beliefs as those that are less central and easier to alter, dual-process models defined the peripheral route to belief change as more quick and superficial, and therefore resulting in rather weak changes in beliefs. Underived beliefs, on the other hand, are more central and difficult to alter; however, the central route to belief change in the dual process model, which takes thoughtful and effortful processing, can result in strong alteration of initial beliefs (Dole & Sinatra, 1998; Gregoire, 2003).

According to dual-process theory, there are several factors that determine the level of processing (central versus peripheral) that will take place when an individual is confronted by a persuasive message. First, the argument must be strong and persuasive. A weak argument very rarely instigates central, deep, thoughtful processing. Second, the individual must be motivated and interested enough to hear and understand the argument, and the argument must be personally relevant to him or her. Finally, an individual must have the ability to process the information that has been presented. If the person does not have sufficient background knowledge or sufficient processing time or space, he or she will have difficulty in achieving strong belief change (Dole & Sinatra, 1998).

Interestingly, dual-process theory notes the mediating effect of a familiar person, context, or message, which because of its familiarity may instigate peripheral processing rather than central processing. Such a situation generally leads to weak belief change even though the argument is accepted. Yet, it is also postulated that this sort of original peripheral processing may, over time, instigate deeper processing of the original message, particularly if the person, context, or message is esteemed in some way (Dole & Sinatra, 1998).

Teacher educators who wish to help teachers achieve lasting belief change should focus on helping them through central cognitive processing. There are several ways this might be accomplished. First, teacher educators must present a strong and convincing argument to the teachers that the teachers' beliefs should be changed. If we combine dual-process theory with Rokeach's model of beliefs, perhaps a combination of compelling ideas in coursework along with aligning "hands on" field experiences would have the most persuasive impact. Second, teacher educators must allow sufficient time for teachers to process the argument at a deep, central level. Many teacher education and professional development programs compact a great deal of activity and knowledge into a relatively short period of time, after which the teachers are expected to effortlessly incorporate the newly acquired ideas into their teaching, In order for significant belief change to occur, more time and support are necessary (Kahle et al., 1993; Luft, Roehrig, & Patterson, 2003; Yerrick, Parke, & Nugent, 1997). Third, since teachers must be sufficiently motivated and interested in the argument presented by the teacher educators, and they must have the ability to process the argument, it makes some sense for teacher education and professional development programs to not accept teachers who do not fit this description. Otherwise, the ideas presented will make little difference. Counseling some teachers out of the profession based on developmental readiness and other dispositional factors has been recommended by other researchers (Garmon, 2004; Kagan, 1992b).

Dual-process models have been somewhat criticized for not discussing specifically how emotion and affect shape the process of change, as well as how motivation in a specific situation may be influenced in order to better activate central processing (Gregoire, 2003). More recent models have attempted to reconcile these problems, but none of these models has been well-tested with teachers (Dole & Sinatra, 1998; Gregoire, 2003).

Summary

Rokeach's (1968) theory of the structure of beliefs suggests two types of beliefs: Derived beliefs are more malleable and are learned from others, while underived beliefs are more static and are generally established through direct personal experiences. Three theories of belief change were also presented in this section: cognitive dissonance theory, conceptual change theory, and dual-process theory, along with their implications for teacher education and professional development programs. The question remains of if teacher education programs can impact teacher beliefs, and if they do so, then what elements of the programs are associated with changes in beliefs.

Problem Statement

The purpose of this study was to examine preservice secondary science teachers' changes in teacher efficacy beliefs and beliefs about the teaching and learning of students in science as they learned how to teach. The ultimate goal of this study was to understand what experiences and characteristics promote a more positive sense of teacher efficacy and constructive beliefs toward the teaching of science to all students, to better prepare beginning teachers to work with an increasingly diverse student body.

The study addressed the following research questions:

1. What teacher efficacy beliefs, beliefs about the role of the teacher, and beliefs about students do preservice secondary science teachers possess at various time points during their teaching preparation program?
2. Do preservice secondary science teacher efficacy beliefs, beliefs about the role of the teacher, and beliefs about students change between the beginning and end of their teaching preparation program? If the beliefs do change, what events are associated with these belief changes?
3. Do relationships exist between teacher efficacy beliefs, beliefs about students, and beliefs about the role of the teacher? If so, do these relationships act in accordance with the proposed model (Figure 1.2) such that beliefs about students and the role of the teacher have an impact on teacher efficacy beliefs, and such that mastery experiences have more of an impact than vicarious experiences and verbal persuasive experiences, and affective states act as an intensifying force?

CHAPTER 2

A REVIEW OF THE LITERATURE

Introduction

Researchers have paid increasing amounts of attention in recent years to teachers' ways of thinking and to understanding different components of teachers' practice. As Nespor (1987) states: "To understand teaching from teachers' perspectives we have to understand the beliefs with which they define their work." (p. 323). Only when teacher educators understand teacher beliefs more fully will they be able to elicit changes in those beliefs (Bullough & Baughman, 1997; Eisenhart, Shrum, Harding, & Cuthbert, 1988; Kagan, 1992a; Nespor, 1987). Toward that end, this chapter is devoted to explicating what is already understood about teacher efficacy beliefs, teacher beliefs about students, and teacher beliefs about the role of the teacher. The variety of factors—falling into the categories of teacher characteristics, student characteristics, and school characteristics—that have been found to impact different aspects of teacher beliefs is summarized in Figure 2.1.

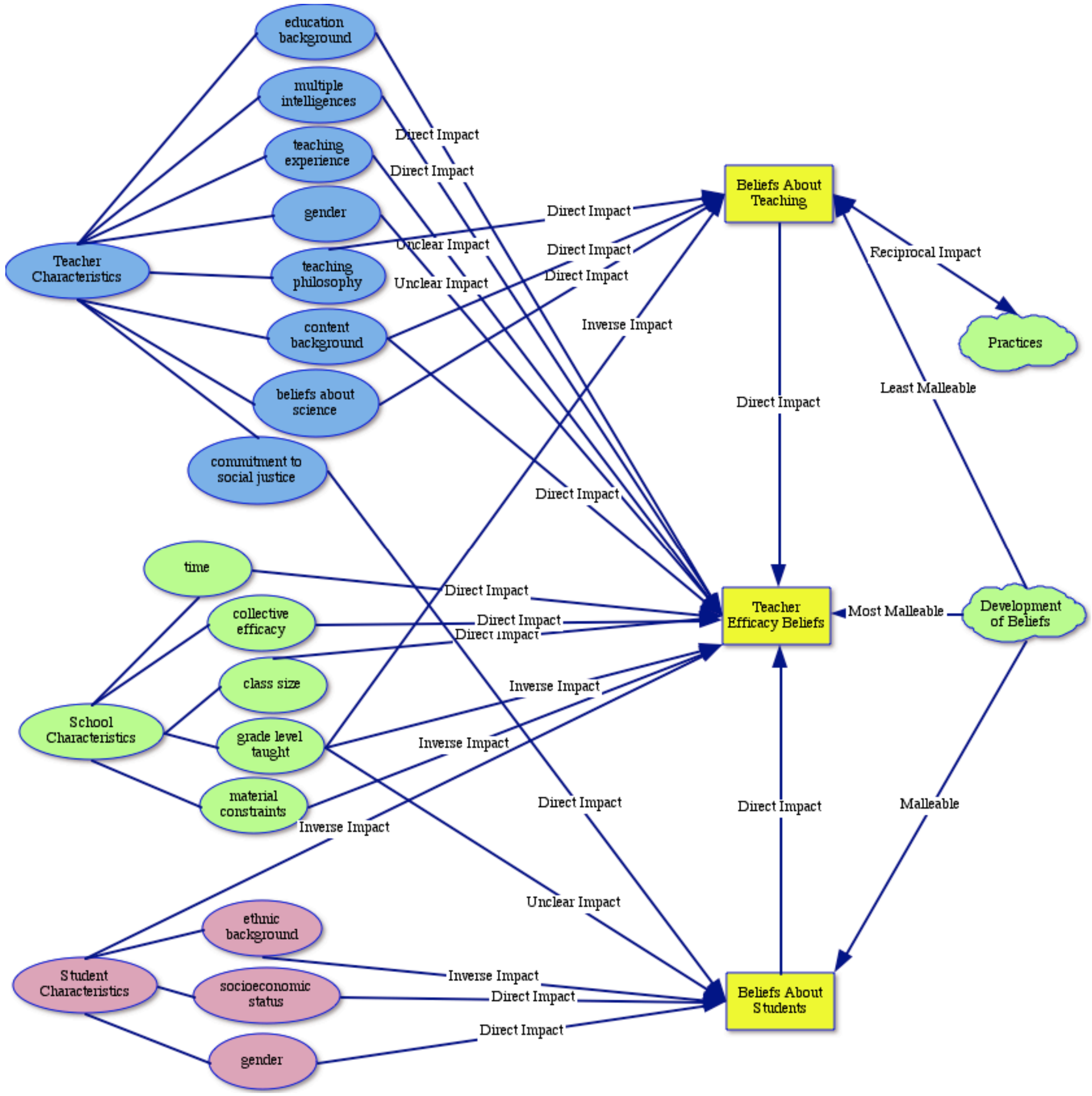

Figure 2.1: Factors influencing teacher beliefs

Teacher Efficacy Beliefs

Many characteristics, beliefs, and experiences have been associated with teacher efficacy beliefs. Several of these include experiences with the content and with teaching, personal attributes, and aspects of the environment in which they will be teaching.

Teacher Characteristics

Several teacher characteristics have been associated with measurements of teacher efficacy. These include science background, science education background, grade level taught, gender, multiple intelligences, and number of years teaching.

It has been found repeatedly that beginning teachers who have strong science content knowledge, as evidenced by having taken a large number of science courses (Cantrell, Young, & Moore, 2003; Ramey-Gassert et al., 1996), by possessing a science degree (Desouza, Boone, & Yilmaz, 2004), by being able to answer commonly misunderstood science questions accurately (Schoon & Boone, 1998), or by exhibiting low levels of anxiety toward the teaching of science (Bursal & Paznokas, 2006), have higher teacher self-efficacy toward the teaching of science. Likewise, many beginning teachers who took the minimum required number of science courses feel that their content knowledge is lacking (Bohning, Hale, & Chowning, 1999). As a result, they tend to avoid teaching topics that they do not know well for fear that their students will ask questions that they cannot answer (Mulholland & Wallace, 2001; Tosun, 2000), and they lack confidence in the subjects that they do choose to teach (Rice & Roychoudhury, 2003). The relationship between content knowledge and self-efficacy beliefs has been generally explained through the "success breeds success" adage (Ramey-Gassert et al., 1996). In short, teachers who know a lot about science typically feel comfortable with their understanding of science. As a result, they are comfortable sharing that understanding of science with students and have a high expectancy that students will be able to learn from them as teachers.

Many beginning teachers have had unsuccessful and psychologically jarring experiences in science courses, resulting in a fear of taking more coursework and of teaching the material to their own classes (Ginns & Tulip, 1995; Huinker & Madison, 1997; Ramey-Gassert et al., 1996; Tosun, 2000). Additionally, because so many college science courses are taught by transmission, beginning teachers have rare opportunities to see hands-on, minds-on science teaching before they are asked to do so in their classrooms, and so they lack pedagogical content knowledge (Huinker & Madison, 1997; Plourde, 2002a; Rice & Roychoudhury, 2003). The combination of science anxiety resulting from early, unsuccessful science experiences and limited exposure to teaching strategies other than transmission is dominant among teachers who express very low teacher self-efficacy.

Beginning teachers' ratings of their teacher preparation program have been positively correlated with their science teacher efficacy beliefs (Knobloch & Whittington, 2002), as has the possession of a master's degree in education over a bachelor's degree (Ross, 1998). Similarly, the number of science teaching strategies utilized in teaching has been positively correlated to science teacher efficacy, as has the total number of science methods courses taken within the teacher education program (Lumpe, Haney, &

Czerniak, 2000), and the overall belief that innovative teaching is important and possible (McKinney, Sexton, & Meyerson, 1999). By contrast, a study in which preservice teachers had great difficulty making connections between the teacher education coursework and practicum experiences resulted in lowered confidence, particularly in their first year of professional teaching (Aitken & Mildon, 1991). The results of these studies demonstrate the overall effect of teacher preparation coursework and field experiences on teacher efficacy.

Cantrell et al. (2003) examined the relationship of gender to teacher efficacy over time for undergraduate elementary education majors. They found that although there was an initial significant difference between men and women, with men expressing a higher sense of science teaching efficacy than did women, this effect decreased over time until the end of the teacher preparation program. It was proposed that this initial effect was due to men having taken more high school science and participated in more extracurricular science activities before starting teacher education, a trend that has been stated earlier as resulting in higher science teaching efficacy. Other studies and reviews of studies have found that women have higher teacher efficacy (although not specific to science) (Evans & Tribble, 1986; Raudenbush, Rowan, & Cheong, 1992; Ross, 1998), an effect that has been explained through reference to the traditionally feminine role of the teacher.

There have been quite mixed results in finding a correlation between time teaching in schools and teacher efficacy beliefs or confidence. Some studies found that teacher efficacy beliefs grew more positive with experience (Mulholland & Wallace, 2001; Riggs & Enochs, 1990; Soodak & Podell, 1996). Several studies found very little correlation at all between experience and teaching efficacy beliefs (Cantrell et al., 2003; Lumpe et al., 2000; Plourde, 2002b), while others have found a negative correlation, meaning that teacher efficacy beliefs or confidence eroded with time teaching (Aitken & Mildon, 1991; Desouza et al., 2004; Ghaith & Yaghi, 1997; Guskey & Passaro, 1994). It is possible that these mixed results are due to the difference between various school climates and university climates—new teachers build up efficacy quickly in university programs but the climate in most schools is not as supportive or encouraging and so efficacy may stabilize or even decrease (Cantrell et al., 2003). Another suggestion is that with experience, teachers grow to believe that student learning is due to factors beyond their control (Ghaith & Yaghi, 1997) and so their sense of efficacy decreases. Finally, results may differ depending on how researchers defined and measured efficacy beliefs, an unfortunate outcome of the difficulty in defining and measuring the construct (Soodak & Podell, 1996; Tschannen-Moran & Hoy, 2001).

School Characteristics

Several features of schools have been associated with the development of positive or negative teacher efficacy beliefs. Some of these include classroom and materials constraints, the collective efficacy of the school, beliefs about students, the amount of time available and needed to teach science, and class size.

Teaching science using free-discovery or inquiry requires the manipulation of materials, the use of cooperative learning groups, and the freedom for students to explore independently. Many beginning teachers who are uncomfortable with their classroom management skills (Bohning et al., 1999), particularly with larger class sizes (Raudenbush et al., 1992), simply avoid teaching science or transform student-centered inquiry activities into teacher-directed demonstrations (Mulholland & Wallace, 2001) in order to better manage the students and the materials. This behavior has been associated with low teacher efficacy, as these teachers feel that controlling the class is a superior measure of their teaching ability than student engagement and learning.

Certain school characteristics also appear to affect teacher efficacy beliefs. For example, overall student engagement has a positive effect on teacher efficacy (Raudenbush et al., 1992), as does a positive perception of the school principal (Knobloch & Whittington, 2002; Riggs & Enochs, 1990). Furthermore, as has been stated earlier, many teachers, even experienced ones, are uncomfortable with the teaching of science in their classes. When teacher candidates or novice teachers join schools with an atmosphere of low collective efficacy with respect to the teaching of science, these beginning teachers are less inclined to teach science and may be persuaded to avoid it or teach in a transmission manner (Mulholland & Wallace, 2001; Ramey-Gassert et al., 1996). This can be explained as due to the social processes and collective beliefs that make up any culture, including that of a school (Knobloch & Whittington, 2002; Plourde, 2002b). When an entire school or leadership within a school reflects low efficacy toward its ability to influence student learning, this is known as collective efficacy and this has been significantly correlated with individual teacher efficacy (Goddard & Goddard, 2001; Goddard et al., 2004; Knobloch & Whittington, 2002; Schriver & Czerniak, 1999). Part of the enculturation process for beginning teachers is the assumption of the cultural norms—in this case, a low sense of efficacy toward the teaching of science or toward teaching in general.

Moreover, many researchers have looked into the impact of grade level taught on teacher efficacy beliefs, with rather mixed results. One found that middle childhood preservice teachers had significantly higher efficacy than did teachers of younger children (Wertheim & Leyser, 2002), while other researchers have found that preservice teachers of younger children had higher efficacy than preservice teachers of older children (Evans & Tribble, 1986; Raudenbush et al., 1992; Ross, 1998; Soodak & Podell, 1996). Wertheim and Leyser hypothesized that because middle childhood teachers generally have better grades in high school and higher college entrance examination scores than do teachers of younger children, they also possess a similarly positive sense of teaching efficacy. The opposite may have been true for the other groups of participants. Another possible interpretation is that the difference results from the enculturation process that happens in the teacher education program, that the middle childhood program in one study and the early childhood/elementary programs in the other were more successful at raising teacher efficacy in their students. It is also notable that the Wertheim and Leyser study involved Israeli teachers, so perhaps the enculturation process of teachers in that nation differs from the process in the United States, resulting in variable self-efficacy beliefs. Finally, it has been suggested that teachers believe that older children have to deal with more issues outside of school such as broken families and responsibility for younger siblings. As a result, teachers of older children may feel that how much their students learn is more out of their control than do teachers of younger children (Brophy, 1985).

Student Characteristics

Some characteristics of students have been associated with teacher efficacy beliefs. Most notably, teachers of high ability or honors students have a more positive sense of teacher efficacy (Raudenbush et al., 1992; Ross, 1998). This is generally explained through student engagement rather than innate intelligence—honors students are perceived by teachers as more engaged, and therefore easier to teach and influence than students in lower track classes. Student socioeconomic status appears to have a mixed impact on teacher efficacy beliefs (Ramey-Gassert et al., 1996; Ross, 1998).

Beliefs About Students

As stated previously, many beginning teachers express worry that children will not be able to deal cognitively, affectively, and skillfully with science, perhaps as a result of the teachers' own negative experiences with science as children. Teachers also come to teaching with certain beliefs about specific students in science; beliefs that impact their expectations of students (Delpit, 1995), their behaviors toward students, and eventually student achievement in the classroom (Ashton & Webb, 1986). More specifically, teachers commonly have negative beliefs and lowered expectations for children from minority ethnic backgrounds (Baron, Tom, & Cooper, 1985; Dusek & Joseph, 1983; Wigfield et al., 1999), for girls or feminine students, particularly in the physical sciences

(Dusek & Joseph, 1983; Hatchell, 1998; Li, 1999; Tobin & Gallagher, 2003), and for children of lower socioeconomic status (Baron et al., 1985; Brown et al., 2004; Dusek & Joseph, 1983; Hauser-Cram et al., 2003; Norman et al., 2001; Solomon, Battisch, & Hom, 1996; Tiezzi & Cross, 1997; Wigfield et al., 1999). Furthermore, when asked to analyze and confront their own beliefs with regard to diverse populations in science, many feel guilty, shameful, defensive, and hopeless (Rodriguez, 1998).

Some teachers completely refuse to acknowledge their initial beliefs; instead, they tend to stereotype their students and possess disparate expectations for different cultural or gender groups (Southerland & Gess-Newsome, 1999). Many of these beginning teachers were successful students when they were in school and so profess the expectation that their own future students would also be able to succeed using the same teaching and learning methods that they experienced (Rodriguez, 1998; Veal, 2004; Yerrick & Hoving, 2003). Typically, when these teachers entered the classroom and were confronted with children who were culturally different and who had previously not been successful in school, they resorted to their ingrained, stereotypical beliefs. Rather than seeing a diverse student body as making a positive contribution (Southerland & Gess-Newsome, 1999) or realizing that low student motivation and achievement might be due to factors other than innate laziness or lack of intelligence (Rodriguez, 1998), these teachers used traditional methods with students to help them reach certain school norms, that contribute little effort to help students beyond their current capabilities (Southerland & Gess-Newsome, 1999). Teachers tended to blame students' lack of previous content knowledge as the reason for future underachievement rather than accepting the responsibility for trying new instructional methods to help all students learn (Gilbert & Yerrick, 2001). Additionally, these teachers characteristically measured achievement of underrepresented groups in science according to effort rather than achievement (Southerland & Gess-Newsome, 1999), which again did not press children beyond their current capabilities and propagated the teachers' stereotyped beliefs. Another study showed that teachers tended to avoid having low achieving students engage in higher order thinking, while they encouraged high achieving students to challenge themselves (Zohar, Degani, & Vaaknin, 2001). As a result, the differentiation between low and high achieving students is exacerbated.

Teacher Characteristics

It has been proposed that there are certain characteristics, including openness, self-awareness, and particularly a commitment to social justice, that predispose a preservice teacher toward having high expectations and beliefs toward all students (Garmon, 2004; Upadhyay, 2005). While these characteristics may be developed in teacher preparation programs, Garmon suggested that teacher preparation programs consider such dispositions when admitting future teachers. Experience working with students from diverse backgrounds may also be crucial before teachers can fully appreciate and respect all students (D. F. Brown, 2004). Finally, the disposition toward and ability to establish positive teacher-student relationships in classroom environments may impact the beliefs of teachers in those classrooms as well as the learning of all of their students (Brand et al., 2006).

Content knowledge may also have an impact on beliefs about students. Potentially, according to Bandura's (1997) theory of self-efficacy, teachers with more positive levels of self-efficacy beliefs should also have higher expectations for the teachability and future achievement of all students. This has generally been borne out in empirical studies (Ashton & Webb, 1986; Warren, 2002). And, as presented previously, content knowledge has been associated with more positive levels of self-efficacy beliefs. Hence, it logically follows that an increased depth of content knowledge should lead to more positive expectations about students.

School Characteristics

It has been found that teachers in higher grades were more likely to describe the effects of broken homes as an external and unavoidable influence on student achievement than teachers of lower grades. It has also been found that teachers in higher grades were more likely to describe students as responsible for their own learning than teachers of lower grades (Brophy & Evertson, 1981). Since researchers have not often approached this topic empirically, a between-article comparison seemed useful. Toward that end, six articles dealing with elementary or secondary school teachers and using a variety of research methods were compared.

Of three studies involving elementary school teachers and their beliefs about students, one study presented a beginning teacher who had very high expectations for the ability of all students to learn mathematics (Raymond, 1997), while the second and third study presented inservice and preservice teachers had rather low expectations for students

(Levitt, 2001; Southerland & Gess-Newsome, 1999). It is notable that the beginning and inservice teachers in these studies worked in suburban school districts and the preservice teachers were students at a teacher preparation program in an area with little diversity in terms of ethnicity/race and socioeconomic status, so context is not an issue here.

Of three studies involving secondary teachers and their beliefs about students, two presented predominantly negative teacher beliefs about students (Brighton, 2003; Yerrick & Hoving, 2003). It is again notable that while the inservice teachers came from a variety of teaching backgrounds, the preservice teachers were all enrolled in a field experience with lower achieving students. That experience probably made an important impact on their beliefs about students. The third study differentiated between suburban and urban inservice teachers, and found a striking difference: suburban teachers had much higher expectations for their students and possessed the belief that all students could and were learning; the urban teachers in the study had more pessimistic beliefs that some students could not learning, and that many students were not learning (Brown et al., 2004).

It has been suggested that secondary teachers believe that content instruction is their primary teaching function. As a result, they tend to direct most of their instruction to high achieving students and to possess differential beliefs about the abilities and capabilities of high and low achieving students. Elementary teachers, conversely, believe that student socialization is their primary teaching function. As a result, they tend to get to know and interact with students more individually, and may possess more positive beliefs about the teaching and learning of all students (Brophy, 1985). Overall, it appears that elementary and secondary teachers have mixed beliefs about the capabilities of students to learn. It is possible that the difference between urban and suburban teachers or between teachers of high achievers and low achievers may result in the more significant difference in beliefs, but the dearth of studies in this area leaves this conclusion tentative.

Student Characteristics

As was mentioned previously, student characteristics make a rather significant impact on teacher beliefs about students. Teachers commonly have negative beliefs and lowered expectations for children of minority ethnic backgrounds (Baron et al., 1985; Dusek & Joseph, 1983; Wigfield et al., 1999), and for children of lower socioeconomic status (Baron et al., 1985; Brown et al., 2004; Dusek & Joseph, 1983; Hauser-Cram et al., 2003; Norman et al., 2001; Solomon et al., 1996; Tiezzi & Cross, 1997; Wigfield et al., 1999). When teachers perceived that students' parents have different values from their own, they also tend to express lowered expectations for the children of those parents (Hauser-Cram et al., 2003). Additionally, girls or feminine students are not expected to succeed or be interested in science to the degree that boys and masculine students are, particularly in the physical sciences (Dusek & Joseph, 1983; Hatchell, 1998; Li, 1999; Tobin & Gallagher, 2003),

Beliefs About the Role of the Teacher

Teachers see their jobs in a variety of ways. These roles fall into several categories, including different teaching styles, teaching focuses, and associated responsibilities. Beliefs about the role of the teacher appear to vary depending on a teacher's science content knowledge, beliefs about science, and grade level taught.

When asked to identify their most important responsibilities as teachers, a huge number of roles have been identified with several common themes. Teachers often identify themselves as classroom managers or disciplinarians (Haritos, 2004; Hoy & Weinstein, 2006), occasionally even ahead of the educator role as their primary responsibility (Ashton & Webb, 1986). They also often mention that their job is to deliver content so that parent, student, and school expectations are met (Ashton & Webb, 1986; Bohning et al., 1999; Rodriguez, 1998; Tobin & Gallagher, 2003; Upadhyay, 2005), and less often that their job is to promote cognitive growth, facilitate learning (Haritos, 2004), and teach real world knowledge (Upadhyay, 2005). Some teachers identify themselves as entertainers (Brighton, 2003; Carlone, 2003; Haritos, 2004), while still others think of themselves as listeners and role models (Bianchini, Johnston et al., 2003; Haritos, 2004). Finally, many teachers define their role in terms of affective goals for students, working to develop student enthusiasm, motivation, and interest in the content (Eisenhart et al., 1988; Friedrichsen & Dana, 2005).

Teaching styles fall onto a continuum in which teacher-centered, expository instruction lies at one end and student-centered, constructivist or social constructivist instruction lies at the other. Teacher-centered instruction involves the more traditional methods of lecture, verification labs, and teacher-designed worksheets and assignments. The vast majority of preservice and inservice teachers fall onto the teacher-centered end of the continuum (Brand & Glasson, 2004; Hancock & Gallard, 2004; Levitt, 2001;

Simmons et al., 1999). Student-centered instruction includes the more progressive methods of authentic inquiry and student-created questions that are currently taught in most colleges of education. Few preservice and inservice teachers fall close to this end of the continuum, despite teacher education efforts to the contrary (Levitt, 2001; Mcginnis, Parker, & Graeber, 2004; Simmons et al., 1999). It has been proposed that preservice teachers take from teacher education that which aligns to their original beliefs. When their original beliefs prove faulty, they have trouble cognitively coping with the dissonance and so cope in a way that preserves their original beliefs. The result is usually teacher-centered teaching methods (Bullough, 1991).

Teacher Characteristics

A teacher's beliefs about science may influence his or her focus in teaching science, as well. For example, some teachers focus on science concepts, some on laboratory experiments, some on problem solving, and others on the broader nature of science (Bianchini & Solomon, 2003; Hancock & Gallard, 2004; Wallace & Kang, 2004). Still others see their role as science teachers in a more transformational way, that they must promote the interests of underrepresented populations in science and help to change the face of science from the bottom up (Bianchini, Cavazos, & Helms, 2000; Bianchini & Solomon, 2003; Brand & Glasson, 2004; Upadhyay, 2005).

Although few studies have explicitly examined how knowledge of content impacts beliefs about teaching and learning, several studies have presented results indicating that more in-depth content knowledge is related to several positive beliefs and practices. For example, several studies have found that when teachers possess more content knowledge, they believe more fervently in using inquiry teaching and are able to implement it with less explicit guidance (Harcombe, 2001; Lee & Krapfl, 2002; Schneider et al., 2005). On the other hand, when teachers possess less content knowledge, they tend to teach out of the textbook more frequently (King, Shumow, & Lietz, 2001). It has also been found that when teachers are more comfortable with the content, they are able to interact with students more readily and to focus on student learning over instruction (Ritchie, 1999), as well as to better help students see connections between science and real life so that students do not perceive science as "magic" and "abstract" (Veal, 2004).

The association between content knowledge and more progressive instructional methods has been explained as follows: Teachers who possess more content knowledge tend to also have a better understanding of science in general (Harcombe, 2001). As a result, they are better able to use time and materials in class, better able to design tasks that challenge and interest students, and better able to assess student learning (Knapp & Plecki, 2001). They are also willing to experiment with innovative activities, to take risks, and to get involved in professional development activities (Ramey-Gassert et al., 1996). In all, they are better teachers.

This trend is not without exception, however. One study of secondary chemistry teachers found that teachers with a degree in chemistry were more resistant to teaching according to a new curriculum utilizing constructivist methods, whereas out-of-area teachers quickly adopted the new curriculum (Roehrig & Kruse, 2005). Previously, the out-of-area teachers were not as comfortable with the content, so they were less able to design inquiry lessons. Given the new, more prescribed curriculum, they implemented it to a greater extent than the teachers with more chemistry background.

School Characteristics

A limited number of studies have explicitly examined the differences in teacher beliefs about students or about the role of the teacher between different grade levels. In terms of beliefs about their roles, it has been found that secondary teachers were more concerned with taking on the role of parent and with being interesting to their students, while elementary teachers were more concerned with being a positive role model and creating an environment that promotes cognitive growth (Haritos, 2004). Since researchers have not often approached this topic empirically, a comparison between research articles seemed warranted. I compared twelve studies of elementary, middle, and secondary teacher beliefs about teaching.

Seven of the studies involved elementary school teachers and their beliefs about teaching; five of these studies concluded that the participating teachers believed in more progressive models of teaching and learning (Davis & Wilson, 1999; Lee & Krapfl, 2002; Mcginnis et al., 2004; Mulholland & Wallace, 2005; Raymond, 1997), while only two concluded that the participating teachers subscribed to more traditional teaching philosophies (Levitt, 2001; Southerland & Gess-Newsome, 1999). This possibly indicates that elementary level teachers possess generally constructivist beliefs about teaching and more positive beliefs about the learning of all students. It is perhaps notable that four of these five studies included preservice or beginning teachers, and it has been hypothesized that teachers tend to start off teaching more in line with recommendations of their teacher education programs (Mcginnis et al., 2004).

Of the five studies involving secondary (middle and high school) teachers and beliefs about teaching, four of the studies concluded that the participating teachers predominantly believed in more traditional models of teaching and learning (Brighton, 2003; Hancock & Gallard, 2004; Simmons et al., 1999; Tsai, 2002), while a fifth study found an even mixture of traditional and constructivist beliefs (Veal, 2004). There was no significant difference among these studies between preservice and inservice teachers, although it is perhaps notable that the studies involving preservice and beginning teachers at least uncovered some constructivist beliefs about learning and teaching.

Therefore, it appears that elementary teachers believe in mainly non-traditional or constructivist models of teaching, whereas secondary teachers typically believe in traditional or transmission models of teaching. The difference between preservice or beginning and more experienced teachers may present a significant difference, as well, as was suggested previously. Brophy (1985) explained the difference between elementary and secondary teacher beliefs as being due to different ways they define their roles. Elementary teachers tend to define themselves as student socializers, and therefore move through the curriculum at a slower pace, allowing students to make more sense of the material on their own terms. Secondary teachers tend to define themselves as subject matter instructors, and therefore move at a faster pace, focusing more on the content and less on the students.

Summary of Teacher Beliefs

In conclusion, a great deal of research already has examined a variety of teacher beliefs. It has been generally found that experiences with content and with teaching, personal attributes, and aspects of the environment in which they will be teaching affect teacher efficacy beliefs. It has also been found that experiences with diverse students and personal dispositions affect teacher beliefs about students. No differences among elementary and secondary teachers were found with respect to beliefs about students. The lack of research relating content knowledge and beliefs about students disallows any conclusions from being drawn, although I speculate that content knowledge should, again, directly relate to positive beliefs about students. Science content knowledge, beliefs about science, and grade level taught appear to affect teacher beliefs about the role of the teacher.

Relationship Between Teacher Beliefs and Practices

Recent empirical research has found rather mixed results with respect to the relationship between teacher beliefs and practices. A selection of this research is summarized in Table 2.1. Many researchers have found that teacher beliefs do not predict teacher practices or that beliefs predict practices only for very specific teachers or in very specific contexts, but equally many have found that beliefs do predict teacher practices.

Study	Participants	Results
Deemer, 2004	91 high school science teachers	Beliefs do not match practices
Brighton, 2003	4 middle school teachers	Beliefs do not match practices
Brickhouse & Bodner, 1992	1 beginning middle school teacher	Beliefs do not match practices
Simmons et al., 1999	116 beginning secondary science and math teachers	Beliefs rarely match practices
King, Shumow, & Lietz, 2001	3 urban elementary science teachers	Beliefs rarely match practices
Eick & Reed, 2002	12 secondary preservice science teachers	Beliefs sometimes match practices
Schneider, Krajcik, & Blumenfeld, 2005	4 urban middle school science teachers	Beliefs sometimes match practices
Davis & Wilson, 1999	1 urban middle school reading teacher	Beliefs sometimes match practices
Verelas, House, & Wenzel, 2005	3 beginning secondary science teachers	Beliefs sometimes match practices
Solomon, Battisch, & Hom, 1996	476 elementary school teachers	Beliefs match practices
Stipek, Givven, Salmon, & MacGyvers, 2001	21 elementary school teachers	Beliefs match practices
Windschitl & Sahl, 2002	3 middle school teachers	Beliefs match practices
Luft, Roehrig, & Patterson, 2003	18 beginning secondary science teachers	Beliefs match practices
Roehrig & Kruse, 2005	12 inservice secondary science teachers	Beliefs match practices
Fuchs, Fuchs, & Phillips, 1994	121 elementary and middle school teachers	Beliefs match practices

Table 2.1: Summary of research on teacher beliefs and practices

Several different interpretations of discrepancies between teacher beliefs and practices have been proposed. The first two interpretations blame teachers for not understanding their own beliefs or for pretending to have beliefs that align with current educational trends. For example, it has been suggested that some teachers mainly possess tacit, unexpressed, and unanalyzed beliefs about teaching. Therefore, when asked about their beliefs, these teachers simply create beliefs that justify their teaching actions in the classroom. As a result, beliefs may sometimes align and sometimes misalign with their practices (Simmons et al., 1999). A second interpretation is that teachers have picked up on current trends in education, either through teacher education coursework or professional development, and adopt the jargon to express what they feel are educationally correct beliefs, but they do not actually subscribe to the beliefs they articulate (Brighton, 2003; King et al., 2001). Teachers who adopt reform-teaching strategies in their classrooms in response to coursework or professional development but do not develop beliefs in the effectiveness of reform-teaching may fall into this category (Luft, 2001).

A third interpretation allows for the fact that teacher practices are related to a complex variety of personal beliefs, not just those about teaching. For instance, it has been suggested that teachers often feel they have to teach in ways that do not represent their true beliefs; in short, they cannot enact beliefs in practice (Deemer, 2004). This happens because of the interference of a variety of external factors such as the school-wide culture (Davis & Wilson, 1999; Deemer, 2004; Mcginnis et al., 2004), the pressure to prepare students for high-stakes standardized tests, discipline problems with students

(Davis & Wilson, 1999), parental and student expectations and discomfort with new types of instruction (Mcginnis et al., 2004), student motivation toward grades and not pursuit of knowledge (Brickhouse & Bodner, 1992), a lack of comfort of a given teacher with the material to be taught (Brickhouse & Bodner, 1992; Johnson, 2006; King et al., 2001; Schneider et al., 2005), and constraints of time and classroom materials (Brickhouse & Bodner, 1992; Johnson, 2006; Verelas, House, & Wenzel, 2005). Teachers may adapt either their beliefs or practices as they grow into expert teachers and confront some of the issues stated above that originally caused a conflict between the two constructs (Flores, 2003; Mulholland & Wallace, 2005). It is possible that by including a broader array of personal beliefs and by factoring in developmental factors in the analyses of teacher beliefs and practices, better alignment between the two might be found.

Development of Teacher Beliefs

Researchers have debated for some time about whether or not teacher educators can significantly change inservice and preservice teacher beliefs, and empirical results have been quite mixed. A selection of research on belief change is summarized in Table 2.2. Although there is a great deal of scatter in the effectiveness of teacher education programs, professional development activities, and even regular teaching experience on changing teacher beliefs, it seems fairly clear that teacher beliefs are malleable, depending on the intervention and/or experience that has been designed to promote belief change. Experiences that have been particularly successful in promoting belief change will be discussed in the following sections.

Study	Participants	Intervention	Results
Yerrick, Parke, & Nugent, 1997	8 inservice science teachers	Summer professional development	No change in beliefs about teaching
Tillemma & Knol, 1997	153 preservice teachers	Teacher education program	No change in beliefs about teaching
Brighton, 2003	4 middle school teachers	3-year professional development	Mixture of change in beliefs about teaching
Roehrig & Kruse, 2005	12 inservice secondary teachers	New curriculum implementation	Mixture of change in beliefs about teaching
Beswick, 2006	155 preservice secondary math teachers	2 mathematics methods courses	Mixture of change in beliefs about teaching
Simmons et al., 1999	116 beginning secondary science and math teachers	First 3 years of teaching	Shift to belief in teacher-centered teaching
Levitt, 2001	16 inservice teachers (variety of levels)	Professional development in science education	Shift to belief in student-centered teaching
Mulholland & Wallace, 2005	1 inservice elementary teacher	First 9 years of teaching	Shift to beliefs in student-centered teaching
Mulholland & Wallace, 2001	1 preservice elementary teacher	Teacher education program and induction year	Shift to belief in student-centered teaching; Shift to belief that all students can learn
Garmon, 2004	1 preservice elementary teacher	Teacher education program	Shift to belief that all students can learn
Brand & Glasson, 2004	3 preservice secondary science teachers	Teacher education program	Mixture of change in beliefs about students
Zohar, Degani, & Vaaknin, 2001	40 Israeli inservice secondary teachers	Professional development	No change in beliefs about students and higher order thinking
Henson, 2001	8 inservice teachers (variety of levels)	Involvement in research	Increase in teacher efficacy beliefs
Plourde, 2002	59 preservice elementary teachers	Student teaching	Decrease in science teaching outcome expectancy, no change in personal science teaching efficacy
Cantrell, Young, & Moore, 2003	268 preservice teachers	Teacher education program	Increase in personal science teaching efficacy
Huinker & Madison, 1997	62 preservice elementary teachers	Science methods course	Increase in science teaching outcome expectancy and personal science teaching efficacy
Andersen, Dragsted, Evans, & Sorensen, 2004	39 first year elementary teachers	Induction year	Self-efficacy decreased

Table 2.2: Some recent empirical research on the malleability of teacher beliefs

Beliefs About the Role of the Teacher

In general, a review of the literature reveals that beliefs about the role of the teacher seem most difficult to change, particularly for teacher educators who wish to convert teachers to more student-centered instructional methods. It has been proposed that these beliefs are intricately connected to epistemological beliefs, and so without changing teachers' beliefs about the nature of knowledge, it would be rather impossible to change their beliefs about teaching (Tsai, 2002; Yerrick, Pedersen, & Arnason, 1998; Zohar et al., 2001). Some researchers, on the other hand, have suggested that through a modeling of constructivist pedagogical strategies and by forcing teachers to consciously reflect on how they have experienced learning and teaching that may be connected to constructivism, teacher educators may stimulate a change in beliefs about the role of the teacher (Finson, Pedersen, & Thomas, 2006; Jeanpierre, Oberhauser, & Freeman, 2005; Rodriguez, Zozakiewicz, & Yerrick, 2005). Some researchers note that less confident, less experienced teachers may be drawn to more traditional teaching roles (Flores, 2003); building confidence could be a key way to steer teachers toward more student-centered teaching roles (Stipek et al., 2001).

While many studies have found that teacher education courses and programs have little effect on teacher beliefs and behaviors (Graber, 1998; Hancock & Gallard, 2004; Tillema & Knol, 1997; Yerrick et al., 1997), certain experiences have shown promise in orienting teachers away from traditional teaching methods and toward the more progressive ones taught in colleges of education in the United States. One longitudinal study of a five-year, hands-on science training program succeeded in shifting its participants along the teaching style continuum toward more student-centered instruction (Levitt, 2001). The success of this program was attributed to its long-term nature and the fact that teachers could implement the techniques and so directly see students learning with them. A study of 1-year teaching induction programs yielded similar progress: the induction program aligned with university teachings about the teaching of science resulted in teachers who viewed their roles as less didactic (Luft et al., 2003). Even single semester teacher education courses can have an impact on the teaching styles of preservice teachers (Hart, 2002), although longer interventions appear to have a more significant impact (Mulholland & Wallace, 2005; Simmons et al., 1999). Finally, authentic science research programs left participants with changed beliefs about science teaching and learning; in particular, they were more open to using inquiry in their own teaching after experiencing the inquiry activities of professional scientists (Jeanpierre et al., 2005; Verelas et al., 2005).

Teacher education coursework has been most successful at changing beliefs about science, and as a result, at changing beliefs about the focus of science teaching. Specifically, science methods courses and workshops that focus on the nature of science and/or the interaction of science with society have shown great promise in encouraging teachers to focus more on the features of science and to teach science in emancipatory ways (Bianchini, Cavazos, & Rivas, 2003; Kahle et al., 1993; Rodriguez, 1998; Yerrick & Hoving, 2003).

Observations of other teachers have occasionally made impacts on beliefs about teaching. In one study, observations of a teacher who was more inventive and demanding of her students instigated a beginning teacher to develop a more innovative approach to teaching and to be more demanding of her own students (Bullough & Baughman, 1997).

Teaching experiences appear to have the largest effect on the concerns of teachers. Student teaching or beginning teaching in urban or low-income schools and schools with other significant constraints seems to create the most noteworthy belief changes, as many preservice teachers initially have concerns about helping students achieve and about using new and innovative curricula, and through experience they develop concerns over a lack of materials, lack of student abilities, and a general concern over obstacles to be overcome (Andersen, Dragsted, Evans, & Sorensen, 2004; Bullock, 1997; Mcginnis et al., 2004; Rodriguez et al., 2005). Some teaching experiences have succeeded in helping teachers maintain their concern for students and curricula, but these were often associated with less formal learning environments such as service learning (Barton, 2000), and occasionally with student teaching or induction-year teaching (Luft, 1999; Mulholland & Wallace, 2001). Changes in teaching context were frequently cited as instigating belief changes. In one case, this was due to movement to a lower SES school where expectations for students were different (Bullough & Baughman, 1997), and in another where much more strict classroom discipline was necessary (Adams & Krockover, 1997). Similarly, forced implementation of new curriculum has resulted in teachers possessing more constructivist beliefs, although the extent to which the new curriculum has been implemented very much depends on the teachers' original beliefs about teaching (Roehrig & Kruse, 2005).

It has been frequently suggested that the success of a teacher education or professional development program, or any other intervention, is related to how significantly the program's message is aligned with the existing beliefs of a given teacher (Adams & Krockover, 1997; Brighton, 2003; Doolittle, Dodds, & Placek, 1993; Eick & Reed, 2002; Hollingsworth, 1989; Jeanpierre et al., 2005; Roehrig & Kruse, 2005; Tillema, 1994). According to these researchers, unless a teacher already has leanings toward the theme of a program meant to reform his or her practices, the program will not make a lasting impact.

Doolittle, Dodds, and Placek (1993) noted:

> Until researchers can access belief systems successfully, and until beliefs systems of both recruits and teacher educators can be articulated carefully, then compared and debated fully, recruits will continue to resemble their former teachers and coaches far more than they will be recognizable products of their teacher education programs. (p. 365)

Beliefs About Students

Beliefs about students seem more readily changed, but even here some teachers are quite resistant to new ideas. It has been proposed that beliefs about students can only be changed through direct and unexpectedly positive or negative experiences teaching diverse students (Barton, 2000); otherwise, teachers focus on characteristics and events that reproduce their original beliefs (Brand & Glasson, 2004; Tiezzi & Cross, 1997). Other researchers insist that only through informing teachers about issues surrounding diversity and equity can teachers' beliefs be permanently changed (Bianchini, Cavazos et al., 2003).

Preservice teachers who were given time, space, and encouragement to articulate, reflect on, and confront their own views of science teaching and beliefs about students in science were more likely to confront negative beliefs and stereotypes about diverse learners having predetermined abilities in science (Bianchini & Solomon, 2003; Bryan & Atwater, 2002; Garmon, 2004; Howard, 2003; Middleton, 2002; Southerland & Gess-Newsome, 1999; Yerrick & Hoving, 2003). While breaking down negative stereotypes is clearly essential before beginning to teach, it appears equally important for teachers to create a framework of positive beliefs about teaching all students in science. Initially possessing a positive framework of beliefs about students works to combat the multiple negative influences that may exist in their future teaching assignments (Luft, 1999). Consequently, it is advantageous for preservice coursework to address the interaction between culture and learning (Howard, 2003; Southerland & Gess-Newsome, 1999) as well as culture and science (Bianchini, Johnston et al., 2003; Rodriguez, 1998; Southerland & Gess-Newsome, 1999), so that beginning teachers see diversity in their classrooms as an asset rather than a detriment.

Field experiences and student teaching experiences also have been found to be powerful in challenging preconceptions and stereotypes of diverse science learners. Preservice teachers have benefited from opportunities to have mastery teaching experiences in diverse settings as early as possible within a teacher preparation program (Bullock, 1997; Luft, 1999). It was interpreted that this allowed the preservice teachers enough time to build positive teacher efficacy beliefs and positive beliefs about students.

A strategy that has shown great promise involves allowing preservice teachers to co-teach with a single expert cooperating teacher and/or other preservice teachers (Roth, 2001; Tobin & Roth, 2005; Tobin et al., 2001). This allows the preservice teachers to see their own teaching biases through the eyes of at least two other teachers, ideally, one of whom has years of teaching experience in science and has dealt with many issues of teaching and one of whom is another preservice teacher and is dealing with comparable learning-to-teach issues. This technique has been especially powerful at developing respect between students and teachers, and has lead many preservice teachers to successful professional teaching careers. Another useful strategy involves placing preservice teachers in less formal, community-service situations where they can work more closely with a smaller group of children and without the outside pressures of standardized curricula and tests (Barton, 2000). In this situation, they can be more experimental in their pedagogies, get to know a diverse group of children and their community more carefully, and develop a respect for children who are unlike themselves. In addition, participation in community service that promotes the interests of the community in which they are teaching, or having a positive experience with culturally-different people, has shown to be helpful in developing more positive beliefs toward all students, as well as higher self-efficacy beliefs (Brand & Glasson, 2004; Bryan & Atwater, 2002; Garmon, 2004; Howard, 2003).

Teachers are also impacted by the expectations of teacher educators. After participating in a professional development program with rather expectations of participants, and where they were able to fulfill those expectations, participants returned to their own classrooms with higher expectations for their own students in terms of how much and what type of science they were able to accomplish (Jeanpierre et al., 2005).

Teacher Efficacy Beliefs

Teacher efficacy beliefs appear to be the most malleable, since almost every study found significant changes as a result of a given intervention. The problem with studying shifts in teacher efficacy beliefs is that they seem to shift with few apparent patterns and over relatively short periods of time. Teaching experiences, courses, and other interventions have demonstrated mixed effects on teacher efficacy beliefs, leading researchers to struggle to understand under what conditions positive teacher efficacy beliefs may be fostered.

Several studies have indicated that some science methods courses have been successful at nurturing positive teacher efficacy beliefs, particularly when negative efficacy beliefs are the result of negative experiences with science. A well-designed and executed science methods course can offer a positive and successful experience with science; as a result, prospective teachers are able to confront and move beyond their fear of science (Bohning et al., 1999; Ginns & Tulip, 1995; Huinker & Madison, 1997; Mulholland & Wallace, 2001; Rice & Roychoudhury, 2003). Similarly, designing content courses that are themselves taught in ways that relate concepts, avoid memorization, use prior student experiences, and steer clear of lecturing may help students break free of their uneasiness about non-traditional science teaching and gain positive science teaching self-efficacy (Schoon & Boone, 1998).

Additionally, a science methods course instructor can model the hands-on, minds-on science teaching that beginning teachers will be expected to use when instructing their own classes (Huinker & Madison, 1997; Rice & Roychoudhury, 2003). The teacher educator can also act as a role model for the preservice teachers by modeling exemplary science teaching (Yerrick & Hoving, 2003) as well as by sharing their research goals in science education (Bianchini & Solomon, 2003). Although few studies have dealt directly with the impact of observing cooperating teachers or even science methods instructors on the teacher efficacy beliefs of preservice teachers, Labone (2004) noted that the vicarious experience of observing another teacher may be especially influential for teachers in training due to their inexperience with the many facets of teaching in classrooms. Pairing such a science methods course with a successful field experience teaching science to children in schools has been quite effective in boosting teacher efficacy (Cantrell et al., 2003; Mulholland & Wallace, 2001; Tosun, 2000), although teacher preparation programs must be careful not to send beginning teachers into field experiences and classroom environments where there is a low likelihood of experiencing science teaching successes, as that has been shown to lower teacher self-efficacy (Ginns & Tulip, 1995). Such mastery experiences, either positive or negative, may be the most powerful way to raise or lower efficacy beliefs, creating the expectation within a prospective teacher that future experiences will also be successful or unsuccessful (Bandura, 1997). In order to raise the teacher efficacy of beginning teachers, training programs must prepare them to a high standard and give them as many tools as possible with which to teach (Knobloch & Whittington, 2002).

On a larger scale, as was discussed earlier, school context issues and collective efficacy of a school can impact individual teacher efficacy beliefs. By assigning beginning teachers to mentors, cooperating teachers, and schools that have high collective efficacy toward science teaching, positive teacher efficacy beliefs may be developed in beginning and preservice teachers (Czerniak & Chiarelott, 1990; Mulholland & Wallace, 2001). Encouraging teachers to collaborate with each other also has had positive effects on teacher efficacy beliefs (Henson, 2001).

Finally, a large body of research has examined the relationship between teacher experience and teacher efficacy, with mixed outcomes. Overall, a successful experience with teaching science appears to always have a positive impact on teacher efficacy (Cantrell et al., 2003; Ginns & Tulip, 1995; Knobloch & Whittington, 2002; Mulholland & Wallace, 2001). Successful mastery experiences, where success is attributed to self and not external factors, have significant positive impacts on teaching efficacy (Tschannen-Moran et al., 1998), and science teaching is no exception to this pattern. The sense of teacher efficacy of preservice teachers, in particular, has been hypothesized to be more susceptible to both positive and negative direct teaching experiences as a result of their lack of previous experiences in classrooms and their lack of a sense of identity as a teacher (Labone, 2004). It is also important to note that changes in teaching context may temporarily depress a teacher's sense of efficacy as a result of engaging in the process of change. If the situation offers opportunities for teacher growth, however, the teacher's sense of efficacy may rebound or even result in more positive teacher efficacy beliefs than in the initial situation (Ross, 1998).

General Belief Change

It is perhaps noteworthy that when preservice teachers were asked about the experiences in their teacher education program that were most valuable to them, overwhelmingly they cited topics and experiences that provided them with specific teaching tools and that were experienced through active learning techniques (Beswick, 2006). Similarly, when preservice teachers were asked why they did not implement many of the learning theory and pedagogical methods they learned in coursework, they noted that the university's teachings did not reflect the realities of classroom teaching (Eisenhart & Behm, 1991). For example, they stated that using concrete materials, discussing with peers, and learning about topics that were relevant to immediate classroom issues were the most useful (Beswick, 2006). Least valuable aspects included the topics that were least applicable to classroom practice, such as content knowledge and an understanding of theoretical and philosophical issues (Beswick, 2006; Eisenhart & Behm, 1991). Teacher beliefs were most significantly impacted, then, by coursework that was designed to confront issues directly related to teaching practice.

It has been noted that preservice teachers most effectively learn new ideas and skills in smaller steps, allowing new ideas and skills to be scaffolded onto existing ones (Czerniak & Chiarelott, 1990; Hollingsworth, 1989), rather than by swamping them with a tremendous amount of theory, as is the case in many teacher preparation programs. For example, one study of preservice reading teachers found that general managerial routines had to be in place before the teachers could focus on content and pedagogical methods, and both managerial and academic routines needed to be in place before teachers could focus on student learning (Hollingsworth, 1989). Another study found that an inservice teacher could not begin to innovate or experiment in her teaching until she had routines, content knowledge, and a system of class discipline in place and was comfortable utilizing them (Bullough & Baughman, 1997).

Preservice teachers who reached advanced states of development had several experiences in common: they possessed an awareness that they needed to change their initial beliefs in order to deal with their classroom organization (such an awareness was often instigated when the preservice teachers and their cooperating teachers had contrasting beliefs, and the preservice teachers were forced to justify their ideas), they worked with a cooperating teacher who encouraged them to experiment in their teaching, and/or they were specifically required by either the teacher preparation program or the university supervisor to attempt innovative teaching in the classroom (Hollingsworth, 1989). Furthermore, it appears to be important for preservice teachers to have a clear conception of themselves as teachers before any change in beliefs can take place. Otherwise, they continue to be concerned only with themselves and immediate classroom concerns (Bullough, 1991; Hollingsworth, 1989). Unfortunately, many teacher education programs are set up such that preservice teachers are forced to look for quick fixes in their coursework and field experience teaching, not allowing them the time to be reflective, to examine their beliefs, and to gain confidence (Eisenhart & Behm, 1991).

Summary

A review of the literature reveals that teacher beliefs are malleable, under the right conditions and interventions. Beliefs about teaching, while appearing least easy to change, may be influenced through long-term interventions, science methods courses that focus on the nature of science, and most importantly, direct teaching experiences. Beliefs about students may be influenced through education courses in which the teachers are forced to identify, reflect on, and confront their initial beliefs about students, and through positive teaching experiences with students from diverse backgrounds. Teacher efficacy beliefs may be influenced by a science methods course instructor and/or mentor teacher who models good teaching and science practices, and most importantly, through direct, successful teaching experiences. General belief change may be fostered through more clearly relating theories of teaching and learning to classroom practices and by allowing teachers more time and space to process new content and skills they have learned.

CHAPTER 3

RESEARCH METHODS

Participants and Program Description

This study included two full cohorts of Master of Education students in the secondary science education program at The Ohio State University during the 2004-2005 and 2005-2006 school years, as well as a randomly chosen sub-sample from each cohort. More specifically, the 2004-2005 cohort consisted of 28 preservice teachers and the 2005-2006 cohort consists of 9 preservice teachers; every person consented to participate. The 2004-2005 cohort was composed of 11 men and 17 women, 7 who possessed Master's degrees in their content area. Twenty-five preservice teachers in this group self-identified as White, 2 as Asian, and 1 as East Asian. The 2005-2006 cohort was composed of 4 men and 5 women, none who possessed master's degrees in their content area. Eight preservice teachers in this group self-identified as White and 1 as Asian. From this original group, 9 students from the 2004-2005 cohort and 4 students from the 2005-2006 cohort were randomly chosen to participate in interviews and to submit written work from throughout the teacher education program. Characteristics of participants in the sub-sample are presented in Table 3.1. All names are pseudonyms in order to protect the identity of research participants.

Participant	Content Area	Educational Background	Other Background
Lucy	Life Sciences	B.S. in Biological Sciences	1st year out of college
Emily	Life Sciences	B.S. in Biological Sciences	1st year out of college
Raina	Life Sciences	B.A. in Biological Sciences	1st year out of college
Henry	Earth Sciences	B.S. and M.S. in Earth Sciences	1st year out of master's degree
Josh	Technology/Physical Sciences	B.S. in Education	1st year out of college
Nancy	Life Sciences	B.S. in Biological Sciences	Worked for years before coming back to graduate school
Ingrid	Life Sciences	B.S. in Biological Sciences	1st year out of college
Aaron	Life Sciences	B.A. and M.S. in Biological Sciences	1st year out of master's degree
Alyssa	Earth Sciences	B.S. and M.S. in Earth Sciences	1st year out of master's degree
Rachel	Life Sciences	B.S. in Biological Sciences	1st year out of college
Anna	Life Sciences	B.S. in Health Sciences	Worked for a short time before coming back to graduate school
Tom	Physical Sciences	B.S. in Physical Sciences	Worked for a short time before coming back to graduate school
Dan	Physical Sciences	B.S. in Engineering	Worked for years before coming back to graduate school

Table 3.1: Research participants

The teacher preparation program consisted of an initial quarter of intensive coursework, two subsequent quarters in which the preservice teachers were engaged in both coursework and part-time teaching, a fourth quarter of full-time student teaching including an action research project, and a final quarter of writing the action research project and passing a comprehensive exam. Course requirements are outlined in Appendix A. Preservice teachers finished the program with a Master of Education degree and licensure in secondary science teaching.

One participant, Tom, was an alternative licensure candidate. He undertook the same coursework and action research requirements as the rest of the M.Ed. group, but over two years instead of one, and while teaching half-time for both years within the Columbus Public district. Tom's quantitative data is not included in any of the quantitative analysis in this study, but he is included in the presentation of qualitative data.

I identify as a European American woman, and worked as a university field experience supervisor during the 2004-2005 school year with 14 of the 28 secondary science preservice teachers in that cohort, as well as 6 of the 9 people who participated in the interviews and document collection. I also assisted in teaching one of the summer courses in which members of that first cohort were enrolled, although that class was finished by the time the initial surveys and interviews were conducted. I was not a stranger to any participant in the 2004-2005 cohort, and while that may have helped me obtain access to preservice teachers' thoughts that an outsider could not, it is possible that my relationship with participants in this cohort could have had a biasing effect. I had no relationship with any of the members of the 2005-2006 cohort, aside from interacting with them for research purposes, so including this group helped me account for any effect of my personal involvement with members of the 2004-2006 cohort.

Additionally, I possess strong beliefs that all children, regardless of gender, sexual orientation, ethnic background, socioeconomic background, disability, previous achievement, or any other categorizing variables are capable of learning and achieving in science, and that teachers can significantly impact the learning of all children. I also am a firm believer in the power of constructivist teaching and learning. Although I attempted not to reveal these beliefs in my interviewing of research participants, those preservice teachers who worked with me throughout the school year may have been affected by or may pretend to have been affected by my beliefs, and may have adjusted their behaviors and responses accordingly. This may limit the credibility and trustworthiness of the results of this study, but may also provide some insight into what experiences promote belief changes in preservice teachers

Data Collection and Analysis

Research Questions

The purpose of this study was to examine preservice secondary science teachers' changes in teacher efficacy beliefs and beliefs about the teaching and learning of students in science as they learn how to teach. The ultimate goal of this study was to understand what experiences and characteristics promote a more positive sense of teacher efficacy and constructive beliefs toward the teaching of science to all students, to better prepare beginning teachers to work with an increasingly diverse student body.

The study will address the following research questions:

1. What teacher efficacy beliefs, beliefs about the role of the teacher, and beliefs about students do preservice secondary science teachers possess at various time points during their teaching preparation program?
2. Do preservice secondary science teacher efficacy beliefs, beliefs about the role of the teacher, and beliefs about students change between the beginning and end of their teaching preparation program? If the beliefs do change, what events are associated with these belief changes?
3. Do relationships exist between teacher efficacy beliefs, beliefs about students, and beliefs about the role of the teacher? If so, do these relationships act in accordance with the proposed model such that beliefs about students and the role of the teacher have an impact on teacher efficacy beliefs, and such that mastery experiences have more of an impact than vicarious experiences and verbal persuasive experiences, and affective states act as an intensifying force?

Data Sources

In order to gain the most full picture of preservice science teacher beliefs and experiences throughout the year, a mixed-methodology research design was utilized. The first two research questions were analyzed with respect to both qualitative and quantitative data, while analysis of the third research question relied mainly on qualitative data.

Two standardized, quantitative instruments were utilized: the *Science Teaching Efficacy Beliefs Instrument* (Riggs & Enochs, 1990) and the *Reformed Teaching Observation Protocol* (Piburn et al., 2000). The *Science Teaching Efficacy Beliefs Instrument* (STEBI-A) may be found in Appendix B. The *Reformed Teaching Observation Protocol* (RTOP) may be found in Appendix C. All preservice teachers completed the STEBI-A during a class in the first quarter and then during a seminar in the last quarter of the teacher preparation program. The RTOP was utilized by university supervisors during weekly observations of instruction for all preservice teachers in the third and fourth quarters of the teacher preparation program. A more detailed description of each instrument will be presented in a subsequent section of this chapter.

The sub-sample of preservice science teachers in each cohort was interviewed three times during the school year: during the first quarter in the program, before student teaching, and after student teaching. It has been shown that teacher preparation programs can impact teacher beliefs (Bullock, 1997; Hart, 2002; Knobloch & Whittington, 2002; Lumpe et al., 2000), so it is important to assess the preservice teachers' beliefs before and after the program. Additionally, through the researcher's previous experience supervising the preservice teachers in their field experiences, it was determined that the winter field experience, in which the preservice teachers are engaged in teaching a single class for a full 6 weeks, is a highly powerful experience in determining the teachers' beliefs and practices. Therefore, a third interview was completed during this time.

Interviews focused on the preservice teachers' beliefs about the their roles as teachers, their impact on student achievement, and the experiences that shaped their ideas about teaching and learning. Several of the interview questions were derived from the *Teacher Pedagogical Philosophy Interview* (Richardson & Simmons, 1994), while others were created based on the research questions for this project and initially tested in a pilot study. Interview questions may be found in Appendix D. Interviews were audio-taped and then transcribed by the researcher.

Reflective journal writing, statements of teaching philosophies, and lesson plans (all completed during course and field work as a part of normal program requirements, not specifically for this study) were gathered for the same sub-sample. Reflection prompts may be found in Appendix E. Classroom observations (in the form of field notes from supervisors' weekly observations of teaching) of teaching actions, classroom management practices, and student behaviors were completed for the sub-sample of preservice science teachers in order to gain a more complete understanding of beliefs, as well as what caused those beliefs to shift. Due to logistical issues, not all participants in either cohort submitted reflections and lesson plans. The actual number of preservice teachers submitting each type of data may be found in Table 3.2. Additionally, due to the researcher not being in residence during the 2005-2006 school year, none of the participants in the 2005-2006 was observed teaching by the researcher.

Additionally, demographic and field placement information for each participant was gathered during every quarter. Such demographic data included the gender, ethnic background, and content background of the preservice teachers, and the distinction between urban/suburban field placement school (based on the percentage of students on free or reduced price lunch.

Previous researchers have used similar qualitative data to that which was collected in this study. Interviewing preservice teachers before and after their student teaching experience is a common practice (Bullock, 1997; Luft, 1999; Plourde, 2002a, 2002b), as is examination of reflective journal writing and classroom artifacts such as lesson plans and assignments (Brand & Glasson, 2004; Bullock, 1997; Hancock & Gallard, 2004; Hart, 2002; Luft, 1999; Rodriguez, 1998). Although observing classroom teaching is less common, it is very much an accepted practice (Andersen et al., 2004; Brand & Glasson, 2004).

Source of Data	When Collected	Number of Participants in 2004-2005 Cohort	Number of Participants in 2005-2006 Cohort
STEBI-A	Summer; Spring	28	9
RTOP	Through school year	28	9
Demographic information	Through school year	28	9
Semi-structured interviews	Summer, Winter, & Spring	9	4
Lesson plans	Through school year	7	3
Weekly reflections	Through school year	7	3
Teaching observations	Through school year	9	0

Table 3.2: Data sources

Instruments

The *Science Teaching Efficacy Beliefs Instrument* (Riggs & Enochs, 1990) was originally developed in order to measure, in elementary teachers, two components of self-efficacy (Bandura, 1997) as applied to teaching science: Personal science teaching efficacy (PSTE, 13 items) and science teaching outcome expectancy (STOE, 12 items). As a result, the STEBI-A instrument has two scales for a total of 25 statements in a 5-point Likert-response format. Individuals complete the instrument by reading each of the 25 statements and circling numbers between 1 and 5 (where 1 is "strongly disagree" and 5 is "strongly agree") to indicate how much they agree or disagree with the statement. Thirteen of the statements are positively worded (for example, "When teaching science, I usually welcome student questions") and twelve of the statements are negatively worded (for example, "I am not very effective in monitoring science experiments"). Personal science teaching efficacy scores range from 13 to 65, and science teaching outcome expectancy scores range from 12 to 60. A person who scores high in personal science teaching efficacy on this instrument possesses strong beliefs in his or her own self-efficacy as a science teacher. A person who scores high in science teaching outcome expectancy possesses high expectations of the outcomes of his or her science teaching.

Two changes were made in this instrument by the researcher to be used with secondary teachers rather than elementary teachers. The changes that were made to adapt the instrument for use with secondary teachers may be found in Table 3.3.

Original Statement	Adapted Statement
Even when I try very hard, I don't teach science as well as I do most subjects	Even when I try very hard, I do not teach science well
I understand science concepts well enough to be effective in teaching elementary science	I understand science concepts well enough to be effective in teaching secondary science

Table 3.3: Changes to *Science Teaching Efficacy Belief Instrument*

This instrument was chosen because its results are specific to the field of science and it has been validated in a number of studies in the United States and around the world, with Cronbach alphas of 0.92 and 0.77 (Enochs & Riggs, 1990), 0.73 and 0.68 (Ginns & Tulip, 1995), 0.87 and 0.69 (Cantrell et al., 2003) and 0.92 and 0.73 (Mji & Kiviet, 2003) for the two embedded scales. For the present study, the PSTE subscale of the instrument exhibited an alpha coefficient of 0.85, and the STOE subscale exhibited an alpha coefficient of 0.65. Reliabilities were similar when the subscales were examined at the pretest point (PSTE alpha coefficient of 0.81, STOE alpha coefficient of 0.63) and at the posttest point (PSTE alpha coefficient of 0.81, STOE alpha coefficient of 0.69). The PSTE subscale reliability is reasonable for assuming that the instrument is reliable for the current study, but the STOE subscale reliability is somewhat low. The lower reliability coefficient has been noted in earlier studies (Enochs & Riggs, 1990; Huinker & Madison, 1997; Plourde, 2002b); it has been suggested that outcome expectancy is a less definite construct, and thus more difficult to measure accurately (Riggs & Enochs, 1990).

The *Reformed Teaching Observation Protocol* (Piburn et al., 2000) was developed to evaluate how well science and mathematics instruction—at any level from elementary school to university—adheres to the tenets of inquiry teaching, as suggested by professional societies of scientists, mathematicians, and educators. The instrument is made up of 5 different scales (lesson design and implementation, 5 items; propositional pedagogical knowledge, 5 items; procedural pedagogical knowledge, 5 items; communicative interactions, 5 items; and student/teacher relationships, 5 items) for a total of 25 statements in a 4-point Likert scale format, such that higher scores reflect a greater degree of inquiry teaching.

The instrument was chosen because its results are specific to science and mathematics education and because it measures the type of teaching promoted in the teacher education program in this study. It has also been validated in a number of studies (Roehrig & Kruse, 2005; Sawada et al., 2002), with overall Cronbach alphas of 0.97 and subscale Cronbach alphas ranging from 0.80 to 0.93 (Sawada et al., 2002). For the present study, the instrument as a whole exhibited an alpha coefficient of 0.93, and the five subscales exhibited alpha coefficients of 0.83, 0.57, 0.79, 0.77, and 0.78, respectively.

Data Analysis

The first research question was analyzed quantitatively and qualitatively. An analysis of variance was completed in order to detect the effects of gender and content knowledge on teacher efficacy beliefs (as measured by the STEBI-A), as it has previously been shown that there are differences in beliefs among men and women, and between people with less and more content background (Cantrell et al., 2003; Desouza et al., 2004; Ramey-Gassert et al., 1996; Raudenbush et al., 1992). I looked for correlations between the two aspects of science teacher efficacy (personal efficacy and outcome expectancy) at the beginning and end of the teacher preparation program, based on gender and content knowledge differences. This type of analysis has previously uncovered some interesting trends (Desouza et al., 2004). My approach to the qualitative analysis went as follows: I began by searching through data from interviews and written reflection responses, and I coded the data according to emergent themes in the larger categories of beliefs about students, the role of the teacher, and teacher efficacy beliefs. I used the constant comparative approach (Glaser & Strauss, 1967) to assure that themes were no missed and simultaneously that themes were not redundant. Ultimately, I created matrices (Miles & Huberman, 1984) of teacher efficacy beliefs, beliefs about the role of the teacher, beliefs about students, and classroom practices at different times in the year for each participant in the sub-sample. An example matrix may be found in Appendix F.

The second research question was analyzed quantitatively and qualitatively, as well. STEBI-A data was analyzed statistically using a t-test to detect differences between the beginning and end of the teacher preparation program. I then examined the belief matrices mentioned previously in order to explore any changes in beliefs over time. I also recoded interview and written reflection data with an eye toward explaining these changes in beliefs—incidents of cognitive dissonance, conceptual change, dual process change, and Bandura's (1997) four sources of self-efficacy information were sought out, in particular, as well as emergent themes. In order to look for trends over time, I created matrices of events impacting beliefs at different times in the year for each participant in the sub-sample.

The third research question was again analyzed quantitatively and qualitatively. STEBI-A data and RTOP data were correlated to determine if there was a relationship between teacher efficacy beliefs and constructivist teaching practices. Additionally, participants with particularly strong or weak senses of teacher efficacy were identified based on STEBI-A scores, interview data, and written reflections. I looked for trends and contrasts in beliefs about students and the role of the teacher for those with a stronger or weaker sense of efficacy. In addition, I examined the matrix of events impacting teacher efficacy beliefs in order to determine which types of events (mastery experiences, vicarious experiences, verbal persuasive experiences, or affective states) most strongly influenced participants' sense of efficacy.

Throughout this analysis, I tried to be non-judgmental about the preservice teachers' beliefs, in accordance with the suggestions of previous researchers (Tiezzi & Cross, 1997). Although it was occasionally difficult to separate the researcher side of my brain from the teacher educator side, I felt strongly that it was not my goal to criticize or praise my participants' beliefs and practices, but rather to describe and analyze.

Trustworthiness

Several precautions were undertaken to assure the trustworthiness of these data and this data analysis. Triangulation between participants and sources of data ensured that conclusions are robust, as did the process of doing member checks with several participants in the sub-sample. I used the method of constant comparative analysis (Glaser & Strauss, 1967) to check and recheck that the data aligned well with the emergent themes, along with analysis of discrepant cases in order to show that alternative conclusions were explored and discounted. Additionally, I kept an audit trail (Lincoln & Guba, 1985) so that conclusions could be traced backwards and retraced forwards. A timeline of data collection may be found in Figure 3.1.

Summer, 2004: First cohort data collection

- Science Teaching Efficacy Beliefs Instrument responses
- Semi-structured interviews

Autumn, 2004: First cohort data collection

- Reflection responses
- Lesson plans
- Teaching observations
- Placement school demographics

Winter, 2004: First cohort data collection

- Semi-structured interviews
- Reformed Teaching Observation Protocol records
- Reflection responses
- Lesson plans
- Teaching observations
- Placement school demographics

Spring, 2005: First cohort data collection

- Science Teaching Efficacy Beliefs Instrument responses
- Semi-structured interviews
- Reformed Teaching Observation Protocol records
- Reflection responses
- Lesson plans
- Teaching observations
- Placement school demographics

Summer, 2005: Second cohort data collection

- Science Teaching Efficacy Beliefs Instrument responses
- Semi-structured interviews

Autumn, 2005: Second cohort data collection

- Reflection responses
- Lesson plans
- Placement school demographics

Winter, 2006: Second cohort data collection

- Semi-structured interviews
- Reformed Teaching Observation Protocol records
- Reflection responses
- Lesson plans
- Placement school demographics

Spring, 2006: Second cohort data collection

- Science Teaching Efficacy Beliefs Instrument responses
- Semi-structured interviews
- Reformed Teaching Observation Protocol records
- Reflection responses
- Lesson plans
- Placement school demographics

Figure 3.1: Timeline of data collection

CHAPTER 4

FINDINGS: TEACHER EFFICACY BELIEFS

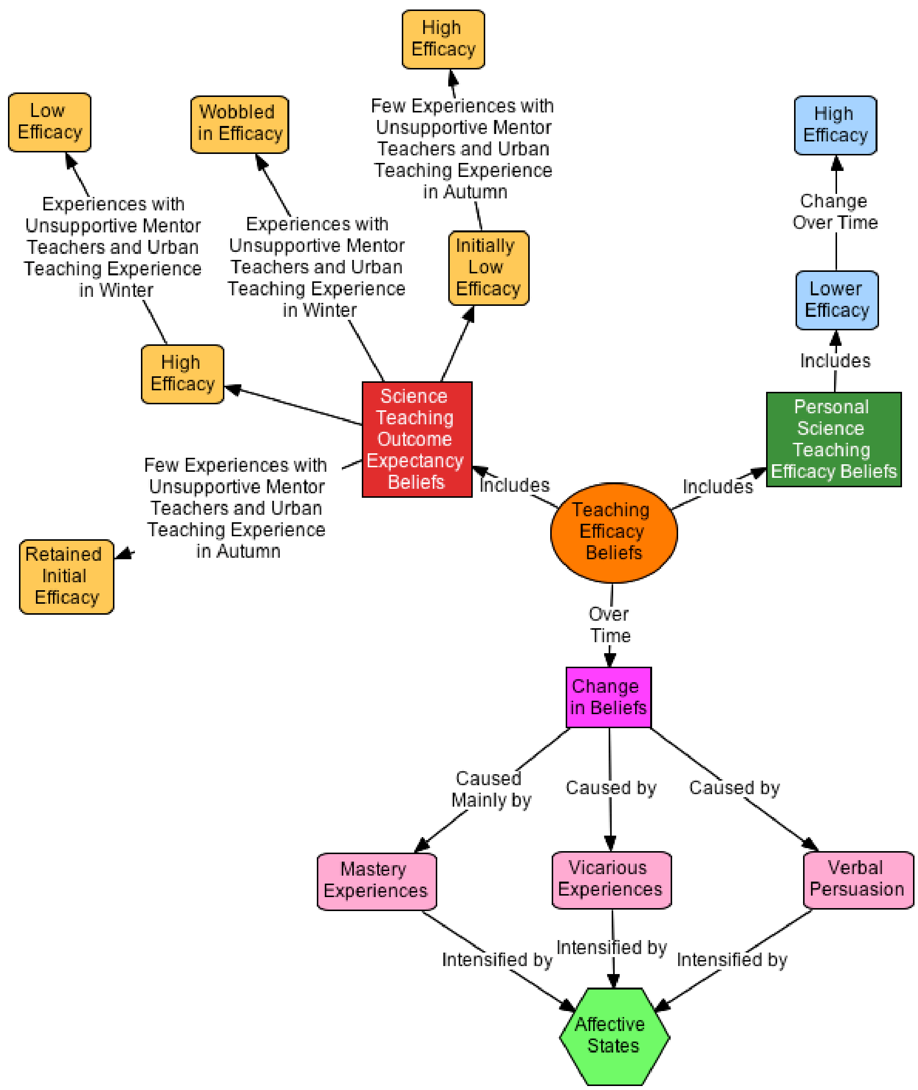

Figure 4.1: Map of factors impacting and changes in teacher efficacy beliefs

Overall Trends: Quantitative Results

Descriptive statistics for both cohorts in personal efficacy and outcome expectancy are found in Table 4.1. When the two cohorts' PSTE and STOE scores were compared, they were not significantly different ($t = 1.463$, $p = 0.147$ for PSTE sub-scale, $t = 0.748$, $p = 0.457$ for STOE sub-scale). For the remainder of this study, then, the two cohorts were grouped into one collection for data analysis purposes. Descriptive statistics for the entire group may be found in Table 4.2.

		Pre-Test		Post-Test				
		M	SD	M	SD	t	p	Partial η^2
2004-2005 Cohort	PSTE Score	3.809	0.454	4.284	0.381	-4.381	0.000	0.235
	STOE Score	3.361	0.425	3.405	0.425	-0.400	0.691	0.001
2005-2006 Cohort	PSTE Score	3.726	0.557	4.178	0.357	-1.965	0.063	0.155
	STOE Score	3.417	0.346	3.083	0.379	2.070	0.051	0.169

Table 4.1: Comparison of PSTE and STOE scores by cohort

	Pre-Test		Post-Test				
	M	SD	M	SD	t	p	Partial η^2
PSTE Score	3.793	0.484	4.263	0.373	-4.791	0.000	0.221
STOE Score	3.391	0.394	3.341	0.431	0.550	0.584	0.004

Table 4.2: Comparison of PSTE and STOE scores for entire group

The personal science teaching efficacy mean was significantly ($p < 0.001$) higher for preservice teachers when they were finishing the teacher preparation program than when they were beginning, with a medium-large effect size. On the other hand, the science teaching outcome expectancy means were not significantly different between the beginning and end of the teacher preparation program.

Furthermore, at the time of the pre-test, the time of urban teaching experience made the only significant impact on PSTE beliefs, and no factor made a significant impact on PSTE beliefs at the time of the post-test (See Table 4.3). More specifically, preservice teachers who engaged in their urban teaching experience in the fall initially possessed significantly more positive PSTE beliefs. Because the urban teaching experience happened only after the pre-test was given, this factor could only have made an impact due to chance. There were no interactions between these factors at either the time of pre- or post-test.

	Source	SS	df	MS	F	p	Partial η^2
PSTE Pre-test	Content	0.072	1	0.072	0.609	0.443	0.027
	Urban teaching experience	0.916	1	0.916	7.742	0.011	0.260
	Gender	0.000	1	0.000	0.003	0.960	0.000
	Content * Urban T.E.	0.318	1	0.318	2.686	0.115	0.109
	Content *Gender	0.152	1	0.152	1.288	0.269	0.055
	Urban T.E. * Gender	0.037	1	0.037	0.285	0.599	0.013
	Error	2.602	22				
	Total	3.983	29				
PSTE Post-test	Content	0.378	1	0.378	2.841	0.103	0.095
	Urban teaching experience	0.380	1	0.380	2.856	0.103	0.096
	Gender	0.111	1	0.111	0.833	0.370	0.030
	Content * Urban T.E.	0.478	1	0.478	3.593	0.069	0.117
	Content *Gender	0.347	1	0.347	2.608	0.118	0.088
	Urban T.E. * Gender	0.002	1	0.002	0.013	0.909	0.000
	Error	3.591	27	0.133			
	Total	4.737	34				

Table 4.3: Summary of the analysis of variance for PSTE scores

Regarding STOE beliefs, none of the factors made significant impacts on these beliefs at the time of the pre-test, while the time of urban teaching experience made a significant impact on STOE beliefs by the end of the teacher preparation program (See Table 4.4). In this case, preservice teachers who engaged in their urban teaching experience in the fall possessed significantly more positive STOE beliefs at the end of the teacher preparation program than did preservice teachers who engaged in their urban teaching experience in the winter. A significant interaction was found between content knowledge and the time of urban teaching experience by the end of the program, as well. Those preservice teachers who possessed master's degrees developed significantly more positive STOE beliefs when they did their urban teaching experience in the fall than those who did their urban teaching experience in the winter. This effect was not visible among preservice teachers possessing only bachelor's degrees in their content area.

	Source	SS	df	MS	F	p	Partial η^2
STOE Pre-test	Content	0.356	1	0.356	1.984	0.173	0.083
	Urban teaching experience	0.404	1	0.404	2.251	0.148	0.093
	Gender	0.001	1	0.001	0.005	0.945	0.000
	Content * Urban T.E.	0.332	1	0.332	1.849	0.188	0.078
	Content *Gender	0.096	1	0.096	0.533	0.473	0.024
	Urban T.E. * Gender	0.066	1	0.066	0.370	0.549	0.017
	Error	3.952	22	0.180			
	Total	5.316	29				
STOE Post-test	Content	0.133	1	0.133	0.802	0.379	0.029
	Urban teaching experience	0.733	1	0.733	4.414	0.045	0.141
	Gender	0.029	1	0.029	0.173	0.681	0.006
	Content * Urban T.E.	1.099	1	1.099	6.619	0.016	0.197
	Content *Gender	0.189	1	0.189	1.137	0.296	0.040
	Urban T.E. * Gender	0.172	1	0.172	1.037	0.318	0.037
	Error	4.482	27	0.166			
	Total	6.311	34				

Table 4.4: Summary of the analysis of variance for STOE scores

When the two aspects of science teacher efficacy (personal science teaching efficacy and science teaching outcome expectancy) were correlated, several interesting trends came to light. First, for people with master's degrees, there was a significant, strong, and positive correlation (0.583, $p = 0.018$) between PSTE and STOE. There was no significant correlation for participants with bachelor's degrees only. No differences between men and women were noted, nor between participants who completed their urban field experience in the winter versus fall. Finally, STOE and PSTE were significantly and positively correlated (0.368, $p = 0.030$) for the entire group at the time of the post-test, but not at the pre-test.

Overall Trends: Qualitative Results

Analysis of interview responses revealed a similar conclusion about changes in personal science teaching efficacy beliefs and changes in science teaching outcome expectancy beliefs. Preservice teachers expressed doubts about their abilities to teach science at the beginning of the science teacher education program, but were more confident and definite that they wanted to be science teachers at the end of the teacher education program. This trend held true for almost every preservice teacher in the sub-sample. As a group, the preservice teachers did not change in their outcome expectancy beliefs; however, individual preservice teachers did exhibit significant changes in outcome expectancy beliefs. Some preservice teachers developed more positive beliefs about the capabilities of teachers on student learning, whereas some of the preservice teachers developed more negative beliefs.

Personal Teacher Efficacy Beliefs

Almost all of the preservice teachers developed more positive personal teacher efficacy beliefs during the course of the teacher preparation program, although they took different paths to reach that point. Several of the preservice teachers expressed confidence in their teaching abilities from the beginning, and still developed further confidence during the year. For example, Henry progressed from "I'm pretty good"

(Henry, interview, 8/04) but not knowing if teaching was he really wanted to do to "Really good…I've really expanded" (Henry, interview, 6/05) and feeling confident that he wanted to be a teacher and to work with underprivileged kids. Similarly, Aaron began the program feeling comfortable teaching: "I feel like I've been doing it [teaching] for a while, and I feel like the science part of it is something I'm very comfortable with." (Aaron, interview, 8/04) Initially, Aaron was worried about structuring entire courses, but felt at ease teaching individual lessons. By the end of the year, he had gained confidence and a strong sense of himself as a teacher:

> I think of myself much more now as a teacher than just as a scientist who was doing some teaching…I feel much more comfortable as a teacher now, knowing a little bit more about what I'm actually doing in the classroom. So I feel pretty good about who I am as a science teacher at this point. (Aaron, interview, 6/05)

Emily was initially quite confident in her teaching, and expressed specific goals for herself and her students. Her only worries were about school politics and being a role model outside of the classroom. The coursework and field experiences seemed to only enhance her sense of efficacy. By winter, she was already feeling ready to be a professional teacher:

> I'm looking more forward to next year. Like, student teaching just feels like another hurdle I have to cross, and I know I can get a lot out of it and it is good that I'll have another opportunity and I'll be in school the whole day, but—maybe this is too confident—I feel like I can just do it, just go ahead and start in a school. (Emily, interview, 2/05).

Spring was the first time her confidence flagged a bit: "I think I'll be all right. I try to be real. There are days when I want to be better, but then others where I think I'm fine." (Emily, interview, 5/05).

Nancy and Dan also were confident at the beginning of the program, mainly because of their relationships with their own children and the fact that they had both been thinking about being a teacher from quite some time, and in fact, had left other careers to start over as teachers:

> I'm just excited about it, I'm excited. This is really something I've always wanted to do, and so I'm excited. Particularly looking forward to actually getting hands-on, getting out there in the classroom. So hopefully I'll do okay…I can see myself out there. (Nancy, interview, 8/04)

> I'm excited about it. The change for me from being an engineer to pursuing teaching was a significant decision, and so far I'm pleased with the program and the professors and my peers. So I'm excited about the next step. (Dan, interview, 7/05).

During the winter, Nancy already noted changes in her confidence and beliefs about herself as a teacher: "I'm good now that I've been in the classroom for two quarters. I'm getting a lot more confident in my abilities to teach." (Nancy, interview, 3/05). Nancy already felt somewhat stifled by her mentor teachers and confident that she could teach her own classes by the winter and spring quarters. By the mid-point of the teacher preparation program, Dan had developed a much more specific sense of himself and his goals as a teacher, and felt confident that he was well-prepared going into his student teaching placement.

Josh, Alyssa, and Rachel initially expressed reservations about teaching due to their inexperience and concern over the large variety of issues that would confront them in actual classrooms, but all three developed more confidence over the year. An example of how they changed:

> As a future science teacher, my first few years, I'll probably be at least mediocre, and after that I would like to hope I'll be good…I see myself as improving, just not being that good at the start of it…thus far I have to report of the program feeling almost completely unprepared. (Josh, interview, 8/04)

> I think I'm acceptable right now but still have vast room for improvement. Every time I do something I get better at it, though, so I think I'm a teacher who will improve…I'm looking forward to running my own class next quarter. (Josh, interview, 3/05)

Similarly, Raina, Ingrid, Tom, and Anna expressed difficulty imagining themselves as professional teachers at the beginning of the program: "It's really hard for me to envision being in a classroom because I really haven't yet." (Anna, interview, 7/05). Raina and Tom further noted that they were not entirely sure that teaching was the career for them.

> Looking at myself as a teaching professional is a very hard thing for me to do at this point. I have been a student for so long that sometimes sitting at the teacher's desk instead of the student's desk just seems odd. (Raina, written reflection, 11/04).

By the end of the program, however, all four developed strong images of themselves as teachers. During the spring interview, Ingrid described in great detail and with enthusiasm how she saw herself as a teacher:

> I definitely, with a science classroom, think you need to have a lot of things hands-on. I'd really like to do more discovery learning because I think that it's something that kids have trouble with at first because it's so new and so unfamiliar, that they don't want to try…and do more where the students are interacting with each other, and they're presenting the material instead of me lecturing to them or giving them guided notes or something like that. (Ingrid, interview, 6/05)

Raina recalled feeling unsure about teaching at the beginning of the program, but noted that her confidence in herself as a teacher had changed substantially: "I was a little iffy when I started this program. I didn't know if teaching was for me, but I really didn't know what else I wanted to do with my life. And it's so for me. I love it." (Raina, interview, 6/05). Similarly, Tom was convinced after just a few months of teaching and coursework that teaching was the career for him:

> I started this off—this has been a career change for me, and so now you've had a chance to talk to me before I was actually in the classroom, now after I've been in the classroom, and in what I consider not the most pristine and beautiful classroom. And my thought is I absolutely, one hundred percent want to stick with it. (Tom, interview, 2/06).

One of the preservice teachers was an exception to this general trend and did not seem to substantially gain more positive teacher efficacy beliefs during the program. Lucy began the program with a specific image of herself as a teacher-facilitator, and high confidence that she could accomplish that image and impact student learning. During the year, she developed a slightly more complex description of herself as a teacher, but she retained her initial sense of efficacy.

Scores from the STEBI-A instrument are presented in Table 4.5 and Figure 4.2 below. Both actual and normalized gains in PSTE were calculated, in order to account for the initial high PSTE scores of some participants. It is evident from the scores that the qualitative results compare closely with these quantitative results. Other than Lucy, all of the participants gained more positive teacher efficacy beliefs between the beginning and end of the teacher preparation program. Interestingly, although Emily's qualitative data seemed to reveal little change in her teacher efficacy beliefs, the quantitative data demonstrated a fair amount of change.

Participant	Initial PSTE	Final PSTE	Change in PSTE	Normalized Change in PSTE
Nancy	3.46	4.46	1.00	0.65
Lucy	4.23	4.23	0	0
Emily	4.00	4.77	0.77	0.77
Aaron	4.00	4.38	0.38	0.38
Ingrid	3.23	4.23	1.00	0.56
Dan	4.08	4.60	0.52	0.57
Raina	4.15	4.62	0.47	0.55
Alyssa	3.69	4.04	0.35	0.27
Tom	4.38	4.77	0.39	0.63
Henry	4.23	4.85	0.62	0.81
Anna	3.00	3.80	0.80	0.40
Rachel	3.15	3.92	0.77	0.42

Table 4.5: STEBI-A PSTE scores for individual participants

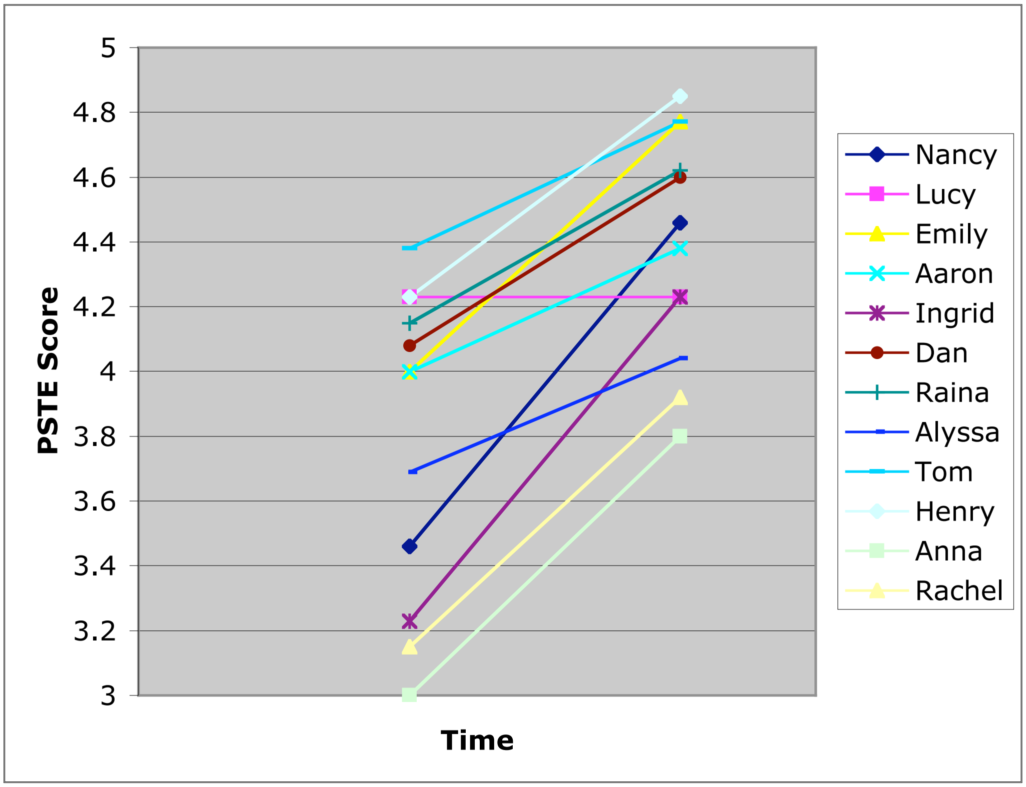

Figure 4.2: STEBI-A PSTE scores for individual participants

In sum, preservice teachers at the beginning of the teacher preparation program expressed lower confidence that they could be effective teachers than at the end of the program.

Outcome Expectancy Beliefs

In terms of their perceptions of how they could impact student learning, less of a clear overall trend could be detected. One group of participants seemed to grow more positive in their perception of their ability to impact student learning, while a second group wobbled in their initial beliefs, a third group grew more negative in their estimation of the extent to which they could impact student learning, and a fourth group retained their initial positive beliefs in their capabilities to influence student learning. Approximately equal numbers of preservice teachers from the sub-sample fell into each group. Two preservice teacher's beliefs did not fall into one of these categories, as they both began the teacher preparation program with tentative beliefs about their ability to impact student learning, and these beliefs did not substantially change over the course of the year.

The first group was characterized by preservice teachers who at the beginning of the teacher preparation program expressed relatively low confidence that they could reach every student in science, but who grew more positive about their impact over time. Henry, Emily, and Aaron fell into this group. Initially, they generally felt that student motivation or interest was the deciding factor of whether or not a student would benefit from their science teaching; therefore, a teacher could only reach students who were sufficiently motivated or interested:

> There's some students that no matter how poor a job you do, they're going to learn, and the reverse is true, that no matter how good a teacher you are, they're will be some students who will just refuse to pay attention. (Aaron, interview, 7/04)

On the other hand, by the end of the program, the preservice teachers in this group expressed relatively high confidence that they could reach every student in science, although some noted that it would take large amounts of time and energy to do so.

Emily embodied this change in beliefs about her ability to influence student learning. When interviewed in the summer before beginning her first field experience, she expressed the belief that student motivation was the strongest indicator of academic success: "You can't really help the student that doesn't want the help." (Emily, interview, 8/04). Additionally, she believed that student background knowledge and skills determined a student's academic performance. As a result, there was only so much that she as a teacher could do to help students learn.

When interviewed in the middle of her second field experience, Emily assumed responsibility for her students' successes and interest in science. She described a lesson in which she did a K-W-L activity with her students. Students asked a variety of questions, and Emily responsively found the answers and presented them in class the next day. Emily ascribed the success of the lesson to her knowing her students, putting forth a great deal of effort, and planning well. Interestingly, in the same interview, Emily blamed student failures on the lack of student background knowledge and skills (in this case, they were mathematics skills), in the same way that she had before her first field experience. Some change in beliefs was evident, however, because after Emily described the unsuccessful teaching experience and attributed it to the lack of student background knowledge, she was able to explain (prompted by the interviewer, however) how she might teach the lesson differently in the future in order to account for this background deficiency. If she had believed purely that the lack of student background determined whether or not they could learn the material she presented, she would not have been able to reflect in such a positive, forward-looking way.

Finally, when interviewed at the end of her student teaching experience, Emily attributed both student success and student failure to actions of the teacher; in particular, to good and insufficient teacher planning, respectively. Successful teaching was mainly due to her incorporating her understanding of student interests and previous knowledge into a cohesive and meaningful lesson. Although she admitted that student motivation played a role, she noted that her knowledge of students and the content helped her achieve an environment wherein students would be naturally motivated, again placing responsibility for the lesson's success on herself. Similarly, unsuccessful teaching was due to poor planning. She described a lesson in which she neglected to point out connections between student activity and content already learned: "There was all of this equipment and they wanted to eat them [marshmallows], and it was supposed to be fun, and yet it was really bad. It was my fault. I really felt like I blew it." (Emily, interview, 5/05). Additionally, Emily explained (unprompted by the interviewer this time) in great detail how she would change the lesson for the future. All the changes she suggested related to her own teaching of the material and running of the class, in contrast to her winter interview, in which she was focused on how to avoid dealing with student knowledge deficiencies.

The second group was characterized by preservice teachers whose beliefs seemed to wobble more than to change in a unidirectional manner. Raina, Lucy, and Nancy fell into this group. Lucy exemplified this second trend. Before beginning her first field experience, Lucy expressed strong positive beliefs about her ability to affect student learning. When asked to what she attributed successful teaching, she replied: "I'd go with helping them learn because they were not motivated at all, and they had it set in their head that they were not good at math and science…so I had to get creative and help them learn things." (Lucy, interview, 8/04). She could not think of a situation where she had ever felt unsuccessful in teaching, and expressed that she could not imagine a situation where she would not know what to do in order to help a student: "I don't usually get frazzled or anything, so I think I'd handle it okay, and I'll come up with something." (Lucy, interview, 8/04).

During her winter field experience, Lucy expressed serious doubts about her ability to impact student learning. She attributed successful teaching to a combination of both student motivation and teacher planning and effort: "I would say that it was partly that they were motivated and partly that I got them excited about something." (Lucy, interview, 2/05). Unsuccessful teaching, however, was entirely due to forces outside the teacher's control. Lucy cited low student motivation and low morale among the school community:

> Some of the kids, they just don't want to be in school anyway. Even if they get excited about your class, by the time they get back the next day, they're so cheesed off at all their other teachers, and they're so down with the system, and you have to start all over with them. And if all the teachers were excited and the principal would make it a point, hey you guys aren't the best and brightest students, but you're still a part of this school and you're still important. And I don't think a whole lot of students feel that. (Lucy, interview, 2/05)

Lucy's spring student teaching experience allowed her to revert partially back to her original beliefs in her ability to impact student learning. She retained the belief that successful teaching was due to a combination of student motivation and teacher effort and planning: “Even if I helped them learn something, if they’re not motivated, they’re not going to get too far. I think if they’re a little bit motivated and I can understand where they’re thinking is coming from, then I can kind of help them get the ball rolling.” (Lucy, interview, 6/05). Interestingly, when asked about unsuccessful teaching experiences, Lucy almost exclusively discussed how the situation was under her control. She mentioned lack of teacher preparation, not understanding where the students were coming from, not addressing student needs adequately, and not getting the students interested. As a very last thought, she mentioned briefly that student motivation could also be a factor, but it clearly was not as important to her as were her own influences.

The third group was characterized by preservice teachers who began the program with very positive beliefs about their abilities to impact student learning: “I would tell you now, a year away from ever being a science teacher, and not having experienced it, that I’m going to get every single student I have.” (Dan, interview, 7/05). Dan, Anna, and Raina fell into this group. By the winter quarter, this group had already begun to realize that they had less influence than they initially expected, and by the end of the spring student teaching experience, they typically felt that their influence was severely limited, at least with some students: “I think you have to realize that you can [impact student learning] with many of the students and you might not be able to with some of the students.” (Dan, interview, 6/06).

Anna exemplified this third group. Anna began the teacher preparation program with the expectation that not only would she impact student learning, but student lives: “I think you have a wonderful impact on people’s lives, that’s why I want to do it.” (Anna, interview, 7/05). During the fall and winter quarters, she began to realize that her influence was, in fact, quite limited, particularly in comparison with some of the other factors in her students' lives:

> Knowing that sometimes because of outside forces like parents and intrinsic motivation, that those are a big deal in the classroom learning environment…so I'd like to say that I'm a big influence, but full well knowing that I'm not nearly as much as I would hope. (Anna, interview, 3/06).

The differences among changes in beliefs between participants in the first three groups can be attributed to differences in the contexts of their field experiences and relationships with their mentor teachers. Emily's first field experience was at a middle school in a lower income school district on the outskirts of Columbus, Ohio. Although she described the students as coming from low income families and having to deal with a number of issues of other urban children, Emily was remarkably positive about the school environment:

> The students seem to be generally upbeat and in a good mood. Some students do have serious personal/home problems that they bring to class with them, but for the most part, school is a safe place for these kids where they can get support and encouragement. The teachers at this school really do care about the students, and I think the students realize it. (Emily, written reflection, 11/04).

Emily also expressed positive feelings about her mentor teacher, a man who had been teaching for five years, whom she described as holding high expectations for students and trying to make a difference in the lives of his students. She found that she shared important beliefs about teaching with her mentor teacher, who embodied several of the beliefs that she felt were most important to her.

Emily's winter field experience was at a high school in an affluent suburb of Columbus. Again, she expressed very positive feelings toward the school, which expressed high expectations of students and teachers, as well as toward her students, whom she perceived as working hard to earn good grades in order to get into college. She also had a constructive relationship (albeit an often combative one) with her mentor teacher, a man who had been teaching for more than a decade, who pushed her to think carefully about her instructional choices.

Finally, Emily's spring student teaching assignment was at a middle school in the same affluent suburb of Columbus where she taught during the winter. Once again, Emily expressed generally positive feelings toward the school, students, and her mentor teacher (an award-winning male teacher with more than 20 years teaching experience): "I have been really happy with my spring field placement. My students are quite friendly and fun to work with, and my mentor teacher is supportive, but not overbearing." (Emily, written reflection, 4/05).

Overall, Emily experienced positive relationships with each of the schools, classrooms, and mentor teachers in which she came into contact. In each case, the school and mentor teachers expressed high expectations for students and gave Emily the freedom to teach the way she wished, and she felt that her students generally respected and appreciated her efforts. It seems likely that the support of each of her mentor teachers and school communities allowed Emily to develop more positive beliefs about her ability to influence student learning.

Lucy’s first field placement was at a middle school in a suburb of Columbus. As did Emily, she expressed quite positive beliefs about her students and school community, focusing on the school emphasis on tolerance and respect, as well as the fact that teachers and administrators encourage the students to feel important and smart. She had a respectful but not entirely friendly relationship with her mentor teacher, a man in his fourth year of teaching, with whom she shared some reasons for wanting to become a teacher, if not all of her specific beliefs about what was important in teaching middle school.

Lucy’s winter field placement was at a high school in a lower income school district on the outskirts of Columbus. She taught a large percentage of students who did not intend to graduate from high school or go to college, and was often frustrated by the apathetic attitudes of her students as well as other teachers at the school, including her mentor teacher, a woman in her third year of teaching: “My mentor teacher is apathetic when it comes to attempting to motivate students. According to her, most of them won’t graduate and those that do can’t get into college, so let’s just fill in some worksheets and yell at them for talking.” (Lucy, written reflection, 2/05). She pointed out that the entire school expressed low expectations toward students, and students responded as expected: “The students are lower-performing, not conscientious about turning in work, and unlikely to listen while I’m talking or follow directions. They are fairly friendly, but very distrustful of authority.” (Lucy, written reflection, 2/05).

Lucy's spring student teaching placement brought her to an affluent middle school in a suburb of Columbus. Here she returned to a much more positive teaching environment, where her students were respectful and interested in learning, the school community was supportive, and she had a positive relationship with her mentor teacher, with whom she had chosen to work because she respected him and his teaching so greatly. Although she was challenged by teaching some special needs students and by needing to motivate students at the end of the school year, she was much more positive about the teaching environment.

Lucy's beliefs about her capability to influence student learning seemed to map directly onto her field experience context and relationship with her mentor teacher. During the winter field placement, Lucy was frequently frustrated by the lack of effort on the part of her mentor teacher, other teachers and administrators at the school, and her students. As a result, she felt that she could not impact some students, and that factors outside her own influence were more important in determining students' academic successes. Interestingly, when she returned to the more nurturing environment of her spring field placement, Lucy regained confidence that she could impact student learning.

Raina's field experiences began similarly to those of Lucy. She taught at an affluent suburban high school during the fall field experience and had very positive relationships with her mentor teacher (a woman with more than ten years of teaching experience), her students, and the school as a whole. In response to seeing a videotape of herself teaching during that first field experience, she reacted positively and mainly focused on what went well: "Overall, I suppose I like what I saw. I realize that this was the first time through for this lesson, and perhaps if I had videotaped fourth period, things would have gone more smoothly. Once I got over the fact that I hate seeing myself on video, I actually kind of enjoyed watching my class and my teaching." (Raina, written reflection, 11/04).

Raina taught at an urban middle school for the winter field placement, and experienced frustration very similar to Lucy, in terms of student apathy and student behavior. Although Raina did not believe that her mentor teacher (a woman in her third year of teaching) was a bad teacher, she did not feel that her mentor was helpful or supportive of what Raina chose to do in the classroom. As a result, Raina had several traumatic experiences with out of control students:

> I had a situation today in which all but seven of my students were engaged in inappropriate behavior at the same time…While the students were flying their paper airplanes, mass chaos erupted. The students went from throwing their paper airplanes toward a designated area, to throwing them at each other, running around the room, and sneaking into the hallway to fly their planes. (Raina, written reflection 1/05)

Her reaction to her seeing a videotape of herself teaching during the winter field experience was in sharp contrast to her reaction from the fall, as she mainly focused on what went wrong: "I don't think this was the best lesson I taught this quarter, but I think it went okay. Even if it didn't, all I can do is learn from it and move on." (Raina, written reflection, 2/05).

Finally, Raina returned to a suburban high school for her spring student teaching assignment, but was assigned to a class of low-performing students and two classes made up of what she felt were difficult students, in addition to two regular classes. Here she had a very positive relationship with her mentor teacher (a woman who had been teaching for six years but who was older with some life experience prior to teaching), but dreaded teaching her classes with student behavior problems:

> When I was sitting at lunch today enjoying my Hot Pocket, the overwhelming sense of dread that I get everyday around 11:45 began to set in. While everyone chatted about their lives, their students, and what they were doing later in the day, all I could think was, "Oh dear, I have to go to 7/8 in ten minutes." My afternoon wouldn't even be so bad if 7/8 was the only nightmare class that I had, but it's not. My tenth period environmental science class might be worse than my 7/8. It really just depends on the day. Anyway, the point is that I have come to the conclusion that I hate my afternoon classes. This is probably not good. (Raina, written reflection, 4/05)

Consequently, she continued to lose confidence that she could have an impact on all students' learning of science.

A fourth group of preservice teachers retained the same beliefs about their abilities to affect student learning from the beginning of the program through the end of the program. Ingrid and Rachel retained the belief that they could positively impact all students' learning, while Tom and Alyssa retained the belief that their influence on student learning was limited. Interestingly, Ingrid and Rachel retained confidence in their ability to impact students in spite of similar experiences to those of Lucy and Raina, including teaching at lower income schools and dealing with unsupportive mentors. The difference between the experiences of preservice teachers in groups 2 and 3 from the experiences of preservice teachers in groups 1 and 4 leads to the following conclusion: Preservice teachers who retained or gained more positive beliefs about their abilities to impact student learning throughout the teacher education program had fewer experiences with apathetic, unsupportive, and inexperienced mentor teachers who were located in lower income schools. In order to retain or gain these beliefs, it was also important for preservice teachers to undergo their urban teaching experience early in the teacher preparation program. The impact of the time of the urban teaching experience was noted previously (See Table 4) as making an impact on STOE beliefs, but the trend was visible through analysis of the qualitative research, as well.

Several examples may serve to explore this trend. Nancy experienced teaching in an urban school for two of her three field experiences; however, she had a very positive relationship with her mentor teacher (a man with over twenty years of teaching experience) in both of those experiences, choosing to return to his classroom for her spring student teaching. Even though the school setting could have created some frustrating and difficult situations (which it did), Nancy felt supported by her mentor and was therefore able to retain positive beliefs about her ability to affect student learning.

Aaron taught in an urban middle school with a mentor teacher (a man who had been teaching for five years) who he felt was inexperienced and disorganized during his first field experience. Although he was somewhat bothered by his mentor teacher's lack of organization and understanding of the curriculum, the fact that this experience came early in his teacher preparation and during a field experience when he was not required to teach a great deal helped Aaron to overcome whatever negative aspect the situation had on his beliefs.

In a negative case, Alyssa began the year with the expectation that she would only be able to reach students who were motivated to learn. Her first field experience, while in a suburban district, was with a teacher with whom she had a personality conflict and who constantly prevented her from teaching in a manner that made her comfortable and confident. She then taught at an urban high school during the winter field placement with a mentor teacher that was not only unsupportive but seemed to consciously degrade her teaching by forcing her to teach at an unreasonable pace, losing her grades, and sabotaging her classroom management. Although she had a positive experience during her spring student teaching at a suburban middle school, it was apparently too late. Her beliefs about the possibilities of impacting student learning remained tentative at best.

Scores from the STEBI-A instrument are presented in Table 4.6 and Figure 4.3 below. Both actual and normalized gains in STOE were calculated, in order to account for the variation in initial STOE scores of participants in the sub-sample. It is evident from the scores that the qualitative results compare somewhat closely with these quantitative results. Aaron and Henry gained more positive STOE beliefs, in accordance with the qualitative results presented above. Both men had mainly positive experiences with mentors throughout the year-long program, and completed their first urban school teaching experience during the fall quarter. Emily's STOE scores actually decreased, in contrast with the qualitative results. Alyssa, Dan, and Ingrid lost the most in terms of their STOE beliefs. While this was expected for Alyssa and Dan based on the qualitative data and the experiences of these participants in urban schools and with unsupportive mentors, Ingrid's drop was a bit of a surprise. It should be noted, however, that Ingrid had the highest STOE score initially, so it is possible that a ceiling effect was at work.

Participant	Initial STOE	Final STOE	Change in STOE	Normalized Change in STOE
Nancy	3.67	3.50	-0.17	-0.13
Lucy	3.92	3.67	-0.25	-0.23
Emily	3.92	3.42	-0.5	-0.46
Aaron	3.50	3.67	0.17	0.11
Ingrid	4.33	3.58	-0.75	-1.12
Dan	2.92	2.50	-0.42	-0.20
Raina	3.17	2.92	-0.25	-0.14
Alyssa	3.00	2.58	-0.42	-0.21
Tom	2.83	2.58	-0.25	-0.12
Henry	3.67	3.83	0.16	0.12
Anna	4.00	3.67	-0.33	-0.33
Rachel	3.33	3.08	-0.25	-0.15

Table 4.6: STEBI-A STOE scores for individual participants

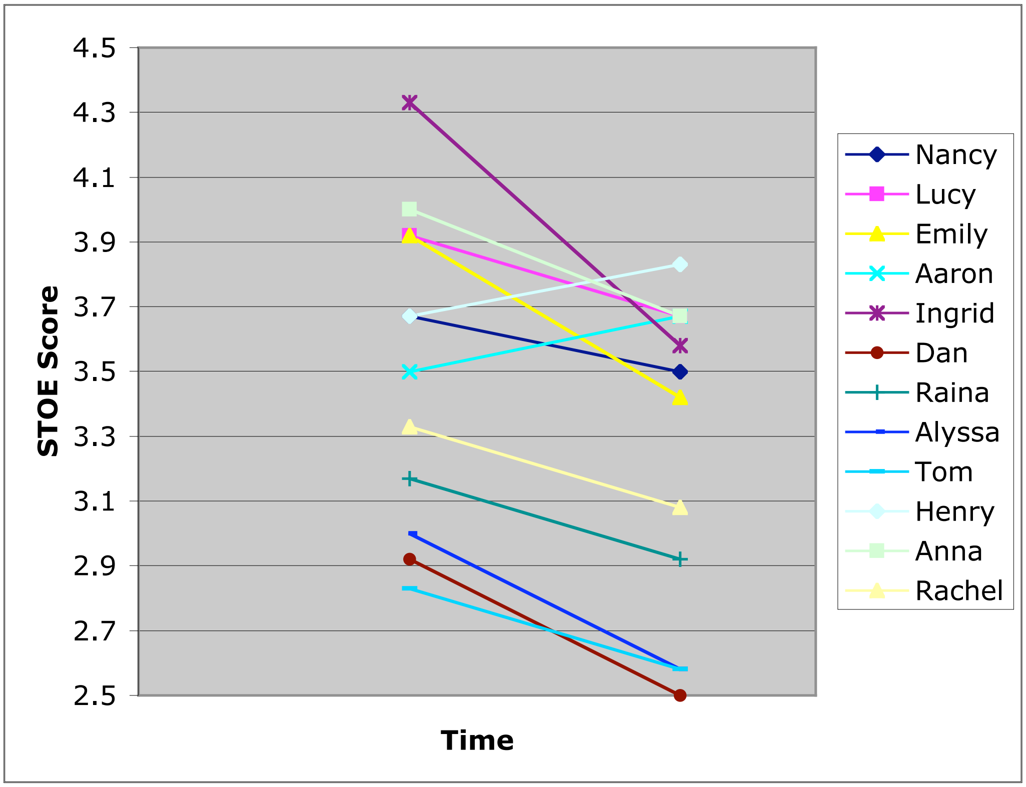

Figure 4.3: STEBI-A STOE scores for individual participants

Influences on Teacher Efficacy Beliefs

Although I have discussed some of the factors affecting teacher self-efficacy beliefs, I have not yet approached the topic of how those beliefs are specifically formed. According to Bandura (1997), self-efficacy beliefs are affected by the following influences: mastery experiences, vicarious experiences, verbal persuasions, and affective states. In this study, all of Bandura's influences were found to have an effect, but some of the influences had a more important effect than others. More specifically, teacher efficacy beliefs of the preservice science teachers in this study can be attributed mainly to mastery experiences, but the influences of vicarious experiences and verbal persuasion were notable. Affective states seemed to impact teacher efficacy beliefs by intensifying a given mastery experience rather than by acting on its own. In addition, the impact of personal reflection emerged as a facilitator of teacher efficacy information for some participants.

Mastery experiences were cited by the preservice teachers at all stages of the teacher education program much more often than any other source of self-efficacy beliefs. The vast majority of mastery experiences cited were teaching experiences, both successful and unsuccessful. The second most often cited mastery experiences were experiences as students, although the citing of student experiences tailed off quickly after the preservice teachers engaged in their first formal field experience. Vicarious experiences, particularly those of observing mentor teacher actions, as well as verbal persuasion experiences, including student and mentor response to the preservice teachers' instruction, seemed to become increasingly important toward the middle of the year, but again lost importance during the student teaching experience, when the preservice teacher relied almost entirely on mastery teaching experiences (and occasionally on student response to instruction) for teacher efficacy belief information.

Summer

At the beginning of the teacher preparation program, participants mainly cited mastery experiences, both as students and as teachers, as impacting their teacher efficacy beliefs. Emotive incidents often accompanied these mastery experiences. Very few of the preservice teachers noted the influence of vicarious experiences or verbal persuasion.

When citing experiences that made impacts on their confidence in teaching science before they encountered their first field experience, almost all of the preservice teachers noted that their experiences as students shaped their confidence in teaching and the way they saw themselves taking on the role of the teacher. Emily and Anna both described themselves as successful students who gained confidence in their teaching abilities through these successful experiences as learners: "Being a student for forever had a big influence because I was kind of a good student, so I did take to heart what the teachers said." (Emily, interview, 8/04). Ingrid discussed a less successful experience as a student, in which she was not engaged during a teacher's lecture. As a result, she had confidence in her ability to use constructivist teaching to better help students learn.

Even before their first program field experience (and therefore prior to many of them having any experience teaching at the middle and high school level), the preservice teachers also mentioned previous teaching (both formal and informal) episodes. Several of them had taught or tutored at the college level, and mentioned those experiences as shaping their confidence and interest in teaching younger children: "I taught undergraduate labs, and I definitely learned some things that didn't work." (Alyssa, interview 8/04). Others had worked with younger children in a non-school-related teaching capacity, such as volunteer tutoring or teaching classes at church: "I used to teach religious studies classes to fourth graders…they listened a little more because they realized that I was trying to give them information that was a little more geared toward them." (Elizabeth, interview, 8/04). Still others noted more informal experiences with children, such as coaching sports teams, helping family members, and teaching kids in other arenas: "I come from a big family, so I'm used to always having people around. And I coached youth soccer, and I was the party planner in my neighborhood growing up, doing kids' parties…I guess I know where they're coming from." (Lucy, interview, 8/04). Dan described that his sense of confidence arose from a combination of all these types of teaching:

> I haven't done any formal subject teaching, but I've done quite a bit of teaching, having said that. I've been—specifically, in my church, I've been a Sunday school teacher for many years and a youth group leader. I've also—before coming to this program, I was an engineer for ten years, I was responsible for training, and seminars, and teaching in that perspective. I've been a math tutor. I've been a coach of a variety of sports teams. So have I taught calculus or physics in a public school—no. But I have lots of teaching experiences. (Dan, interview, 7/05)

Finally, Ingrid noted that her confidence had already been impacted in her science methods class through the opportunity to try out teaching on a small scale in front of friendly peers

Six preservice teachers during this first set of interviews cited the vicarious experience of observing other teachers in action as influencing their beliefs about themselves and about teaching. Ingrid claimed that she learned how to better deal with students by observing other teachers with students. Alyssa and Rachel both identified education course instructors as models for their own teaching. In Rachel's case, she was quite positive about the resources provided by her science methods instructor: "She's done so many demonstrations, and even all of us who are graduate students are like, wow, that's really cool!..Knowing those sources and what we've seen in class and stuff, that will help." (Rachel, interview, 7/05). On the other hand, Alyssa felt that her education course instructors had acted as reverse-models, and that she planned to purposefully teach different than they had: "Sitting in these classes, I've been sitting there going, this is something I think I shouldn't do. You know? There've been a lot of moments in these classes, where we're sitting there for several hours and they're not really engaging us, they're not really following any of these great little techniques that they're telling us about." (Alyssa, interview, 8/04).

Finally, participants were asked directly if they had been impacted by persuasive messages in the initial quarter of the teacher preparation program, and there was a mixed response. The majority of participants noted that they had learned a great number of educational and psychological theories, but they did not feel that knowing theory would help them in the classroom, so it did not impact their sense of teacher efficacy. A typical response: "I hope student teaching is a real learning experience, because thus far I have to report of the program feeling almost completely unprepared. Like I was saying earlier, all of the theoretical teaching…I'm kind of pessimistic about thinking it does much." (Josh, interview, 8/04). Both Rachel and Anna took what their professors taught more to heart than their peers; as a result, they began to feel more confident and more prepared through learning about science teaching. They were clearly in the minority, however.

Many of the quotations in the previous paragraphs reveal an emotive incident that coincided with a mastery experience, vicarious experience, or verbal persuasive experience that influenced self-efficacy beliefs. Several participants described feeling happy or upset during various teaching experiences; such emotions intensified the feeling of success or non-success. For example, Lucy, who was normally a reserved person and teacher, described one such event with a tutoring student from a low-income family:

> She would always want to sit down and read the textbook with me, and she had such a hard time figuring out what each sentence said that she didn't have time to absorb the content of it. Once she was not afraid of it, she started doing a lot better. We never got to the reading part, because I only worked with her for like two quarters, but her science grades went up…It was hard, but I helped her, so. I was like, I want all the neighborhood kids to come over. I'll help you all! (Lucy, interview, 8/04)

Autumn

During the fall field experience, participants relied similarly heavily on mastery teaching experiences, but significantly less on mastery experiences as students or in other capacities. They also began relying quite heavily on vicarious experiences, mainly involving mentor teachers.

The preservice teachers talked most frequently about concrete teaching experiences, both positive and negative, as impacting their self-efficacy beliefs as teachers. Several of the fall field experience reflection prompts asked the preservice teachers to reflect on their beliefs about teaching, about themselves as teachers, how they came up with those beliefs, and how they enact those beliefs. Although the preservice teachers commonly mentioned the vicarious experiences of watching teachers and professors teach, the majority noted how their experiences teaching students in that first field experience made important impacts on their self-efficacy beliefs. For example, Raina named several characteristics of good teachers, and discussed how she fit into one of those characteristics:

> The second quality that I identified was patience. This is one I find myself struggling with sometimes. Once again, I'm not sure I have a specific example, but every day takes patience when you're trying to get kids to understand something new. I suppose that when I was trying to explain human evolution and nobody was with me, I was a bit frustrated, but I did my best to be patient with the students. (Raina, written reflection, 11/04)

Emily expressed similar feelings about how teaching experiences with a particular difficult student had resulted in the belief that she was a capable teacher:

> In the beginning, I observed him as stubborn, bored, and apathetic towards grades and school. I knew I could not totally change his attitude, but I made special effort to address his learning needs a little bit each lesson…He has not had a huge change in attitude, but I do see small improvements that keep me feeling optimistic. (Emily, written reflection, 11/04)

Lucy noted specifically the impact of a single, pivotal teaching experience in developing her feeling of self-confidence as a teacher:

> The most difficult thing I've taught my students involved using the computer lab and MS Excel. Since I'm far from an Excel whiz, I was concerned that I would be ineffective in giving my students directions on how to make their graphs. However, I practiced the day before, made use of the whiteboard, and went for it without asking my mentor teacher to bail me out at all. After that, I have felt much more confident talking to my students. (Lucy, written reflection, 11/04)

Participants also frequently mentioned how observations of former or current teachers and current mentors had impacted their beliefs both in positive and negative ways. In terms of their teachers, Lucy and Alyssa both felt that her own teachers had impacted them in a variety of ways, but were not specific about their influences other than as models of good and bad teaching. Raina and Nancy shared more detail about what specifically they gained through analyzing their own teachers' behaviors. Raina gained an appreciation of the importance of interacting with students: "These teachers have made me realize just how essential engaging your students is. I hope that if you asked my students, they would group me among their more successful teachers." (Raina, written reflection, 10/04). Nancy described a teacher about whom she said:

> I would like to model myself on [Mrs. Smith's] teaching style. I want to make students comfortable in my class; I want to get to know them so I have an understanding of 'where they are coming from'; I want to make class interesting and fun so they want to come to science; and most of all I want to take the time to make sure they all understand the concepts. (Nancy, written reflection, 10/04)

In essence, each of these preservice teachers learned what about good and/or bad teaching through observing their own teachers, and developed confidence in their own teaching abilities by comparing themselves to these exemplary teachers.

In terms of their mentors, participants frequently mentioned how speaking to their mentors and observing them in action impacted them in the same manner as did their own teachers. Raina was influenced most positively by her mentor teacher's model: "[My mentor teacher's] responses really do energize me toward the profession of teaching. The fact that she is still excited about her job and her students 11 years into her job is awesome!" (Raina, written reflection, 11/04). Nancy had her initial beliefs about good teaching similarly confirmed by her fall field experience mentor teacher:

> I believe that he has a great attitude toward the students and he feels that academics are extremely important. I would say that I share these same beliefs with him. Everything that he talks about affirms my beliefs in what a good teacher should be. (Nancy, written reflection, 11/04)

Finally, Emily confirmed some of her original ideas about herself as a teacher during her fall field experience by observing a less efficacious mentor teacher:

> I am not convinced that the student's abilities are *that* low. I have found that many of them understand quite a bit more than they let on, and often they just want to avoid doing any work. This is especially true involving math and reading…due to these low achievement levels, [my mentor teacher] avoids addressing math and reading issues in his class. He feels that it takes away all of the time from teaching science, and the kids are just at too low of a level to even begin to teach it….Personally, this really concerns me! It may seem a bit idealistic to attempt to teach math and reading in a science class, but I feel that both are critical to science and success in general, so should not be ignored….I know this will be a challenge, and I really hope I do not "lose steam" on this issue as the years go by. (Emily, written reflection, 11/04)

Interestingly, Alyssa was the only participant to specifically make the point that her mentor teacher did not have an important impact on her own beliefs: "I don't think that his beliefs and values will change or make me rethink my own values and beliefs about teaching." (Alyssa, written reflection, 11/04). Alyssa did not share either the teaching style or beliefs about teaching with her mentor teacher, and thus she seemed especially interested in distancing herself from his methods and ideas.

In contrast with vicarious experiences involving their own teachers, each of these participants confirmed (rather than developed) what was good and/or bad teaching through observing their field experience mentor teachers, and developed confidence in their own teaching abilities by comparing themselves to these representative teachers.

Verbal persuasive experiences were occasionally discussed as impacting preservice teachers beliefs about themselves. Raina noted that her mentor teacher frequently bragged about her knowledge of biology content and how it would be helpful in her teaching, and this clearly positively impacted her teacher efficacy beliefs. Mentor teachers and/or university supervisors of Emily, Lucy, and Nancy convinced them to try certain teaching strategies, which they said would be worthwhile for students. As a result, these preservice teachers felt that they would be successful at using the strategies; hence, this verbal persuasion enhanced their self-efficacy beliefs.

As in the summer, mastery experiences were frequently accompanied by emotional incidents that influenced teacher efficacy beliefs. Several participants described feeling happy or upset during various teaching experiences; such emotions intensified the feeling of success or non-success. For example, Emily passionately described her first experience using inquiry with students:

> The students were asking great questions of their own and participating in the stations. Rather than simply giving them answers, I encouraged them to use prior knowledge and to think on their own….I feel this method of learning is beneficial to the student because they will likely attain a deep understanding of the material and also because it is student-led and fun! The skills that students learn through using the scientific process can be applied to a variety of settings both in the realm of science and society as a whole. (Emily, written reflection, 11/04)

As a result of the emotional impact of her successful teaching experience using inquiry, Emily’s teacher efficacy beliefs were enhanced. Lucy had a similar experience during an early teaching experience in which she was successful at reaching some previously underachieving students:

> When talking about friction this week, some of the students had the idea that friction was always bad and some thought it was always good. We used the generic forum of sports to talk about instances when friction was useful and when it was a hindering factor. It was like a light bulb went off in everyone's head who didn't get it already. Finally! We just had to talk about basketball. (Lucy, written reflection, 11/04)

Lucy's emotional response to the successful teaching experience made more powerful what was already a teacher efficacy enhancing experience.

Winter

By the middle point of the teacher education program, participants had generally moved beyond relying on their experiences as students to determine their beliefs and feelings toward teaching and instead begun relying strongly on their teaching experiences and their relationships with supervisors, mentor teachers, and school administration. Emotive incidents frequently accompanied mastery experiences, vicarious experiences, and verbal persuasion experiences during the winter quarter.

The preservice teachers continued to speak of concrete teaching experiences, both successful and unsuccessful, as significantly impacting their beliefs about their abilities as teachers. Ingrid expressed an important change in her own beliefs about herself as a teacher:

> I think you can definitely influence student learning. I think it kind of depends on your relationship with the student, actually. I think the better the relationship you have with the student, the more they want to do well in your class. That's what I've kind of found this year. It's kind of funny because before I thought that a lesson has to be great, has to be perfect, or whatever, but it doesn't have to be that, as long as you have that connection. (Ingrid, interview, 3/05)

Many of the preservice teachers expressed a change in their overall confidence as a result of two quarters of teaching experience: "Now that I've been in the classroom for two quarters, I'm getting a lot more confident in my abilities to teach." (Nancy, interview, 3/05) Several of the preservice teachers even expressed such high confidence at the end of the winter quarter that they felt ready to have their own classroom, and that the student teaching experience was a necessary but useless obstacle to overcome:

> Student teaching just feels like another hurdle I have to cross, and I know I can get a lot out of it and it is good that I'll have another opportunity, and I'll be in school the whole day, but—maybe this is too confident—I feel like I can just do it, just go ahead and start in a school. (Emily, interview, 2/05)

On the other hand, Josh, Rachel, and Ingrid were much more reserved about their overall abilities as teachers: "I think I'm acceptable right now but still have vast room for improvement. Every time I do something I get better at it, though, so I think I'm a teacher who will improve. Even if I'm not too great right now." (Josh, interview, 3/05). Rachel also spoke of her clinical teaching experiences as valuable but that she still needed to improve:

> I feel like right now I am more experienced than I was previously but I wouldn't by any means say I'm experienced…I definitely think things come with

> experience, and these past two quarters have given me the experience I need to continue to improve. (Rachel, interview, 2/06)

Winter also marked the transition for most of the preservice teachers to relying on student feedback for information about their teaching and the determination of whether it had been successful or not. Almost all of the participants described student feedback as being an important indicator to them about how they were doing as teachers. Student motivation and enthusiasm seemed to have a particularly strong impact on their beliefs about themselves as teachers, particularly in the cases where students had been especially not motivated previously. For example, Rachel described successful teaching:

> There were a few times when students in my class spoke up for the first time. And that's when I feel really excited, and it just made my day because it's like—they're obviously engaged, they obviously want to contribute, they want to be there, they're speaking up about personal experiences…That really meant a lot to me. (Rachel, interview, 2/06)

Student performance on assessments did not strike as much a chord with most of the preservice teachers in this study, except in the cases where motivation and assessment score were tied together and where the assessment score was significantly improved over the student's previous performance. Henry described a situation where this occurred:

> They all thought it was great. They were like, this is so much more fun! They were moving around. I have a kid in my class who has Ausberger's [syndrome], and he loved the fact that there were big colors on it, and he's great at measuring things, and he got a perfect on the exam. (Henry, interview, 3/05)

All of the preservice teachers were required to have students evaluate their teaching at the end of the field experience, but Alyssa was the only participant in this study who asked students to evaluate her near the midpoint of the experience so that she could change her teaching:

> I gave my students an evaluation today, after the test, because I wanted to give them an intermediate assessment, and so maybe I can change stuff…there are some good things in there, and that's what's going to help me in the long run to be more effective, is that kind of feedback. (Alyssa, interview, 2/25)

Although almost all of them relied on student feedback for information on how well they were doing as teachers, only Alyssa asked for it formally.

Winter was also the time when the preservice teachers began talking more strongly about the impact of verbal persuasive elements on their beliefs about teaching. Mentor teacher feedback—positive, negative, and non-existent—was mentioned by almost every participant as key in determining their sense of efficacy and for some, their identity as teachers. For example, Aaron took advice from both his fall and winter mentor teachers about the ultimate goal of teaching, and decided to student teach and search for permanent teaching positions in lower income school districts, where he hoped he could make more of a difference. Raina, Alyssa, and Lucy mentioned the impact of general negativity among teachers and administrators at their winter field experience schools, which in Raina's case lowered her expectations for her students, in Alyssa's cases lowered her expectations for her own teaching, and in Lucy's case increased her expectations for her own teaching. The differential responses to similar situations may be explained by the relationship of each preservice teacher with her mentor teacher. Lucy's relationship with her mentor teacher was quite antagonistic, and Lucy seemed to take some pride in running her class different than her mentor had:

> My mentor teacher is apathetic when it comes to attempting to motivate students. According to her, most of them won't graduate and those that do can't get into college, so let's just fill in some worksheets and yell at them for talking. Funny, this strategy doesn't seem to be working for any party involved, but that's fine as long as she doesn't get too involved. I'm guessing this teacher apathy comes from a sense of hopelessness and frustration. It can't be gratifying to have 2/3 of a class failing; however, if this were my own class I would take some of the blame and change my instructional methods. The students can be engaged with some effort and creativity. I have proof!" (Lucy, written reflection, 2/05)

Lucy also stated repeatedly through the year that she believed all students have something important to contribute, and so these strong beliefs may have created a situation wherein an atmosphere of negativity did not result in lowered expectations for herself or her students.

Josh, Emily, Anna, and Nancy felt that their mentors were overly involved in their teaching: "He gives me a lot of input before, during, and after my lessons. I appreciate his comments, but often I find them to be 'lateral' suggestions that are just a matter of opinion." (Emily, written reflection, 2/2/05). Josh complained about the lack of freedom and control that he had in his field experience teaching, feeling frustrated that his mentor teacher had to approve every aspect of his teaching. Nancy and Anna both objected that their mentor teachers forced them to teach according to the mentor teacher's lesson plans, in order to best prepare students for an upcoming high-stakes test, and this made them rather uncomfortable in their teaching positions. Interestingly, Josh and Emily both ended up making some of their decisions about teaching in opposition to the advice of their mentor, with the result appearing to be a heightened sense of teacher efficacy, while Nancy and Anna felt too constrained to do so and as a result, seemed to lose some confidence in their teaching abilities.

On the other hand, Alyssa and Raina both complained about a lack of specific feedback from their mentor teachers, and felt as though they were left to flounder:

> Feedback is very important in teaching. I feel like I'm getting a lot less this quarter, but I feel like I need it a lot more. I'm doing my own personal feedback, but it would be really important to get someone else's input, before doing my lesson, just looking at it, and after I do my lesson, pointing things out. My mentor teacher, she never looks at my lessons. If she looks at them it's like two seconds before and she says, oh, I wouldn't have done that….Afterwards, she's always running off somewhere, so I never get that post feedback….I still feel kind of at a loss, so that feedback is kind of critical. (Alyssa, interview, 2/05).

Raina felt similarly about her winter mentor teacher, whom she said rarely helped her with lesson planning or delivery, even in a case when students were unsafely out of control during a class meeting.

> [My mentor teacher] told me that she thought it was my fault that they were so out of control because I hadn't given them enough direction. She doesn't think that she should ever step in because I need to learn from what happens. While I agree with this, it would be nice to have her step in when things are obviously falling apart (or even before mass chaos erupts). You saw [my former mentor teacher] do this a couple of times last quarter. Its one thing to not want to step on my toes, but completely another to just sit back and watch me fail miserably at getting things under control. (Raina, interview, 2/05).

Only two participants mentioned being specifically persuaded by messages in the teacher preparation program or in other areas of education. Anna felt that two of her classes had greatly added to her confidence—her science methods course and a reading across the curriculum course—mainly because they presented practical, useful ideas that resonated with her. Alyssa described extensive reading and research, including attending a science education research conference, which changed how she thought about using scientific inquiry and questioning in her class. In her case, because this information answered some questions that she had previously about how to implement specific instructional techniques, she developed a more positive sense of efficacy as a result.

Several of the preservice teachers also mentioned the influence of vicarious experiences on their beliefs about teaching. Aaron and Emily both mentioned that observing their mentor teachers teaching had changed their beliefs about what was important in teaching; in both their cases, this vicarious experience made them rethink the importance of the class environment. Because neither of them had paid much attention to their classroom environments previously, they both felt slightly as if they had failed; as a result, their sense of efficacy temporarily took a dip. Dan and Tom noted that through hearing about or directly observing the teaching experiences of their peers, they gained confidence in their own abilities as teachers:

> The students in the classes have to do these little microteaching things, and so people do microteaching, and of course, things are highlighted based on what the class is supposed to be, but I really don't care about that. It's did they do a cool lesson? Was it a cool idea for a demonstration in this particular lesson? I've used a couple of those in my teaching at Inner City Public and it's been really nice to have those ideas of how that goes. (Tom, interview, 2/06)

Much as throughout the rest of the program, participants frequently described their emotional responses to teaching experiences. Excitement or thrills when teaching was successful, as well as anger and hostility when teaching was not successful, often but not always accompanied teaching experiences. Several of the preservice teachers noted emotional responses to vicarious experiences and verbal persuasive experiences, as well. Mentor teacher feedback often resulted in a variety of emotional responses, from appreciation and joy to frustration and anger. Henry had one of the most positive experiences receiving feedback from his mentor teacher:

> He doesn't do any of the geology lessons—he hasn't done any lessons since I've been there. I write the lessons. We team-teach first period, I teach second period, and he teaches third period…He's more than happy to say, you obviously know a lot more, you have a master's in this, so how should we explain it? Rather than saying, it's my way or the highway. It's great, that's why I want to stay there! (Henry, interview, 3/05)

On the other hand, Alyssa describes verbal persuasion from her mentor teacher as resulting in her "freaking out" and "driving her nuts" (Alyssa, interview, 2/05). Although verbal persuasion of coursework did not seem to impact their beliefs about themselves for the majority of the participants in the sub-sample, many of the participants quite emotionally described their feelings towards the university coursework. Josh was the most vocal: "That's another thing I blame the program for: classes are worthless *and* they cut into my student teaching, because I don't have as much time to work on things that matter to teaching." (Josh, interview, 3/05).

Finally, the facilitating influence of personal reflection was noted by two preservice teachers in the sub-sample during the winter quarter. Dan explained that through reflecting on the huge variety of factors impacting student learning, teaching, schools, and communities, he gained a different understanding of students and teaching, but also a great deal of confidence in his abilities as a teacher. Tom felt similarly, explaining that through the process of sharing his own teaching experiences with others, he gained a deeper appreciation for himself as a teacher. As a side note, although only two participants spoke on record of the impact of reflection on their sense of teacher efficacy, many times during this study at the end of interviews, participants expressed how much better about themselves as teachers they felt after having the opportunity to talk freely about their ideas and experiences.

Spring

By the end of the spring student teaching experience, participants strongly relied on mastery experiences, with some reliance on vicarious experiences and verbal persuasive experiences as influencing their beliefs about teaching. Mastery experiences were frequently accompanied by emotive incidents, while the vicarious experiences and verbal persuasive experiences were rarely accompanied by emotive incidents.

Mastery teaching experiences continued to make the strongest impact on the preservice teachers' beliefs about themselves as teachers. In particular, four of the preservice teachers specifically mentioned incidents where they felt successful in teaching students that had previously not exhibited much academic success. Of these, Aaron's experience was most extreme. Aaron spent his student teaching placement at "a very urban middle school" (Aaron, interview, 6/05) in a classroom where the original teacher had been "run off", as well as two subsequent teachers. His own mentor teacher had taken over the class just a few weeks before Aaron began student teaching there. As a result, "it was difficult at first, and they certainly pushed me more than a lot of students do." (Aaron, interview, 6/05). But Aaron took great pride in the fact that he influenced some of his students, and ultimately gained a great deal of confidence in his abilities as a teacher: "A year ago, if I had walked into the setting where I was student teaching, I would have just been killed up there. I didn't realize the value of being in the classroom, in the field experience, before I started this program. But I think I do now." (Aaron, interview, 6/05).

In the very different setting of a middle school in one of the wealthiest school districts in the area, Henry expressed similar feelings: "I reached the kids who were supposedly unreachably horrific, students who other teachers complained about." (Henry, interview, 6/05). Ingrid described a similar experience with a student who could not get to class on time and never turned homework in: "I finally got through to her or something, just kept talking to her about getting in homework…And that makes me feel a little successful, that she did the work and she didn't just give up." (Ingrid, interview, 6/05). Finally, Raina taught a class of lower-performing high school students, and was consistently impressed at her ability to help students who did not have much success in school: "The [lower-performing] kids have been doing awesome this week…Just expect to see great things tomorrow! Since our little talk, they've been super awesome!" (Raina, written reflection, 5/12/05).

Others experienced the opposite, and were frustrated by teaching experiences in which they were unable to influence some of their students: "there were kids there in some of the classes that I taught that just didn't care, who just weren't interested—they weren't interested in education at all. And it's very difficult to reach those kids, particularly if they don't have parents who are interested in education." (Nancy, interview, 6/05). While Nancy retained her positive outlook on her abilities as a teacher, she began to doubt how many students she could truly impact, as a result of these negative mastery experiences. Interestingly, while Raina had experienced some success teaching lower-performing students, she experienced frustration with two of her other classes: "They are the neediest, most annoying, most hyperactive, disrespectful group of people that I have ever had to work with. They drive me crazy. By the time the fifty minutes is up, I need a stiff drink." (Raina, written reflection, 4/21/05). As a result, Raina began to dread teaching these classes and avoided having her university supervisor observe her teaching those classes.

Vicarious experiences continued to have some effect on the preservice teachers' self-efficacy beliefs. Ingrid and Alyssa expressed frustration over mentor teachers who had different—and contradictory—beliefs to their own. Ingrid's mentor teacher asked her to frequently use guided notes, a teaching method with which she was uncomfortable, and solely multiple choice questions on tests, assessing students in a way that she disagreed with. As a result, her idea of herself as a teacher grew deeper, as she realized what strong feelings she had about what constituted good teaching. Ingrid expressed one experience where she gave a student the opportunity to make up a great deal of missed work, defying her teacher's advice to not accept any late student work:

> I attribute the success to just hard work, thinking more about the students than about will it be convenient to me, because it's inconvenient to me to get on her and make the exceptions that I had. So thinking more about the student, and being student-centered rather than thinking about it as a job—what's good for her. (Ingrid, interview, 6/05)

Alyssa simultaneously was stifled by and grew from interactions with her mentor teacher. Although she complained that her mentor teacher was meddlesome when she was planning and executing her classes, with the result that her confidence in her own teaching ability was somewhat lowered, she also gained confidence in dealing with students as a result of her mentor teacher's model of how to get to know her students. Alternately, Dan found positive role models in his student teaching school community and formulated his identity as a teacher around these positive examples. As a result, his confidence in his abilities as a teacher was enhanced.

Verbal persuasive elements were also sometimes mentioned by the preservice teachers as impacting their senses of teacher efficacy, although not nearly to the extent that they were during the winter field experience. Mentor advice was only cited by four of the participants, although the effect of such advice again depended on the preservice teacher and her relationship with the mentor teacher. Emily used her mentor's advice to amplify her confidence in her teaching abilities. She also learned from her mentor that teaching is not all about "covering" the required content:

> After talking to my mentor and reflecting on progress so far, I decided to "get real". I may not be able to cover each topic in as much depth as I would like, but if I don't make it a point to discuss and review what we have learned, it will be a disservice to the students. (Emily, written reflection, 4/28/05)

Anna relied heavily on compliments and general support provided by her mentor teacher when expressing her sense of confidence: "My mentor teacher was so helpful—I couldn't have asked for a better assignment. It was great. She just made it so easy." (Anna, interview, 6/06).

Participants also noted the verbal persuasive influence of professors, parents, other teachers, and school administration. Emily felt pushed by professors to try non-traditional teaching methods, such as cooperative learning. Even though she was unconvinced that cooperative learning was as important a pedagogical tool as her professors, she was persuaded to keep trying it:

> Cooperative learning, that's a fundamental principle that I've tried really hard to get better at because I realized it's not just group work, type of things. I used to say, this is crap, it doesn't work, everyone's fighting, everyone's miserable…I've yet to see it be a great thing, but it doesn't mean that I'm going to give up trying. (Emily, interview, 5/05)

Parental feedback made an impact on Alyssa's beliefs about herself as a teacher:

> I had one complaint this spring from a parent. She didn't like what we were doing in science. It turned out not to be about me, but it was a little intense. She complained about what the student teacher "is teaching, or isn't teaching"—I was like, whoa, okay. (Alyssa, interview, 5/05)

Although her teacher efficacy beliefs initially took a hit when the parent accused her of not being an effective teacher, they rebounded when she discovered that she was not at fault—the student had lied to her parents about Alyssa's teaching in order to raise her grade. Raina noted the influence of feedback from a teacher other than her mentor at her placement school. In her case, is was the compliments of the inclusion teacher in one of her classes that made a rather large impact in her teacher efficacy beliefs:

> [A teacher] asked me to help him present the kids with their biology certificates tomorrow at the breakfast. [Two other biology teachers] are going to be there as well, but apparently he feels like I've really connected with the kids more (I didn't tell [my mentor teacher] this of course). I'm super excited and flattered that he feels that good about what I've been doing with the kids. (Raina, 5/23/05, written reflection)

Finally, Tom developed a sense of confidence based on his school administration's appreciation and need for chemistry teachers. Through feeling needed by his school community, he developed a stronger sense of efficacy as a teacher.

As was true throughout the year, emotive incidents often accompanied successful and unsuccessful teaching experiences (mastery experiences). Emily had a negative emotional reaction to a non-mastery teaching experience:

> It was totally my fault. I ruined the reebop activity—who could do that? It was the greatest lesson on earth and it had marshmallows, and I still messed it up! And there was all of this equipment and they wanted to eat them, and it was supposed to be fun, and yet it was really bad. It was my fault. I really felt like I blew it. (Emily, interview, 5/05)

Although Emily was being somewhat sarcastic during the first part of this statement, she was quite serious for the last half of the statement in her feelings of despondency that she had ruined a lesson to which her students were looking forward. As a result, her teacher efficacy beliefs were lowered, at least temporarily. On the other hand, Raina was an example of a participant whose positive emotive responses intensified feelings of positive teacher efficacy during a mastery experience: "And every hand goes up—rigormortis. And I'm like, yes! You learned something!…And that kind of reflects positively on my teaching." (Raina, interview, 5/05).

Vicarious experiences and verbal persuasive experiences were rarely accompanied by emotive incidents, as the preservice teachers appeared to have gained enough confidence that examination of the model or feedback from mentor teachers or university supervisors did not impact their feelings. The only exception was Ingrid, who found herself in a situation where her mentor teacher discouraged her after she allowed a student special circumstances to complete missing work. Ingrid was quite angry at her mentor's criticism, but used the anger constructively to gain perspective on the type of teacher that she wanted to be, and thus gained positive teacher efficacy beliefs despite the negative response and experience.

Summary

Quantification of the data on Bandura's influences at various points during the teacher preparation program noted similar results, which are summarized in Table 4.7.

Type of Influence	Percentage of times type of influence was mentioned			
	Initial	Middle	Final	Total number of times mentioned
Mastery experience as student	7%	3%	1%	19
Mastery experience as teacher	54%	72%	62%	234
Master experience in other capacity	5%	1%	0%	7
Vicarious Experience	20%	14%	17%	64
Verbal Persuasion	14%	10%	17%	52
Total number of times mentioned	121	105	150	376

Table 4.7: Type of influence as changed with time

Mastery experiences as teachers accounted consistently for more than half the times these influences on teacher efficacy beliefs were mentioned by the preservice teachers in this study. Additionally, participants relied more heavily on teaching mastery experiences for teacher efficacy information as the teacher preparation program progressed. Mastery experiences as students and in other capacities (mainly dealing with children as a family member) accounted for much less teacher efficacy information between the first interview and remainder of the year. Vicarious experiences accounted for a fairly large chunk of teacher efficacy influence comments throughout the year, with the largest proportion during the fall field experience, which was mainly observational in nature.

Verbal persuasive experiences accounted for a smaller but still sizeable proportion of teacher efficacy influences throughout the year.

Synopsis

Preservice teachers at the beginning of the teacher preparation program in secondary science exhibited several differences in teacher efficacy beliefs from those who were finishing the program. Results from the STEBI-A revealed that preservice teachers at the end of the program had significantly higher personal science teaching efficacy beliefs than those at the beginning of the program, indicating that they possessed significantly stronger beliefs in their own effectiveness as science teachers as a result of the teacher preparation program. No significant difference in science teaching outcome expectancy beliefs were found on the STEBI-A, indicating that there was no detectable difference between the beginning and end of the program in preservice teacher expectations of the outcomes of their teaching. Analysis of qualitative data revealed the development of more positive personal teaching efficacy beliefs during the course of the teacher preparation program.

Outcome expectancy beliefs, however, tended to shift more erratically; in particular, participants who engaged in their urban field experience during the winter and/or had particularly discouraging experiences with mentor teachers were affected quite negatively in outcome expectancy as compared to preservice teachers who participated in a fall urban teaching experience and/or who had positive experiences with mentor teachers. As a result, these participants developed an overall more negative set of outcome expectancy beliefs for the remainder of the year. The conflict between the qualitative and quantitative results regarding outcome expectancy beliefs may be explained due to the insensitivity of the STEBI-A toward capturing finer details relative to the qualitative measures such as the interviews and written reflections, which allow for a "thick description" (Geertz, 1973), as well as the relatively low reliability of the STOE sub-scale. It is possible with a large sample size that patterns in outcome expectancy as measured by the STEBI-A would be clearer.

PSTE and STOE scores at the beginning and end of the teacher preparation program were not significantly ($p < 0.05$) dependent on participants' science content knowledge or gender. Because all but one of the preservice teachers in this study had at least a bachelor's degree in their content area, it is possible that the content knowledge differences were too minor to influence the preservice teachers' sense of efficacy. The time of engagement in the urban teaching experience did have an impact on STOE beliefs at the end of the program, however, again emphasizing the importance of getting involved in teaching in urban environments as early as possible during teacher education.

Furthermore, participants at the end of the study expressed teacher efficacy beliefs in which there was a significant correlation between outcome expectancy beliefs and personal teacher efficacy beliefs. No correlation was found for participants at the beginning of the study. Significant correlations between PSTE and STOE were also found for participants with master's degrees but not for participants with bachelor's degrees alone. It is certainly possible that with increased experience and comfort with their content area, teachers become more confident both in their abilities to teach the material and to impact student learning.

In this study, teacher efficacy beliefs were directly affected by three of Bandura's four sources of self-efficacy beliefs—Mastery experiences, vicarious experiences, and verbal persuasion—as well as through the process of personal reflection. The most powerful mastery experiences resulted from teaching students and obtaining an unexpected result, whether it was that students did not learn by way of a traditional technique or that students did learn when they did not normally do so. The most powerful vicarious experiences involved observing course professors and mentor teachers teach both successfully and unsuccessfully. The most powerful verbal persuasive elements came from mentor teachers. No evidence was found that affective states by themselves had resulted in belief changes, although many of the mastery experiences, vicarious experiences, and verbal persuasive experiences were more powerful because they were accompanied by an emotional incident.

Additionally, the influence of each source of self-efficacy information appeared to change during the course of the teacher preparation program. The preservice teachers relied more strongly on mastery teaching experiences as the year progressed after initially expressing beliefs related to their experiences as students. Vicarious experiences appeared to be most powerful during the quarter in which participants were engaged in their first field experience, when preservice teachers spent the majority of their time observing their mentor teacher and other teachers. Verbal persuasive experiences accounted for a steady but relatively minor proportion of influences on teacher efficacy beliefs throughout the year; however, for several individual participants, the verbal persuasion and support of their mentor teachers made an important impact on their teacher efficacy beliefs. Most notably, preservice teachers with unsupportive mentors during their field placements in urban schools developed rather negative senses of teacher efficacy.

CHAPTER 5

FINDINGS: THE ROLE OF THE SCIENCE TEACHER

Figure 5.1: Map of beliefs about teaching and changes in beliefs about teaching

Characteristics of Effective Science Teachers

Participants in this study were asked at various times during the teacher preparation program to discuss what they believed were characteristics of effective science teachers. Effective teacher characteristics fell into five main categories: knowledge of content, knowledge of teaching, knowledge of students, external influences, and personal characteristics. These corresponded closely with the three expert teacher knowledge bases of science subject knowledge, general teaching knowledge, and interactive knowledge (Turner-Bisset, 1999).

Content Knowledge

Many of the preservice teachers noted the importance of content knowledge as a characteristic of an effective teacher. Henry explained the significance of content knowledge in teaching:

> If you can explain it verbally, that's one thing, but to draw a picture, to come up with something kinesthetic, you really have to know. I've seen people try to explain things in different ways and they don't understand that drawing it a particular way will completely show the wrong thing…So I think that a teacher really has to know all the aspects of a particular part of science in every possible way, and be able to apply it. (Henry, interview, 8/04).

Every participant who mentioned content knowledge emphasized how important it was to be able to simplify concepts, to apply them to the students' lives, or to see various angles of a given idea before they could teach the concepts effectively.

Turner-Bisset's (1999) science subject knowledge base includes three components: syntactic knowledge of science, substantive knowledge of science, and beliefs about science. None of the participants in this study mentioned the importance of understanding the nature of science (syntactic knowledge) or distinguishing what was important to know about their subject area (beliefs about the subject) at any point during the teacher preparation program. Instead, they focused exclusively on knowledge of specific concepts (substantive knowledge).

Knowledge of Teaching

Almost all of the participants noted that effective teachers must know various pedagogical techniques and must be able to present ideas in a variety of different ways to students at different levels. Aaron declared that effective teachers "Make it interesting, and relate it at the right level, and…they make students understand the why it's important to know, that sort of stuff. So instead of having students just memorize the periodic table, they relate why that knowledge is useful." (Aaron, interview, 8/04). Most of the preservice teachers mentioned the importance of knowing and using active learning techniques such as hands-on activities and inquiry science. Several also noted their use of cooperative learning strategies, and how they thought having students work together helped both high and low achievers. Only two participants noted the importance of being an effective classroom manager. As Alyssa put it:

> Being able to do classroom management, that's one thing I've been thinking more about lately. You know me, I'm kind of quiet, so that's one of the things I

> struggle with in the classroom. So I am realizing this quarter with the high school students and with the different mix and with the less motivated students, that it's a bigger issue in the classroom and it's important to establish that good classroom management so that you can do everything else. (Alyssa, interview 2/05).

Turner-Bisset's (1999) knowledge bases of teaching include two categories that fit with what these preservice teachers believed were characteristics of effective teachers. General pedagogical knowledge includes a comprehension of general teaching and classroom management principles. Most of what the preservice teachers mentioned in this study fall into this category. Turner-Bisset also uses a category of beliefs about teaching, which includes preferences of teaching methodology. As stated above, participants judging that active and cooperative learning were good teaching strategies falls into this category of beliefs about teaching. Turner-Bisset also has a third category of knowledge of curriculum. I found no evidence that the participants in this study felt that curriculum knowledge was an essential characteristic of an effective teacher.

Knowledge of Students

Knowledge of students was a characteristic mentioned by several of the preservice teachers in this study. Lucy noted several important pieces of information that are helpful to effective teachers: "Just understanding where your students are coming from, like culturally, and what their previous learning experiences are." (Lucy, interview, 8/04). Raina mentioned a similar idea: "Each an every student has a unique background and a unique personality. Discovering and understanding their backgrounds and personalities may help you to better communicate with your students." (Raina, written reflection, 9/04). Additionally, some of the preservice teachers noted that general appreciation of student differences was a characteristic of effective teachers. As Lucy put it: "Life is a potluck, and we all have something to bring to the table…Teachers who fail to respect their students aren't likely to get much in return. It is important to recognize the personal value of each student and not play the tyrant role while making students know you are in charge." (Lucy, written reflection, 9/04).

Turner-Bisset's (1999) knowledge bases of teaching include two categories that fit what these preservice teachers believed were characteristics of effective teachers. Turner-Bisset distinguishes two types of knowledge of students: cognitive knowledge and empirical knowledge. Cognitive knowledge of learners includes a comprehension of child development and how instruction may be differentiated for different learners, while empirical knowledge of learners includes knowledge of what students of a particular age and background are like. Both of these aspects of knowledge of students were mentioned by preservice teachers in this study.

External Influences

Several preservice teachers mentioned characteristics that fell into the category of external influences; they believed in order to be an effective teacher, one needed to have some level of control over bureaucratic decisions in their schools and school districts. For example, Alyssa very heartily discussed the need for teachers to have small class sizes in order to be effective: "It all goes back to having smaller class sizes. If the classes were smaller, I could give those kids just enough attention that it would make all the difference. But there are just too many students and I can't get to all of them, so that I don't get to know them, except maybe a couple." (Alyssa, interview, 5/05). Lucy and Raina, on the other hand, mentioned the importance of having enough influence in the school to get the appropriate mixture of students in class: "I guess also to be a good science teacher you need to know how to get your classes set up so that that doesn't happen, because that shouldn't happen—having half gifted and half L.D. in the same class." (Lucy, interview, 6/05).

This category of external influences may somewhat overlap with Turner-Bisset's (1999) category of knowledge of educational contexts, which includes knowledge of schools and classrooms. For the preservice teachers in this study to express their concern over class size and class placement of difficult students, they clearly possessed an understanding of operations of their field experience schools.

Personal Characteristics

The majority of characteristics named by the preservice teachers in this study fell into the category of personal characteristics, which were mainly dispositions that could not be taught in university coursework or learned through teaching experience. Personal characteristics included patience, fairness, flexibility, caring, a sense of humor, good organization, humility, open-minded, reflective, respectful, curious, persistent, and an effective communicator.

The category of personal characteristics is also emphasized by Turner-Bisset (1999) in the category knowledge of self, which includes the ability to reflect accurately on one's strengths and weaknesses.

Development of Beliefs About Effective Teachers

Since I was interested in the development of beliefs over time, I examined whether or not participants in this study mentioned different types of beliefs more or less as the teacher preparation program progressed. Results of this analysis are presented in Table 5.1.

Dimension	Percentage of Times Mentioned Over Time			
	Beginning	Middle	End	Overall
Knowledge of Content	18%	21%	12%	31
Knowledge of Teaching	28%	40%	21%	53
Knowledge of Students	6%	4%	12%	14
External Influence	0%	0%	4%	2
Personal Characteristics	47%	35%	51%	82
Total Number of Characteristics Mentioned	77	48	57	

Table 5.1: Development of beliefs about effective teachers

As is clear from Table 5.1, personal characteristics accounted for the overwhelming majority of characteristics mentioned by participants throughout the year, accounting for 47% of mentions at the beginning of the year, 35% of mentions in the middle of the year, and 51% of mentions in the spring. The importance of this characteristic appeared to be highest during the fall field experience, when the preservice teachers were engaged in their first formal teaching experiences at the middle and high school levels, and during the spring student teaching experience, when the preservice teachers were most fully engaged in the work of teaching.

Some of these personal characteristics were mentioned throughout the entire year—namely, patience, flexibility, perseverance, a sense of humor, and enthusiasm. Being organized and prepared, curious, and passionate about what one is teaching were characteristics that were overwhelmingly mentioned by participants during the first half of the year. It is perhaps notable that these are characteristics of a good scientist, and not just a good science teacher. As the preservice teachers were mainly familiar with what it was like to be a scientist, it makes sense that they would single out these characteristics for science teachers, as well. Being caring and understanding towards students, confident, reflective, and open-minded were characteristics mentioned primarily during the second half of the year. These characteristics do not necessarily describe good scientists, but they are often associated with teaching, indicating the preservice teacher's movement away from identifying themselves as scientists and toward identifying themselves as science teachers.

The perceived importance of content knowledge appeared to decrease over the course of the year. Simultaneously, the importance of knowledge of students appeared to increase, particularly by the end of the program. Raina noticed this change in her own emphasis after just the first field experience:

> I think that the most important thing I would change would be to put less emphasis on a good content knowledge and more on caring about and understanding your students. It really doesn't matter how much biology I know if I can't connect with my kids and get them interested in learning it. (Raina, written reflection, 11/04).

Additionally, the reason for content knowledge being important to effective teachers appeared to change over time. At the beginning of the year, the preservice teachers were focused on content knowledge because it allowed effective teachers to transmit knowledge in a variety of ways:

> A good science teacher, I would say, really has to know the content. I think that's really important, because I don't think a lot of science teachers really do know the content. Even me, that's going to be—make sure I don't mess up my p's and q's, simple things, you say them fast, or whatever, and you really need to make sure you say them right. I think they need to be able to communicate at the level of a student, bringing these complex ideas and making them simple…sometimes putting things in the simplest of terms really shows how much more you know it. Anyone can quote a book, but to really say, this is what happens and say it in terminology that students can relate to, that's really important. (Emily, interview, 8/04).

At the beginning of the year, participants commonly used words such as "relate the material", "explain it", and "tell them". By the end of the year, some of the preservice teachers recognized that knowing content was important because it allowed them to design class activities that allowed students to construct their own understanding of the content. Most participants retained their focus on transmitting content, however. For example, compare what Emily said at the end of the year to her quote above:

> Knowledgeable about the content, definitely is important. Able to simplify those things in such a way that is accurate and yet understandable, which is a struggle—to oversimplify to the point of making it inaccurate, I hate doing that. (Emily, interview, 5/05).

Clearly, Emily was still relying on the same transmission model of teaching in which her role involved simplifying and explaining concepts to students.

The importance of knowledge about teaching was highest during both the summer and winter quarters, the quarters that were most heavy with education coursework. Participants during the summer were concerned with knowing teaching methods that would make the content interesting and meaningful to students. They were also focused on knowing classroom management methods. Finally, several participants mentioned the importance of effective teachers being able to discern and quickly address student misconceptions:

> The good teachers seemed to sniff out why someone doesn't get it so they can address that in particular. So I guess you would have to read up on what are common misconceptions, and again being patient, letting the student rephrase his questions several times ties into that. (Josh, interview, 8/04)

> I think a good science teacher understands their students and addresses their misconceptions before trying to pile on more knowledge. I think they need to be aware of what their students understand and make sure they clear up any misunderstandings. (Rachel, interview, 7/05)

During the winter quarter, the preservice teachers were still concerned with how to make the content interesting and meaningful to students, but had begun thinking about more specific teaching methods that were used by effective teachers.

> You've got to get the kids involved. Like, sometimes you do have to give notes. You can't let them discover Newton's law of motion, or I guess you could, if that was all you had to cover in a year. But you have to do something that excites them a little bit, I guess…I guess just getting them involved really makes for the best science teacher, which is hard to do sometimes. But I think that any time you stand and lecture, or even if you're the one doing demos all the time, kids can zone out. I think you've got to be interactive to be a really good science teacher. (Raina, interview, 3/05)

> You need to try to teach using a variety of methods so that you're reaching everyone. Some people do fine with lecture, some people don't. Some want to hear everything. You just have to try a variety of things. (Rachel, interview, 2/06)

Participants also focused more strongly on the importance of effectively managing the classroom during the winter quarter, for very practical reasons: "It's important to establish that good classroom management so that you can do everything else." (Alyssa, interview, 2/05). The importance of creating a supportive classroom atmosphere was also noted during the winter quarter by several participants:

> I think a teacher that can find a way—and I aspire to be this—to create an environment where the students feel safe, where the students feel welcome, the students want to be there, and what's being taught is relevant and interesting to their lives, will most definitely have an impact on their learning. (Dan, interview, 3/06)

Finally, external influences were only mentioned by preservice teachers during the spring quarter, when they were engaged in full-time student teaching. This is not unexpected, since spring was the first time participants were required to be at their placement schools for the entire day, were required to participate in all aspects of life as a teacher, and many had their first experiences dealing with school and school district bureaucracy.

The Role of the Science Teacher

Five main categories of beliefs about the role of the science teacher emerged based on answers to questions about how they envisioned themselves as teachers, the types of teaching techniques they both preferred and used, and their expectations for students. More specifically, participants in this study were categorized as expository, constructivist, empathizer, maturationist, or social constructivist according to the outline in Table 5.2 below, adapted from Daniels and Shumow (2003).

Label	Role of Teacher	Description of Classroom Practices	Valued Qualities of Child in Class
Expository	Authority figure Dispenser of knowledge and skills	Didactic instruction Student practice Rewards and punishments Competitive environment	Knowledge of specific facts and skills Effort exerted
Constructivist	Collaborator Guide Designs learning experiences	Student choices Guided discovery/inquiry Cooperative learning	Critical thinking skills Problem-solving skills Intrinsic motivation
Empathizer	Parent Friend Nurturer	Develop relationships with students Positive classroom environment	Self-regulation Social competence
Maturationist	Observer Follower Prepares classroom	Student free exploration Student play	Intuition Self-direction Developmental readiness
Social Constructivist	Consultant Cultivator	Community of learners Student interaction Authentic tasks	Life skills Collaboration Metacognition Habits of mind

Table 5.2: Categories for role of teacher

Expository Teachers

Expository teachers were identified through their focus on being the “giver of knowledge”. They tended to describe teaching in terms of telling or explaining, and thought of themselves rather than students as providing knowledge to be learned: “In teaching, I’ll reiterate a point until I’m satisfied that the students have absorbed the information.” (Nancy, written reflection, 9/04). The job of their students was to passively receive the knowledge and skills that were provided and to remember them for later use. When student questions were asked, teachers in expository classrooms answered them themselves: "An effective teacher must possess a mastery of the subject matter they are teaching so that the teacher can effectively answer all the students' questions." (Nancy, written reflection, 9/04). Expository teachers also frequently mentioned rewarding students for good behavior, through tangible goods such as candy as well as through praise: "Children need positive reinforcement as often as a teacher can give it in order for the student to get enthusiastic about the subject." (Nancy, written reflection, 9/04).

Constructivist Teachers

Constructivist teachers were identified through their focus on helping students construct their own understanding; preservice teachers frequently cited the use of discovery and inquiry activities, which fell under this category. In this case, students were expected to be active learners in class, and teachers hoped they would develop critical thinking skills and curiosity rather than learning strictly factual knowledge: "The dominating theme of my philosophy is to teach students how to think, question, and solve problems on their own." (Emily, written reflection, 11/04). "I think I have a responsibility to develop young minds in the curriculum, and the content knowledge… to instill in the young minds science as inquiry. The whole methodology of interest and investigation and yearning and earning for knowledge. " (Dan, interview, 7/05). Constructivist teachers also occasionally mentioned allowing students to choose what they learned: "Students could be given a choice about how they will communicate their knowledge. For example, a student might turn in a traditional paper about the subject, build a diorama, perform a skit, write a mock quiz show, or whatever they can think of." (Emily, written reflection, 11/04).

Social Constructivist Teachers

Social constructivist teachers were identified mainly through their focus on student-to-student interaction; discussions and other group work fell under this category:

> Everything I do, I want it in some way to be interactive. Be it, okay, let's work with a partner, or—So student interaction is my main thing….I just want students to interact with everyone around them, all the time. Because that's when you start to really learn. Asking questions is when you learn. (Raina, interview, 6/05).

In social constructivist classrooms, students were expected to learn social skills such as collaboration, thinking skills such as metacognition, and general habits of an intellectual mind, rather than strictly factual knowledge or even critical thinking skills specific to science: "I feel that a teacher is a person who gives students the resources they need to grow as scholars and, more importantly, as world citizens." (Lucy, written reflection, 9/04). Inspiring their students was a goal of several preservice teachers: "I have a responsibility as a science teacher to mold and develop and inspire scientists and engineers, innovators." (Dan, interview, 3/06). Social constructivist teachers helped students to understand how what they learn in school was applicable and useful in their daily lives:

> I believe that the ultimate goal of an education is to develop/acquire the ability to make wise, informed choices that benefit not only the individual, but society as a whole. A good education, therefore, is one in which a person not only acquires factual knowledge, but thinking skills such as analyzing data, assessing validity and viability of sources and designs, pulling together disconnected factors to see a coherent bigger picture, applying information to new situations and drawing conclusions. (Alyssa, written reflection, 11/04)

Social constructivist teachers also emphasized the importance of understanding student backgrounds and helping individual students develop.

Empathizer Teachers

Empathizer teachers were identified through the focus on establishing caring and friendly relationships with students:

> I believe that it is so important for your students to like you. As a science teacher, you are going to encounter a lot of students who come into your classroom with the attitude that they hate science. There is a very negative image of scientists in a lot of the students' minds. If you can dispel this image and get your students to think that you are "cool", you might just get them to start thinking that scientists are "cool", and maybe, if you are really lucky, or really good, that science itself is "cool". (Raina, written reflection, 11/04)

> I want to create a warm, inviting classroom, I want to respect the individuality and uniqueness and diversity of all of my students. I want them to feel comfortable in my classroom. I want them to want to ask me questions. I want them to answer questions even if they're not sure that it's the right answer. I want to create an environment where they see me as someone helping them understand the content—a guide. I want them to like me. (Dan, interview, 3/06)

In the empathizer's classroom, the teacher's role was to create a supportive and nurturing classroom environment, to learn about his/her students, and to share equally about him/herself.

Maturationist Teachers

Finally, only two teachers expressed maturationist beliefs. These were identified through the preservice teachers' focus on allowing students "free play" time in class:

> For mine [future classroom], it would be all kinds of cool models of science everywhere, where people could actually play with. Because there's always five minutes at the beginning of class, and if I had the ability to let the kids go around and look at these demos without breaking them, that would be great. (Henry, interview, 6/05).

In the maturationist classroom, the teacher's role, then, was to provide the context and materials with which the students could play, and then to watch the students explore. Students, conversely, had the responsibility of deciding in what direction and to what extent their learning would progress.

Development in Beliefs About the Role of the Science Teacher

I next examined whether or not participants in this study mentioned different types of beliefs more or less as the teacher preparation program progressed. Participants were categorized according to the scheme outlined in Table 5.2 at the beginning, middle, and end of the teacher preparation program, based on the overall nature of their responses to interview questions and reflection prompts. Table 5.3 contains the categorization of each participant, along with some representative quotes, at each point in time.

Participant	Beginning of Program	Middle of Program	End of Program
Raina	*Mainly Expository* *Also Empathizer* "you must be able to communicate and transfer this knowledge to your students." "showing general warmth and caring towards your students will make them more receptive to you, and more willing to let you educate them."	*Mainly Expository/Social Constructivist* *Also Empathizer* "I try to be a fun teacher, whenever I can, and I try to bring stuff from their lives so they'll see it as applicable to them." "Sometimes you do have to gives notes. You can't let them discover Newton's laws of motion." "Being a good science teacher means that kids don't fail every exam." "I think just showing them that extra little bit of attention and caring…that can kind of motivate them."	*Mainly Expository* *Also Empathizer* "Everything I would do, I would want student interaction to be an essential part of it." "I just like to do stuff that's really interactive, I don't think it necessarily has to be hands on" "Should you give notes every day? No. But kids can't discover everything." "I really feel like there are some things where you need direct instruction." "You have to build that bond with them in order to influence them."
Alyssa	*Mainly Expository* *Also Constructivist* "to be able to talk about the same things in different ways." "being able to simplify, too, being able to talk about things in colloquial terms."	*Constructivist* "to help people who are trying to figure out things on their own, try to help them along the way" "teaching inquiry through questioning" "in the end, it's ultimately up to someone whether or not they want to learn."	*Social Constructivist* "I would like to have a lot more student to student dialogue." "I'm more than just a science teacher, I'm a social teacher."

Continued

Table 5.3: Categories for role of teacher

Table 5.3 continued

Emily	*Mainly Expository* *Also Empathizer* "I kind of see it as having two goals. One is to teach them the cool stuff they should know and want to know, and the other is to prepare them for what they really need to know." "I think they need to be able to communicate at the level of a student, bringing these complex ideas and making them simple." "I will be able to connect with my students and become a positive force in their lives."	*Mainly Expository* *Also Social Constructivist* "I do the straight lecture, and I expect them to memorize things. I see memorization as a tool." "to do debates, like current issues, and the reading activity that I'm doing for my action research." "I thought if I gave them an opportunity to at least tell me what they wanted to learn, they might take a little more interest. They don't necessarily make the most of being there."	*Mainly Expository* *Also Social Constructivist/Constructivist* "just hearing and processing what I was saying so that I didn't have to repeat things that were just because they didn't listen." "I want them to figure things out on their own." "I really like guided inquiry." "I really like this idea of group work."
Henry	*Expository* "kids just suck in information." "if you can explain it verbally, that's one thing, but to draw a picture, to come up with something kinesthetic, you really have to know." "she does not have the ability to know [be metacognitive about what she does not know]."	*Mainly Expository/Social Constructivist* *Also Constructivist* "the kids there ask really great questions, and they don't let it drop until they get an answer [from me]." "they don't sit at their seats, they're up moving around or modeling stuff." "able to realize there's lots of levels of learning and that you need to teach to the bottom level while keeping it interesting for the ones at the top." "group work is one of the best ways."	*Mainly Expository/Social Constructivist* *Also Constructivist/Maturationist* "The best way is to teach them to be good scientists, to make good observations, to put those observations into a nice order, to make a hypothesis, and come to their own conclusions." "there'd be constructive talking" "it would be all kinds of cool models of science everywhere, where people could actually play with." "people already know everything, and that it's just a matter of putting it into a new order"

Continued

Table 5.3 continued

Aaron	*Mainly Expository* *Also Constructivist* "they know how to make that interesting to the students, and how to relate the material at an appropriate level." "To me, a lesson, although you worry about methods, it's a lot more content-based." "Ideally I'd like to do some more lab-based, interactive stuff."	*Mainly Social Constructivist* *Also Constructivist* "Students can't learn just on their own. I think it's incredibly influential as to how the classroom is structured." "the other really important thing is to connect what you're trying to teach with the lives of the students." "I just sort of have to be there to direct discussion."	*Mainly Constructivist* *Also Social Constructivist* "having students up in the classroom, moving around, being active" "I would like to see most of the class be students talking to each other, and working in small groups, and then reporting back to the classroom as a whole."
Nancy	*Mainly Constructivist* *Also Empathizer* "I want them to be excited and want to learn more." "I really want to do a lot of hands-on, make sure they're occupied all the time and thinking all the time, and then thinking outside the box, thinking what else this is related to." "I'm going to make sure I have different approaches for different levels of kids." "In teaching I'll reiterate a point until I'm satisfied that the students have absorbed the information." "if I show an interest in the kids…maybe they'll want to take it a step further."	*Mainly Social Constructivist* *Some Expository/Empathizer* "I hope to be able to get kids to feel enthusiastic about science, so they'll want to take their learning a bit further." "teachers prepare them for this by making them more independent and responsible for their own choices." "I found that the more activities you do, the busier you keep them, the more on track they stay." "I think being able to relate to kids is extremely important"	*Mixture of All Five* "kids would be at tables so that there could be a lot of group work." "a bit of cooperative learning and a bit of discovery learning and certainly there needs to be a bit of me up there lecturing." "I try and plan so that they're active the whole class period, that helps with classroom management, since there's no down time so they don't get into trouble." "if they don't have that parental support, I can try to be that for them."

Continued

Table 5.3 continued

Lucy	*Mainly Constructivist/Social Constructivist* *Also Empathizer* "I think I'm more of a facilitator. Like it's my job to help kids find out what they're good at, and use their own experiences to help them learn." "understanding where your students are coming from, like culturally, and what their previous learning experiences are." "I tried to do stuff like drawing and manipulating things." "establishing a positive, mutually respectful relationship with a struggling student"	*Constructivist/Expository* "I'm interesting, and interactive, and…I try to use stories to get people to listen." "The top three, I gave them candy. And I told them that we were going to keep doing that." "Getting everybody to participate in class is a big deal." "One assessment that I have used this quarter was to have students design their own animal that fit into one of the phyla we discussed in class. I used this project in place of a test."	*Constructivist* "I see myself as a person that facilitates learning. I get them started and they have to take it from there." "I need to give them more choices in terms of what they do." "I would like to do more of a discovery and inquiry approach."
Ingrid	*Mainly Constructivist* *Also Social Constructivist* "I hope to ask very open-ended questions and let the students figure things out for themselves." "I'd like to show them the relevance of science in every day life." "Students just aren't that motivated to learn by themselves, but you can prompt them a little so that they're more motivated to search for things."	*Mainly Constructivist* *Also Empathizer* "I want to be confident and have the students do hands-on things, activities. They seem to grasp things a lot better when they can actually do them." "You need to have them doing something active, or at least participating somehow, asking them questions." "the better the relationship you have with the student, the more they want to do well in the class"	*Mainly Constructivist* *Also Social Constructivist/Empathizer* "you need to always try new things and not everything is going to work for that one person." "you need to have a lot of things hands on." "I would like to do more discovery learning , and do more where the students are interacting with each other." "thinking more about the student…and being more caring."

Continued

Table 5.3 continued

Rachel	*Expository/Constructivist* "Sometimes you get rushed and you don't have enough time to cover so much material." "Give them different ways to think about it so they can tackle their problems, even if they aren't subject-related, give them different ways to think about things." "Make it fun and activity—hands on, and build on their knowledge"	*Expository* "I try to get everyone to answer questions, and I try to go around the room—kind of pick on people at random." "we've had to go at like lightning speed over some topics so we could get them in."	*Constructivist* "to encourage them to explore on their own and figure things out on their own." "me to be a facilitator and be there as a source for them to go to, and have a classroom resource center for them to go and explore things on their own."
Anna	*Expository* "it would help to…present it in a more basic way." "we're learning lots of different, various methods that are better than what I had as a student in the past. I'm not sure, in the real world, how to do what they're teaching."	*Expository/Constructivist* "I try to promote student-centered learning and hands-on discovery, but given the circumstances and the situations that I've been in, it's not always the case." "I really think that the best learning is—the things that they remember the most—is when you put the learning in their hands." "I gave lots of busywork."	*Constructivist* "I've tried to do hands-on and group work, because that's really positive." "I would hope to facilitate student learning." "I feel more comfortable facilitating rather than standing up and doing direct instruction."

Continued

Table 5.3 continued

Dan	*Constructivist* "I have a responsibility to instill in the young minds science as inquiry." "to teach the students to analyze things that are in front of them." "I would be more proud as a teacher if a student that I had won a science fair award for an innovative project than a student that aced a standardized content test."	*Social Constructivist, Constructivist, and Empathizer* "I have a responsibility as a science teacher to mold and develop and inspire scientists and engineers, innovators." "I want them to ask me questions….they see me as someone helping them to understand the content—a guide." "I want to respect the individuality and uniqueness and diversity of all of my students…I want them to like me."	*Social Constructivist/Constructivist Also Empathizer* "I think if you create interesting environments and lessons and learning experiences for the students." "I see myself as…finding a way to help them accomplish their goals." "Collaborative, more independent, activity-based, doing real things." "I believe in student collaboration…I believe in inquiry-based learning." "someone that the students can trust, someone that the students can open up to."
Tom	*Social Constructivist/Empathizer* "if kids have problems with different areas of their life, maybe not just science, that they're comfortable coming to me and asking about that." "if a kid comes up to me and he's got an interest in this, I've got a directly relatable experience that I can say—well, okay, you like that, they do that with this!"	*Expository* *Also Social Constructivist* "No matter how much I want to force feed it to them, if they don't want to take it, they're not going to take it." "you're going to give me this, and tell me what I need, and I'm going to spit back at you what you gave me." "75% or more of the time I'm teaching them everything from how to study and what knowledge is, and what gaining knowledge means."	*Expository/Social Constructivist* "I'm trustworthy, and I can answer questions about science." "how much just teaching the basic social skills and basic communication skills." "sometimes they just need to hear it in a different way." "I love it when the students teach each other."

It is notable that at the beginning of the program, predominantly expository beliefs were the most common among this group of preservice teachers (possessed by 8 participants), with predominantly constructivist and social constructivist beliefs exhibited by 5 and 2 participants, respectively. Empathizer beliefs were predominantly expressed by a single person at the beginning of the program. By the midpoint of the program, participants were evenly divided between predominantly expository and social constructivist beliefs, with constructivist beliefs accounting for slightly fewer, and empathizer beliefs expressed by only one participant. At the end of the program, predominantly social constructivist (exhibited by 4 participants) and constructivist (exhibited by 6 participants) beliefs outnumbered expository and empathizer (exhibited by 4 participants and 0 participants, respectively). Overall, then, the group progressed from focusing on a more traditional, teacher-centered role to believing that their job as teachers was to guide student learning, facilitate student interaction, and develop student understanding of science as applicable in the real world. This trend is summarized in Figure 5.2.

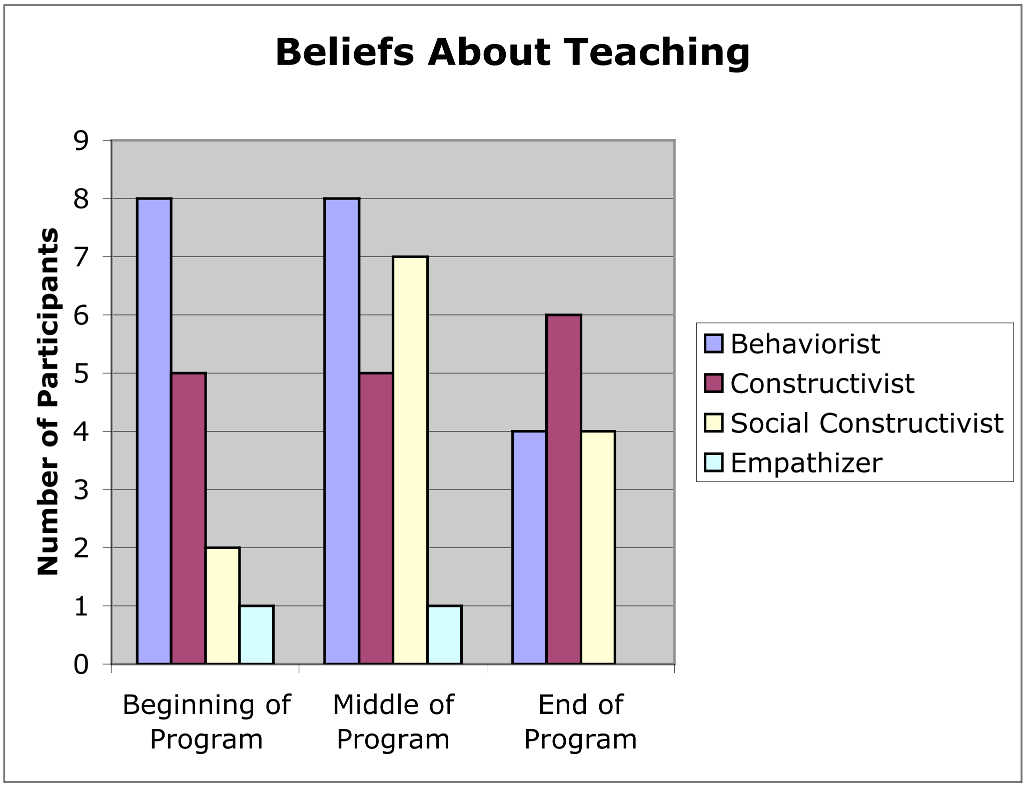

Figure 5.2: Changes in beliefs about teaching

Aside from this overall trend, two populations of participants emerged in this analysis: those who initially possessed more traditional expository beliefs and those who initially possessed more constructivist or social constructivist beliefs. The majority of participants (seven) in this study fell into the first population, initially possessing expository beliefs about the way children learn and therefore teacher-centered beliefs about the role of the teacher. By the midpoint of the program, all except for one of these preservice teachers had developed alternate beliefs about the role of the teacher. Two of them transitioned completely to constructivist or social constructivist beliefs, while the remaining five expressed a mixture of expository and social constructivist or constructivist beliefs at the midpoint of the program. Interesting, the two preservice teachers who developed alternative beliefs by the midpoint of the program tended to not return to their initial expository beliefs by the end of the program. On the other hand, several members of the group that shared expository beliefs along with constructivist or social constructivist beliefs did revert back to their initial expository beliefs by the end of their student teaching. Demographic differences between the two groups were not detected; Both groups included men and women, as well as those who had earned master's and bachelor's degrees as their highest degrees, and no differences were found based on the time of urban teaching experience.

The second population, accounting for five preservice teachers, initially expressed constructivist and social constructivist beliefs about the way children learn and therefore more student-centered beliefs about the role of the teacher. This group seemed to undergo much less significant change in beliefs about the role of the teacher throughout the program, although they did tend to develop a more complex understanding of their roles as teachers. Two of these three preservice teachers retained essentially the same beliefs for the entire span of this study, while a second pair developed a more complex mixture of beliefs as the year progressed. The final member of this group was a special case, as he developed expository beliefs, albeit in conjunction with social constructivist beliefs, as the year progressed.

One participant did not fit into either population, initially expressing a mixture of expository and constructivist beliefs, and retaining that mixture (or rather alternating between them) for the remainder of the year.

Comparison of Beliefs and Practices

Participant lesson plans during the Autumn, Winter, and Spring field experiences were then analyzed to determine the extent to which the preservice teachers adhered in practice to the beliefs they espoused in their interviews and written reflections. Individual daily lesson plans were holistically categorized as expository, constructivist, empathizer, maturationist, or social constructivist, and then each teacher was labeled based on the number of lessons falling into each category. Lessons that predominantly involved teaching strategies such as teacher lecture, student listening, students completing worksheets, or students watching a video were categorized as expository. Lessons that mainly involved student activity/experimentation or students constructing knowledge were categorized as constructivist. Lessons that involved student-to-student interaction or authentic activities were categorized as social constructivist. Lessons whose main goal was to develop the student-teacher relationship were labeled empathizer. And lessons in which students were allowed free exploration time were labeled maturationist. Lessons that contained approximately equal amounts of two or more teaching styles were attributed to each category. The results of this analysis may be found in Table 5.4, which includes information on each participant's field placement and espoused beliefs about the role of the teacher.

Person	Beginning of Program	Middle of Program	End of Program
Raina	Classroom Setting: Suburban grade 10 Anatomy/physiology, evolution Beliefs: Mainly Expository Also Empathizer Practices: Expository/Social Constructivist	Classroom Setting: Urban grade 8 Motion, forces Beliefs: Mainly Expository/Social Constructivist Also Empathizer Practices: Expository	Classroom Setting: Suburban grade 10 Body systems, genetics, CSI Beliefs: Mainly Expository Also Empathizer Practices: Expository/Social Constructivist
Alyssa	Classroom Setting: Suburban grade 8 Astronomy Beliefs: Mainly Expository Also Constructivist Practices: Constructivist	Classroom Setting: Urban grades 9-12 Environmental science Beliefs: Constructivist Practices: Mainly Expository Also Constructivist	Classroom Setting: Suburban grade 8 Evolution, geological time Beliefs: Social Constructivist Practices: Constructivist/Social Constructivist
Emily	Classroom Setting: Urban grade 8 Astronomy Beliefs: Mainly Expository Also Empathizer Practices: Constructivist	Classroom Setting: Suburban grades 11-12 Physiology Beliefs: Mainly Expository Also Social Constructivist Practices: Expository	Classroom Setting: Suburban grade 8 Geology, genetics Beliefs: Mainly Expository Also Social Constructivist/ Constructivist Practices: Expository
Henry	Classroom Setting: Urban high school Life/earth sciences Beliefs: Expository	Classroom Setting: Suburban grade 8 Geology Beliefs: Mainly Expository/Social Constructivist Also Constructivist Practices: Mainly Expository Also Constructivist	Classroom Setting: Suburban grade 8 Geology, genetics Beliefs: Mainly Expository/Social Constructivist Also Constructivist/ Maturationist Practices: Expository/Constructivist

Continued

Table 5.4: Comparison between beliefs and practices

Table 5.4 continued

Aaron	Classroom Setting: Urban high school Life sciences Beliefs: Mainly Expository Also Constructivist	Classroom Setting: Suburban grade 7 Beliefs: Mainly Social Constructivist Also Constructivist	Classroom Setting: Urban grades 7-8 Energy and motion, animal diversity Beliefs: Mainly Constructivist Also Social Constructivist Practices: Expository
Nancy	Classroom Setting: Urban grade 8 Astronomy Beliefs: Mainly Constructivist Also Empathizer Practices: Constructivist	Classroom Setting: Suburban grade 10 Genetics Beliefs: Mainly Social Constructivist Some Expository/Empathizer Practices: Expository	Classroom Setting: Urban grade 8 Genetics Beliefs: Mixture of All Five Practices: Expository
Lucy	Classroom Setting: Suburban grade 7 Motion Beliefs: Mainly Constructivist/ Social Constructivist Also Empathizer Practices: Constructivist	Classroom Setting: Urban grade 10 Animal diversity, cellular biology Beliefs: Constructivist/Expository Practices: Expository	Classroom Setting: Suburban grade 7 Anatomy/physiology Beliefs: Constructivist Practices: Mainly Expository Also Constructivist
Ingrid	Classroom Setting: Urban grade 10 Life science Beliefs: Mainly Constructivist Also Social Constructivist	Classroom Setting: Suburban grade 7 Physical science Beliefs: Mainly Constructivist Also Empathizer	Classroom Setting: Suburban grade 10 Anatomy/physiology Beliefs: Mainly Constructivist Also Social Constructivist/ Empathizer Practices: Expository
Rachel	Classroom Setting: Urban grade 6 Genetics Beliefs: Expository/Constructivist Practices: Expository	Classroom Setting: Suburban grade 10 Genetics Beliefs: Expository Practices: Expository/Social Constructivist	Classroom Setting: Suburban grade 10 Evolution, CSI Beliefs: Constructivist Practices: Expository/Constructivist/ Social Constructivist

Continued

Table 5.4 continued

Anna	Classroom Setting: Urban grade 7 Physics Beliefs: Expository Practices: Social Constructivist	Classroom Setting: Suburban grade 10 Genetics Beliefs: Expository/Constructivist Practices: Expository	Classroom Setting: Suburban grade 10 Biology Beliefs: Constructivist
Dan	Classroom Setting: Urban grade 6 Cellular biology Beliefs: Constructivist Practices: Constructivist/Expository	Classroom Setting: Suburban grade 11 Chemistry Beliefs: Social Constructivist/ Constructivist/Empathizer Practices: Constructivist	Classroom Setting: Suburban grade 10-12 Chemistry/physics Beliefs: Social Constructivist/ Constructivist Practices: Constructivist/Expository

Most of the preservice teachers attempted constructivist and/or social constructivist teaching strategies during the autumn field experience, while by the winter and spring, they used overwhelmingly expository instructional methods. This trend is summarized in Figure 5.3. Only Alyssa consistently used constructivist teaching strategies in her spring student teaching classroom. This finding is in sharp contrast to the beliefs espoused by participants in the study; participants beliefs about teaching grew more constructivist and social constructivist with time, yet their practices developed in the opposite direction. There appeared to be no important differences based on the level or subject being taught at each point in time.

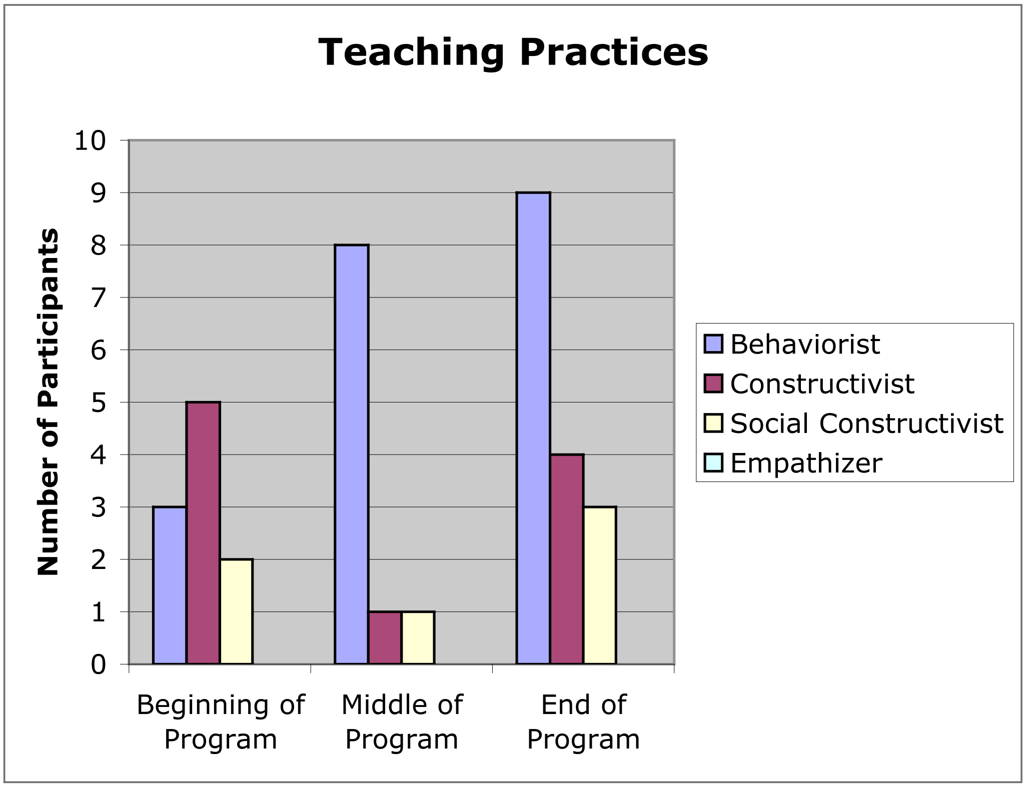

Figure 5.3: Changes in teaching practices

Preservice teachers were required to teach only five lessons during the autumn field experience, so they had sufficient time to create less traditional lessons. They also received a great deal of encouragement to do so from their university supervisors and the teacher preparation program on the whole. Although this support system remained constant throughout the year, the preservice teachers were required to teach one class period each day during the winter field experience and the entire school day during the spring student teaching experience. Almost all of the participants complained about the amount of work required of them during the winter and spring, so it appears that many fell back on more traditional teaching methods because they required less preparation; however, some additional influences may be evident.

On a broader scale, analysis of teaching observations (via the Reformed Teaching Observation Protocol) of all preservice teachers in both M.Ed. cohorts revealed some interesting trends. Most notably, the larger group of preservice teachers did not grow more or less constructivist in any component of their teaching practices over time. However, those teachers who student taught in urban schools exhibited significantly fewer constructivist teaching strategies than those who taught in suburban schools, as is visible in Table 5.5, where the mean scores are out of a maximum of 5 points. In all categories except for student-teacher relationships, preservice teachers at suburban schools displayed more constructivist teaching behaviors than did preservice teachers at urban schools.

Component of Teaching	Type of School	Mean Score	t (equal variances not assumed)
Lesson design and implementation	Urban	2.013	2.288*
	Suburban	2.283	
Propositional knowledge	Urban	2.741	2.625*
	Suburban	2.952	
Procedural knowledge	Urban	1.379	4.533**
	Suburban	1.844	
Communicative interactions	Urban	2.113	3.091**
	Suburban	2.435	
Student-teacher relationships	Urban	2.522	1.808ns
	Suburban	2.718	
Total score	Urban	2.158	3.689**
	Suburban	2.474	

* $p < 0.05$; ** $p < 0.01$; ns: non-significant result

Table 5.5: Comparison of constructivist teaching practices at urban and suburban schools

Furthermore, some interesting differences were found when comparing preservice teachers at middle and high schools. Results of this analysis may be found in Table 5.6. Preservice teachers placed in high schools were significantly more likely to exhibit procedural knowledge and communicative interactions, and generally scored higher on the RTOP than did preservice teachers in middle schools.

Component of Teaching	Type of School	Mean Score	t (equal variances not assumed)
Lesson design and implementation	Middle School	2.180	0.524^{ns}
	High School	2.236	
Propositional knowledge	Middle School	2.828	1.504^{ns}
	High School	2.937	
Procedural knowledge	Middle School	1.527	3.058**
	High School	1.831	
Communicative interactions	Middle School	2.186	2.647**
	High School	2.438	
Student-teacher relationships	Middle School	2.629	0.655^{ns}
	High School	2.690	
Total score	Middle School	2.271	2.473*
	High School	2.459	

* $p < 0.05$; ** $p < 0.01$; ns: non-significant result

Table 5.6: Comparison of constructivist teaching practices at middle and high schools

Influences on Beliefs About the Role of the Science Teacher

Although I have discussed some of the beliefs preservice teachers had about their roles as science teachers and how these beliefs and their actual teaching practices shifted over time, reasons for these beliefs and shifts have not yet been discussed. A total of seventeen different influences on participants' beliefs about their roles as teachers were identified from interviews and written reflections. These seventeen separate influences were grouped into seven major categories as outlined in Table 5.7:

Category	Influences
Direct experience teaching	Teaching experiences
	Informal experiences with children; parenting
	Action research
Vicarious experiences	Being a student and observing his/her teachers
	Observations of mentor/other teachers
	Media
Theoretical knowledge obtained	Understanding of social issues
	University coursework/learning theory
Verbal persuasion by authority	Stated opinion of mentor/other teachers
	Stated opinion of course instructors/university supervisors
Student expectations	Student opinion
	Student perceived receptivity to teaching
Personal reflection	Written weekly reflections
	Discussion of teaching issues with other preservice teachers
Pressures outside classroom	Perceived need to prepare students for high-stakes tests
	Parental expectations
	Expectations of school administration

Table 5.7: Factors influencing changes in preservice teacher beliefs about the role of the teacher

It is noteworthy that several of the categories overlap with Bandura's four categories of self-efficacy influences: Direct teaching experience, vicarious experience, and verbal persuasion by authority/student expectations. In addition to these, however, three additional categories were identified as important in influencing beliefs about the role of the teacher. Direct experiences were discussed by the largest number of preservice teachers as influencing their beliefs about teaching and learning, with vicarious experiences and knowledge of theory being noted by fewer numbers of preservice teachers, and verbal persuasion by authority figures, student expectations, and pressures outside the classroom making the smallest contributions. Personal reflection was mentioned by two participants as helping lead to change in their beliefs but in cooperation with other experiences. A more extensive description of each category follows.

Direct Teaching Experiences

Direct experiences took a variety of forms, ranging from formal classroom teaching, to being a teaching assistant for a university science course lab section, to tutoring individual students, to microteaching in science methods courses, to parenting. During the initial interviews, most of the preservice teachers referred to informal teaching in which they had participated. Tutoring individual students was most commonly mentioned, as was teaching of swimming/dance/religious classes.

As the year progressed, direct experiences almost always referred to the preservice teachers' field teaching experiences, and the preservice teachers tended to change beliefs in a variety of different directions. Many participants changed beliefs about teaching based on unsuccessful teaching experiences. For example, Lucy explained that an experience with an unruly class forced her to adopt expository beliefs and practices:

> Because I have many students who aren't motivated and lack proper decorum in class, I realized that my crowd-control methods weren't working too well. So, I instituted some rewards. The top three scores on tests and quizzes get a piece of candy, as well as people who put forth a lot of effort. If the entire class behaves

> well for one class period and everyone finishes their assignment before the end of the period, they can also get a reward. (Lucy, written reflection, 2/05).

Raina tried an inquiry-based activity with her high school biology class, and felt that it did not go well. As a result, she felt that inquiry would not work except in situations where plenty of guidance was provided and where students were sufficiently motivated. Similarly, Tom had an experience substitute teaching two summer school classes, one of which was relatively structured and the other which he described as more “progressive”. Students in the “progressive” class learned the material significantly worse, and Tom attributed it to the students having too much freedom: “It’s almost like there’s so much freedom that the kids can’t—they don’t have anything to really grab onto and keep for themselves.” (Tom, interview, 7/05). As a result, he spent the rest of the time lecturing to all of these students.

Ingrid, on the other hand, developed alternate beliefs based on an unsuccessful experience with traditional instructional methods:

> I came in one time and did a lecture where I had images and stuff, and I thought it was interesting and the images were interesting, and I just got blank stares. I mean, you can lecture to them, but not for a very long time. You need to have them doing something active, or at least participating somehow, asking them questions, that sort of stuff. That time was bad—I was like, no one is listening!” (Ingrid, interview, 3/04)

Some of the preservice teachers successfully attempted student-centered teaching methods, resulting in the belief that they should be less teacher-centered in class. Nancy had a successful experience with a class activity that resulted in her adopting a belief that she should be less dominating in class: I found that the more activities you do, the busier you keep them, the more on track they stay. “And so that’s what I intend to do when I go into a classroom, I don’t intend to be standing and lecturing at kids for a whole period. It just doesn’t work. You lose them after ten minutes.” (Nancy, interview, 3/05). Similarly, Emily attempted a class discussion and found it surprisingly successful:

> While teaching the lesson, I had a really great time! I love to hear what students think and feel and I am often impressed by the ideas they are able to develop on their own. Even students who may not do well on traditional content quizzes often make great contributions to discussion. (Emily, written reflection, 5/05)

Finally, Henry transitioned from seeing himself as the person who needed to be the expert and answer student questions to forcing students to think for themselves as a result of his teaching experiences:

> I have found that many students ask question that they already know the answers to. The problem is that they are not able to organize their thoughts (make connections to past materials) or are afraid to commit to a particular way of thinking (fear of being wrong). It is a dangerous habit to answer questions for students without making them think for themselves. (Henry, written reflection, 5/05)

Vicarious Experiences

Vicarious experiences mainly came from experiences that participants had as students in high school and in higher education. Good and bad teachers both had impacts: “These people have definitely affected my beliefs regarding teaching because I have been provided with positive and negative examples." (Lucy, written reflection, 10/04). Emily agreed:

> After thinking about these teachers, I have realized what a profound affect the successful ones have had on my education and my beliefs about what constitutes a good teacher. I hope to emulate the teaching philosophies shared by my two favorite teachers. They challenged us, were creative, and were very knowledgeable in their content. They also made a very important effort to develop our thinking and reasoning skills.
>
> The unsuccessful teachers have also helped me to form some ideas about teaching. They have demonstrated how difficult being a good teacher can be. Also they have motivated me to keep the class interesting, but also to have enough structure that the students know what is expected of them. I also have learned how important some of the little things are. For example, I hope to provide rapid feedback on tests, and to avoid excessive rote memorization and note copying. (Emily, written reflection, 10/04)

Others identified mainly good teachers making impacts on beliefs: "I would like to believe that I am similar to [my favorite former teachers] in the fact that I love to teach interactive lessons…These teachers have made me realize just how essential engaging your students is." (Raina, written reflection, 10/04).

Some participants were familiar with constructivist teaching methods through their laboratory work as undergraduates: "I knew inquiry-based learning because that's what we did in a lot of our undergrad stuff, in science classes. Like, they'd say, today in lab, you're going to learn about mussels, so here's a battery, and teach yourself something about it." (Lucy, interview, 2/05). Lucy noted that this experience with inquiry as a student had encouraged her to use inquiry in her own teaching. Similarly, Tom had learned much of his knowledge about chemistry through a chemical engineering internship. This experience convinced him that learning by doing was the best way to teach.

Finally, a number of participants noted the impact of observing their mentor teachers or other teachers in action. When asked what impacted his beliefs about teaching and learning, Aaron noted: “I think most of it came from field experiences in terms of observing what other teachers do and how my mentor teachers created their environments.” (Aaron, interview, 2/05). Along the same lines, Dan noted the influence of teachers he had observed:

> When I look at the folks I’ve met in the last year that I’ve been most impressed with as science teachers, to model myself towards, have been the ones that have some ability to influence their environment and bring in enrichment opportunities that someone else might not be able to put together. (Dan, interview, 6/06)

Ingrid experienced the opposite with her spring mentor teacher, who insisted that students complete guided notes and long multiple-choice tests. After being confronted with a mentor whose beliefs were in opposition to her own, Ingrid became even more adamant about her own beliefs about teaching.

Theoretical Knowledge Obtained

Some of the participants in this study adamantly insisted that what they learned in their coursework about theories of learning made no impact on their beliefs about teaching. Participants with these views tended to emphasize the disconnect between what they learned in coursework (which was termed by Henry as “too metaphysical”) and what they experienced in their classroom teaching.

> I don’t think that most of those techniques really work in the real world. I think it’s been very useful in passing Praxis, but as far as changing the way that I think about teaching and learning in my own personal teaching, I don’t think it’s really changed that much. (Raina, interview, 3/05)

> Oh, classes have done almost zero for me. It’s all been in the classroom…Classes haven’t done much at all. I seriously think we could cram the program down into nine weeks and save everyone the trouble. (Josh, interview, 3/05)

> I read a lot of stuff that was interesting, but would I ever actually stop in my classroom and say, I have this classroom management issue so let me whop out my copy of whatever and give this kid a time out?…It’s great in theory and it probably works great with some kids, but I think in practice you just have to find what works. (Raina, interview, 6/05)

Other preservice teachers were simply skeptical of what they learned: “To answer your question, no. I won’t use that stuff in the preparation or execution of daily teaching…I look at psychology as a pseudo-science of individuals who have taken the common sense and made difficult language.” (Dan, interview, 3/06).

On the other hand, many participants admitted that their coursework had changed the way they thought about themselves as teachers. Nancy noted the particularly important influence of her educational psychology and reading across the curriculum courses, because they transformed the way she thought about student learning and therefore her own teaching. For Dan, learning what good teaching consisted of led him to critically re-evaluate his own chemistry teacher from high school, with the result that he developed a vision of himself as teacher in opposition to this person. For Aaron, Henry, and Lucy, understanding some of the theory of how students learn helped them substantiate previous beliefs about what was good teaching:

> I certainly had an intuitive idea that classrooms in which there's a lot of discussion and group work and hands on activities were better classrooms to be in as a learner than the sort of sit and taking boring notes off the chalkboard type of classrooms. But if you were to ask me to articulate why that is before the program, I'm not sure I could have done that. And I think if I were to answer that now, it would involve kind of the theory behind it, which comes out of the coursework. (Aaron, interview, 6/05)

And for Tom, coursework provided him with a framework of ideas to implement in the classroom, as well as a "scientific way" to approach and improve his teaching.

Interestingly, knowledge of theory seemed to significantly impact some of the preservice teachers only after they had some time and experience with which to utilize that theory. Henry recalls his experience learning about educational theorist Jerome Bruner:

> For the longest time I was so confused with what he said, and it maybe didn't click until about a month ago. The whole thing that people already know everything, and that's just a matter of putting it into a new framework—I'm sorry, I mean a new order. I was like, how the hell is that possible, for them to know everything. But I think that's really the best way to teach something to someone, is if they're already familiar with it—it's not necessary that they already know it, they just already have a framework to put it into. (Henry, interview, 6/05)

Ingrid and Anna expressed similar feelings toward learning theory in a vacuum, but then later seeing how it played out in her own classrooms: "They told you in the fall, and you're like, yeah, I know that. But you don't really until you see it." (Ingrid, interview, 6/05).

Two participants expressed that coursework had not significantly changed their beliefs because they did not feel there were enough applications of theory embedded in the courses. Consequently one of them pursued additional knowledge outside of her coursework, and the information she obtained through reading books and attending conferences did make an important impact on her beliefs:

> In terms of the program itself, the things we do, the projects and the class work and the time, I feel like that hasn't really changed me at all, and I haven't really learned anything….it's more strategy and tips rather than changing how I think about teaching. And so in terms of on my own, going to [Science Education Council of Ohio conference] and reading some books—like, I came across this book on teaching inquiry through questioning, like how to question, so I'm actually learning how to question rather than like in the program, you need to question but they don't explain how to do these things. So I'm trying to find more about this stuff on my own and learn the techniques, which is more useful than learning these practices are good practices. (Alyssa, interview, 2/05)

In Alyssa's case, it seems likely that the combination of coursework and self-directed learning contributed to her orientation toward more constructivist/social constructivist beliefs. University coursework may have provided the initial impetus to change, whereas her independent reading and attending conferences actually influenced the change to occur.

Verbal Persuasion by Authority

Participants were increasingly susceptible to their mentor teachers' and other teachers' opinions about what should be their role as teachers. In some cases, others' opinions lead the preservice teachers toward the belief that their goal should be student understanding rather than "covering" content:

> After talking to my mentor and reflecting on progress so far, I decided to "get real". I may not be able to cover each topic in as much depth as I would like, but if I don't make it a point to discuss and review what we have learned, it will be a disservice to the students. (Emily, written reflection, 4/05)

Other preservice teachers took more specific ideas from their mentor teachers and other teachers, changing individual lessons to make them more student-centered: "As you can see from my initial lesson plan, on talking to my mentor, I decided to change the format of the game so that all student groups would participate." (Nancy, written reflection, 5/05).

Finally, some preservice teachers felt forced to take on their mentor teachers' focus on teacher-directed instruction. Rachel and Anna both felt somewhat stifled by their winter mentor teachers:

> A bunch of students were complaining that I gave lots of busywork, but it was in accordance with my mentor teacher, who I was walking a fine line between assigning work that she wants or—you kind of have to, there are these strong social cues. You don't want to wreck a relationship with your mentor teacher, you're connected to them and tied to them, there's their recommendation and stuff. (Anna, interview, 3/05)

Rachel agreed on the importance of being diplomatic as a field experience student: "You're in a way limited by your mentor teacher—you're in their turf, in their classroom, you don't want to step on anyone's toes." (Rachel, interview, 3/05).

Student Expectations

The importance of student receptivity or resistance to certain methods of teaching became important to many participants during the winter field experience. Students who were receptive to certain teaching methods helped preservice teachers to believe more strongly that those teaching methods were useful and that they would continue to utilize them. For example, Henry expressed concern at the beginning of the program that he would not be able to answer every students' questions, and so he was reluctant to relinquish time for students to ask questions of him. Student enthusiasm toward asking questions changed this belief, however: "I was always worried that the kids would ask me really off the wall questions…The kids there ask really great questions, and they don't let it drop until they get an answer, which is nice. I like that." (Henry, interview, 3/05). Similarly, Lucy noted that her students became significantly more receptive to learning biology content when she told stories in class:

> Because if I say: "Hey guys, I have a story to tell you", they'll actually stop talking for five minutes and listen to what I'm saying. But if I'm just up there saying "today we're going to talk about mitosis", then everybody's eyes glaze over, and they don't pay attention so much. (Lucy, interview, 2/05)

On the other hand, the majority of the preservice teachers noted the impact of resistance in shaping their beliefs about their role as a teacher. For several, encountering resistance resulted in focusing on how they could better extrinsically motivate students: "They were just very apathetic about it, no matter what I did. I guess sometimes they got excited. So that's the thing I really have to work on this quarter is finding ways to motivate students to want to learn." (Nancy, interview, 3/05). Others attempted more student-centered teaching methods and encountered enough resistance that they began to believe that expository methods were more appropriate: "I did a K-W-L and the kids didn't want to learn anything, like that was the answer, I don't want to learn anything. I thought if I gave them an opportunity to at least tell me what they wanted to learn, they might take a little more interest." (Emily, interview, 2/05). Tom and Rachel found that students at their placement schools were quite resistant to thinking for themselves, and preferred to be "spoon-fed" information:

> The kids at Columbus Public, the majority of the kids that I have are used to: you're going to give me this, and tell me what I need, and I'm going to spit back at you what you gave me. They're very used to, for lack of a better word, things being handed to them. And they don't have to do anything, they just give it back. (Tom, interview, 3/05)

As a result, he began to rely more on expository instructional techniques.

Additionally, several participants experienced student resistance to expository teaching methods. Anna and Nancy encountered student complaints about completing worksheets and other "busywork": "It is clear that the students are getting tired of these worksheets as I have heard comments like 'Oh, not another worksheet!', 'Why do we have to do so many of these things?'" (Nancy, written reflection, 4/05). Consequently, she believed that hands-on activities and student interaction were more valuable teaching tools. Similarly, Henry showed a video to his classes one day and was told by his students that it was boring and too long. He responded by changing his lesson plan for the future to include discussion and an activity instead of the video. Lucy's students encouraged her to adopt a more social constructivist orientation by continually questioning the meaning of what she had taught them: "And now I realize I need to provide more of a real life context to everything, because I had a whole class ask me: 'Why do I have to do this? This is stupid. What purpose does this have?'" (Lucy, interview, 6/05).

Personal Reflection

Two preservice teachers noted the influence of the reflection process on their beliefs about teaching. Dan and Tom both expressed that through written reflection as well as sharing their thoughts and experiences with other preservice teachers, they gained a better understanding of their own beliefs about teaching.

> Time and time again, we're asked to reflect on situational things, educational topics, hot topics, diversity, poverty, disability, gender, pop quizzes, you name it. At times, too much, because you get to the point of I really love this stuff but I'm just swimming in reflecting on everything that's going on. The whole reflection process, and sharing, and discussing, has been great. And it's been through that process that I think I have changed over this past year, in my viewpoint toward different things. (Dan, interview, 3/06)

Tom compared the process of reflecting on his own teaching and sharing with other preservice teachers to what he gained from formal university coursework: "As far as I'm concerned, we could all sit around a fireplace and drink hot chocolate and tell stories all night, and we'd get the same out of what I'm getting out of the classes." (Tom, interview, 2/06).

Pressures Outside the Classroom

Pressures outside the classroom came from a variety of sources, but mainly the pressure to prepare students for standardized tests and pressure from parents of students. One participant noted that parent involvement could limit the freedom of a teacher to teach in a more student-centered manner:

> If parents care that much about their lawns and how they look when they show up for school, you can guarantee that those kids better be getting the best education their property taxes can afford. For this reason, a lot of parents are in contact via email with teachers to check up on their kids. I think letting kids do their own thing at their own pace is sometimes a good thing, so sometimes this is intrusive on behalf of a student who does well but does it differently." (Lucy, written reflection, 10/04)

Another participant (also in a suburban school district) stated that parental pressure encourages teachers to push students hard academically but also to treat them as individuals:

> Because the parents are so involved and because of the high socioeconomic of the community, there exists a high level of expectation for teachers…They are expected to bend over backwards to get students "back on track."…On the other

> hand, the intensity or difficulty level of the curriculum appears to be rarely questioned. It almost seems that the more challenging the better because the community values education. (Alyssa, written reflection, 10/04)

One preservice teacher noted the influence that school administration has on teaching, as well:

> It totally changes how you teach and classroom management, because again, you have to have the classroom management before you have the effective teaching. But if the administration isn't supporting the classroom management, you're not going to get to the effective teaching, so you're not going to get to the student performance. (Alyssa, 2/25)

Finally, the preservice teachers complained frequently about the pressure to prepare students for standardized tests, particularly the Ohio Graduation Test (OGT), and to cover content standards: "I've got to teach to the OGT, I've got to teach this chapter, I've got to get them through this specific content." (Dan, interview, 3/06). Many noted how the large amount of content that students needed to know prevented the preservice teachers from utilizing anything but expository teaching techniques: "Kids can't discover everything. With all the standards there are to cover, there's not enough time." (Raina, interview, 6/05). "I try to promote student-centered learning and hands-on discover but given the circumstances and the situations that I've been in, it's not always the case. Due to like the OGT and the amount of information you have to go through." (Anna, interview, 3/06). None of the preservice teachers who mentioned the influence of standardized testing noted that the OGT promoted inquiry learning—they all perceived the exam as testing content knowledge rather than thinking skills. In fact, after describing his ideal teaching scenario, which was highly student-centered, collaborative, and based in real-life activities, Dan pointed out:

> I'm laughing because those opportunities that I've described I think are awesome, but at some point there's a certain amount of knowledge and rote learning and preparation for next year that everyone has to do. And everything can't be fun, and everything can't be unique, and everything can't be expensive, and everything can't involve what I just described. There's a point where you have to prepare folks for next year. (Dan, interview, 6/06)

Changes Over Time

Little change took place among many of these influences; most notably, the impact of direct teaching experiences and theoretical knowledge remained relatively constant throughout the year. Vicarious experiences appeared to decrease in importance as a function of time, as participants were more engaged in their own teaching and less in observing the teaching of others. The impact of verbal persuasion became more significant with time, on the other hand, as participants were impacted by mentor teachers' advice about how to teach. The importance of personal reflection appeared to be most influential at the midpoint of the year, when the preservice teachers were engaged in both coursework and teaching simultaneously. Similarly, student expectations appeared much more important to the preservice teachers after their winter field experiences, in which they, for the first time, were engaged in teaching the same class for six weeks. Finally, pressures outside the classroom also became more influential over time, peaking—not surprisingly—during the period of time that many were preparing their students for the Ohio Graduation Test. The proportion of participants noting the influence of each of the six categories at the beginning, middle, and end of the year may be found in Table 5.8.

Category	Percentage of sub-sample noting influence of each factor Beginning of Program	Middle of Program	End of Program
Direct experience teaching	83%	100%	100%
Vicarious experiences	78%	61%	42%
Theoretical knowledge obtained	61%	46%	58%
Verbal persuasion	17%	31%	33%
Student expectations	0%	69%	33%
Personal reflection	0%	15%	0%
Pressures outside classroom	0%	31%	25%
Total number of participants	13	13	12

Table 5.8: Factors influencing changes in preservice teacher beliefs about the role of the teacher

Summary

In general, while knowledge of theory, pressures outside the classroom, student expectations, personal reflection, vicarious experiences, and verbal persuasive experiences influenced the preservice teachers during their teacher preparation program, direct teaching experiences clearly made the most significant impact on beliefs about their roles as teachers. Many predicted that only through experience would they gain a real understanding of what types of instructional methods would be effective. As Nancy anticipated her first year as a professional teacher: “I think that’s going to be a learning curve for me going out and starting teaching, because obviously it’ll take a few years for me to figure out what's going to work and what's not going to work." (Nancy, interview, 6/05). Raina put it most succinctly: "I think in practice you just have to find what works." (Raina, interview, 6/05).

Synopsis

Beliefs about characteristics of effective teachers fell into five main categories: knowledge of content, knowledge of teaching, knowledge of students, external influences, and personal characteristics. Personal characteristics accounted for the majority of preservice teacher beliefs about what made for an effective teacher, with knowledge of content and knowledge of teaching accounting for the next highest proportion. Beliefs about effective teachers shifted during the year, as well. While the proportion of characteristics that fell into the personal characteristics category did not change during the year, the preservice teachers appeared to change from focusing on characteristics of effective scientists to characteristics of effective teachers. There was oppositional changes in the proportions of characteristics that fell into the knowledge of content and knowledge of student categories, as well—preservice teachers felt that content knowledge was less important and knowledge of students was more important between the beginning and end of the program. Additionally, while preservice teachers at the beginning of the teacher preparation program believed strongly that possessing a solid foundation of content knowledge was a key characteristic in all successful science teachers because it allowed them to pass along the content with more ease, by the end of the program these same teachers felt that content knowledge was important because it provided them more strategies to help students learn the material and to make it meaningful to the students. Finally, external influences were only mentioned by preservice teachers at the end of their spring student teaching experience.

Most preservice teachers in this study underwent a change in belief about their roles as teachers, from more traditional expository beliefs to constructivist and social constructivist beliefs. This general trend is not unexpected, as the teacher preparation program intended to promote constructivist teaching and learning. Teaching practices of participants in the sub-sample developed in the opposite direction as beliefs, progressing from more constructivist practices at the beginning of the teacher preparation program to more expository practices by the end of the program. Teaching practices of participants in the full cohort, as measured by the RTOP, did not grow either more or less constructivist over time. Notably, preservice teachers at suburban schools used significantly more constructivist teaching strategies in all categories than did preservice teachers at urban schools. Preservice teachers at high schools more frequently demonstrated the constructivist teaching categories of procedural knowledge and communicative interactions, and generally scored higher on the RTOP than did preservice teachers at middle schools.

Seven major categories of change instigators emerged from the data: direct teaching experiences, pressures outside the classroom, student expectations, theoretical knowledge obtained, vicarious experiences, personal reflection, and verbal persuasive experiences. Direct teaching experiences made by far the greatest impact on participants' beliefs about the role of the teacher. A conceptual change process appeared to be responsible for some of these changes in beliefs. Typically, participants attempted to teach in traditional, expository ways, and were unexpectedly met with low levels of student learning. As a result, they considered whether other models of teaching and learning would work better. Some participants, when strongly encouraged to venture into constructivist methodologies, had surprisingly positive experiences with constructivist teaching. Several participants had negative experiences with constructivist teaching, as well, and that unexpected result tended to result in those preservice teachers considering more teacher-structured class time. Only one participant admitted to relying on her experiences as a student in determining what type of teaching she wished to utilize.

Unexpected student resistance may have also contributed to conceptual change in some participants, particularly in cases where the preservice teachers strongly expected students to react positively to an instructional strategy but instead where students complained or even refused to participate.

University coursework impacted some participants, particularly those who were able to connect the knowledge they learned in courses with their teaching experiences. Alternately, many of the preservice teachers in this study thought they were not impacted by teacher education coursework at all due to the perceived mismatch between the university's priorities and what they encountered in their field experience classrooms.

Some participants also mentioned modeling of teaching by their previous teachers and by their mentor teachers as vicarious experiences that encouraged them to try either constructivist or expository methods in their own classrooms. Similarly, verbal persuasion by authority figures often came in the form of mentor teachers attempting to persuade the preservice teachers to teach in more expository ways, in order to cover material more quickly. The preservice teachers often struggled to deal with competing pressures to try more constructivist methods (coming from the university) and to use strictly expository methods (coming from the mentor teacher). Most eventually decided that it was more important to appease their mentor teachers than their university supervisors.

Two participants noted the impact of personal reflection and sharing with others as instigators to change their beliefs about teaching and learning. This suggests a deeper cognitive processing, which may have allowed for more significant and lasting change, as proposed in the dual-change model of beliefs.

Finally, pressures outside the classroom, such as the need to prepare students for standardized testing and expectations of parents, appeared to impact participants' beliefs and practices by the midpoint of the teacher preparation program, when they were more fully engaged in the life of the school in which they were placed. Specifically, the preservice teachers felt pressured to "cover" content quickly, which they perceived could be done most efficiently through expository methods such as lecturing and note-taking.

CHAPTER 6

FINDINGS: BELIEFS ABOUT STUDENTS

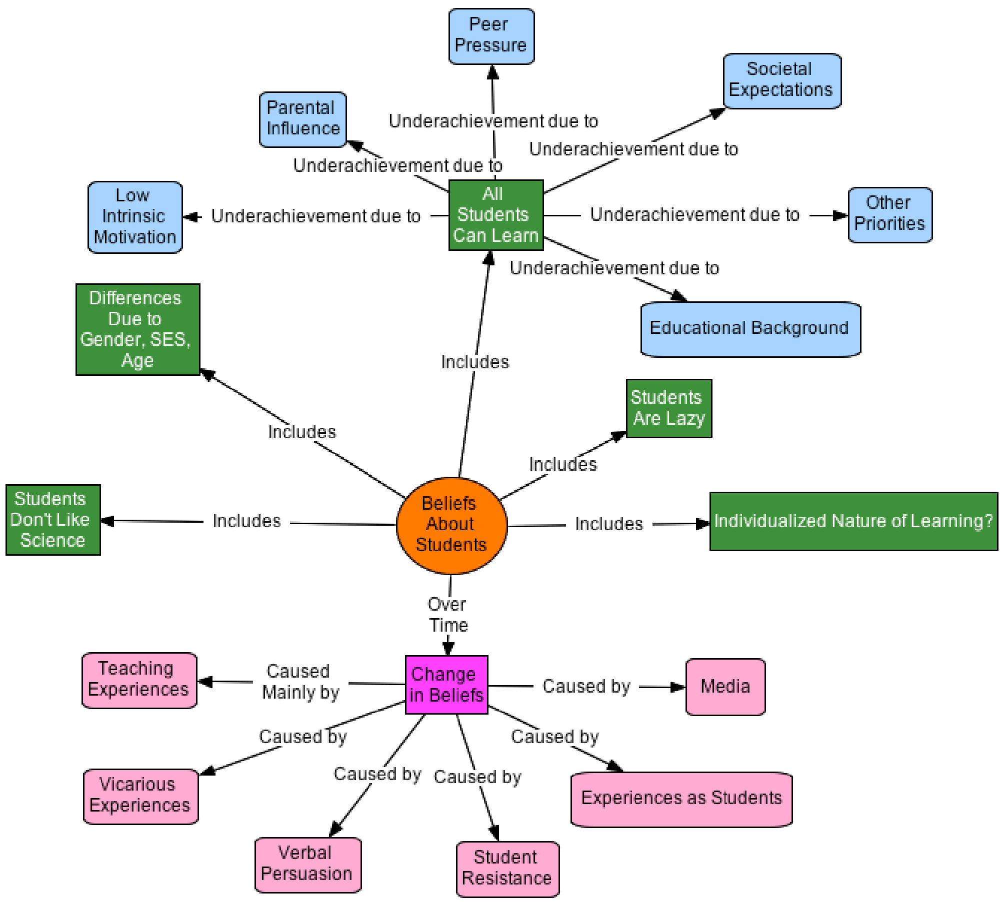

Figure 6.1: Map of beliefs about students and changes in beliefs about students

Beliefs About Students

Participants in this study were asked at various times during the teacher preparation program to discuss what they believed about students; in particular, participants discussed and wrote about why students perform well or not so well in their science classes. Several themes came to light. First, participants generally believed that all students were able to learn, and that differences in student performances were due to factors aside from innate intelligence. Second, participants believed that students were intrinsically lazy. Third, participants believed that students would not naturally like science, specifically, and/or that they would feel that science was difficult to learn. Fourth, participants noted differences in students based on gender, socioeconomic status, and age. Fifth, some participants emphasized the individual nature of student learning, while some tended to believe that all students need the same instructional strategies. Few systematic changes in these beliefs were noted during the course of the teacher preparation program, but some individual teachers did develop certain understandings about students during the year. Additionally, some beliefs tended to surface when preservice teachers taught at schools in which their were large numbers of urban versus suburban students or at middle versus high schools.

All Students Can Learn

Every preservice teacher but one in the sub-sample emphasized his/her belief that every student could learn in school; however, they all admitted that some students do not achieve in school, and attributed these lower performances to a variety of factors. These factors included parental influence, peer pressure, societal expectations, educational background, priorities of other parts of student lives such as athletics, jobs, and taking care of family members, and intrinsic student motivation. Aside from student motivation (over which participants disagreed about how much influence they had), all of these factors were outside of the preservice teachers' control. The one participant who did not think that all students could learn believed strongly that students needed to be internally motivated in order to learn, and if that motivation was not present, that learning would not follow.

Parental influence was named by ten of the thirteen preservice teachers in the sub-sample as making a significant impact on how students performed in their classes. According to participants, if parents were uneducated, they did not value education for their children; as a result, their children did not engage or achieve in school:

> There were kids there in some of the classes that I taught that just didn't care, who just weren't interested—they weren't interested in education at all. And it's very difficult to reach those kids, particularly if they don't have parents who are interested in education. And there were several kids at [the school where I student taught] who came from bad family life, so they didn't see the necessity to get an education. Whereas if they had parents behind them who would push them and tell them how important it is, like we tell our kids, it would help so much." (Nancy, interview, 6/05)

> At [my first field placement school], it was difficult to communicate with parents. In fact, our team of 90 students had an open house and only two sets of parents showed up! I was shocked by this. In some cases it is that the parents have not made their child's education a priority. (Emily, written reflection, 2/05).

Similarly, Dan noted that his own influence as a teacher would be limited based on what his students' parents provided: "I know that the ability of someone to learn in a classroom environment has as much to do with what's going on inside the classroom as what's going on outside the classroom." (Dan, interview, 7/05). Many of the preservice teachers specifically noted differences in parental involvement between urban and suburban school districts: "Right now, there really is no motivation problems with my students. It's parents. All of our grades are put online, so parents can check their grades at any time. So if little Billy does that on his exam, they come down on him….Now if I was at [a Columbus Public School], that's different." (Henry, interview, 3/05). Furthermore, the preservice teachers only noted the problems of parental influence (or lack thereof) in the context of their field experience at an urban school or by way of a comparison between an urban and suburban school. Thus, they perceived that students at urban schools had parents who did not value education and who did not help their children engage in formal schooling.

Peer pressure was named by five participants as impacting student performances in their classes. Participants perceived that peer pressure occurred at both suburban and urban schools, and was visible throughout middle and high school. Lucy put it most poetically:

> I think remembering the stresses that adolescents are under will help me understand the bizarre courting behavior and promiscuously inappropriate clothing we all remember and love. If you can get past the glitter gel, fake confidence, and cologne there exists thirsty and anxious people that want help and guidance but can't ask for it without committing social suicide. (Lucy, written reflection, 10/04)

Four of these five preservice teachers noted that being smart was not socially accepted in their schools; therefore, students underachieved academically to gain “cultural capital” (Bourdieu, 1977) within their social circles. The fifth preservice teacher found that student attitudes toward school varied wildly depending on what else had happened during the day, but that when a few students had a negative or positive attitude, it got adopted by the rest of his classes:

> I would almost say that the kids in our school, and the kids I have in particular, they’re kind of clique-y. It’s almost how that group of kids is doing on that particular day. If the kids are having a good day, regardless of what I have planned, it’ll be a good lesson. If the kids are upset, looking for a fight because administrators have started coming down on people—it just kind of depends on where everyone is. (Tom, interview, 2/06)

Societal expectations were named by two of the preservice teachers as impacting their students’ performances. In this case, both occurrences were at urban high schools. “I’ll discuss the students first. They are not generally college-bound and thus have been conditioned to think this means they don’t need an education.” (Lucy, written reflection, 2/05). Lucy felt that the sum of low school and societal expectations lead her students to disregard formal education. Alyssa agreed, noting that many of her students commented frequently about dropping out of school because they felt it did not meet their needs.

Educational background was named by six of the preservice teachers as impacting their students’ science achievement. In particular, Raina and Lucy noted the impact of students lacking math skills that were essential for understanding science: “Some kids will underachieve because there's a lot of math. And a lot of kids struggle with math, and they lack that background knowledge that they need." (Raina, interview, 6/05). Anna and Dan both described students lacking actual science background knowledge. Anna blamed students for lacking effort in previous science courses, whereas Dan thought the blame fell on the educational system as a whole for licensing elementary school teachers who have little science content knowledge:

> I think that any knowledge that any of us have has been a journey of building blocks from a young age, and I think at times the foundation which is established in the younger years toward science, with elementary school teachers that have very minimal if any knowledge have science, has a negative impact. (Dan, interview, 6/06)

Henry and Tom were concerned with the lack of basic critical thinking and self-regulation skills that many of their students possessed: "You can't expect a kid to take good notes on an experiment if they don't even know how to make observations. To me, that's just making observations is so easy, but kids don't even know the difference between making observations and inferences." (Henry, interview, 6/05). As Henry, pointed out, kids who fell behind because they were lacking these basic skills were often labeled "stupid"; consequently, they exerted less effort and fell further behind. Tom found that his students had grown so used to and skilled at regurgitating knowledge that they were unable to think for themselves and regulate their understanding of content learned.

Commitments outside of school took priority for many students, according to preservice teachers in this study. Depending on the commitment, students of different ages and socioeconomic levels were affected differently. Preservice teachers generally did not notice the impact of these commitments until the spring student teaching experience. Jobs and athletics were perceived as commitments that mainly (but not exclusively) affected students at suburban schools, while needing to care for family members and deal with neighborhood violence were commitments that only affected students at urban schools. Emily summed up some of the impacts on her students' performance at a suburban high school: "A lot of kids can do better, they just don't care. They don't care about science, they don't care about school. They care about other things more….High school was really rough with that because a lot of kids had jobs…Sports, too." (Emily, interview, 5/05). Aaron summed up the variety of impacts on his students' performance at an urban middle school:

> They had so much other stuff going on outside of school—parents didn't care about school, a lot of them were from single parent families so they were supporting younger siblings or they were doing other things…Our students came into school upset because their house had been broken into for the sixth time this year. I had students whose parents and brothers and sisters had been killed within the last year. (Aaron, interview, 6/05)

Intrinsic student motivation was named by almost every preservice teacher in this study as impacting student achievement in school. Many participants noted that teachers could impact student motivation to a limited extent due to factors such as parental influence, peer and societal expectations, and commitments outside of school, as mentioned previously. Some participants expressed their beliefs, however, that students could be motivated by carefully selecting teaching methods that would be interesting and engaging for them. Two methods emerged as useful for motivating students of participants in this study, that contrasted quite sharply in orientation: entertaining students, and using meaningful, real-life examples and experiences. Each method was preferred by given preservice teachers, but did not seem to relate to the type of school in which they were teaching. Lucy explained her rationale for entertaining her students to motivate them:

> I have to entertain them more to get them interested, more than I thought I would…there's a reliance of kids on electronic stuff—they need to be constantly stimulated. You can't just have them sit down and read something, unless it's full of like glossy pictures and interactive doodlings to do, because they can't do anything by themselves. They have to be constantly entertained. (Lucy, interview, 6/05)

Other preservice teachers said that students could be motivated, even in spite of some of the issues discussed previously, by making the content more meaningful to them:

> They can't see the relevance to their life. They know that they're not interested in science, they know that's not the job that they want to do, is not science-related. So that's why it's really important to connect what you're doing to their lives, real life things. I think that's pretty much because they can't see the relevance. (Ingrid, interview, 6/05)

By showing students how the content and their daily lives intersected, then, the preservice teachers expected that students would grow motivated to learn the content.

Several of the preservice teachers also noted that they could get students to perform in classes by tricking them or manipulating them. Josh mentioned that developing an ability to "manipulate the kids to do what you want" (Josh, interview, 3/05) was one of the major things he had learned was important in teaching. Alyssa explained more specifically how she "tricked" her students into learning the content:

> Alyssa: You can kind of trick them into learning.
> Interviewer: How would you do that?
> Alyssa: Through different activities, kind of game kind of things, or I did this review thing where people think they're just reading questions and even if they don't realize it, they're picking up little facts as they go. (Alyssa, interview, 2/05)

In sum, participants emphasized their beliefs that all students could learn in school. They attributed students underachievement to a variety of factors, including parental influence, peer pressure, societal expectations, educational background, priorities of other parts of student lives such as athletics, jobs, and taking care of family members, and intrinsic student motivation. As is clear from the above results and quotations, preservice teachers who attributed student underachievement to factors beyond their students' control tended to be more sympathetic towards their students, whereas the notion that students are lazy, which follows, resulted in less sympathy, and more frustration and anger towards students.

Students are Intrinsically Lazy

Beyond believing that some students lack in motivation, due to a variety of factors, several of the preservice teachers in this study remarked that students were inherently lazy. In the words of two participants: "students just aren't that motivated to learn by themselves." (Ingrid, interview, 8/04) and "Kids are lazy." (Lucy, interview, 6/05). The belief that students were lazy did not seem to depend on the age or socioeconomic status of the school in which the preservice teachers were placed, but did vary by preservice teacher—some participants mentioned student laziness as a factor, whereas others did not. For example, Ingrid and Aaron began the year with the belief that students are inherently lazy, but both developed the understanding as the year progressed that other factors impacted student motivation, and that student laziness was due to actions of the teacher as well as external factors. On the other hand, Tom did not specifically mention student laziness until his winter teaching experience, but this belief became a strong part of his identity as a teacher. He recognized that students at his school were lazy and so defined himself as the teacher who was approachable due to not requiring students to work when they came to him for help:

> With kids in the school, they think these are the good teachers that they like spending time with and these are the teachers I really don't like, that make me work, and if I go to them they're just going to tell me to do something, they're not going to give me the answer. I've been trying, and with most of the kids—they at least feel like I'm approachable. They're not like, that's Mr. Smith's corner of the building, and if he sees you he'll make you work. (Tom, interview, 2/06)

Nancy, Lucy, Emily, Alyssa, and Henry did not mention student laziness until the spring student teaching experience, but at that point all felt that students try to get away with the easiest possible path. After being faced with students who refused to think through class activities and homework assignments on their own, Emily reflected: "What I have realized is that my students are extremely needy and are not used to doing much on their own. While I really enjoy my students, it is really disheartening to see how lazy they can be and how unwilling they are to take responsibility for themselves." (Emily, written reflection, 4/05). Alyssa and Henry both had confrontations with students who had performed poorly on tests or assignments because they had been too "lazy" to do well the first time, and who wanted a second chance.

Students Don't Like Science

Many of the preservice teachers noted an issue that was specific to the field of science: Students don't like and/or are afraid of science. This issue did not appear to vary based on age or socioeconomic level, but differences between boys and girls were noted. Alyssa, Raina, and Henry noted the impact of the societal stereotype that science is hard and scientists are socially awkward geniuses. Alyssa explained her experience handing back quizzes and encountering student surprise at earning good grades on the assessment: "they said 'science quiz', they had this association that they would do bad in science. Therefore, they shouldn't like it or something. I think that's a big problem." (Alyssa, interview, 5/05). Raina, Henry, and Dan focused on the influence of the classical image of the scientist: "As a science teacher, you are going to encounter a lot of students who come into your classroom with the attitude that they hate science. There is a very negative image of scientists in a lot of students' minds." (Raina, written reflection, 11/04). Dan was more specific: "Science is hard, it's boys, it's boring, science is only if you're going to be an engineer." (Dan, interview, 3/05). Raina also compared student dislike of science to prior experiences in math classes, in which they felt learning the content had little relevance to their lives: "Everyone always says 'I hate math, when am I ever going to use it?" so I think for a lot of kids, they feel the same way about science." (Raina, interview, 3/05).

Rachel, Anna, and Tom focused on specific—and for some students, difficult and dull— skills and methods that are used in science. In particular, Rachel and Anna explained that science is hard for some students because of its abstract nature: "I think that it might be hard for some students to understand some concepts because they might have a difficult time visualizing it when they can't see it, they can't touch it." (Rachel, interview, 5/06). Tom compared science for some students with washing dishes, as a chore that gets completed but with little enthusiasm or interest, while other students find it intrinsically fun and exciting: "Some people are just—it's in the spirit, it makes them very happy to think scientifically, to do things scientifically…And on the other hand, some people really just don't like science." (Tom, interview, 6/06).

Some Types of Students Are More/Less Successful

A few participants initially possessed or developed the idea that certain groups of students have strengths over other groups of students. In particular, the preservice teachers identified differences in students between middle schools versus high schools, urban schools versus surburan schools, and girls versus boys.

Initially, Nancy, Raina, and Alyssa believed that high school students would be easier to teach because they had more self-control and would pay attention better, whereas middle school students would be more dominated by hormonal shifts and so less easy to manage. After the first field experience, however, Nancy and Alyssa both developed the belief that middle school students would be easier to motivate, engage, and influence than high school students because of their younger, more impressionable age. Nancy made the comparison: "I'm back to middle school, and they're a bit easier, they're more amenable, they're much more enthusiastic, they're much more willing to participate than high schoolers. High schoolers don't want to be seen as different from their peers." (Nancy, interview, 3/05). Lucy and Henry both began the year with the belief that younger students were more easily taught science. Henry explained that kids lack a lot of basic knowledge, so having the opportunity to build that base would allow his teaching to have a greater impact for his students later in life. Lucy, on the other hand, made a comment similar to Nancy's above, in which she expressed her belief that middle school students would be more volunteering and more interested in class participation.

No participants identified differences between urban and suburban school students at the beginning of the teacher preparation program, but participants frequently noted differences between their urban and suburban field placement students once they had been in schools for a few months. In general, the academic and behavioral expectations of the preservice teachers were lower for students from urban schools, independent of age level of the students. Lucy compared her experiences teaching students at an urban high school and students at a suburban middle school, and found students from the urban school lacking:

> The seventh graders I worked with last quarter, they write well, I could have them write a paragraph and they would actually write me a paragraph with at least five

> sentences in it. Decent grammar and punctuation, you know, maybe not perfect. I would guess I was thinking that by the time they got into tenth grade, they would at least stayed the same, but it's a totally different batch of kids in a different school system, and it's just not there. (Lucy, interview, 2/05)

Dan explained that expectations for kids at urban versus suburban schools were just completely different: "Getting knowledge is not the number one priority in an urban middle school. It's not. Making positive humans, so providing a safe environment where you find a way to influence them positively—character, self-control, community-related awareness, and that sort of things—that's a different ballywag." (Dan, interview, 6/06). Josh described an experience coming up with an impromptu lesson working with computers at a suburban school, which he believed would not have worked well with students at an urban school because of misbehavior: "I know at [an urban school], if I was doing the same thing, I'd have at least a few kids in the back screwing around. I wouldn't have trusted them as much to handle any computer parts that I brought out because they'd be more likely to be lost or damaged." (Josh, interview, 3/05). After attempting to teach a chemistry class at an urban high school in a more inquiry-based style during his first field experience, Tom came to the realization that these students actually needed more structure than what he expected, and that they could not handle the "freeform thinking" (Tom, interview, 7/05) he asked of them. Conversely, expectations were higher for students at suburban schools. Emily compared her fall field experience at an urban middle school to her winter field experience at a suburban high school: "the students at [suburban district] are also a lot more goal-oriented and seem to have a better probability of future academic success." (Emily, written reflection, 2/05). Hence, Emily held her suburban students to a higher standard than she did her urban students.

Finally, many participants noticed differences between girls and boys of all ages in their classes. In general, girls were thought to be more well-behaved, more organized, and more conscientious, but less naturally capable in science and math. Nancy, Raina, Lucy, Emily, and Alyssa all noticed that girls were easier to teach because of their better behavior, organization, and work ethic. Alyssa pointed out that boys in her middle school classes were just as smart as the girls, but lacked the organizational skills to get their work done and turned in:

> I've noticed the boys in middle school tend to really struggle in science not with the labs and doing stuff because they always want to do stuff because they are that age, but they really struggle with the paperwork part. They just don't want to have to write something down or turn it in. They know it but they don't want to do it. (Alyssa, interview, 5/05).

Nancy noticed that girls listened well in her class and exhibited less distracting behavior, while boys tended to participate (even when they did not know the answers) and get involved more, but also were more often off-task: "The girls seem to listen to the teacher better than the boys although when the teacher asks questions they do not volunteer to answer them." (Nancy, written reflection, 11/04). Similarly, Lucy found that boys and girls focused on different aspects of doing science in her classes:

> In terms of gender, the girls tend to participate in a more verbal fashion to demonstrate that they are engaged in classroom discussion. When they ask questions, they are of a more factual type. The girls are more likely to ask for

> something to be repeated or clarified in different language. The boys, on the other hand, like to jump in and ask a lot of extension-type hypothetical questions. For example, most of their questions start out with "what if" statements. (Lucy, written reflection, 1/05)

In general, girls were viewed as better students in terms of behavior, work ethic, and "doing school", but boys were viewed as more naturally capable and truly engaged. These differences were visible to preservice teachers at both middle and high schools and in lower-income and higher-income school placements. Interestingly, the two preservice teachers who initially expressed the most appreciation for student differences and interest in empowering underrepresented students in science—Lucy and Nancy—both developed stereotyped ideas about how gender and socioeconomic status impacted their students' learning. This finding is in direct opposition to previous research that found preservice teachers possessing a commitment to social justice issues also possessed more positive beliefs about the capabilities of all learners (Garmon, 2004).

Students Learn Differently?

Eleven preservice teachers in the sub-sample explored their beliefs on whether there are individual learning differences between students, or if "kids are kids" and what works for one in terms of teaching strategies should work for all of them. While the majority of the preservice teachers hung onto their belief throughout the year, two of them expressed contradictory beliefs with respect to student learning differences.

The overwhelming majority (nine) of the preservice teachers in the sub-sample articulated the idea that students learn differently and they, therefore, must teach individual students rather than focusing on the whole group. Nancy explained her ideas about individual student learning: “I don’t think they’ll all learn at the same rate, no, so I’m going to have to make sure I have different approaches for different levels of kids.” (Nancy, interview, 7/04). Similarly, several preservice teachers spoke of assessing students according to their individual levels and potentials:

> I think to be successful you need to take them beyond what they already know, so regardless of what their initial intelligence of knowledge is, you’re only successful if you expand it. Whether you’re taking someone who’s already really high to even higher levels or someone who’s low to more moderate levels. (Aaron, interview, 2/05)

It is perhaps notable that even though such a large majority of preservice teachers in this study expressed the need to focus on student learning differences, very few of them described actual ways in which they had adapted classroom instruction to meet individual student needs. Of those who did describe their adaptations for particular students, this was almost always in response to student disability—either physical or mental—rather than for “normal” student differences in their classrooms.

This tendency is perhaps most notable when looking more in depth at one of the preservice teachers who simultaneously expressed the beliefs that students have individual learning needs and that all students should be taught the same. When dealing with her inclusion classes, Raina was patient and willing to examine individual reasons for misbehavior and underachievement:

> In my inclusion classes, the challenge will be reaching every student through a variety of instructional methods. My inclusion students vary greatly in disability and in what kind of assistance they need. I have students with everything from ADHD to severe emotional disturbance. Each student is a unique individual who will require unique instructional methods. I will have to work to vary the means of instruction that I use in order to reach every student. (Raina, written reflection, 4/05)

Yet with her classes of "normal" students, she was quick to group and label them, rather than focusing on how personal differences might account for misbehavior: "…all a few fries short of a Happy Meal. They are ridiculously rude and disrespectful…I try the silent treatment, they don't get it. I yell, they don't get it." (Raina, written reflection, 4/05).

Last, Henry possessed a rather complex understanding of individual student differences. Early in the M.Ed. program, Henry latched onto a specific instructional style—kinesthetic learning—which he felt was good for every student, including those with special learning and physical needs:

> Kinesthetic is the best way to teach these kids. (Henry, interview, 8/04)
>
> Henry: It was so evident that big things, where they're active, they learned so much better and they understood it more.
> Interviewer: Did you run into any kids who did better the other way?
> Henry. No, absolutely none. (Henry, interview, 3/05)
>
> Any time you can bring in kinesthetic during the learning process, the students seem to develop a greater understanding of the taught materials. (Henry, written reflection, 5/05)

While Henry believed that kinesthetic learning worked for all children, he did not ascribe the same standards of learning to all of his students. He took great care to design separate assessments for his students with Individualized Educational Programs, and to think differently about his definition of “teaching success” based on individual student needs: “You just can’t put all kids on the same level of expectation.” (Henry, interview, 6/05).

Changes in Beliefs About Students

An analysis of whether or not participants in this study mentioned different types of beliefs more or less as the teacher preparation program progressed was completed. Results of this analysis are presented in Table 6.1.

Dimension	Percentage of Times Beliefs Were Mentioned			
	Beginning	Middle	End	Total Times Mentioned
All Students Can Learn	41%	38%	33%	42
Students are Lazy	7%	13%	15%	14
Science is Hard/Unlikable	4%	4%	15%	9
Demographic Group Differences	26%	26%	13%	24
Individual Student Learning	22%	19%	23%	24
Total Number of Characteristics Mentioned	27	47	39	

Table 6.1: Development of beliefs about students

As is clear from the proportion of times each belief was mentioned, there was not a tremendous shift in most of these beliefs over time. There was less of a tendency for the preservice teachers as a group to focus on the idea that all students could learn, and they appeared to substitute the beliefs that students were lazy and were not interested in learning science. While this trend was true for the group as a whole, individual preservice teachers did not exhibit this change in beliefs over time. Instead, individual preservice teachers tended to wobble rather than permanently change their beliefs.

For example, Raina initially expressed the strong belief that all students could learn, and that student achievement in school was greatly impacted by social pressure and parental influences, as well as the expectation that students dislike science. By the midpoint of the program, she had completely ceased attributing student underachievement to anything but demographic differences, student laziness, and student dislike of science. Yet at the end of the year, Raina reverted to her original belief that all students could learn, and that student underachievement was due to students setting academics low on their priority list, and lack of educational background.

There was much less focus on demographic group differences at the end than at the middle of the program. A majority of the preservice teachers in the sub-sample discussed age, gender, and SES differences between students at the beginning and middle of the teacher preparation program, but only five mentioned student demographic differences at the end of the program. An exemplar of this trend, Nancy frequently mentioned age differences at the beginning and middle of the year, but did not mention them at all in the spring. Similarly, Lucy mentioned age differences at the beginning of the year, SES differences and gender differences at the middle of the year, and yet finished the year without mentioning the impact of any student demographics.

Influences on Beliefs About Students

The existence and changes in preservice science teachers' beliefs about students in science can be attributed mainly to teaching experiences, but also to the opinions of other teachers, to observations of other teachers, to personal experiences as students themselves, and to media portrayals of students. It is perhaps notable that no preservice teacher attributed their beliefs about students to anything learned in university courses. None of these sources of beliefs about students appeared to be differentially dominant at different points during the teacher preparation program; teaching experiences were the strongest source of beliefs at all points in the year, and all other sources of beliefs remained a constant but small influence throughout the year. There emerged great variability in how the preservice teachers explained how they obtained some of these beliefs—some beliefs appeared to be developed through the influences stated above, while other beliefs were commonly stated but not justified.

The first category of beliefs—those involving the idea that all students are capable of learning, but a variety of factors gets in the way—was well justified through teaching experiences, observations of other teachers, opinions of mentor teachers, personal experiences as students, and media portrayals. Most of the participants who noted the influence of parental expectations and pressures on student performance justified it in some way. Personal experiences with parents mainly accounted for these beliefs:

> We had a parent-teacher thing yesterday, and no parents came, because there's no reason to, because they know throughout. If so-and-so does bad on an exam, you know the next day, and you get it situated. There's no reason for them to get in their car and come down because they already know. (Henry, interview, 3/05)

> The parental involvement level can also be seen in the number of emails and calls my mentor teacher receives from parents about their concerns for their child. I have even met two parents informally because they came in to make certain that their child turned something in or to discuss their child's plan to recover from poor grades. (Alyssa, written reflection, 10/04)

The opinions of other teachers and observations of other teachers also made a difference for some preservice teachers:

> Now for every parent who was there [parent-teacher conferences], there were probably two or three others who just don't care. On talking to [my mentor teacher] about this he pointed out that some of the behavioral issues he sees in the classroom are because you would not believe some of the home lives these kids come from. (Nancy, written reflection, 10/04)

Anna and Raina were not specific how they knew that student performance was due to parental influences. For example, Raina explained her expectation that parental influence was important based on the fact that her students were well-behaved and performed at a high level: "I haven't really noticed any controversial issues needing to be addressed. Although I have had a few chances to hear about parental interactions, I would guess that the majority of them are probably supportive." (Raina, written reflection, 10/04).

The impacts of peer and societal expectations were often justified, although it was by more of a variety of experiences. Teaching experiences and the opinion of the mentor made an impact on these beliefs. Additionally, depictions of students and teachers in the media appeared to make an impact on some participants. Movies such as *Mean Girls* in which the role of social pressures was quite apparent and struck a chord with one preservice teacher: "The most important thing I gained from *Mean Girls* is that high school isn't really about school at all; it is merely the setting." (Lucy, written reflection, 10/04).

Most of the preservice teachers who mentioned that students lacking background knowledge were likely to perform lower, in spite of the desire to be good students, justified this belief through a previous experience. Three of the preservice teachers cited teaching experiences in which they worked closely enough with a student or group of students that it was clear the students were lacking in specific background knowledge and skills: "Today we did part of my integrated unit with ratios, and in eleventh and twelfth grade, I really though I wouldn't have to teach how to do ratios, but come to find out that a lot of kids didn't know how to do ratios." (Emily, interview, 2/05). A fourth participant remembered his own experiences as a student learning mathematics and realizing that he struggled because he lacked some basic skills that were necessary in order to make progress in mathematics:

> I was in an accelerated program in school, and it was the first year of the accelerated program, and the professor that was involved with it really wanted to look good, so he ushered a lot of us through stuff even when we didn't understand it. So I have some huge deficits that weren't visible on my transcript…that literally engrained in me that yes, I suck at math. And it wasn't that I suck at math, it was just that I had never been given the basics. (Henry, interview, 6/05)

One participant justified the belief as being partially due to a vicarious experience. He described his observation of a poor science lesson in a sixth grade classroom: "I was watching a teacher in sixth grade in the winter that was teaching a science lesson and completely blew it. Just totally, 180° what should have happened, happened." (Dan, interview, 6/06). It was more clear to Dan why some of his students lacked basic science content knowledge after this observation.

Although several participants mentioned the importance of priorities outside of school, only three discussed reasons for these beliefs. In two cases, it was due to teaching experiences with students who talked with the participants about their lives outside of school. In the third case, it was due to a personal experience as a student dealing with prioritizing a job over her schoolwork: "I remember when I was in school—I didn't really care about school. I would go to work 4 to 10, and I would come home." (Emily, interview, 5/05). According to other participants, the fact that some students dealt with issues outside of school and that took immediate priority over school was common knowledge.

About half the preservice teachers in this study justified their beliefs about how best to motivate students. The majority mentioned personal teaching experiences in which they had success motivating students using the specific method they advocated, or else experiences in which they were unsuccessful in motivating students and so refused to try the method again. For example, Henry noticed that introducing content through kinesthetic means motivated students to learn the material: "This activity was held in the highest regards by the students…Anytime you can bring in kinesthetic during the learning process, students seem to develop a greater understanding of the taught materials." (Henry, written reflection, 5/05). One participant also mentioned an experience observing his mentor teacher, who was successful motivating her students.

Finally, one participant noted the influence of reading some popular psychology that promoted the idea that motivation could not be externally influenced:

> I think in the end, it's ultimately up to someone whether or not they want to learn. And my experiences over the last couple of months just sort of confirms that. But I have always kind of thought that throughout my life. It's like psychology, you can provide people with guidance and such, but in the end they have to want to change. If they don't want to change, it's not going to happen. (Alyssa, interview, 2/05)

It was unclear why the remainder of the preservice teachers in this study believed that students either could or could not be motivated.

The belief that students are lazy clearly arose through personal teaching experiences. Every participant cited personal experiences in which they interpreted student actions as due to laziness. Furthermore, one participant cited a personal experience that he then brought to the attention of other teachers at his placement school; the opinions of the other teachers appeared to reinforce his tentative belief in student laziness. Experiences that elicited this belief typically involved student resistance to new, student-centered, teaching methodologies in which they were asked to think for themselves, students who performed poorly on an assessment and asked for special consideration, and occasionally student misbehavior. For example, Emily attempted to develop scientific thinking skills in her students, but was disappointed by their tendency to ask for answers rather than figuring things out on their own: "If they were able to do the activities—and I don't want to have to not do any work, that's not the thing—but I want them to try to figure things out on their own, and only come to me when they had problems understanding what they were supposed to do…that would be the greatest." (Emily, interview, 5/05). Alyssa was disgusted by an experience with a student who was underperforming and who complained that it was Alyssa's fault: "it turned out that her grade wasn't very good and she needed an excuse…I'm a little worried about what's going to happen with that because she's kind of a whiner. She doesn't want to work for her grade." (Alyssa, interview, 5/05).

The belief that students dislike science was only justified by one of the preservice teachers who expressed it. Upon returning good science quizzes, this preservice teacher's students reacted with surprise because they expected science to be hard:

> I was handing back quizzes today, and I was surprised to hear how many students say "wow, this is the best I've ever done on a science quiz!"…the fact that they said "science quiz", they had this association that they would do bad in science. Therefore, they shouldn't like it or something. (Alyssa, interview, 5/05)

It was unclear where this belief originated for the remainder of these participants. It is possible they had picked it up from the prevailing culture of the United States, which does promote the image of science as difficult and the image of scientists as socially inept nerds (Hughes, 2001).

The belief that some students were naturally better in science or easier to teach in science was justified almost completely through personal teaching experiences, with the opinion of other teachers making some impact. Age and socioeconomic status differences were noted as a result of teaching experiences entirely. The program requirement that preservice teachers spend a full quarter in each of the high/middle school and urban/suburban school environments seemed to help develop this belief by promoting a comparison of the different teaching contexts. Nancy noticed significant differences between her fall experience in a middle school and her winter experience in a high school:

> I have been disappointed with the level of participation that high school students exhibit. The students in my class are not enthusiastic, are difficult to motivate and are only interested in whether material will "be on the test"….I found the middle school students to be fun but much more unruly that their high school contemporaries. A lot more classroom management was required to keep them in line but they were much more receptive to participation in the classroom by actively answer questions and volunteering to do silly things in front of their peers which, a high schooler would be too cool to do. (Nancy, written reflection, 2/05)

Lucy, on the other hand, mainly noticed the differences between her fall experience in a suburban school and her winter experience in an urban school:

> At [suburban middle school], the students were friendly and never disrespectful. They were able to get excited about school, were attentive when the teacher was talking, and responsible about turning in work. It's not surprising that they had decent grades. At [urban high school], the students are lower-performing, not conscientious about turning in work, and unlikely to listen while I'm talking or follow directions. They are fairly friendly, but very distrustful of authority. (Lucy, written reflection, 2/05)

Beliefs about gender differences mainly resulted from shorter-term teaching experiences in which a difference between girls and boys during a given lesson was notable: "I've noticed an interesting trend: the students in the class who have multiple missing assignments are all males!…the other group of students who might have trouble are those that have been absent for multiple classes—interestingly this has been primarily females." (Emily, written reflection 2/05). In addition, one preservice teacher described a conversation with one of her own teachers about gender differences in science as making an impact on her beliefs about her future students. In this last case, however, the opinion of her teacher pushed her to think beyond apparent differences and to encourage girls to excel in science.

The sharp decrease in the number of times this belief was mentioned at the end of the teacher preparation program was possibly due to the fact that most preservice teachers did their student teaching at suburban schools where the ethnic and SES differences were not pronounced, and due to the fact that they had already experienced the transition between teaching at middle and high schools during the fall and winter.

Finally, the belief that students have individual learning differences was not frequently justified when it was declared early in the teacher preparation program, but as the year progressed, it was typically explained as a result of teaching experiences. For example, Josh described how he came to the conclusion that students learn differently based on a set of teaching experiences: "The fact that one exercise will work with one kid, and will completely fail on another. I underestimated the variability from kid to kid." (Josh, interview, 3/05). Rachel expressed a similar sentiment: "At the beginning, you go in, I'm going to be a wonderful teacher and all my students are going to learn everything I teach them. And then reality sets in. Everyone is so different, and there's a lot of adjustment that has to be made." (Rachel, interview, 5/05).

Synopsis

Preservice teachers in this study expressed in common five beliefs about students and why they tend to perform well or not so well in their science classes. First, participants generally believed that all students were able to learn, and that differences in student performances were due to factors aside from innate intelligence. Such factors included parental influence, peer pressure, societal expectations, educational background, priorities of other parts of student lives such as athletics, jobs, and taking care of family members, and intrinsic student motivation. Second and relatedly, participants believed that students were intrinsically lazy. Preservice teachers who perceived that students underachieved due to factors aside from laziness appeared more sympathetic and willing to help students than those who perceived that students were lazy. Perceived student laziness tended to result in frustration and anger in the preservice teachers.

Third, participants believed that students would not naturally like science and/or that they would feel that science was difficult to learn. The traditional view of the scientist as nerdy genius, the abstract nature of scientific thought, and lack of student background in science and math were all provided as justifications for this belief.

Fourth, participants noted differences in students based on gender, socioeconomic status, and age. Girls were expected to behave better and to get the academic work of school done better than boys, but boys were expected to be more intrinsically interested in science. Expectations were different for students from suburban and urban schools; students at suburban schools were expected to have high academic achievement, whereas students at urban schools were expected to develop social and behavioral skills. Younger children were generally expected to be more impressionable and easier to get interested in science than were older children.

Fifth, the majority of participants felt strongly that all children should be taught and treated as individuals, while a minority of the group expressed a mixture of this belief and the belief that that good teaching was good teaching regardless of individual student differences. It is important to note that in spite of expressing the belief that all children should be taught as individuals, the overwhelming majority of preservice teachers in this study only made changes to their teaching for individual students who had documented special needs; “normal” children were consistently catalogued together.

Few systematic changes in these beliefs were noted during the course of the teacher preparation program. There was less of a tendency for the preservice teachers as a group to focus on the idea that all students could learn, and they appeared to substitute the beliefs that students were lazy and were not interested in learning science. While this trend was true for the group as a whole, individual preservice teachers did not exhibit this change in beliefs over time. Instead, individual preservice teachers tended to wobble rather than permanently change their beliefs. Additionally, there was less focus on demographic group differences between the middle and end of the program. A majority of the preservice teachers in the sub-sample discussed age, gender, and SES differences between students at the beginning and middle of the teacher preparation program, but only five mentioned student demographic differences at the end of the program.

Changes in the preservice teachers’ beliefs about students were attributed overwhelmingly to personal teaching experiences, but also to the opinions of other teachers, observations of other teachers, personal experiences as students themselves, and media portrayals of students. Notably, some beliefs tended to surface most strongly when preservice teachers made the transition between teaching in suburban and urban schools or between middle versus high schools.

CHAPTER 7

DISCUSSION AND IMPLICATIONS

The purpose of this study was to examine preservice secondary science teachers' changes in teacher efficacy beliefs and beliefs about the teaching and learning of students in science as they learned how to teach. The ultimate goal of this study was to understand what experiences and characteristics promoted a more positive sense of teacher efficacy and constructive beliefs toward the teaching of science to all students, to better prepare beginning teachers to work with an increasingly diverse student body. More specifically, the study addressed the following research questions:

1. What teacher efficacy beliefs, beliefs about the role of the teacher, and beliefs about students do preservice secondary science teachers possess at various time points during their teaching preparation program?
2. Do preservice secondary science teacher efficacy beliefs, beliefs about the role of the teacher, and beliefs about students change between the beginning and end of their teaching preparation program? If the beliefs do change, what events are associated with these belief changes?
3. Do relationships exist between teacher efficacy beliefs, beliefs about students, and beliefs about the role of the teacher? If so, do these relationships act in

accordance with the proposed model such that beliefs about students and the role of the teacher have an impact on teacher efficacy beliefs, and such that mastery experiences have more of an impact than vicarious experiences and verbal persuasive experiences, and affective states act as an intensifying force?

In this chapter, each research question will be dealt with in turn, as will implications based on the results of this study, along with suggestions for future research.

Research Question 1

What teacher efficacy beliefs, beliefs about the role of the teacher, and beliefs about students do preservice secondary science teachers possess at various time points during their teaching preparation program?

Teacher Efficacy Beliefs

Preservice teachers began the teacher preparation with relatively high levels of personal science teaching efficacy and science teaching outcome expectancy, as measured by the STEBI-A (See Table 7.1). By the end of the year, science teaching outcome expectancy scores had not significantly changed, while personal science teaching efficacy scores had increased quite drastically.

	Pre-Test		Post-Test	
	M	SD	M	SD
PSTE Score	3.793	0.484	4.263	0.373
STOE Score	3.391	0.394	3.341	0.431

Table 7.1: Comparison of PSTE and STOE Scores

PSTE and STOE scores at the beginning and end of the teacher preparation program were not significantly ($p < 0.05$) dependent on participants' science content knowledge or gender, in contrast to previous research that found gender differences (Cantrell et al., 2003; Evans & Tribble, 1986) and content knowledge differences (Cantrell et al., 2003; Enochs & Riggs, 1990; Ramey-Gassert et al., 1996; Rice & Roychoudhury, 2003; Ritchie, 1999) in teacher efficacy beliefs and overall confidence in teaching. Because all of the preservice teachers in this study had at least a bachelor's degree in their content area, it is possible that the content knowledge differences were too minor to influence the preservice teachers' sense of efficacy. The time of engagement in the urban teaching experience did have an impact on STOE beliefs at the end of the program, however, emphasizing the importance of getting involved in teaching in urban environments as early as possible during teacher education.

Furthermore, participants at the end of the study expressed teacher efficacy beliefs in which there was a significant correlation between outcome expectancy beliefs and personal teacher efficacy beliefs. No correlation was found for participants at the beginning of the study. This result is not without precedent. It has been found previously that with experience, there is more correlation between PSTE and STOE beliefs, and hypothesized that this is due to the fact that more experienced teachers have better mastered the content and have learned to present the material in meaningful ways to students (Desouza et al., 2004). Significant correlations between PSTE and STOE were also found for participants with master's degrees and for men, but not for participants with bachelor's degrees alone or for women. Previous research has found that with more educational background, the correlation between PSTE and STOE decreases, although this was in a study of elementary and middle school teachers (Desouza et al., 2004). It is possible that with increased experience and comfort with their content area, teachers become more confident both in their abilities to teach the material and to impact student learning. The finding about the correlation between PSTE and STOE for men is rather puzzling, but it is notable that there were significantly more men in the study who possessed master's degrees in their science field, so possibly the gender difference is actually due to a difference in content background.

Beliefs About the Role of the Teacher

Beliefs about characteristics of effective teachers fell into five main categories: knowledge of content, knowledge of teaching, knowledge of students, the ability to control aspects of their environment, and personal characteristics. Personal characteristics such as organization, curiosity, enthusiasm, and a caring nature accounted for the majority of preservice teacher beliefs about what made for an effective teacher, in accordance with previous research (Akyeampong & Stephens, 2002; Doolittle et al., 1993; Korthagen, 2004), with knowledge of content and knowledge of teaching accounting for the next highest proportion. Participants in this study were categorized as expository, constructivist, empathizer, maturationist, or social constructivist based on the beliefs they expressed in reflections and interviews. At the beginning of the program, expository beliefs were the most common within the sub-sample of preservice teachers, with constructivist and social constructivist beliefs expressed by many fewer. By the midpoint of the program, participants were approximately evenly divided between expository and social constructivist beliefs, with constructivist beliefs accounting for slightly fewer. At the end of the program, social constructivist and constructivist beliefs outnumbered expository beliefs. Teaching practices, however, appeared to operate incongruously with beliefs. Most of the preservice teachers in the sub-sample attempted constructivist and/or social constructivist teaching strategies during the autumn field experience, while by the winter and spring, they used overwhelmingly expository instructional methods. Teaching practices of participants in the full cohort, as measured by the RTOP, did not appear to be significantly different between the winter and spring field experiences. Notably, preservice teachers at suburban schools used significantly more constructivist teaching strategies in all categories than did preservice teachers at urban schools. This result was not unexpected, as it has been previously found that teachers in urban schools utilize more teacher-centered methods (Hewson, Kahle, Scantlebury, & Davies, 2001; Norman et al., 2001) in response to the emotional and academic problems that teachers often perceive impacting students from urban backgrounds (Bullock, 1997). Preservice teachers at high schools more frequently demonstrated the constructivist teaching categories of procedural knowledge and communicative interactions, and generally scored higher in reform-based teaching strategies than did preservice teachers at middle schools.

Beliefs About Students

Preservice teachers in this study expressed in common five beliefs about students and why they tend to perform well or not so well in their science classes. First, participants generally believed that all students were able to learn, and that differences in student performances were due to factors aside from innate intelligence. Such factors included parental influence, peer pressure, societal expectations, educational background, priorities of other parts of student lives such as athletics, jobs, and taking care of family members, and intrinsic student motivation. The impact of student educational background has been noted previously (Gilbert & Yerrick, 2001), as has the issue of parental involvement, particularly in lower-income schools (Brown et al., 2004; Bullough, 1989; Eisenhart et al., 1988; King et al., 2001; Solomon et al., 1996), so these findings were not surprising.

Second, participants believed that students were intrinsically lazy. Other studies—all with secondary school teachers—have previously uncovered the teacher belief that students have difficulty dealing with and/or are resistant to challenges in their classes, and that students in general are not internally motivated (Brighton, 2003; Bullough & Baughman, 1997; Yerrick & Hoving, 2003). On the other hand, some other studies—although these all involved elementary school students—have found the direct opposite, that teachers believe that students are inherently motivated to learn (Raymond, 1997; Wigfield et al., 1999). It is possible that most secondary school teachers, including the ones in this study, perceive that students are intrinsically lazy. Preservice teachers who perceived that students underachieved due to factors aside from laziness appeared more sympathetic and willing to help students than those who perceived that students were lazy. Perceived student laziness tended to be associated with frustration and anger in the preservice teachers, in agreement with previous research (Georgiou, Christou, Stavrinides, & Panaoura, 2002; Hoy & Weinstein, 2006; Weiner, 2000).

Third, participants believed that students would not naturally like science and/or that they would feel that science was difficult to learn. Although it has previously been found that preservice teachers believe that students will enjoy learning about science (Mulholland & Wallace, 2001), the concern over children's natural interest in science also has been demonstrated previously (Bohning et al., 1999). Perhaps more oddly, previous studies in which teachers hypothesize that students will have difficulty with science have typically involved elementary teachers whose content knowledge is not as strong as that of the teachers in the present study. One would expect that preservice teachers who have bachelor's degrees in their content areas and who therefore succeeded in scientific fields of study would believe that science was interesting and achievable by all children.

Fourth, participants noted differences in students based on gender, socioeconomic status, and age. The result that preservice teachers expressed lower expectations of children from lower-income schools than in higher-income schools replicates results from many previous studies (Ashton, 1984; Brown et al., 2004; Dusek & Joseph, 1983; Hewson et al., 2001; Solomon et al., 1996), as did the result that teachers have differential expectations for boys and girls (or masculine versus feminine students) in their classes (Bullough & Baughman, 1997; Dusek & Joseph, 1983; Tobin & Gallagher, 2003). Very few studies have directly measured beliefs about younger versus older students, so the finding of the belief that younger students are easier to engage and motivate than are older students appears to be novel. However, as noted previously, teachers of younger children tend to possess more positive beliefs about their capabilities than do teachers of older children.

Fifth, some participants felt strongly that all children should be taught and treated as individuals, while others believed that good teaching was good teaching regardless of individual student differences. This contrast has been noted in previous studies, wherein some teachers felt that to be fair and to teach effectively to all students, it was important to treat all students the same; while other teachers felt that in order to be fair and teach effectively, they needed to treat students as individuals (Bianchini et al., 2000; Bullough, 1989).

Research Question 2

Do preservice secondary science teacher efficacy beliefs, beliefs about the role of the teacher, and beliefs about students change between the beginning and end of their teaching preparation program? If the beliefs do change, what events are associated with these belief changes?

Teacher Efficacy Beliefs

Preservice teachers at the beginning of the teacher preparation program in secondary science exhibited several differences in teacher efficacy beliefs from those who were finishing the program. Results from the STEBI-A revealed that preservice teachers at the end of the program had significantly higher personal science teaching efficacy beliefs than those at the beginning of the program. This result was expected, as it has commonly been found in previous research that personal teaching efficacy beliefs are enhanced between the beginning and end of a teacher preparation program (Cantrell et al., 2003; Hart, 2002; Hoy & Spero, 2005; Huinker & Madison, 1997) and with experience in general (Soodak & Podell, 1996). No significant difference in science teaching outcome expectancy beliefs were found on the STEBI-A, indicating that there was no difference between the beginning and end of the program in preservice teacher expectations of the outcomes of their teaching. This result was somewhat unexpected, as research has generally shown that outcome expectancy beliefs deteriorate as a result of teaching experiences (Desouza et al., 2004; Ghaith & Yaghi, 1997; Plourde, 2002b); however, the result found in the present study has certainly been detected in previous studies (Soodak & Podell, 1996).

Analysis of qualitative data revealed the development of more positive personal teaching efficacy beliefs during the course of the teacher preparation program. Outcome expectancy beliefs, however, tended to shift more erratically, in accordance with previous research finding that preservice teachers have mixed beliefs on their influence over student learning (Akyeampong & Stephens, 2002). In particular, participants who engaged in their urban field experience during the winter and/or had particularly discouraging experiences with mentor teachers were affected quite negatively in outcome expectancy as compared to preservice teachers who participated in an earlier urban teaching experience and/or who had positive experiences with mentor teachers. As a result, these participants developed an overall more negative set of outcome expectancy beliefs for the remainder of the year. The impact of teaching experiences in undesirable, unsupportive environments on teacher efficacy beliefs has been found previously (Andersen et al., 2004).

In this study, teacher efficacy beliefs were directly affected by three of Bandura's four sources of self-efficacy beliefs—mastery experiences, vicarious experiences, and verbal persuasion—and changes were facilitated through the process of personal reflection. The most powerful mastery experiences resulted from teaching students and obtaining an unexpected result, such as that students did not learn by way of a traditional technique or that students did learn when they did not normally do so. Other researchers have found similar outcomes; that unexpectedly successful teaching experiences resulted in an enhanced sense of teacher efficacy (Mulholland & Wallace, 2001).

The most powerful vicarious experiences involved observing course professors and mentor teachers teach both successfully and unsuccessfully. The importance of course professors modeling the teaching behaviors they wish their preservice teachers to emulate has been noted previously (Rice & Roychoudhury, 2003), as has the influence of observing mentor teachers, particularly those who avoid teaching in ways that preservice teachers are encouraged to teach (Mulholland & Wallace, 2001). The most powerful verbal persuasive elements came from mentor teachers. No evidence was found that affective states by themselves had resulted in belief changes, although many of the mastery experiences, vicarious experiences, and verbal persuasive experiences were more powerful because they were accompanied by an emotional incident. Affective states have been previously noted to not affect science teacher efficacy beliefs as significantly as the other three sources of efficacy information (Mulholland & Wallace, 2001), and so this result is not entirely unexpected.

Additionally, the influence of each source of self-efficacy information appeared to change during the course of the teacher preparation program. The preservice teachers relied more strongly on mastery teaching experiences as the year progressed after initially expressing beliefs related to their experiences as students, in accordance with previous research (Yerrick & Hoving, 2003). Vicarious experiences appeared to be most powerful during the quarter in which participants were engaged in their first field experience, when preservice teachers spent the majority of their time observing their mentor teacher and other teachers. Verbal persuasive experiences accounted for a steady but relatively minor proportion of influences on self-efficacy beliefs throughout the year; however, for several individual participants, the verbal persuasion and support of their mentor teachers made an important impact on their teacher efficacy beliefs. Most notably, preservice teachers with unsupportive mentors during their field placements in low SES schools developed rather negative senses of teacher efficacy. The impact of support on teacher efficacy beliefs has been explored previously, with similar results (Hoy & Spero, 2005).

Beliefs About the Role of the Teacher

Beliefs about effective teachers shifted during the year. While the proportion of characteristics that fell into the personal characteristics category did not change during the year, the preservice teachers appeared to change from focusing on characteristics of effective scientists to characteristics of effective teachers. There were oppositional changes in the proportions of characteristics that fell into the knowledge of content and knowledge of student categories, as well: preservice teachers felt that content knowledge was less important and knowledge of students was more important between the beginning and end of the program. Additionally, while preservice teachers at the beginning of the teacher preparation program believed strongly that possessing a solid foundation of content knowledge was a key characteristic in all successful science teachers because it allowed them to pass along the content with more ease, by the end of the program these same teachers felt that content knowledge was important because it provided them more strategies to help students learn the material and to make it meaningful to the students. Finally, external influences were only mentioned by preservice teachers at the end of their spring student teaching experience. Studies of inservice teachers have uncovered the belief that the ability to establish trusting, nurturing, and respectful relationships with students is the most important characteristic of a teacher (Eisenhart et al., 1988; Hoy & Weinstein, 2006; Lasky, 2005; Proweller & Mitchener, 2004; Yerrick et al., 1998). A small number of preservice teachers in this study developed that belief over the course of the program, but most did not. Possibly, this is one of the differences between novice and expert teachers.

Most preservice teachers in this study underwent a change in belief about their roles as teachers, from more traditional expository beliefs to constructivist and social constructivist beliefs. This general trend is not unexpected, as the teacher preparation program intended to promote constructivist teaching and learning, and other research has found a similar trend as a result of teacher education courses and programs (Hart, 2002). However, it is in sharp comparison with other studies that noted the inflexibility of beliefs about the role of the teacher (Yerrick et al., 1997), and those in which preservice or beginning teachers grew more expository in their beliefs over time (Flores, 2003). Additionally, few previous studies have examined the extent to which teachers subscribe to social constructivist beliefs of learning, and the research in this area has found that a very small number of teachers adhere to these beliefs and their accompanying teaching methods (Daniels & Shumow, 2003). Although previous research has found differences in response to science teacher education based on science content knowledge background (Roehrig & Kruse, 2005), preservice teachers in this study seemed to develop alternate conceptions of teaching regardless of content background.

Teaching practices of participants in the sub-sample developed in the opposite direction as beliefs, progressing from more constructivist practices at the beginning of the teacher preparation program to more expository practices by the end of the program. This result does not agree with previous research findings that teachers' beliefs predicted teacher practices (Stipek et al., 2001), but does agree with research that found a conflict between beginning teachers' beliefs and practices (Brickhouse & Bodner, 1992; King et al., 2001; Simmons et al., 1999). This result was not entirely unexpected, as previous researchers have found that beginning and student teachers feel pressure to establish their authority and retain control of their classrooms (Bloomfield, 2000; Davis & Wilson, 1999). As a result of this pressure, constructivist beliefs about teaching and learning may have been given a lower priority in favor of more immediate concerns about class management. Following up with study participants after they have been engaged in full-time teaching for several years might reveal that through further developing their pedagogical content knowledge and classroom management skills, the preservice teachers in this study might more readily utilize constructivist teaching methods in their classes (Mulholland & Wallace, 2005). Another hypothesis is that there was a cognitive conflict between their initially and primarily expository beliefs about teaching and learning and the constructivist message of their teacher education program. As a result, they learned to "talk the talk" about constructivist teaching and learning, but ultimately were not interested in putting it into practice because the philosophy conflicted with their incoming beliefs. Other studies have found similar results, in which teachers temporarily adopted program messages, but follow-up interactions revealed that many reverted to their initial beliefs (Akerson, Morrison, & McDuffie, 2006; Eick & Reed, 2002; King et al., 2001). A third hypothesis is that the preservice teachers lost the idealism that they expressed before they were engaged in classroom teaching as a result of enculturation into their mentor teachers' classrooms and school (Simmons et al., 1999). In contrast to the above result from the qualitative data, teaching practices of participants in both full cohorts did not grow either more or less constructivist with time, as measured by the RTOP (Piburn et al., 2000).

Seven major categories of change instigators emerged from the data: direct teaching experiences, pressures from outside the classroom, student expectations, theoretical knowledge obtained, vicarious experiences, personal reflection, and verbal persuasive experiences. Direct teaching experiences made by far the greatest impact on participants' beliefs about the role of the teacher. A conceptual change process appeared to be responsible for some of these changes in beliefs. Typically, participants attempted to teach in traditional, expository ways, and were unexpectedly met with low levels of student learning. As a result, they considered whether other models of teaching and learning would work better. Some participants, when strongly encouraged to venture into constructivist methodologies, had surprisingly positive experiences with constructivist teaching. This result has been noted previously, as teachers are often surprised and excited by how students became more engaged with hands-on science activities (Rodriguez et al., 2005). Several participants had negative experiences with constructivist teaching, as well, and that unexpected result tended to result in those preservice teachers considering more teacher-structured class time. Only one participant admitted to relying on her experiences as a student in determining what type of teaching she wished to utilize, in contrast with previous research indicating the importance of student experiences (Raymond, 1997).

Unexpected student resistance may have also contributed to conceptual change in some participants, particularly in cases where the preservice teachers strongly expected students to react positively to an instructional strategy but students instead complained or even refused to participate. Student resistance has been noted in the literature previously, and appears to act in different ways depending on the socioeconomic status of the school and surrounding community. More specifically, teachers at urban schools tended to perceive resistance to constructivist instructional strategies, and higher standards of achievement (Gilbert & Yerrick, 2001; Verjovsky & Waldegg, 2005), as the students at those schools are trained to be more passive (Finn, 1999).

University coursework impacted some participants, particularly those who were able to connect the knowledge they learned in courses with their teaching experiences. This result is similar to that found previously; in short, preservice teachers' beliefs were most influenced by courses and aspects of courses that they believed most directly related to their teaching practices (Beswick, 2006), and that many preservice teachers thought they were not impacted by teacher education coursework at all due to the perceived mismatch between the university's priorities and their own priorities as teachers (Eisenhart & Behm, 1991; Friedrichsen & Dana, 2005; Tillema & Knol, 1997).

Some participants also mentioned modeling of teaching by their previous teachers and by their mentor teachers as vicarious experiences that encouraged them to try either constructivist or expository methods in their own classrooms. Other researchers have noted the significance of the mentor-preservice teacher relationship as well as the impact of inservice teachers observing other teachers (Bullough & Baughman, 1997). Interestingly, even when preservice teachers were unconscious of it, they still adopted many of the habits and even mannerisms of their mentor teachers (Roth, Tobin, Carambo,

& Dalland, 2004). Along the same lines, it has previously been found that school culture and the presence or absence of a supportive atmosphere can impact teacher beliefs (Flores, 2003; Mcginnis et al., 2004), and that was clearly true in the present study, as well.

Two participants noted the impact of personal reflection and sharing on their beliefs about teaching and learning. This factor has been found previously, in which beginning and experienced inservice teachers valued and were significantly impacted through a sharing and reflection process (Flores, 2003; Luft, 2001).

Verbal persuasion by authority figures typically came in the form of mentor teachers attempting to persuade the preservice teachers to teach in more expository ways, in order to cover material more quickly. The preservice teachers often struggled to deal with competing pressures to try more constructivist methods (coming from the university) and to use strictly expository methods (coming from the mentor teacher). Most eventually decided that it was more important to appease their mentor teachers than their university supervisors, in accordance with previous research (Bullough, 1991; Luft, 1999).

Pressures outside the classroom, such as the need to prepare students for standardized testing and the expectations of parents, appeared to impact participants' beliefs and practices by the midpoint of the teacher preparation program, when they were more fully engaged in the life of the school in which they were placed. This factor has been commonly found in previous studies of influences on teacher beliefs and practices (Brighton, 2003; Bullough, 1989; Flores, 2003; Mcginnis et al., 2004; Verjovsky &

Waldegg, 2005; Wallace & Kang, 2004). The pressure to prepare students for standardized tests has grown into a particularly important influence in recent years, as inservice and preservice teachers believe that the assessments are innately in conflict with the philosophy of constructivist teaching promoted in colleges of education (Johnson, 2006). Interestingly, this belief is prevalent in spite of some state standards and assessments that have included questions requiring students to analyze, synthesize, and evaluate information (Ohio.Department.of.Education, 2004).

Beliefs About Students

Few systematic changes in these beliefs were noted during the course of the teacher preparation program. There was less of a tendency for the group of preservice teachers to focus on the idea that all students could learn; in fact, they appeared to substitute the beliefs that students were lazy and were not interested in learning science. The idealism that preservice teachers initially possessed regarding student learning potential appeared to dissipate over time, similar to in other studies (Doolittle et al., 1993). While this trend was true for the group as a whole, individual preservice teachers did not exhibit this change in beliefs over time. Instead, individual preservice teachers tended to wobble rather than permanently change their beliefs. The tendency of initial beliefs about students to wobble and more often be validated through coursework and field experiences has been noted previously (Ashton, 1984). Additionally, there was less focus on demographic group differences between the middle and end of the program. An overwhelming majority of the preservice teachers in the sub-sample discussed age, gender, and SES differences between students at the beginning and middle of the teacher preparation program, but only five mentioned student demographic differences at the end of the program.

Changes in the preservice teachers' beliefs about students were attributed to five types of experiences. These were personal teaching experiences, the opinions of other teachers, observations of other teachers, personal experiences as students themselves, and media portrayals of students.

Personal teaching experience was overwhelmingly the most frequent event mentioned by participants in this study as impacting their beliefs about students. Many of them had not previously had any experience with children of different ages and from different neighborhoods, and so working with students who were unfamiliar to them caused adjustments in their beliefs. This was most visible when preservice teachers made the transition between urban and suburban schools or between middle and high schools. The impact of teaching experiences, particularly with students from diverse backgrounds, has been noted commonly in the literature (E. L. Brown, 2004; Brown et al., 2004; Gilbert & Yerrick, 2001; Proweller & Mitchener, 2004), as has the impact of changing schools and working with a more diverse group of students (Bullough & Baughman, 1997).

The opinions and observations of other teachers also made impacts on the preservice teachers' beliefs about students. For example, although the preservice teachers did not have much contact with students' parents (particularly prior to student teaching), and therefore could not have much of a sense through personal teaching experience of what their impact was on their children's learning, preservice teachers frequently mentioned the impact of parent involvement on student learning. This belief could in many cases be attributed to dialogue with the mentor teacher. Mentor teachers often complained about the lack or excess of parental involvement, and preservice teachers frequently adopted this belief. The persuasion by and observation of other teachers has not surfaced often in previous research as impacting teachers' beliefs about students.

Personal experiences as students themselves also had some impact on several preservice teachers' beliefs, especially when justifying student underachievement as due to setting different priorities and lacking background knowledge. Previous research has come to similar conclusions (Brand & Glasson, 2004).

Media portrayals such as television shows like *The Simpsons* and *Boston Public* and movies such as *Mean Girls* were cited as impacting the way the preservice teachers thought about their students and the various pressures on students. This result has previously but not frequently surfaced in research on factors impacting teacher beliefs about students (Ashton, 1984).

Research Question 3

Do relationships exist between teacher efficacy beliefs, beliefs about students, and beliefs about the role of the teacher? If so, do these relationships act in accordance with the proposed model (Figure 7.1) such that beliefs about students and the role of the teacher have an impact on teacher efficacy beliefs, and such that mastery experiences have more of an impact than vicarious experiences and verbal persuasive experiences, and affective states act as an intensifying force?

The proposed model (see Figure 7.1) was adapted from the Tschannen-Moran, Woolfolk Hoy, and Hoy (1998) model of self-efficacy. First, beliefs about students, beliefs about the role of the teacher, and content and pedagogical content knowledge were added to the factors accounted for in the cognitive processing of teacher efficacy. Second, the importance of mastery experiences over vicarious experiences and verbal persuasive experiences was emphasized, and affective states were described as intensifying one of these other experiences but not impacting teacher efficacy beliefs independently. In order to test this model, each of these changes will be discussed in turn.

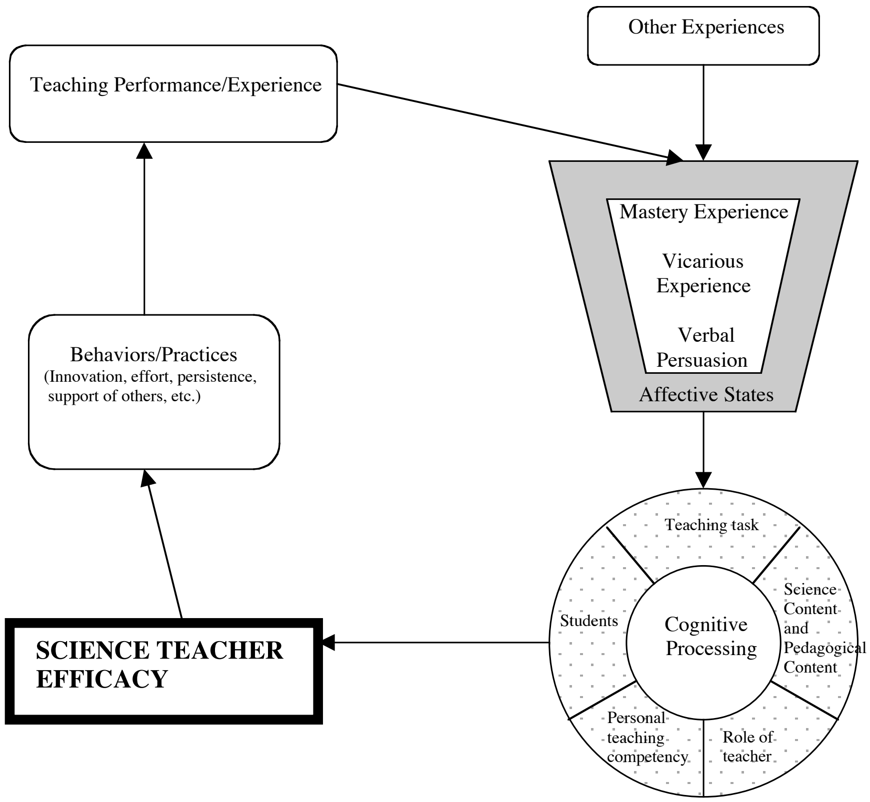

Figure 7.1: Model of science teacher efficacy

Importance of Beliefs About Role of Teacher

Several preservice teachers in this study noted that there was a relationship between their teacher efficacy beliefs and their beliefs about their roles as teachers. Many of the preservice teachers in this study felt that self-confidence helped them to be more experimental in their teaching and to develop more sophisticated ideas about teaching and learning; hence, a heightened sense of teacher efficacy allowed them to try less familiar instructional methods. This result corresponded strongly with that found in previous studies (Ghaith & Yaghi, 1997; McKinney et al., 1999; Wertheim & Leyser, 2002). Emily summarized how her own confidence allowed her to try new things in her classes: "The biggest skill is that I was confident in the content and I was also a confident person, which is really, really useful in life, even if you have to fake it. And so I think I have a good potential to try things." (Emily, 2/05). Conversely, several of the preservice teachers expressed a lack of confidence at trying instructional methods that were new to them. They were comfortable teaching via lecture because most had some experience teaching through lecture from a variety of times earlier in their lives, but less confident at trying something different.

In terms of STEBI-A personal science teaching efficacy within the sub-sample, Nancy and Ingrid demonstrated the largest gains during the one-year program (See Table 7.2). Interestingly, they also possessed constructivist beliefs about teaching and learning from the beginning of the year, when the rest of the participants expressed more expository beliefs. Perhaps the fact that the teacher preparation program's mission and message corresponded with their initial beliefs allowed Nancy and Ingrid to develop more confidence in their abilities as teachers. For other participants, their attempt to align their own initial beliefs with the message from their course professors may have undermined confidence, or at least not allowed it to grow as rapidly.

Henry was the major discrepant case for this overall trend. Henry expressed a very positive sense of teacher efficacy from the beginning of the program through to the end, yet he also expressed mainly expository beliefs about teaching and learning throughout the year. In Henry's case, his extreme confidence in his own initial ideas may have allowed him to ignore the message of the teacher education program without losing his sense of efficacy. Additionally, Henry noted the influence of his mentor teachers and previous research mentors on helping to validate his ideas about teaching and learning. The teacher education program may have advised him to think about teaching in more constructivist ways, but the congruence of his previous experience and his initially high efficacy beliefs with the beliefs of his research mentor and mentor teachers encouraged him to retain his initial expository beliefs about teaching and learning.

Participant	Initial PSTE	Final PSTE	Initial STOE	Final STOE
Nancy	3.46	4.46	3.67	3.50
Lucy	4.23	4.23	3.92	3.67
Emily	4.00	4.77	3.92	3.42
Aaron	4.00	4.38	3.50	3.67
Ingrid	3.23	4.23	4.33	3.58
Dan	4.08	4.60	2.92	2.50
Raina	4.15	4.62	3.17	2.92
Alyssa	3.69	4.04	3.00	2.58
Tom	4.38	4.77	2.83	2.58
Henry	4.23	4.85	3.67	3.83
Anna	3.00	3.80	4.00	3.67
Rachel	3.15	3.92	3.33	3.08

Table 7.2: STEBI-A scores for individual participants

Interestingly, when teaching practices (as measured by the RTOP) were correlated with teacher efficacy beliefs (as measured by the STEBI-A), little of significance was found. A list of correlations between the various aspects of constructivist teaching and the two components of science teacher efficacy may be found in Table 7.3.

Variables	Final PSTE	Change in PSTE	Final STOE	Change in STOE
1. Lesson design & implementation	0.255	0.235	0.108	0.147
2. Propositional knowledge	0.225	0.075	0.174	0.084
3. Procedural knowledge	0.013	0.297	0.160	0.249
4. Communicative interactions	0.188	0.221	0.145	0.218
5. Student-teacher relationships	0.281	0.355*	0.050	0.222
6. Total RTOP Score	0.226	0.276	0.120	0.207

*; $p < 0.05$

Table 7.3: Correlations between teaching practices and teacher efficacy beliefs

A single significant and positive correlation was found between the teaching aspect of student-teacher relationships and change in personal science teaching efficacy. This result possibly indicates that preservice teachers who are better able to establish positive and respectful relationships with their students develop more efficacious beliefs toward teaching; alternately, large gains in teacher efficacy beliefs perhaps allowed the preservice teachers to be more comfortable in their field experience classroom, with the result that they established more constructive relationships with their students.

The lack of statistical relationship between teacher efficacy beliefs and student-centered teaching practices may be explained as due to the separation between cognitive and affective components of a given preservice teacher's belief system. Aside from the "student-teacher relationships" subscale, the RTOP measured more of the cognitive aspects of student-centered teaching. The emphasis of the preservice teachers on establishing student-teacher relationships exemplifies the affective aspect of student-centered teaching. It is possible that the preservice teachers were relying more on affective aspects of their beliefs and experiences teaching; therefore, the affective components of their beliefs more directly impacted their teacher efficacy beliefs. Another possible conclusion is that the differences in measurement timing (weekly measurements versus pre- and post-tests) between the RTOP and STEBI may have hidden possible relationships between teaching practices and teacher efficacy beliefs.

Importance of Beliefs About Students

Participants also noted the connection between their sense of efficacy and how they thought about students. More specifically, a more positive sense of teacher efficacy was associated with the belief that it was important to establish constructive and respectful relationships with students. Alternately, several participants noted that if they were less confident in themselves as teachers, students would pick up on that, and the respectful relationship would not grow:

> The second aspect that I noticed was my need to develop my tonal cues and confidence. I came off as very timid, particularly while teaching from the front of the room. I suspect this lack of confidence transfers over to the students. (Alyssa, written reflection, 11/04)

> I feel that it is important for a teacher to have self-confidence because it will aid in gaining student respect. A teacher who is unsure of their content knowledge or is fickle in management issues out of self-doubt will have more difficulty establishing relationships with students who view them as incompetent. (Lucy, written reflection, 9/04)

The converse also emerged in participants' experiences: when preservice teachers possessed negative beliefs about certain students or certain classes, their sense of efficacy suffered. Raina's student teaching experience provided an illustrative example. Raina taught three classes in the mornings and two classes in the afternoons. Her three morning classes were much more well-behaved than her afternoon classes; as a result, she began to dread her afternoon classes and almost all of the students in them:

> First, we'll take a look at my 7/8 biology class. They are the neediest, most annoying, most hyperactive, disrespectful group of people I have ever had to work with. They drive me crazy. By the time that fifty minutes is up, I need a stiff drink…My tenth period environmental science class consists of juniors and seniors, who are all a few fries short of a Happy Meal. They are ridiculously rude and disrespectful…After all that venting, the point is, I hate my afternoon classes, and I'm sure they can tell. They put me in an absolutely horrible mood, and they drive me to eat chocolate after I'm done with them. I guess the big issue here is, how do I not hate them? I don't hate first, second, or third period. I actually quite enjoy my morning classes. But from lunch on, I'm in hell. (Raina, written reflection, 4/05)

The connection between her beliefs about the students in these classes and her overall sense of efficacy in teaching the classes is quite clear in the statement above and in the remainder of the written reflection. She did not feel capable of dealing with students in her afternoon classes as a result of their bad behavior and what she perceived, in some cases, as serious psychological problems.

Although it was clear from some of the participants comments that a lower sense of efficacy was directly related to negative beliefs about students, no clear connection between teacher efficacy beliefs and beliefs about students was visible in the STEBI-A data. In terms of science teaching outcome expectancy within the sub-sample, Aaron and

Henry demonstrated the largest gains on the STEBI-A; in fact, they were the only participants in the sub-sample to develop a more positive sense of outcome expectancy between the beginning and end of the one-year program. No clear difference emerged in the beliefs about students of Aaron and Henry versus other participants, however. Aaron began the year focusing on the importance of student motivation rather than teacher impact, developed the idea that students actually need teachers to help them learn, and finished the year noting the impact of external influences such as family and community issues. Henry began the year focusing on student differences that impacted learning, developed the idea that external influences can make a significant impact on student learning, and ended the year expressing a large number and variety of beliefs about students and what affects student learning. Other participants followed a similar pattern, developing a more in-depth understanding of the complex variety of factors affecting student learning.

Importance of Mastery Experiences

As was discussed in Chapter 4 in detail, mastery experiences were more frequently mentioned by preservice teachers as impacting their beliefs about themselves as teachers than were vicarious experiences, verbal persuasive experiences, or affective states. Furthermore, the importance of mastery experiences in developing preservice teachers' sense of efficacy remained high throughout the teacher preparation program. A summary of the frequency of each type of influence may be found in Table 7.4. A graphical summary is provided in Figure 7.2.

Type of Influence	Percentage of times type of influence was mentioned			
	Initial	Middle	Final	Total number of times mentioned
Mastery experience as student	7%	3%	1%	19
Mastery experience as teacher	54%	72%	62%	234
Master experience in other capacity	5%	1%	0%	7
Vicarious Experience	20%	14%	17%	64
Verbal Persuasion	14%	10%	17%	52
Total number of times mentioned	121	105	150	376

Table 7.4: Type of influence as changed with time

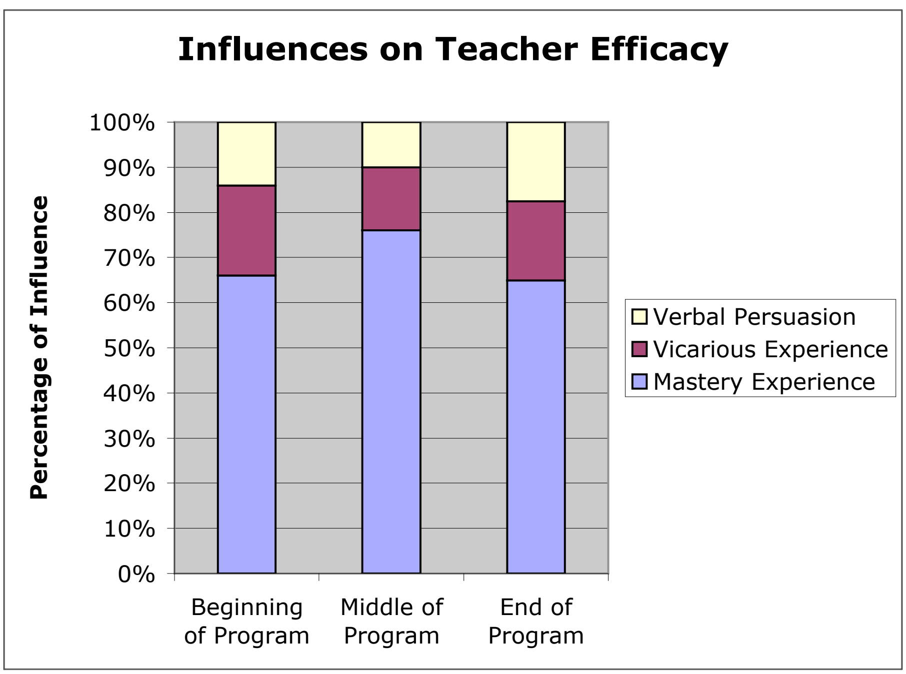

Figure 7.2: Influences on teacher efficacy throughout teacher preparation program

It is clear from the data presented in this study that mastery experiences had a stronger impact on preservice teacher efficacy beliefs than did Bandura's (1997) other sources of self-efficacy information. Vicarious experience and verbal persuasive experiences exerted significantly less influence at all points in the teacher preparation program, including the quarters when the preservice teachers were engaged in much less classroom teaching than classroom observation, learning from course instructors, and discussing with mentor teachers.

Importance of Content Knowledge

Because so few preservice teachers in the participating cohorts possessed master's degrees in their content areas, conclusions about the importance of content knowledge in determining teacher efficacy beliefs are especially tentative. Quantitative data revealed no significant differences in either PSTE or STOE scores between participants with master's and bachelor's degrees, indicating that content knowledge does not have an impact on teacher efficacy beliefs. Nevertheless, for people with master's degrees, there was a significant, strong, and positive correlation (0.583, $p = 0.018$) between PSTE and STOE. There was no significant correlation for participants with bachelor's degrees alone, indicating the content knowledge, does, in fact, make a difference on teacher efficacy beliefs. The qualitative data revealed that content knowledge was an important factor for some of the preservice teachers in this study. Anna's lack of knowledge about certain topics lead her to be not self-confident about teaching those topics. As a result, she adopted teaching strategies that she would not have utilized otherwise:

> I think that I need to really brush up on my content…Like, with genetics, I had a really easy time with it. But ecology, I felt like I didn't have a clue. It just changes per topic. So I feel like I almost need to brush up on my content—I'm kind of weak on my content, as bad as that is to say." (Anna, interview, 6/06)

Similarly, Emily described her fear of being unprepared for her winter teaching assignment: "If I go into a classroom and I don't know something, I'm going to get killed." (Emily, interview, 2/05). Although Anna and Emily were both working toward Life Science licensure and teaching within their content areas, content gaps came most often to a head when the preservice teachers (who were overwhelmingly working on Life Science licensure) were asked to teach physical science at their middle school field placement. Raina, who was pursuing Life Science licensure, wrote about her attempt at teaching Newton's Second Law of Motion:

> I attempted to rearrange the equation for them (I forgot to do this when lesson planning because I forget that they haven't had algebra and can't do it for themselves), and of course, I messed it up. I'm a biologist! Math makes me cry! (Raina, written reflection, 2/05)

On the other hand, strong content knowledge appeared to strengthen the sense of efficacy of many of the preservice teachers. For example, when Henry realized that he knew much more about geology than his mentor teacher, he confidently took over writing all of the lessons for both his class and his mentor teacher's classes during his winter field experience. Emily summed up why possessing sufficient content knowledge was so important to a teacher's sense of self-confidence:

> The hardest lessons to teach are the ones that I, myself, am not very knowledgeable in. Sure, I know the content that I need to teach, but sometimes I have limited examples and am not as quick with off-topic questions. Over time, I am sure I will gain familiarity with all of the content, but for now, teaching biology is certainly my comfort zone. (Emily, written reflection, 5/05)

In sum, it appears that beyond a certain level of content knowledge, teacher efficacy beliefs are not enhanced through the growth of content knowledge; however, below that level of content knowledge, teacher efficacy beliefs are enhanced with the growth of content knowledge.

Confirming the Proposed Model

The adapted Tschannen-Moran, Woolfolk Hoy, and Hoy (1998) model (Figure 7.1) was partially confirmed. One's sense of teacher efficacy emerged as a result of mastery experiences, most importantly, with vicarious experiences and verbal persuasive experiences making the second and third largest impact, respectively. Emotive incidents frequently accompanied mastery experiences and occasionally accompanied verbal persuasive experiences and vicarious experiences, enhancing the impact of these experiences on a given preservice teacher's sense of efficacy. In some cases, it is likely that without an experience carrying with it an emotional reaction, the impact on teacher efficacy beliefs would have been substantially reduced.

Furthermore, this study did find a relationship between teacher efficacy beliefs, beliefs about students, and beliefs about the role of the teacher. Many of the preservice teachers in the sub-sample felt that confidence helped them to be more innovative in their teaching. This may be interpreted as a heightened sense of teacher efficacy allowing them to try less familiar instructional methods. Alternately, it is possible that those preservice teachers who had teaching philosophies that were most aligned with the philosophy of the teacher education program developed a more positive sense of efficacy as a result of their initial beliefs being validated by course professors. A more tentative relationship was found between teacher efficacy beliefs and beliefs about students. Qualitative data revealed that a more positive sense of teacher efficacy was associated with the belief that it was important to establish constructive and respectful relationships with students. Vice versa, a more negative sense of teacher efficacy was associated with negative beliefs about the capabilities of all students.

Finally, participants' knowledge of the content that they were asked to teach appeared to be related to their sense of efficacy. More specifically, preservice teachers who were teaching within their area of expertise felt more confident in their capabilities to be a successful teacher than those who were teaching outside their area of expertise. This trend was quite clear in the qualitative data, but unobservable in the quantitative data, which was only obtained at the beginning and end of the program, rather than at intermediate points within the program. It seems likely that rather than examining how STEBI-A scores change according to highest degree earned, it would be more meaningful to examine STEBI-A scores of preservice teachers who were teaching in and out of their areas of expertise.

Summary: Profiles of High and Low Efficacy Preservice Teachers

The experiences and outcomes of low and high efficacy preservice teachers varied quite significantly during the teacher preparation program. These experiences and outcomes are summarized in Figure 7.3.

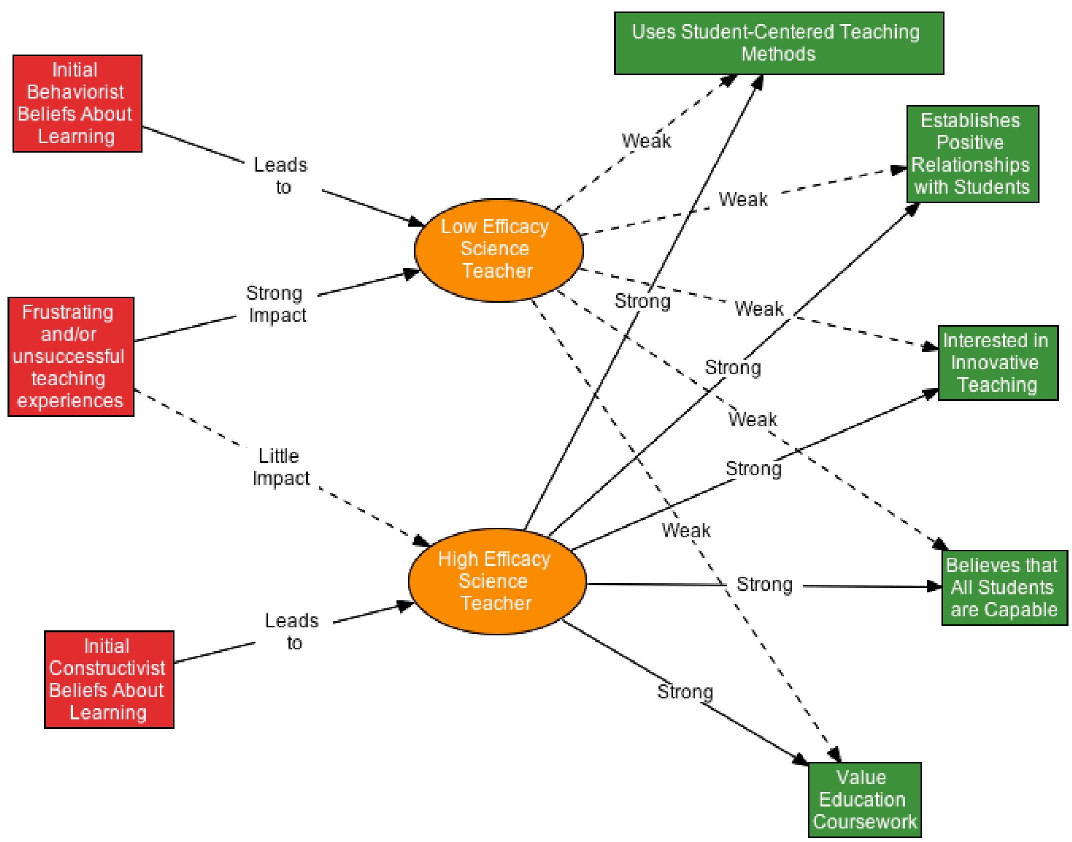

Figure 7.3: Experiences and outcomes of low and high efficacy preservice teachers

Low efficacy preservice teachers, as a group, were more often and more easily negatively impacted by teaching experiences in which they felt frustrated or unsuccessful, and they were more frequently discouraged by mentor teachers who were poor role models and/or unsupportive. High efficacy preservice teachers were more resilient, even in the face of failure and infrequent combative relationships with mentor teachers and students. Low efficacy preservice teachers tended to feel more pessimistic about the value of their education coursework, and frequently complained that they were unable to use in practice the theory they were required to learn. High efficacy preservice teachers were more positive about their coursework, and made special efforts to point out situations in their classrooms where they did use theories they had learned.

Low and high efficacy preservice teachers also differed in their beliefs about teaching. High efficacy preservice teachers were more interested in being innovative in their field placement classrooms. Conversely, low efficacy preservice teachers expressed a lack of confidence at trying instructional methods that were new to them. The two participants who demonstrated the largest gains on the STEBI-A also possessed constructivist beliefs about teaching and learning from the beginning of the year, when the most other participants expressed expository beliefs. For the preservice teachers initially possessing expository beliefs, the attempt to align their initial beliefs with the message from their professors appears to have undermined their confidence.

In their field placement classrooms, high efficacy preservice teachers were better able to establish positive relationships with their students than low efficacy preservice teachers. Additionally, it tentatively appears that high efficacy preservice teachers utilized constructivist teaching techniques more frequently than did low efficacy preservice teachers; however, several discrepant cases indicated that the relationship between teacher efficacy beliefs and teaching practices was more complex than anticipated.

Finally, low and high efficacy preservice teachers differed in their beliefs about students. High efficacy teachers expressed the belief in the importance of establishing positive relationships with students. Lower efficacy teachers expressed negative beliefs about the capabilities of students.

Implications for Teacher Education

In this study, preservice science teacher efficacy beliefs were directly affected by mastery experiences, vicarious experiences, and verbal persuasion. Changes in beliefs were facilitated through the process of personal reflection. Beliefs about teaching were affected by personal teaching experiences, pressures outside the classroom, student expectations, theoretical knowledge obtained, vicarious experiences, personal reflection, and verbal persuasive experiences. Beliefs about students were affected by personal teaching experiences, verbal persuasive experiences, observations of other teachers, personal experiences as students themselves, and media portrayals of students. Hence, teacher education programs must consider utilizing these types of experiences when designing their courses and field experience practica.

In all cases, personal teaching experiences had the largest impact on preservice teacher beliefs. A conceptual change process appeared to be responsible for some of these changes in beliefs. In terms of beliefs about teaching, participants who attempted to teach in traditional, expository ways, were sometimes met with low levels of student learning. As a result, they considered whether other models of teaching and learning would work better. With this result in mind, I would suggest that teacher educators hoping to promote constructivist teaching strategies create situations where expository teaching does not meet with success, and where the preservice teachers are forced to confront their initial beliefs about teaching. Unexpected student resistance may have also contributed to conceptual change in some participants, particularly in cases where the preservice teachers strongly expected students to react positively to an instructional strategy but instead where students complained or even refused to participate. Again, teacher educators could create such situations; these anomalies, in the eyes of the preservice teachers, would encourage them to reexamine their beliefs regarding good teaching (Hollingsworth, 1989; Matanin & Collier, 2003; Posner et al., 1982). Additionally, perhaps encouraging the preservice teachers to analyze specific aspects of their teaching practices would have helped them to gain a more analytic approach to teaching (Ashton, 1984), rather than reacting quickly and negatively.

In terms of beliefs about students, many of the preservice teachers had little previous experience with children of different ages and from different socioeconomic backgrounds, and so working with students who were unfamiliar to them caused (in a few cases) adjustments in their beliefs. This was most visible when preservice teachers made the transition between teaching in urban and suburban schools or between middle and high schools. As some of most powerful mastery experiences resulted from teaching students and obtaining an unexpected result, it may be helpful to set up experiences throughout the program in which the preservice teachers must evaluate their beliefs and deal with cognitive conflicts. Additionally, providing them with opportunities to teach students of as many different backgrounds as possible should help them build a base of knowledge and deal with stereotyping beliefs about students, as has been suggested previously (Ashton, 1984; D. F. Brown, 2004; Garmon, 2004; Haritos, 2004; Luft, 1999). If there is not time or opportunity to engage in field experiences with diverse students, perhaps teacher education program prerequisites might include some sort of experience working with students from diverse backgrounds (Garmon, 2004). Some researchers have also suggested that preservice teachers engage in readings, videos, personal writing, and discussion before they engage in urban teaching experiences so that the preservice teachers do not focus entirely on the problems associated with inner city schools (Tiezzi & Cross, 1997). Allotting sufficient time for cognitive processing, as well as sharing and discussing with others, is important in these endeavors.

As stated above, teacher efficacy beliefs were most often enhanced through mastery teaching experiences. With this in mind, teacher educators might provide the opportunity for preservice teachers to frequently engage in mastery experiences teaching science. Taking it a step further, teacher educators could use the mastery experience as a jumping off point for preservice teachers to engage in critical self-analysis concerning their teacher efficacy beliefs (Ginns & Tulip, 1995). Teacher educators could also take care to identify preservice teachers with inaccurately negative teacher efficacy beliefs, and to point out mastery experiences in which they engage (Gist & Mitchell, 1992).

As most powerful vicarious experiences involved observing course professors and mentor teachers teach both successfully and unsuccessfully, it is important for teacher educators to model and to choose mentor teachers that will model the type of teaching behaviors that they advise their teacher education students to utilize in practice (Czerniak & Chiarelott, 1990; Tosun, 2000). Since this source of influence was most important to preservice teachers' sense of efficacy during their first field experience, most effort should be put into selecting this particular group of mentor teachers. It has been suggested that colleges of education develop closer relationships with their placement schools such that university personnel spend substantial time in the schools and school personnel have input into colleges of education courses and requirements (Tiezzi & Cross, 1997). On the other hand, several preservice teachers in this study benefited by working with mentor teachers who differed substantially in beliefs about teaching or about students, as they were forced to justify their own beliefs about themselves as teachers and about their students. Some researchers have recommended that preservice teachers be placed in classrooms with mentors who have philosophies different from their own, to again induce a sort of cognitive conflict which would need to be resolved (Kagan, 1992b).

The vicarious experience of watching television shows and movies that depict teachers and students might be dealt with head-on by course instructors, who could point out the stereotyped images that are projected by most media and then discuss the contrasts between those media images and actual experiences of the preservice teachers.

The most powerful verbal persuasive elements came from mentor teachers, which again suggests the importance of placing preservice teachers with supportive and experienced mentor teachers, ones who possess the skills, knowledge, and dispositions to assist the preservice teachers in learning how to teach and their enculturation into teaching. The preservice teachers frequently complained that they were stuck between trying to appease their mentor teacher's push to teach in more expository ways in order to cover more content standards and trying to appease their university supervisor and course instructor's push to teach in more constructivist ways. Therefore, teacher education programs might consider choosing mentor teachers whose philosophies of teaching align with their own. Verbal persuasion made a rather negative impact on teacher efficacy beliefs, beliefs about teaching, and beliefs about students during field experiences when a given preservice teacher was placed in an urban school and with an unsupportive mentor teacher, so it is especially key to carefully choose supportive and experienced mentor teachers in urban schools.

No evidence was found that affective states by themselves resulted in belief changes, although many of the mastery experiences, vicarious experiences, and verbal persuasive experiences were intensified due to their accompaniment by an emotional incident. In fact, it was hypothesized that many of the experiences described in this document would not have been powerful and belief-changing if emotional reactions were not a component of them. Therefore, it is important to allow preservice teachers space, in courses and in their field experiences, to express rather than stifle their feelings. This could be accomplished in a variety of ways. After observations of their teaching, university supervisors might encourage the preservice teachers to describe not just what happened in class but to express how they felt about it. Course instructors might ask students to reflect not just cognitively on reading or discussion, but also emotively. It is wise to be cautious in this area, however, as high emotional arousal can result from failed teaching experiences, exacerbating one's already low sense of teacher efficacy (Tosun, 2000).

More generally, preservice teachers in this study were negatively impacted when they did their urban teaching placement in the winter as opposed to in the fall. The obvious suggestion, then, is to assign preservice teachers as early as possible to urban schools or other experiences in urban environments. If it is not feasible for all preservice teachers to teach at an urban school for their first field experience, perhaps they could all be required to do community service, tutoring, or work with children in some other capacity in an urban environment early on in the teacher education program.

University coursework impacted some participants' beliefs about teaching, particularly those who were able to connect the knowledge they learned in courses with their teaching experiences. Course instructors might use this conclusion to redesign their courses to make them align better with what the preservice teachers feel they need in order to be better teachers in their field experiences (Middleton, 2002). They might more explicitly point out connections between theories learned in courses and practical ways to observe and/or apply these ideas in their teaching placements. They might provide opportunities to try out, on a smaller scale, some of the teaching strategies and philosophies that the teacher education tries to instill (Cantrell et al., 2003). Some researchers have even questioned whether or not teaching formal theory to preservice teachers is useful and relevant (Eisenhart & Behm, 1991; Kagan, 1992b); perhaps that time is better spent on the practical aspects of teaching. To enhance teacher efficacy beliefs, they might directly discuss issues of efficacy and burnout (Evans & Tribble, 1986), as well. It is also important for course instructors to spend time in the classrooms in which their teacher education students are engaged, so they are not seen as isolated from real teaching and real schools.

Course instructors might deal directly with the pressure teachers face to prepare students for standardized tests and expectations from parents and administrators. In terms of test preparation, methods course instructors should point out the critical thinking skills and higher order thinking required by some high stakes exams (Ohio.Department.of.Education, 2004), and provide concrete lesson ideas and longer-range teaching plans to help them achieve the goal of preparing students for such exams.

The importance of sufficient time and space has been mentioned repeatedly throughout the above paragraphs for teacher educators who are interested in promoting changes in beliefs. Preservice teachers in this study and in many others were overwhelmed at times with what was asked of them in terms of course and field teaching requirements. They frequently spoke of setting priorities and sacrificing what was asked of them by their course professors in favor of working on their classroom teaching. It is certainly possible that more significant and lasting changes in belief would have emerged from this study if the preservice teachers felt that there was enough time to engage in serious reading, writing, reflection, and discussion about educational issues (Adams &

Krockover, 1997; Bianchini & Solomon, 2003; Evans & Tribble, 1986; Gregoire, 2003; Middleton, 2002). Furthermore, it has been suggested that teachers who are engaged in new teaching contexts develop a lessened sense of teacher efficacy, and time is required in order to see the rebound in efficacy beliefs which hopefully occur later (Ross, 1998). Along the same lines and like any other student, teacher education students need time to learn new concepts and skills before moving on to more complex ones (Czerniak & Chiarelott, 1990). It is important to allow time for the preservice teachers to get comfortable with the routines, classroom management strategies, and content knowledge required of them in their field experiences before asking them to be innovative and creative in their teaching (Bullough & Baughman, 1997). It is even possible that there might be a sequence of order that could help most preservice teachers learn content and skills without feeling like they had to think about all the aspects of teaching at the same time (Hollingsworth, 1989).

Finally, what I noticed in the data from this study more than the overall trends was the fact that each preservice teacher was impacted by different experiences and factors. Some preservice teachers were inspired by positive role models, while others were inspired by negative role models. Some preservice teachers claimed to get a tremendous amount out of education courses, while others claimed they got nothing at all. This is, perhaps, evidence suggesting that preservice teacher education should not be a “one size fits all” program. Individual preservice teachers have learning needs that are specific to them, much as their future students do, and so it is important for teacher educators to consider these needs and initial beliefs about themselves, teaching, and their students when designing their courses and particularly the field experience placements (Bullough & Baughman, 1997; Rennie, 2001).

Implications for Future Research

This research, limited to a single secondary science teacher preparation program, provides some jumping-off points for future research. First, the present study verified some previous research showing the inflexibility of some types of teacher beliefs. Therefore, it is key to ask from where and what experiences do preservice teachers' initial beliefs arise. Second, while this study detected several influences on teacher beliefs, a closer analysis of the mechanism by which belief change happens is warranted. More specifically, how exactly do preservice teachers reconcile the beliefs arising from various aspects of their life experience and teacher education (Hoy, Davis, & Pape, 2006)? Third, the obvious next step is to follow up with these preservice teachers in the first years of their teaching to determine if their beliefs and practices change or remain the same as a result of professional teaching experiences, as well as whether or not their beliefs and practices become more or less aligned with each other.

It is important to examine relationships between teacher beliefs and specific aspects of science classrooms. For example, are less efficacious teachers more or less custodial in their management of the classroom and do they assign different amounts or types of work to their students? Next, the present study examined preservice science teachers from all content areas but lacked sufficient sample size to compare beliefs of preservice teachers from different fields of science. It is certainly possible that life science, earth science, and physical science teachers have fundamentally different ways of seeing and teaching their content; consequently, the teachers' beliefs might differ.

This study found that preservice teacher beliefs about students and teaching were related to teacher efficacy beliefs, so an examination of the outcomes of these relationships would be helpful. For example, what level of teacher efficacy most encourages one to try innovative teaching strategies (Ross, 1998)? Some researchers have suggested that if one's sense of efficacy is too high, one becomes complacent, whereas a middle level of efficacy might most encourage innovation and change (Wheatley, 2002).

Another limitation of the present study was the lack of attention paid to students in the preservice teachers' placement classrooms; future researchers need to examine classrooms from the students' perspectives in order to gain a more full picture of teacher beliefs in practice. A comparison of student perceptions of their teachers compared to the teacher perceptions of themselves seems an important step toward this goal, as has been done previously (Hoy & Weinstein, 2006). Furthermore, not enough attention has been paid to the impact of teacher beliefs on student learning. Although the direct relationship between teacher efficacy beliefs and student achievement has been fairly well established, little research has examined how philosophical beliefs about teaching relate to student achievement.

Conclusion

Bullough and Baughman (1997) point out: “Just as teachers hold beliefs, beliefs hold teachers.” (p. 69). Hence, it is important for teacher educators to consider the beliefs of their students when designing and implementing courses, workshops, and field experiences. The beliefs of the preservice teachers in the present study were influenced—and in some cases, not influenced—in a variety of ways by their course professors, mentor teachers, and most importantly, by their field placement teaching experiences. Suggestions have been presented based on these results to better prepare secondary science preservice teachers to be more resilient and innovative, and to have high expectations for the learning of all students.

APPENDIX A

M.ED. COURSE REQUIREMENTS

First Summer Quarter:

Edu.T&L 636.01	Practicum in Science for Teachers
Edu.T&L 721.03	Logic and Psychology in School Mathematics/Science
Edu.T&L 748.01	Introduction to Teaching Mathematics, Science, and Technology
Edu.T&L 751	Fundamental Ideas of School Science
Edu.T&L 925R23	Seminar in Mathematics, Science, and Technology
	Science content course(s)

Autumn Quarter:

Edu.T&L 642	Teaching Reading Across the Curriculum
Edu.T&L 748.02	Methods of Integrating Mathematics, Science, and Technology
Edu.T&L 884K23	Planned Field Experience (Internship: middle school or high school)
Edu.T&L 884G23	Planned Field Experience (Clinical experience)
	Science content course(s)

Winter Quarter:

Edu.T&L 607	Adolescent Learning & Developmental School Content
Edu.T&L 748.03	Reading All Students in Mathematics, Science, and Technology
Edu.T&L 636.02	Practicum in Science for Teachers
Edu.T&L 850	Integrated Content
Edu.T&L 884K23	Planned Field Experience (Internship: middle school or high school)
Edu.T&L 884G23	Planned Field Experience (Clinical experience)
	Science content course(s)

Spring Quarter:

Edu.T&L 884L23	Planned Field Experience (Student teaching internship)
Edu.T&L 884G23	Planned Field Experience (Clinical experience)

Second Summer Quarter:

Edu.T&L 925E23	Seminar in Mathematics, Science, and Technology
	Science content course(s)

APPENDIX B

SCIENCE TEACHING EFFICACY BELIEF INSTRUMENT

****

Please Indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters to the right of each statement.

SA = Strongly Agree
A = Agree
UN = Uncertain
D = Disagree
SD = Strongly Disagree

****

1.	When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	SA A UN D SD
2.	I am continually finding better ways to teach science.	SA A UN D SD
3.	Even when I try very hard, I do not teach science well.	SA A UN D SD
4.	When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.	SA A UN D SD
5.	I know the steps necessary to teach science concepts effectively.	SA A UN D SD
6.	I am not very effective in monitoring science experiments.	SA A UN D SD
7.	If students are underachieving in science, it is most likely due to ineffective science teaching.	SA A UN D SD
8.	I generally teach science effectively.	SA A UN D SD
9.	The inadequacy of a student's science background can be overcome by good teaching.	SA A UN D SD
10.	The low science achievement of some students cannot generally be blamed on their teachers.	SA A UN D SD
11.	When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.	SA A UN D SD
12.	I understand science concepts well enough to be effective in teaching secondary science.	SA A UN D SD

13.	Increased effort in science teaching produces little change in some students' science achievement.	SA A UN D SD
14.	The teacher is generally responsible for the achievement of students in science.	SA A UN D SD
15.	Students' achievement in science is directly related to their teacher's effectiveness in science teaching.	SA A UN D SD
16.	If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.	SA A UN D SD
17.	I find it difficult to explain to students why science experiments work.	SA A UN D SD
18.	I am typically able to answer students' science questions.	SA A UN D SD
19.	I wonder if I have the necessary skills to teach science.	SA A UN D SD
20.	Effectiveness in science teaching has little influence on the achievement of students with low motivation.	SA A UN D SD
21.	Given a choice, I would not invite the principal to evaluate my science teaching.	SA A UN D SD
22.	When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better.	SA A UN D SD
23.	When teaching science, I usually welcome student questions.	SA A UN D SD
24.	I do not know what to do to turn students on to science.	SA A UN D SD
25.	Even teachers with good science teaching abilities cannot help some kids to learn science.	SA A UN D SD

APPENDIX C

REFORMED TEACHING OBSERVATION PROTOCOL

Background Information

Name of Teacher		
Observation Announced?	(Yes, No, or Explain)	
	Class Location	
District		
School		
Room		
Years of Teaching		
Teaching certification	K through 8	7 through 12
Subjects Observed		
Grade Level		
Observer		
Date of Observation		
Start Time		
End Time		

25) **Contextual Background and Activities**

In the space provided below, please give a brief description of the lesson observed, the classroom setting in which the lesson took place (space, seating arrangements, etc.), and any relevant details about the students (number, gender, ethnicity, etc.) and teacher that you think are important. Use diagrams if they seem appropriate.

III. Lesson Design and Implementation	Never Occurred 0	1	2	3	Very descriptive 4
1) The instructional strategies and activities respected students' prior knowledge and the preconceptions inherent therein.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
2) The lesson was designed to engage students as members of a learning community.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
3) In this lesson, student exploration preceded formal presentation.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
4) This lesson encouraged students to seek and value alternative modes of investigation or of problem solving.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
5) The focus of the lesson was often determined by ideas originating with students.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4

IV. Content

Propositional Knowledge	Never Occurred 0	1	2	3	Very descriptive 4
6) The lesson involved fundamental concepts of the subject.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
7) The lesson promoted strongly coherent conceptual understanding.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
8) The teacher had a solid grasp of the subject matter content inherent in the lesson.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
9) Elements of abstraction (i.e., symbolic representations, theory building) were encouraged when it was important to do so.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
10) Connections with other content disciplines and/or real world phenomena were explored and valued.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4

Procedural Knowledge	Never Occurred 0	1	2	3	Very descriptive 4
11) Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives, etc.) to represent phenomena.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
12) Students made predictions, estimations, and/or hypotheses and devised means for testing them.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
13) Students were actively engaged in thought-provoking activity that often involved the critical assessment of procedures.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
14) Students were reflective about their learning.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4

15) Intellectual rigor, constructive criticism, and the challenging of ideas were valued. ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4

V. Classroom Culture

Communicative Interactions	Never Occurred 0	1	2	3	Very descriptive 4
16) Students were involved in the communication of their ideas to others using a variety of means and media.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
17) The teacher's questions triggered divergent modes of thinking.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
18) There was a high proportion of student talk and a significant amount of it occurred between and among students.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
19) Student questions and comments often determined the focus and direction of classroom discourse.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
20) There was a climate of respect for what others had to say.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4

Student/Teacher Relationships	Never Occurred 0	1	2	3	Very descriptive 4
21) Active participation of students was encouraged and valued.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
22) Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
23) In general, the teacher was patient with students.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
24) the teacher acted as a resource person, working to support and enhance student investigations.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
25) The metaphor "teacher as listener" was very characteristic of this lesson.	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4

Add additional comments you may wish to make about this lesson in the attached page.

APPENDIX D

SEMI-STRUCTURED INTERVIEW PROMPTS

Interview Questions For First Quarter of Coursework

1. How do you think of yourself as a science teacher?
   (Alternately:What image do you have of yourself as a science teacher?)
2. To what extent do you think you can influence student learning?
3. What kind of experiences have made impacts on your education about teaching and learning?
4. What, in your view, are the characteristics of a good science teacher?
5. If you are successful as a teacher, is it
   a. because your students are intelligent and motivated?
   b. because you have helped them learn?
   (compare the importance of the two choices, if you choose both)
6. If your teaching is not successful, is it because
   a. the students were not motivated;
   b. your planning was inappropriate and needs modification in the future.
   (compare the importance of the two choices, if you choose both)
7. Please add any other thoughts that you might have regarding teaching.

Interview Questions For Before Student Teaching

1. How do you think of yourself as a science teacher?
   (Alternately:What image do you have of yourself as a science teacher?)
2. To what extent do you think you can influence student learning?
3. Have your ideas about teaching and learning changed since you began this program (M.Ed.)? In what way? What kind of experiences have made impacts on your education about teaching and learning?
4. What, in your view, are the characteristics of a good science teacher?
5. If you are successful as a teacher, is it
   a. because your students are intelligent and motivated?
   b. because you have helped them learn?
   (compare the importance of the two choices, if you choose both)
6. If your teaching is not successful, is it because
   a. the students were not motivated;
   b. your planning was inappropriate and needs modification in the future.
   (compare the importance of the two choices, if you choose both)
7. Please add any other thoughts that you might have regarding teaching.

Interview Questions For After Student Teaching

1. How do you think of yourself as a science teacher?
   (Alternately:What image do you have of yourself as a science teacher?)
2. To what extent do you think you can influence student learning?
3. Have your ideas about teaching and learning changed since you began this program (M.Ed.)? In what way? What kind of experiences have made impacts on your education about teaching and learning?
4. What, in your view, are the characteristics of a good science teacher?

5. If you could teach exactly the way you wanted to, how would your classroom and interactions with your students look like?
6. What fundamental teaching principles guide your practice?
7. When do you know that your students have learned a concept?
8. How do you know that your teaching was successful in the classroom?
9. If you are successful as a teacher, is it
    a. because your students are intelligent and motivated?
    b. because you have helped them learn?

    (compare the importance of the two choices, if you choose both)
10. If your teaching is not successful, is it because
    a. the students were not motivated;
    b. your planning was inappropriate and needs modification in the future.

    (compare the importance of the two choices, if you choose both)
11. Why do some students underachieve in science?

APPENDIX E

WEEKLY REFLECTION PROMPTS

Autumn Week 1: Perceptions of Becoming

Part I: As you begin your journey to becoming a teacher, you undoubtedly have some initial ideas of what you think constitutes “good teaching” or what qualities make an “effective” teacher. List between *five to seven* values or beliefs that you currently hold about teaching and describe why you feel each of these beliefs and values will aid you in becoming an effective teacher.

Part II: There are multitudes of metaphors that have been used to describe the teaching profession. For example, teaching could be compared to directing a play, hiking up a hill, or baking a cake. Think about your role as a teacher and how you see yourself as you embark on your teaching career. What metaphor would you create that represents your role and your work in the classroom? Create a visual representation of how you envision yourself as a teacher in a classroom. *(If you prefer, write a poem or cartoon strip that reveals your perceptions of your role as a teacher.)* Write a short reflection that explains the choices that you made in your representation.

Autumn Week 2: The role of the media on teachers’ beliefs

For this reflection, take some time to consider how the teaching profession is portrayed within films, books, magazines, and other media. Describe any overall trends you notice within the media and how they portray classrooms, students, teachers, and teaching. Do you feel that these representations are too critical or too romanticized about what actually happens in the day-to-day life of teaching and learning? How closely do they match with your previous experience in classrooms? How closely do they align with how you are currently experiencing classrooms and classroom teaching in your field placement? Select one book, news article, television program, or movie *(past or present)* and specify the ways it has had an impact on your current perceptions of teaching and learning.

Autumn Week 3: Past learning experiences I

In your experiences as a learner, think about two specific instances when you remember learning something important. These experiences could have been in a class, outside of school, at home, with friends, with family, at work, where ever you feel that you have successfully learned something.

Part I: Write out the details of each these learning experiences including the context, the “teacher”, the material you learned, and how you felt about learning this material.

Part II: Discuss any similarities between the two situations—was there a specific condition under which you learn best? Was there a common thread? Were there any complications or obstacles in how you learned?

Part III: How could you, as a teacher, recreate a learning situation similar to the experiences you had in a classroom?

Autumn Week 4: **Past learning experiences II**

Your initial beliefs about teaching have been dramatically shaped by your previous experiences with schools. In fact, you have spent approximately 13,000 hours of your life implicitly learning about teachers and the art of teaching.

Part I: Think about two of the ***most unsuccessful*** teachers you can remember. Write their names and a few characteristics of each person. What specific characteristics lead you to qualify this person as an "unsuccessful" teacher? What did they teach? What method of classroom management did they use? How did they structure lessons? Include as many details about this person(s) as possible.

Think about two of the ***most successful*** teachers that you can remember. Write their names and a few characteristics of each person. What specific characteristics lead you to qualify this person as a "successful" teacher? What did they teach? What method of classroom management did they use? How did they structure lessons? Include as many details as possible about this person(s) as possible.

Part II: Reflect on your responses to these questions. Do you think that other students at your school would respond as favorably or as negatively as you have? Were these teachers as successful or unsuccessful with other students? What makes you similar or dissimilar with these teachers? How do your thoughts about teaching differ? Would you find these teachers as successful or as intolerable today? How have these previous teachers affected your beliefs regarding what constitutes "good teaching"?

Autumn Week 5: The school within the community

Part 1: The schools in which we work are a direct reflection of the communities that they represent. In fact, schools can be viewed as miniature societies. During this week of your field experience, take a short walk (or drive) around the neighborhood of your school, (ideally with your mentor teacher). In the neighborhoods surrounding the school, notice the houses, the business, and people on the street. What do they look like? Where do people work and what do they spend spare time doing?

Make it a point to speak with one or two members of the surrounding community. Mention that you will be working at the school within the next few weeks. What do the people think about the job the schools are doing? What do they think about young people today? What is first and foremost on their minds when they talk about schools? Does the community seem to support the school? What do they seem most proud of? The athletic teams? The band? The facility itself? Scholarship winners? Improved test scores? If the school draws students from several neighborhoods, how do these neighborhoods contrast?

Part II: Write a reflection about your trip through the community that surrounds your school. How are your observations of the neighborhood reflected in the school, its teachers, its students, and their attitudes? What are the implications for the classroom in which you will be teaching? How much emphasis would be placed on proper dress for students and teachers? To what extent are controversial issues addressed within the school? How much support are you likely to receive from parents with respect to curriculum and discipline issues? How could you adjust your lessons to fit this population?

Autumn Week 6 The students in your classroom

Part I: Over the course of several days, from a discrete point within the classroom, make some observation notes about the students in your field placement classroom. Begin observing before any students arrive, during class time, as they leave the room and in the hallways. The following is a ***list of suggestions*** to guide your thinking.

- Notice who arrives first and last.
- What are the ages and genders of the students in the class?
- Do peer groups remain the same within the class as when they entered?
- What is the overall spacing between students and groups?
- Are their cliques? Who are the isolates?
- What roles do you notice the students playing (the joker, the cynic, teacher’s pet, the introvert)
- Who raises their hand most and least often?
- On which students does the teacher never call?
- Compare and contrast the behavior of the student in the front of the class and the back of the class.
- Who is paying the most and least attention? What is the attention span of the students in the room?
- Who is asking for the most help? Who are they asking to help them?
- Who receives the most praise and criticism? Is anyone being ignored?
- How much communication is exchanged between groups?
- Is the relationship between students mostly cooperative, competitive, or individualistic?

Part II: In paragraph form, reflect on your observations of the students and your reactions to what you observed as well. Within your class profile, state the most prominent groups and how they interact. Which individuals play key roles in relationships among students? Are minority/female/disabled students treated differently? Do any of these appear to participate to a greater or lesser degree? What adjectives describe your reactions to some of these observations? Are you at all surprised by your reactions? Use conjecture to describe how students might feel about coming to school here every day. What do you feel it is like to “live” at this school?

Autumn Week 8: Beliefs and values in action

During the first week of this quarter, you identified the values and beliefs you hold that will enable you to become an effective teacher.

Part I: Now that you have had some experience with students and schools, revisit your list. For each value or belief, provide a real example of how you demonstrated each value or belief to your students, your mentor and/or your supervisor during this field experience. The same experience may qualify for more than one value or beliefs.

Part II: Did you have any trouble trying to match a value with an actual experience? Are any of your stated values left without a real example? Which one(s) were most troublesome? What does this mean to you? How would you edit or revise your list of values and beliefs based on the past seven-week experience?

Autumn Week 9: Formulating a philosophy of education

As part of the teaching portfolio you will create during next two field experiences, you will be asked to develop a personal philosophy of education. This personal statement is by no means static, but always being revisited and adjusted based on our personal and professional growth. Your reflection this week is to develop a draft of your philosophy of education. Be sure to consider the following questions in your draft.

What is the ultimate goal of education? Why should people be educated? What constitutes a good education? How do your values and beliefs complement the ultimate goal of education? How do you see yourself as a teaching professional? How are your answers to the above reflected in your own teaching? Cite examples from this quarter, or project what you will do next quarter that will reflect your responses.

Winter Topic 1— Equity in Education

This reflection has two parts. In the first part you are to educate yourself about the issue of equity in school funding in Ohio. In the second part you are to respond to a very real possible scenario. You must be creative and your solution must be feasible. That is, anyone finding herself or himself in the described scenario could implement your proposed solution successfully.

Background: Equity in education is an issue that manifests itself on a variety of levels. At the global level there is the issue of lack of access to education for groups such as females in some cultures, or the rural class of some countries. In this country at the state level, there is the issue of disparity in economic resources from district to district.

> That struggle goes back at least to 1991, when in DeRolph vs. State of Ohio a father brought suit against the state after

> overcrowding left his son without a desk, sitting on a classroom floor to take a test. In 1997, the Ohio Supreme Court decided the case, ruling that school funding in Ohio was inequitable due to the state's reliance on local property taxes.[1]

Why, after 14 years, is there still no solution to this problem? What factors are preventing passionate and informed people from devising a workable solution? Talk with your mentor and other building staff. What is their perception of the problem? What direct experience have you or they had that illustrates the severity of the problem?

For the past year and a half, a task force of 36 members has been working on solutions. They currently have 16 recommendations, including a constitutional amendment that would allow real estate taxes to grow with property values.[2] (See the website for the minutes of their meetings to get a greater sense of the complexity of the problem and all the issues they are trying to address). In the current system, voters at the district level approve a tax levy at a fixed rate for a given number of years that will generate a fairly predictable amount of money. Before it expires, districts estimate current and future needs and put a new levy on the ballot for voters to consider.

Reflection topic: According to your competency packet, you are expected to teach using technology to enhance and enrich your lessons (not only as a student of education, but in your future as an educator). Assume the district you are in has no cart of laptops for student use, and your building has no projector for you to use with your class due to lack of funds. Assume your students have very limited knowledge of how to search the Internet and how to use Word or PowerPoint. How will you meet the expectations? What creative solutions can you think of? Please describe in detail your ideas. They should go beyond your immediate teaching situation such that if you find yourself working in a district like the one described here, you have a ready solution to implement. Remember to do some trouble-shooting by anticipating possible stumbling blocks and how those can be dealt with, should they arise.

Winter Topic 2—Inclusion

Background: Congratulations! You have been chosen to participate in the Society for Making an Improved Learning Environment (SMILE) in your school. As a member of this society, you must decide how to structure future classrooms in your current school. Of particular concern to the society is the issue of how to distribute students in various classes; in particular, should special needs (students with learning disabilities, English as a second language learners, gifted and talented students, students with physical

---

[1] www.whatkidscando.org/ images/general/**schoolfunding**FS.**pdf**

[2] http://www.blueribbontaskforce.ohio.gov/meetings/10-28-04_minutes.asp

disabilities, etc.) students be distributed into regular classes? Should they instead have separate programs with other students who share similar characteristics and/or abilities?

Reflection topic: In one paragraph, discuss at least three reasons to include special needs students in regular classrooms. In a second paragraph, discuss at least three reasons not to include special needs students in regular classrooms. In a third paragraph, state your own opinion about this issue, using evidence from your teaching experiences to support your ideas.

Winter Topic 3—"Withitness"

Background: In his work researching the qualities of effective teachers, Kounin discusses the value of teachers having a sense of "withitness."[3] "Withit" teachers monitor student needs and the overall, ever-changing climate of the classroom by paying close attention to students' nonverbal and verbal responses. When events deviate from a teacher's expectations or plans, a teacher who is "withit" responds by changing the pace of a lesson, moving around the room, and/or interacting with students in an effort to redirect and refocus attention and learning. A "withit" teacher does what may seem impossible, simultaneously perceiving cues from all students (having "eyes in the back of their heads"), thinking about what these cues mean, and continuing the class instruction.

Reflection topic: Using a 20-minute excerpt from one of the lessons you have videotaped during this placement, cite specific examples of how you demonstrated a sense of "withitness" in your teaching. If you find no examples of "withitness" in the videotaped lesson, discuss why you were not "withit" in that lesson and how you will, in future lessons, work toward being more "withit". Then discuss two specific characteristics that you feel have helped in your developing sense of "withitness" as well as one characteristic that you could develop further to be more "withit."

Winter Topic 4— Inappropriate Student Behavior

Background: Inappropriate student behavior may materialize in many forms. For example, while seemingly harmless, some situations in which actions or words are expressed can escalate in intensity and lead to significant problems in the future. A "friendly" punch in the arm might lead to a "pain perception" contest in class, which might later lead to a fight in the hallway. Similarly, the use of certain language can be inappropriate, even though it may be common "lingo" among students, since it might also be disrespectful of a particular population. Inappropriate language use may leave particular students feeling ostracized, may

---

[3] http://www.pecentral.org/climate/april99article.html

reinforce stereotyping, and ultimately, may serve to disadvantage groups of people.

Reflection Topic: For this reflection, choose one scenario that you wish to tackle and respond to the following: 1) Describe (or invent) a situation in which an inappropriate action or expression was observed and 2) Explain why you consider this to be an inappropriate behavior. 3) Explain (or imagine) a potential adverse situation that might result had the situation been ignored by you or another teacher. 4) Describe an appropriate course of action you or another teacher used (or might use) to address the situation. 5) Comment on how well you feel the course of action allowed (or would allow) the "offending" student to maintain his or her dignity. Did (or would) the student realize why the behavior was inappropriate? How did (or would) you know? 6) Did (or would) this student have an opportunity to apologize or correct the behavior and how did you or the teacher (or would you) recognize and respond to this attempt to "make amends"?

Winter Topic 5 — Questioning

Observation: Discourse in the classroom is important in facilitating student learning. One small aspect of discourse is asking good questions. As you know from your methods and content courses, good questions should be designed to draw on students' experiences in previous content courses, experiences outside of school, and diverse personal backgrounds. Good questioning skills may also serve as a means to help students extend their thinking and to monitor each student's understanding of the material.

For this week, you are to track the questioning during an appropriate ***20-minute*** segment of your mentor's teaching AND the questioning in an appropriate ***20-minute*** segment of your own videotaped lesson. To track the questioning, start with a seating chart: Who is asking the most questions and to whom those questions are asked? Are the questions bidirectional? At what level of Bloom's Taxonomy are most of the questions being asked?

Reflection Topic: What patterns of questioning were apparent in your mentor's lesson? What patterns were apparent in your lesson? What do those patterns reveal about student learning in the class? Do the students ask questions of each other? Are there some students more engaged than others? Are certain students allowed to dominate the discourse? How could you structure your lesson differently so that more students are engaged, more students are asking questions of themselves and their classmates and more questions from the higher level of Bloom's Taxonomy are introduced in the class?

Winter Topic 6— Learning Gaps

Background: Some research has demonstrated that the learning gaps in math, science, and technology between girls and boys and between students of different ethnic backgrounds have decreased in recent years. Observe your class through critical gender and ethnicity lenses this week, with an eye for discerning achievement and involvement differences between groups of students. You may choose to examine differences in assessment scores, classroom discourse and interest, or some other performance that you think is valid.

Reflection topic: What trends did you notice in terms of what students are most successful in your class or what students are least successful (either according to gender, ethnic background, or some other characteristic)? What evidence did you find for either the existence of a learning gap or the absence of a learning gap? Do you think the learning gap in your classroom is shrinking or growing, and to what causes do you attribute this trend?

Winter Topic 7—Assessment

Background: As part of the coursework and field experience this quarter, you will develop or modify at least one summative assessment for your students. This might be a quiz, test, project or other performance-based assessment. Prior to implementing this assessment, talk to your mentor teacher (or another teacher who will be assessing the same unit objectives).

Reflection Topic: After administering the assessment, respond to each of the following questions: 1) summarize the results of students' performance. How many students "mastered" the objective? Based on the results, 2) what did you learn about particular students' mastery of the objectives? Who was successful and who was not? For example, what identifiable characteristics describe students who mastered the objectives compared to those who did not? 3) Pick at least one student who did not demonstrate learning of at least one objective (if all students met all objectives, invent a hypothetical student you may encounter in the future). With this student in mind, develop a remediation plan. This might consist of modification to a lesson(s), the assessment, and/or a follow-up re-teaching plan for the unit (after the assessment). For this plan, describe what you would do differently to help that student succeed in learning the objective(s).

Winter Topic 8—Comparison of Autumn and Winter Field Experiences

Observation: Look over your notes, lesson plans, and reflections from both your Autumn and Winter field experiences. Pay special attention to characteristics of your mentor, school, and students for each field experience. It may help you to make a list of important or defining characteristics of each mentor, school, and set of students.

Reflection Topic: Compare and contrast your mentor, school, and students from your Autumn and Winter field experiences. Are there more similarities or differences in the two different contexts? To what do you attribute the similarities (i.e., are there some universal "good practices" in education)? To what do you attribute the differences (i.e., in what ways do the different situations call for different practices)?

Spring Topic 1—Social Justice

Observation in Action: Social justice in the context of the school concerns issues such as bullying, singling particular students out, social cruelty, hazing, and sexual harassment. Note that *all* building members are potential instigators and/or victims. Be observant and cognizant; much of this can be quite subtle and go undetected without "withitness". How is social justice, or the lack thereof, being manifested in your building? Consider maintaining a log for a couple of weeks in which you jot down comments and actions that exemplify the concept. These can be seemingly insignificant comments or gestures made between students or between students and staff. These can lead to significant events, such as altercations or suspensions.

Reflection Topic: After collecting several observations, identify specific things you can do to ensure a climate of social justice for all students within your classroom. What methods of prevention can you have in place before such incidents occur? Describe one of your observations where either you intervened, or you observed a staff member do so. What were the consequences? Now describe a situation where you did not intervene, nor did you see any other staff member do so. Why did no one intervene? What were the consequences? Finally, identify the areas of social justice you feel you will have the most difficulty addressing and explain why.

Spring Topic 2—Clear Goals & Procedures

Observations in Action: When we give students group work, lab activities, or homework assignments, we, as teachers, often provide too little information for the students to know what our expectations for the assignment will be. You may have heard the familiar, "I don't know what I am supposed to do," or "Why are we doing this? It isn't what we are doing in class." Think about an assignment that you have given during this experience in which there was some student confusion or ambiguity regarding the directions that you gave to the students.

Reflection Topic: In your journal, write the direction that you gave to the students for this particular assignment. Once you have them written, go back and reread them for yourself. Do you understand what was being asked? Are you projecting your knowledge onto the students who may not have your level of understanding of the content? What do you feel was their major source of confusion with the assignment? How did you redirect (rephrase) your instructions or your assignment so that your goals and procedures are clear to the students? What will you do to ensure goals/procedures/directions are clear in the future?

Spring Topic 3—Consistency & Fairness

Observations in Action: Students perceive successful teachers as being fair; one common piece of advice is for new teachers to be consistent and fair. Take special note this week of how you are dealing with issues where your fairness is being questioned by and individual student or a group of students. Ask your mentor teacher to keep a record of your patterns of classroom discipline; what was the behavior and what was your response to the behavior? During a conversation with your mentor, look for patterns of consistent standards.

Reflection Topic: How have you responded to different groups of students regarding classroom discipline? Do your responses reflect the kind of teacher you wish to be? How many different options did you consider before you decided to act in a certain way? Describe at least one instance in which you feel it may have been perceived that you responded differently to females as opposed to males, high achievers as opposed to lower achievers, more popular and vocal students as opposed to less popular and reserved students. In retrospect, how would you have handled the situation differently so that all parties involved would have been treated more equitably?

Spring Topic 4—Revisiting an Autumn or Winter Quarter Reflection

Revisit a past reflection topic of your choice. Identify the topic, reflection number, and quarter of this reflection prompt. Describe how your ideas have changed or developed further in light of new experiences, information, and/or a deeper theoretical understanding (for example, do you have a new/renewed awareness of theories that apply to a particular situation?).

Spring Topics 5 & 6—Post-observations

These weekly reflections are for after you have received feedback from a formal observation. After debriefing with an external observer who has made a formal observation (ex. administrator, supervisor), reflect on this experience. For example, you might highlight the strengths of your lesson, new insights, any modifications you made to the same lesson for subsequent classes, and how you felt before, during and after the formal observation with the feedback provided, etc.

Spring Topics 7 & 8—Relevant and Personal Field Experiences

These are essentially "free-writes" where you reflect on your own personal experiences in your field placement site. Describe your observations and experiences by writing, "What I see" in one column, and reflect on these experiences with "What I think" in the other column.

APPENDIX F

MATRIX OF EFFECTIVE TEACHER CHARACTERISTICS

Participant	Beginning of Program	Middle of Program	End of Program
Henry	Content knowledge (1)	Flexible (4) Able to teach various levels of students (2)	Content knowledge (1) Patience (4) Differential expectations for students (3) See from student's point of view (3)
Alyssa	Patience (4) Knowing real world connections (1) Able to simplify ideas (1) Consistent (4) Good listener (4) Cares about students (4) Content knowledge (1) Sense of humor (4)	Good listener (4) Caring (4) Take time to check in with each student (2) Organized (4) Good class manager (2) Patient (4) Willing to admit when don't know something (4)	Know students well (3) Content knowledge (1) Make content relevant (1) Sense of humor (4) Small class size (other)
Ingrid	Organized (4) Prepared (4) Knows enough to present a given concept in different ways (1) Intelligent so can see many angles of a concept (1)	Content knowledge (1) Knows enough to present a given concept in different ways (1) Understanding (4)	Open to trying new things (4) Persistent (4) Critical thinker (4) Reflective (4) Confident (4) Excited about teaching (4) Fun (4)
Aaron	Content knowledge (1) Know how to relate content at appropriate level (2) Know how to make content interesting (2) Gets students to understand why content is important (2)	Content knowledge (1) Connect content to student lives (1)	Enjoy teaching (4) Care for students (4) Content knowledge (1) Enjoy content (4) Comfortable with hands-on teaching (2)
Emily	Content knowledge (1) Relate content at appropriate level (2) Able to simplify ideas (1) Interesting (2) Enjoy content (4) Recognize importance of education (4) Sense of respect towards all (4) Flexibility (4) Sense of humor (4) Open-minded (4)	Confident (4) Content knowledge (1) Teach thinking skills (2) Find way to make content relevant (2)	Content knowledge (1) Able to simplify ideas (1) Doesn't get frustrated (4) Connect activity and content for students (2) Use hands-on methods (2) Be good role model (4)

Lucy	Enthusiastic (4) Content knowledge (1) Knowledge of student backgrounds (3) Confident (4) Flexible (4) Respectful (4) Doesn't give up on students (4)	Knows interesting details to share (1) Gets students excited (2) Gets students to participate (2)	Interesting (4) Content knowledge (1) Uses hands-on methods (2) Has enough pull at school to get good students in class (other)
Nancy	Enthusiastic (4) Good listener (4) Able to identify student misconceptions (2) Patient (4) Sense of humor (4) Content knowledge (1) Interpersonal skills (4) Positive reinforcement (2) Organized (4) Good class manager (2)	Enthusiastic (4) Content knowledge (1) Able to relate to kids (4) Nice so are liked by kids (4)	Enthusiastic (4) Relates to own students (3) Interested in teaching science (4) Caring (4) Sense of humor (4)
Raina	Content knowledge (1) Patient (4) Enthusiastic (4) Sense of humor (4) Cares about students (4) Knowledge of student backgrounds (3)	Gets kids excited (2) Covers standards and gets kids to pass tests (2) Interactive teaching methods (2)	Content knowledge (1) Sets reasonable expectations for students (3) Fair (4) Sense of humor (4)
Rachel	Understands own students (3) Addresses student misconceptions (2) Fun (4) Uses hands-on methods (2) Scaffolds new content onto previous understandings (2) Connects with students (3) Does not use lecture (2)	Understands students (3) Uses a variety of teaching methods (2) Enthusiastic (4) Interested in teaching (4) Content knowledge (1)	Consistent (4) Enthusiastic (4) Interested in students (4)
Anna	Reaches struggling students (2) Asks questions (2) Involves students (2)	Presents real life problems (2) Uses problem-based learning (2) Connects with students (3)	Curious (4) Organized (4)

Dan	Content knowledge (1) Connects content to real life of students (2) Creative (4) Flexible (4) Uses inquiry teaching methods (2)	Interesting (2) Fun (4) Engaging (2) Conveys accurate content (1) Creates warm classroom (2) No drilling (2)	Empathetic (4) Establishes relationships with students (3) Understands students (3) Competent (2) Interesting (2) Presents relevant lessons (2) Loves science (4) Collaborates with other teachers (2) Brings in enrichment ideas for students (2)
Tom	Connects content to real life of students (2) Puts content in terms that students understand (2)	Approachable (4) Content knowledge (1) Connects content to real life of students (2)	Approachable (4) Knowledgeable (1) Gives kids extra chances (2) Willing to work with kids (4)

Coding categories:

(1) Knowledge of content
(2) Knowledge of pedagogy
(3) Knowledge of students
(4) Personal characteristics

LIST OF REFERENCES

Adams, P. E., & Krockover, G. H. (1997). Beginning science teacher cognition and its origins in the preservice secondary science teacher program. *Journal of Research in Science Teaching, 34*(6), 633-653.

Aitken, J. L., & Mildon, D. (1991). The dynamics of personal knowledge and teacher education. *Curriculum Inquiry, 21*(2), 141-163.

Akerson, V. L., Morrison, J. A., & McDuffie, A. R. (2006). One course is not enough: Preservice elementary teachers' retention of improved views of nature of science. *Journal of Research in Science Teaching, 43*(2), 194-213.

Akyeampong, K., & Stephens, D. (2002). Exploring the backgrounds and shaping of beginning student teachers in Ghana: Toward greater contextualization of teacher education. *International Journal of Educational Development, 22*, 261-274.

Andersen, A. M., Dragsted, S., Evans, R. H., & Sorensen, H. (2004). The relationship between changes in teachers' self-efficacy beliefs and the science teaching environment of Danish first-year elementary teachers. *Journal of Science Teacher Education, 15*(1), 25-38.

Arends, R. I., Winitzky, N. E., & Tannenbaum, M. D. (2001). *Exploring teaching: An introduction to education*. Boston: McGraw Hill.

Ashton, P. T. (1984). Teacher efficacy: A motivational paradigm for effective teacher education. *Journal of Teacher Education, 35*(5), 28-32.

Ashton, P. T., & Webb, R. B. (1986). *Making a difference: Teachers' sense of efficacy and student achievement*. New York: Longman.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: W.H. Freeman.

Baron, R. M., Tom, D. Y. H., & Cooper, H. M. (1985). Social class, race, and teacher expectations. In J. B. Dusek (Ed.), *Teacher expectancies*. Hillsdale, NJ: Erlbaum.

Barton, A. C. (2000). Crafting multicultural science education with preservice teachers through service-learning. *Journal of Curriculum Studies, 32*(6), 797-820.

Beswick, K. (2006). Changes in preservice teachers' attitudes and beliefs: The net impact of two mathematics education units and intervening experiences. *School Science and Mathematics, 106*(1), 36-47.

Bianchini, J. A., Cavazos, L. M., & Helms, J. (2000). From professional lives to inclusive practice: Science teachers and scientists' views of gender and ethnicity in science education. *Journal of Research in Science Teaching, 37*(6), 511-547.

Bianchini, J. A., Cavazos, L. M., & Rivas, M. (2003). At the intersection of contemporary descriptions of science and issues of equity and diversity: Student teachers' conceptions, rationales, and instructional practices. *Journal of Science Teacher Education, 14*(4), 259-290.

Bianchini, J. A., Johnston, C. C., Oram, S. Y., & Cavazos, L. M. (2003). Learning to teach science in contemporary and equitable ways: The successes and struggles of first-year science teachers. *Science Education, 87*(3), 419-443.

Bianchini, J. A., & Solomon, E. M. (2003). Constructing views of science tied to issues of equity and diversity: A study of beginning science teachers. *Journal of Research in Science Teaching, 40*(1), 53-76.

Bloomfield, D. (2000). Voices on the Web: Student teachers negotiating identity. *Asia-Pacific Journal of Teacher Education, 28*(3), 199-212.

Bohning, G., Hale, L., & Chowning, F. (1999). Change-of-career preservice elementary teachers: Their concerns about teaching science. *Education, 120*(1), 143-148.

Bourdieu, P. (1977). *Outline of a theory of practice*. Cambridge: Cambridge University Press.

Brand, B. R., & Glasson, G. E. (2004). Crossing cultural borders into science teaching: Early life experiences, racial and ethnic identities, and beliefs about diversity. *Journal of Research in Science Teaching, 41*(2), 119-141.

Brand, B. R., Glasson, G. E., & Green, A. M. (2006). Sociocultural factors influencing students' learning in science and mathematics: An analysis of the perspectives of African American students. *School Science and Mathematics, 106*(5), 228-236.

Brickhouse, N. W. (2001). Embodying science: A feminist perspective on learning. *Journal of Research in Science Teaching, 38*(3), 282-295.

Brickhouse, N. W., & Bodner, G. M. (1992). The beginning science teacher: Classroom narratives of convictions and constraints. *Journal of Research in Science Teaching, 29*(5), 471-485.

Brighton, C. M. (2003). The effects of middle school teachers' beliefs on classroom practices. *Journal for the Education of the Gifted, 27*(2/3), 177-206.

Brophy, J. E. (1985). Teacher-student interaction. In J. B. Dusek (Ed.), *Teacher expectancies* (pp. 303-328). Hillsdale, NJ: Erlbaum.

Brophy, J. E., & Evertson, C. M. (1981). *Student characteristics and teaching*. New York: Longman.

Brown, D. F. (2004). Urban teachers' professed classroom management strategies: Reflections of culturally responsive teaching. *Urban Education, 39*(3), 266-289.

Brown, E. L. (2004). What precipitates change in cultural diversity awareness during a multicultural course: The message or the method? *Journal of Teacher Education, 55*(4), 325-340.

Brown, K. M., Anfara, V. A., Jr., & Roney, K. (2004). Student achievement in high performing, suburban middle schools and low performing, urban middle schools. *Education and Urban Society, 36*(4), 428-456.

Bryan, L. A., & Atwater, M. M. (2002). Teacher beliefs and cultural models: A challenge for science teacher preparation programs. *Science Teacher Education, 86*, 821-839.

Bullock, L. D. (1997). Efficacy of a gender and ethnic equity in science education curriculum for preservice teachers. *Journal of Research in Science Teaching, 34*(10), 1019-1038.

Bullough, R. V., Jr. (1989). *First-year teacher: A case study*. New York: Teachers College Press.

Bullough, R. V., Jr. (1991). Exploring personal teaching metaphors in preservice teacher education. *Journal of Teacher Education, 42*(1), 43-51.

Bullough, R. V., Jr., & Baughman, K. (1997). "*First-year teacher*" *eight years later: An inquiry into teacher development*. New York: Teachers College Press.

Bursal, M., & Paznokas, L. (2006). Mathematics anxiety and preservice elementary teachers' confidence to teach mathematics and science. *School Science and Mathematics, 106*(4), 173-180.

Cantrell, P., Young, S., & Moore, A. (2003). Factors affecting science teaching efficacy of preservice elementary teachers. *Journal of Science Teacher Education, 14*(3), 177-192.

Carlone, H. B. (2003). (Re)producing good science students: Girls' participation in high school physics. *Journal of Women and Minorities in Science and Engineering, 9*, 17-34.

Causey, V. E., Thomas, C. D., & Armento, B. J. (2000). Cultural diversity is basically a foreign term to me: The challenges of diversity for preservice teacher education. *Teaching and Teacher Education, 16*, 33-45.

Cochran-Smith, M. (2005). The new teacher education: For better or for worse? *Educational Researcher, 34*(7), 3-17.

Czerniak, C. M., & Chiarelott, L. (1990). Teacher education for effective science instruction–A social cognitive perspective. *Journal of Teacher Education, 41*(1), 49-58.

Daniels, D. H., & Shumow, L. (2003). Child development and classroom teaching: A review of the literature and implications for educating teachers. *Applied Developmental Psychology, 23*, 493-526.

Davis, M. M., & Wilson, E. K. (1999). A Title I teacher's beliefs, decision-making, and instruction at the third and seventh grade levels. *Reading Research and Instruction, 38*(4), 289-300.

Deemer, S. A. (2004). Classroom goal orientation in high school classrooms: Revealing links between teacher beliefs and classroom environments. *Educational Research, 46*(1), 73-90.

Delpit, L. (1995). *Other people's children*. New York: The New Press.

Desouza, J. M. S., Boone, W. J., & Yilmaz, O. (2004). A study of the science teaching self-efficacy and outcome expectancy beliefs of teachers in India. *Science Education, 88*, 837-854.

Dewey, J. (1963). *Experience and education*. New York: Macmillan.

Dole, J. A., & Sinatra, G. M. (1998). Conceptualizing change in the cognitive construction of knowledge. *Educational Psychologist, 33*(2/3), 109-128.

Doolittle, S. A., Dodds, P., & Placek, J. H. (1993). Persistence of beliefs about teaching during formal training of preservice teachers. *Journal of Teaching in Physical Education, 12*, 355-365.

Dusek, J. B., & Joseph, G. (1983). The bases of teacher expectancies: A meta-analysis. *Journal of Educational Psychology, 75*(3), 327-346.

Eick, C. J., & Reed, C. J. (2002). What makes an inquiry-oriented science teacher? The influence of learning histories on student teacher role identity and practice. *Science Education, 86*, 401-416.

Eisenhart, M. A., & Behm, L. (1991). Learning to teach: Developing expertise of rite of passage. *Journal of Education for Teaching, 17*(1), 51-72.

Eisenhart, M. A., Shrum, J. L., Harding, J. R., & Cuthbert, A. M. (1988). Teacher beliefs: definitions, findings, and directions. *Educational Policy, 2*(1), 51-70.

Enochs, L. G., & Riggs, I. M. (1990). Further development of an elementary science teaching efficacy belief instrument: A preservice elementary scale. *School Science and Mathematics, 90*(8), 694-706.

Errington, E. (2004). The impact of teacher beliefs on flexible learning innovation: Some practices and possibilities for academic developers. *Innovation in Education and Teaching International, 41*(1), 39-47.

Evans, E. D., & Tribble, M. (1986). Perceived teaching problems, self-efficacy, and commitment to teaching among preservice teachers. *Journal of Educational Research, 80*(2), 81-85.

Festinger, L. (1957). *A theory of cognitive dissonance*. Stanford, CA: Stanford University Press.

Finn, P. J. (1999). *Literacy with an attitude: Educating working-class children in their own self-interest*. Albany, NY: State University of New York Press.

Finson, K. D., Pedersen, J. E., & Thomas, J. (2006). Comparing science teaching styles to students' perceptions of scientists. *School Science and Mathematics, 106*(1), 8-15.

Flores, M. A. (2003, April, 2003). *Mapping teacher change: A two-year empirical study*. Paper presented at the Annual Meeting of the American Educational Research Association, Chicago, IL.

Friedrichsen, P. M., & Dana, T. M. (2005). Substantive-level theory of highly regarded secondary biology teachers' science teaching orientations. *Journal of Research in Science Teaching, 42*(2), 218-244.

Fuchs, L. S., Fuchs, D., & Phillips, N. (1994). The relation between teachers' beliefs about the importance of good student work habits, teaching planning, and student achievement. *The Elementary School Journal, 94*(3), 331-345.

Garmon, M. A. (2004). Changing preservice teachers' attitudes/beliefs about diversity: What are the critical factors? *Journal of Teacher Education, 55*(3), 201-213.

Geertz, C. (1973). *The interpretation of cultures*. New York: Basic Books.

Georgiou, S. N., Christou, C., Stavrinides, P., & Panaoura, G. (2002). Teacher attributions of student failure and teacher behavior toward the failing student. *Psychology in the Schools, 39*(5), 583-595.

Ghaith, G., & Yaghi, H. (1997). Relationships among experience, teacher efficacy, and attitudes toward the implementation of instructional innovation. *Teaching and Teacher Education, 13*(4), 451-458.

Gibson, S., & Dembo, M. (1984). Teacher efficacy: A construct validation. *Journal of Educational Psychology, 76*(4), 569-582.

Gilbert, A., & Yerrick, R. K. (2001). Same school, separate worlds: A sociocultural study of identity, resistance, and negotiation in a rural, lower track science classroom. *Journal of Research in Science Teaching, 38*(5), 574-598.

Gill, S., & Reynolds, A. J. (1999). Educational expectations and school achievement of urban african american children. *Journal of School Psychology, 37*(4), 403-424.

Ginns, I. S., & Tulip, D. F. (1995). Changes in preservice elementary teachers' sense of efficacy in teaching science. *School Science and Mathematics, 95*(8), 394-400.

Gist, M. E., & Mitchell, T. R. (1992). Self-efficacy: A theoretical analysis of its determinants and malleability. *Academy of Management Review, 17*(2), 183-211.

Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. New York: Aldine De Gruyter.

Goddard, R. D., & Goddard, Y. L. (2001). A multilevel analysis of the relationship between teacher and collective efficacy in urban schools. *Teaching and Teacher Education, 17*, 807-818.

Goddard, R. D., Logerfo, L., & Hoy, W. K. (2004). High school accountability: The role of perceived collective efficacy. *Educational Policy, 18*(3), 403-425.

Graber, K. C. (1998). Implementing pegagogical principles in the absence of operational knowledge: A longitudinal case study examining the influence of teacher education on the instructional behaviors of a high school teacher. *High School Journal, 81*(3), 140-153.

Gregoire, M. (2003). Is it a challenge or a threat? A dual-process model of teachers' cognition and appraisal processes during conceptual change. *Educational Psychology Review, 15*(2), 147-179.

Guskey, T. R., & Passaro, P. D. (1994). Teacher efficacy: A study of construct dimensions. *American Educational Research Journal, 31*(3), 627-643.

Hancock, E. S., & Gallard, A. J. (2004). Preservice science teachers' beliefs about teaching and learning: The influence of K-12 field experiences. *Journal of Science Teacher Education, 15*(4), 281-291.

Harcombe, E. S. (2001). *Science teaching/science learning : Constructivist learning in urban classrooms*. New York: Teachers College.

Haritos, C. (2004). Understanding teaching through the minds of teacher candidates: A curious blend of realism and idealism. *Teaching and Teacher Education, 20*, 637-654.

Hart, L. C. (2002). Preservice teachers' beliefs and practice after participating in an integrated content/methods course. *School Science and Mathematics, 102*(1), 4-14.

Hashweh, M. Z. (2003). Teacher accommodative change. *Teaching and Teacher Education, 19*, 421-434.

Hatchell, H. (1998). Girls' entry into higher secondary sciences. *Gender and Education, 10*(4), 375-386.

Hauser-Cram, P., Sirin, S. R., & Stipek, D. (2003). When teachers' and parents' values differ: Teachers' ratings of academic competence in children from low-income families. *Journal of Educational Psychology, 95*(4), 813-820.

Henson, R. K. (2001). Effect of participation in teacher research on teacher efficacy. *Teaching and Teacher Education, 17*, 819-836.

Hewson, P. W., Kahle, J. B., Scantlebury, K., & Davies, D. (2001). Equitable science education in urban middle schools: Do reform efforts make a difference? *Journal of Research in Science Teaching, 38*(10), 1130-1144.

Hollingsworth, S. (1989). Prior beliefs and cognitive change in learning to teach. *American Educational Research Journal, 26*(2), 160-189.

Howard, T. C. (2003). Culturally relevant pedagogy: Ingredients for critical teacher reflection. *Theory Into Practice, 42*(3), 195-202.

Hoy, A. W., & Davis, H. A. (2005). Teacher self-efficacy and its influence on the achievement of adolescents. In M. F. Pajares & T. Urdan (Eds.), *Self-efficacy beliefs of adolescents*. Greenwich, CT: Information Age Publishing.

Hoy, A. W., Davis, H. A., & Pape, S. J. (2006). Teachers' knowledge, beliefs, and thinking. In P. A. Alexander & P. H. Winne (Eds.), *Handbook of educational psychology* (2nd ed., pp. 715-737). Mahwah, NJ: Lawrence Erlbaum.

Hoy, A. W., & Spero, R. B. (2005). Changes in teacher efficacy during the early years of teaching: A comparison of four measures. *Teaching and Teacher Education, 21*, 343-356.

Hoy, A. W., & Weinstein, C. S. (2006). Students' and teachers' perspectives about classroom management. In C. M. Evertson & C. S. Weinstein (Eds.), *Handbook for classroom management: Research, practice, and contemporary issues* (pp. 181-220). Mahwah, NJ: Lawrence Erlbaum.

Hughes, G. (2001). Exploring the availability of student scientist identities within curriculum discourse: An anti-essentialist approach to gender-inclusive science. *Gender and Education, 13*(3), 275-290.

Huinker, D., & Madison, S. K. (1997). Preparing efficacious elementary teachers in science and mathematics: The influence of methods courses. *Journal of Science Teacher Education, 8*(2), 107-126.

Jeanpierre, B., Oberhauser, K., & Freeman, C. (2005). Characteristics of professional development that effect change in secondary science teachers' classroom practices. *Journal of Research in Science Teaching, 42*(6), 668-690.

Johnson, C. C. (2006). Effective professional development and change in practice: Barriers science teachers encounter and implications for reform. *School Science and Mathematics, 106*(3), 150-161.

Kagan, D. M. (1992a). Implications of research on teacher belief. *Educational Psychologist, 27*(1), 65-90.

Kagan, D. M. (1992b). Professional growth among preservice and beginning teachers. *Review of Educational Research, 62*(2), 129-169.

Kahle, J. B., Parker, L. H., Rennie, L. J., & Riley, D. (1993). Gender differences in science education: Building a model. *Educational Psychologist, 28*(4), 379-404.

King, K., Shumow, L., & Lietz, S. (2001). Science education in an urban elementary school: Case studies of teacher beliefs and classroom practices. *Science Education, 85*, 89-110.

Knapp, M. S., & Plecki, M. L. (2001). Investing in the renewal of urban science teaching. *Journal of Research in Science Teaching, 38*(10), 1089-1100.

Knobloch, N. A., & Whittington, M. S. (2002). Novice teachers' perceptions of support, teacher preparation quality, and student teacher experience related to teacher efficacy. *Journal of Vocational Educational Research, 27*(3), 331-341.

Korthagen, F. A. J. (2004). In search of the essence of a good teacher: Towards a more holistic approach in teacher education. *Teaching and Teacher Education, 20*, 77-97.

Labone, E. (2004). Teacher efficacy: Maturing the construct through research in alternative paradigms. *Teaching and Teacher Education, 20*, 341-359.

Lasky, S. (2005). A sociocultural approach to understanding teacher identity, agency and professional vulnerability in a context of secondary school reform. *Teaching and Teacher Education, 21*, 899-916.

Lee, C., & Krapfl, L. (2002). Teaching as you would have them teach: An effective elementary school science teacher preparation program. *Journal of Science Teacher Education, 13*(3), 247-265.

Levitt, K. E. (2001). An analysis of elementary teachers' beliefs regarding the teaching and learning of science. *Science Education, 86*, 1-22.

Li, Q. (1999). Teachers' beliefs and gender differences in mathematics: A review. *Educational Research, 41*(1), 63-76.

Lincoln, Y., & Guba, E. (1985). *Naturalistic inquiry*. Beverly Hills, CA: Sage.

Luft, J. A. (1999). The border crossings of a multicultural science education enthusiast. *School Science and Mathematics, 99*(7), 380-388.

Luft, J. A. (2001). Changing inquiry practices and beliefs: The impact of an inquiry-based professional development programme on beginning and experienced secondary science teachers. *International Journal of Science Education, 23*(5), 517-534.

Luft, J. A., Roehrig, G. H., & Patterson, N. C. (2003). Contrasting landscapes: A comparison of the impact of different induction programs on beginning secondary science teachers' practices, beliefs, and experiences. *Journal of Research in Science Teaching, 40*(1), 77-97.

Lumpe, A. T., Haney, J. J., & Czerniak, C. M. (2000). Assessing teachers' beliefs about their science teaching context. *Journal of Research in Science Teaching, 37*(3), 275-292.

Matanin, M., & Collier, C. (2003). Longitudinal analysis of preservice teachers' beliefs about teaching physical education. *Journal of Teaching in Physical Education, 22*, 153-168.

Mcginnis, J. R., Parker, C., & Graeber, A. O. (2004). A cultural perspective of the induction of five reform-minded beginning mathematics and science teachers. *Journal of Research in Science Teaching, 41*(7), 720-747.

McKinney, M., Sexton, T., & Meyerson, M. J. (1999). Validating the efficacy-based change model. *Teaching and Teacher Education, 15*, 471-485.

Middleton, V. A. (2002). Increasing preservice teachers' diversity beliefs and commitment. *The Urban Review, 34*(4), 343-361.

Miles, M. B., & Huberman, A. M. (1984). *Qualitative data analysis: A sourcebook of new methods*. Beverly Hills, CA: Sage Publications.

Mji, A., & Kiviet, A. M. (2003). Psychometric characteristics of the science teaching efficacy belief inventory in South Africa. *Psychological Reports, 92*, 325-332.

Mulholland, J., & Wallace, J. (2001). Teacher induction and elementary science teaching: Enhancing self-efficacy. *Teaching and Teacher Education, 17*, 243-261.

Mulholland, J., & Wallace, J. (2005). Growing the tree of teacher knowledge: Ten years of learning to teach elementary science. *Journal of Research in Science Teaching, 42*(7), 767-790.

Nespor, J. (1987). The role of beliefs in the practice of teaching. *Journal of Curriculum Studies, 19*(4), 317-328.

Norman, O., Ault, C. R., Jr., Bentz, B., & Meskimen, L. (2001). The black-white "achievement gap" as a perennial challenge of urban science education: A sociocultural and historical overview with implications for research and practice. *Journal of Research in Science Teaching, 38*(10), 1101-1114.

Ohio.Department.of.Education. (2004). *Meeting the Challenge: Ohio Graduation Test for Science*. Columbus, OH: Ohio Department of Education.

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62*(3), 307-332.

Piaget, J. (1973). *To understand is to invent*. New York: Grossman.

Piburn, M., Sawada, D., Turley, J., Falconer, K., Benford, R., Bloom, I., et al. (2000). *Reformed teaching observation protocol (RTOP): Reference manual* (No. ACEPT Technical Report No. IN00-3). Tempe, AZ: Arizona Collaborative for Excellence in the Preparation of Teachers.

Plourde, L. A. (2002a). Elementary science education: The influence of student teaching–where it all begins. *Education, 123*(2), 253-259.

Plourde, L. A. (2002b). The influence of student teaching on preservice elementary teachers' science self-efficacy and outcome expectancy beliefs. *Journal of Instructional Psychology, 29*(4), 245-253.

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education, 66*(2), 211-227.

Proweller, A., & Mitchener, C. P. (2004). Building teacher identity with urban youth: Voices of beginning middle school science teachers in an alternative certification program. *Journal of Research in Science Teaching, 41*(10), 1044-1062.

Ramey-Gassert, L., Shroyer, M. G., & Staver, J. R. (1996). A qualitative study of factors influencing science teaching self-efficacy of elementary level teachers. *Science Education, 80*, 283-315.

Rascoe, B., & Atwater, M. M. (2005). Black males' self-perceptions of academic ability and gifted potential in advanced science classes. *Journal of Research in Science Teaching, 42*(8), 888-911.

Raudenbush, S. W., Rowan, B., & Cheong, Y. F. (1992). Contextual effects on the self-perceived efficacy of high school teachers. *Sociology of Education, 65*, 150-167.

Raymond, A. M. (1997). Inconsistency between a beginning elementary school teacher's mathematics beliefs and teaching practice. *Journal for Research in Mathematics Education, 28*, 550-576.

Rennie, L. J. (2001). Gender equity and science teacher preparation. In D. R. Lavoie & W.-M. Roth (Eds.), *Models of science teacher preparation* (pp. 127-147). Dordrecht, Netherlands: Kluwer Academic Publishers.

Rice, D. C., & Roychoudhury, A. (2003). Preparing more confident preservice elementary science teachers: One elementary science methods teacher's self-study. *Journal of Science Teacher Education, 14*(2), 97-126.

Richardson, L., & Simmons, P. E. (1994). *Self-Q research method and analysis, teacher pedagogical philosophy interview, theoretical background, samples of data*. Athens, GA: The University of Georgia.

Riggs, I. M., & Enochs, L. G. (1990). Toward the development of an elementary teacher's science teaching efficacy belief instrument. *Science Education, 74*(6), 625-637.

Ritchie, S. M. (1999). The craft of intervention: A personal practical theory for a teacher's within-group interactions. *Science Education, 83*(2), 213-231.

Rodriguez, A. J. (1998). Strategies for counterresistance: Toward sociotransformative constructivism and learning to teach science for diversity and for understanding. *Journal of Research in Science Teaching, 35*(6), 589-622.

Rodriguez, A. J., Zozakiewicz, C., & Yerrick, R. K. (2005). Using prompted praxis to improve teacher professional development in culturally diverse schools. *School Science and Mathematics, 105*(7), 352-362.

Roehrig, G. H., & Kruse, R. A. (2005). The role of teachers' beliefs and knowledge in the adoption of a reform-based curriculum. *School Science and Mathematics, 105*(8), 412-422.

Roger, A., & Duffield, J. (2000). Factors underlying persistent gendered option choices in school science and technology in Scotland. *Gender and Education, 12*(3), 367-383.

Ross, J. A. (1998). The antecedents and consequences of teacher efficacy. *Advances in Research on Teaching, 7*, 49-73.

Roth, W.-M. (2001). Becoming-in-the-classroom: Learning to teach in/as praxis. In D. R. Lavoie & W.-M. Roth (Eds.), *Models of science teacher preparation* (pp. 11-30). Dordrecht, Netherlands: Kluwer Academic Publishers.

Roth, W.-M., Tobin, K., Carambo, C., & Dalland, C. (2004). Coteaching: Creating resources for learning and learning to teach chemistry in urban high schools. *Journal of Research in Science Teaching, 41*(9), 882-904.

Russell, M. L., & Atwater, M. M. (2005). Traveling the road to success: A discourse on persistence throughout the science pipeline with African American students at a predominantly white institution. *Journal of Research in Science Teaching, 426*(691-715).

Sadker, M. P., & Sadker, D. M. (1995). *Failing at fairness*. New York: Touchstone Press.

Sadker, M. P., & Sadker, D. M. (2000). *Teachers, schools, and society*. Boston: McGraw Hill.

Sawada, D., Piburn, M., Judson, E., Turley, J., Falconer, K., Benford, R., et al. (2002). Measuring reform practices in science and mathematics: The reformed teaching observation protocol. *School Science and Mathematics, 102*, 245-253.

Schneider, R. M., Krajcik, J., & Blumenfeld, P. (2005). Enacting reform-based science materials: The range of teacher enactments in reform classrooms. *Journal of Research in Science Teaching, 42*(3), 283-312.

Schoon, K. J., & Boone, W. J. (1998). Self-efficacy and alternative conceptions of science of elementary teachers. *Science Education, 82*, 553-568.

Schriver, M., & Czerniak, C. M. (1999). A comparison of middle and junior high science teachers' levels of efficacy and knowledge of developmentally appropriate curriculum and instruction. *Journal of Science Teacher Education, 10*(1), 21-42.

Simmons, P. E., Emory, A., Carter, T., Coker, T., Finnegan, B., Crockett, D., et al. (1999). Beginning teachers: Beliefs and classroom actions. *Journal of Research in Science Teaching, 36*(8), 930-954.

Solomon, D., Battisch, V., & Hom, A. (1996). Teacher beliefs and practices in schools serving communities that differ in socioeconomic level. *The Journal of Experimental Education, 64*, 327-347.

Soodak, L. C., & Podell, D. M. (1996). Teacher efficacy: Toward the understanding of a multi-faceted construct. *Teaching and Teacher Education, 12*(4), 401-411.

Southerland, S. A., & Gess-Newsome, J. (1999). Preservice teachers' views of inclusive science teaching as shaped by images of teaching, learning, and knowledge. *Science Education, 83*, 131-150.

Stipek, D. J., Givvin, K. B., Salmon, J. M., & MacGyvers, V. L. (2001). Teachers' beliefs and practices related to mathematics instruction. *Teaching and Teacher Education, 17*, 213-226.

Thompson, G. L., Warren, S., & Carter, L. (2004). It's not my fault: Predicting high school teachers who blame parents and students for students' low achievement. *High School Journal, 87*(3), 5-14.

Tiezzi, L. J., & Cross, B. E. (1997). Utilizing research on prospective teachers' beliefs to inform urban field experiences. *The Urban Review, 29*(2), 113-125.

Tillema, H. H. (1994). Training and professional expertise: Bridging the gap between new information and pre-existing beliefs of teachers. *Teaching and Teacher Education, 10*(6), 601-615.

Tillema, H. H., & Knol, W. E. (1997). Promoting student teacher learning through conceptual change or direct instruction. *Teaching and Teacher Education, 13*(6), 579-595.

Tobin, K., & Gallagher, J. J. (2003). The role of target students in the science classroom. *Journal of Research in Science Teaching, 40*(Supplement), S99-S113.

Tobin, K., & Roth, W.-M. (2005). Implementing coteaching and cogenerative dialoguing in urban science education. *School Science and Mathematics, 105*(6), 313-322.

Tobin, K., Roth, W.-M., & Zimmermann, A. (2001). Learning to teach science in urban schools. *Journal of Research in Science Teaching, 38*(8), 941-964.

Tosun, T. (2000). The beliefs of preservice elementary teachers toward science and science teaching. *School Science and Mathematics, 100*(7), 374-379.

Tsai, C.-C. (2002). Nested epistemologies: Science teachers' beliefs of teaching, learning and science. *International Journal of Science Education, 24*(8), 771-783.

Tschannen-Moran, M., & Hoy, A. W. (2001). Teacher efficacy: Capturing an elusive construct. *Teaching and Teacher Education, 17*, 783-805.

Tschannen-Moran, M., Hoy, A. W., & Hoy, W. K. (1998). Teacher efficacy: Its meaning and measure. *Review of Educational Research, 68*(2), 202-248.

Turner-Bisset, R. (1999). The knowledge bases of the expert teacher. *British Educational Research Journal, 25*(1), 39-55.

Upadhyay, B. R. (2005). Practicing reform-based science curriculum in an urban classroom: A Hispanic elementary school teacher's thinking and decisions. *School Science and Mathematics, 105*(7), 343-351.

Veal, W. R. (2004). Beliefs and knowledge in chemistry teacher development. *International Journal of Science Education, 26*(3), 329-351.

Verelas, M., House, R., & Wenzel, S. (2005). Beginning teachers immersed into science: Scientists and Science Teacher Identities. *Science Education, 89*(3), 492-516.

Verjovsky, J., & Waldegg, G. (2005). Analyzing beliefs and practices of a Mexican high school biology teacher. *Journal of Research in Science Teaching, 42*(4), 465-491.

Wallace, C., & Kang, N.-h. (2004). An investigation of experienced secondary science teachers' beliefs about inquiry: An examination of competing belief sets. *Journal of Research in Science Teaching, 41*(9), 936-960.

Warren, S. R. (2002). Stories from the classroom: How expectations and efficacy of diverse teachers affect the academic performance of children in poor urban schools. *Educational Horizons, 80*(3), 109-116.

Weiner, B. (2000). Intrapersonal and Interpersonal theories of motivation from an attributional perspective. *Educational Psychology Review, 12*(1), 1-14.

Wertheim, C., & Leyser, Y. (2002). Efficacy beliefs, background variables, and differentiated instruction of Israeli prospective teachers. *Journal of Educational Research, 96*(1), 54-63.

Wheatley, K. F. (2002). Potential benefits of teacher efficacy doubts for educational reform. *Teaching and Teacher Education, 18*, 5-22.

Wigfield, A., Galper, A., Denton, K., & Seefeldt, C. (1999). Teachers' beliefs about former head start and non-head start first-grade children's motivation, performance, and future educational prospects. *Journal of Educational Psychology, 91*(1), 98-104.

Yerrick, R. K., & Hoving, T. J. (2003). One foot on the dock and one foot in the boat: Differences among preservice science teachers' interpretations of field-based science methods courses in culturally diverse contexts. *Science Education, 87*(3), 390-418.

Yerrick, R. K., Parke, H., & Nugent, J. (1997). Struggling to promote deeply rooted change: The "filtering effect" of teachers' beliefs on understanding transformational views of teaching science. *Science Education, 81*, 137-159.

Yerrick, R. K., Pedersen, J. E., & Arnason, J. (1998). "We're just spectators": A case study of science teaching, epistemology, and classroom management. *Science Education, 82*, 619-648.

Zohar, A., Degani, A., & Vaaknin, E. (2001). Teachers' beliefs about low-achieving students and higher order thinking. *Teaching and Teacher Education, 17*, 469-485.