SCIENCE TEACHER BELIEFS AND CLASSROOM PRACTICES RELATED TO CONSTRUCTIVIST TEACHING AND LEARNING

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By
Funda Savasci, M.Ed.

The Ohio State University
2006

Dissertation Committee
Professor Donna F. Berlin, Adviser
Professor Arthur L. White
Professor Karen E. Irving

Approved by

Adviser

College of Education
Copyright by
Funda Savasci
2006
ABSTRACT

The purpose of the study was to identify science teacher beliefs and classroom practice related to constructivist teaching and learning, and to examine factors that may influence teacher classroom practice. Four science teachers working in different school settings were purposively selected by the researcher. For over four months, data were collected through interviews with teachers, surveys, classroom observations, and classroom documents. Qualitative methodology including individual case study and cross-case analyses were employed in this study.

The findings of the study revealed that teachers generally reported that they held constructivist teaching and learning beliefs. However, they had difficulty in incorporating their beliefs into classroom practice. Only one teacher could implement his beliefs related to constructivist teaching and learning into classroom practice; as such, his expressed beliefs were consistent with his observed classroom practice. Personal Relevance and Student Negotiation were the most frequently preferred constructivist components and Critical Voice was the most perceived constructivist component in science classrooms. Shared Control was one of the least preferred and was the least frequently perceived and implemented constructivist component in science classrooms.
Whole-class activities were frequently observed in all science classrooms. However, teachers working in the private middle school tended to spend more class time in group work than those working in the public high school. On the other hand, teachers working in the public high school tended to allocate more class time to individual work than those in the private middle school. The teachers working in the private middle school tended to use more student-centered activities in their classrooms. Teachers working in the public high school tended to use more teacher-centered activities in their classrooms. School type (private versus public) and grade level were influential factors that affected teacher practice. Parental involvement was an important factor that influenced teacher practice in the private middle school. Curriculum and standardized testing was the most important factor that influenced teacher practice in the public high school. The nature of students and student ability were the most frequently self-reported factors that influenced teacher classroom practice.
Dedicated to my mom and my dad

Naciye and Sadık Savaşçı

For their endless love and support
ACKNOWLEDGMENTS

I would like to express my gratitude to the members of my program committee who helped me throughout my graduate study. Without their support and encouragement, this project would never have been accomplished.

First of all, I would like to thank my adviser, Dr. Donna Berlin for her patient intellectual support and encouragement which made this dissertation possible. I consider myself lucky to have such a caring and exceptional advisor. I greatly appreciate her many hours of reading, corrections of my grammar mistakes, and her valuable suggestions during this project. I cannot thank her enough for everything she has done for me.

I wish to thank Dr. Arthur White for his generous help and support. He was always readily available for me and willing to share his professional opinions. I greatly appreciate his support during my course work and dissertation.

I would like to thank Dr. Karen Irving for the great feedback, support, and friendship throughout this study. I am glad you came to The Ohio State University before I graduated. Thank you for always treating me as a colleague, and allowing me to join your research project. It was an exceptional opportunity to work with you that promoted my academic growth and helped me to become a better researcher.
Deepest appreciation goes to the four teachers who participated in this study. Thank you for opening your classrooms and sharing your experiences. Without your time and effort, this project could not have been possible. It was a genuine pleasure to work with you during my data collection.

I am grateful for the financial support provided by the Turkish Ministry of National Education during my Master’s and Doctoral study in the U.S. The financial support allowed me to focus more on my studies rather than on financial concerns.

I would like to thank my parents, Naciye and Sadık, who always encouraged and supported me to achieve my dreams. Thank you for patiently waiting for me to complete my study and return home. Special thanks go to my sisters, Nefise and Nesrin; my brother-in-laws, Zülküf and Metin; my nieces Buket, İrem, and İzem; and my nephew Ilker for encouraging me and being with me in difficult times by long hours of phone calls. Being away from all of you for many years was the toughest thing throughout my study. I love all of you and I miss you a lot.

I extend my sincere thanks to my friends in Turkey and in the U.S. for their friendship and support. My special thanks go to my close friend, Sibel Duru, for her many hours of discussion about my dissertation project and her friendship throughout my study. I wish her a successful completion of her own dissertation.

Last, but definitely not least, I am most grateful to my husband, Mehmet Acikalin. Being a doctoral student is hard enough. Being a married couple and doctoral students is much harder. But, you always made me smile even at our most difficult times. Thank you for giving academic feedback, reading my drafts, cooking delicious food, taking care of me, and putting up with me during the long, difficult journey. I love you.
VITA

June 01, 1972
Born-Beysehir, Konya, TURKEY

1994
B. S. Chemistry,
Ankara University, TURKEY

2002
M. Ed. Science Education
The University of Missouri-Columbia

2002-present
Ph. D. Graduate Student
The Ohio State University

FIELDS OF STUDY

Major Field: Education

Specialization: Science Education
## TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>iii</td>
</tr>
<tr>
<td>Dedication</td>
<td>v</td>
</tr>
<tr>
<td>Acknowledgments</td>
<td>vi</td>
</tr>
<tr>
<td>Vita</td>
<td>viii</td>
</tr>
<tr>
<td>List of Tables</td>
<td>xii</td>
</tr>
<tr>
<td>List of Figures</td>
<td>xiv</td>
</tr>
<tr>
<td>Chapters:</td>
<td></td>
</tr>
<tr>
<td>1. Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Theoretical framework</td>
<td>2</td>
</tr>
<tr>
<td>Cognitive constructivism</td>
<td>4</td>
</tr>
<tr>
<td>Radical constructivism</td>
<td>6</td>
</tr>
<tr>
<td>Social constructivism</td>
<td>8</td>
</tr>
<tr>
<td>Statement of the problem</td>
<td>12</td>
</tr>
<tr>
<td>The purposes of the study and research questions</td>
<td>15</td>
</tr>
<tr>
<td>Significance of the study</td>
<td>16</td>
</tr>
<tr>
<td>Limitations of the study</td>
<td>16</td>
</tr>
<tr>
<td>Definition of terms</td>
<td>17</td>
</tr>
<tr>
<td>2. Literature review</td>
<td>23</td>
</tr>
<tr>
<td>Traditional views of teaching and learning</td>
<td>24</td>
</tr>
<tr>
<td>Constructivist views of teaching and learning</td>
<td>26</td>
</tr>
<tr>
<td>Teacher role in a constructivist classroom</td>
<td>30</td>
</tr>
<tr>
<td>Teacher beliefs and classroom practice</td>
<td>32</td>
</tr>
<tr>
<td>Definitions of beliefs</td>
<td>32</td>
</tr>
<tr>
<td>Definitions of knowledge</td>
<td>34</td>
</tr>
<tr>
<td>Distinctions between beliefs and knowledge</td>
<td>35</td>
</tr>
<tr>
<td>Research on teacher beliefs and practice</td>
<td>37</td>
</tr>
<tr>
<td>Summary</td>
<td>53</td>
</tr>
<tr>
<td>3. Methodology</td>
<td>56</td>
</tr>
<tr>
<td>Participants</td>
<td>58</td>
</tr>
<tr>
<td>School context</td>
<td>60</td>
</tr>
</tbody>
</table>
4. Individual Case Study Results ................................................................. 78

The first case: Kathy ......................................................................................... 79
   Classroom context......................................................................................... 79
   Kathy’s beliefs related to constructivist teaching and learning............... 81
   Kathy’s observed classroom practice....................................................... 85
   Factors that influenced Kathy’s classroom practice .............................100
   Summary of Kathy’s case ......................................................................103

The second case: Mike .................................................................................... 105
   Classroom context.....................................................................................105
   Mike’s beliefs related to constructivist teaching and learning.............106
   Mike’s observed classroom practice......................................................111
   Factors that influenced Mike’s classroom practice............................122
   Summary of Mike’s case ......................................................................124

The third case: Patrick ..................................................................................... 125
   Classroom context...................................................................................126
   Patrick’s beliefs related to constructivist teaching and learning........127
   Patrick’s observed classroom practice...............................................132
   Factors that influenced Patrick’s classroom practice .....................144
   Summary of Patrick’s case .................................................................147

The fourth case: John ...................................................................................... 148
   Classroom context...................................................................................149
   John’s beliefs related to constructivist teaching and learning...........150
   John’s observed classroom practice.....................................................155
   Factors that influenced John’s classroom practice...........................167
   Summary of John’s case .....................................................................169

Summary of the individual case study results..............................................171
5. Cross-Case Study Results ........................................................................174
   Research Questions ...........................................................................175
   Research Question 1 .......................................................................175
   Research Question 2 .......................................................................179
   Research Question 3 .......................................................................183
   Summary .........................................................................................186

6. Conclusions and Discussion
   Summary of the study .......................................................................187
   Discussion of the study in relationship to the literature ....................189
   Implications ....................................................................................197
   Teacher education programs .......................................................197
   Policy makers and curriculum developers ...................................199
   Suggestions for further research ................................................199

List of References ..............................................................................202

Appendices ..........................................................................................213
   Appendix A: Constructivist Categories .........................................213
   Appendix B: Constructivist Learning Environment Survey-Preferred
               Form .....................................................................................218
   Appendix C: Constructivist Learning Environment Survey-Perceived
               Form .....................................................................................222
   Appendix D: Demographic Questionnaire ......................................226
   Appendix E: Interview Questions I ................................................228
   Appendix F: Interview Questions II ...............................................230
   Appendix G: Classroom Observation Chart ....................................232
   Appendix H: Classroom Observation Report Chart .......................234
   Appendix I: Proposal to Accompany Principal Support Letter ........236
   Appendix J: Principal Support Letter ............................................238
   Appendix K: Teacher Recruitment Letter .......................................240
   Appendix L: Teacher Consent Form ...............................................242
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Characteristics of traditional and constructivist classrooms</td>
</tr>
<tr>
<td>3.1</td>
<td>Demographic characteristics of participants</td>
</tr>
<tr>
<td>3.2</td>
<td>Interview schedule for each participant</td>
</tr>
<tr>
<td>4.1</td>
<td>A comparison of Kathy’s self-reported preferred and perceived classroom practice on the Constructivist Learning Environment Survey</td>
</tr>
<tr>
<td>4.2</td>
<td>A comparison of Kathy’s preferred, perceived, and observed classroom practice on the Constructivist Learning Environment Survey</td>
</tr>
<tr>
<td>4.3</td>
<td>Kathy’s instructional activities in terms of the amount of time spent</td>
</tr>
<tr>
<td>4.4</td>
<td>Percentage of time spent in teacher-centered, student-centered, and assessment activities in Kathy’s classroom</td>
</tr>
<tr>
<td>4.5</td>
<td>Examples of Kathy’s prompt questions</td>
</tr>
<tr>
<td>4.6</td>
<td>A comparison of Mike’s self-reported preferred and perceived classroom practice on the Constructivist Learning Environment Survey</td>
</tr>
<tr>
<td>4.7</td>
<td>A comparison of Mike’s preferred, perceived, and observed classroom practice on the Constructivist Learning Environment Survey</td>
</tr>
<tr>
<td>4.8</td>
<td>Mike’s instructional activities in terms of the amount of time spent</td>
</tr>
<tr>
<td>4.9</td>
<td>Examples of problems solved in Mike’s classroom</td>
</tr>
<tr>
<td>4.10</td>
<td>Percentage of time spent in teacher-centered, student-centered, and assessment activities in Mike’s classroom</td>
</tr>
<tr>
<td>4.11</td>
<td>A comparison of Patrick’s self-reported preferred and perceived classroom practice on the Constructivist Learning Environment Survey</td>
</tr>
</tbody>
</table>
4.12 A comparison of Patrick’s preferred, perceived, and observed classroom practice on the Constructivist Learning Environment Survey .................. 132

4.13 Patrick’s instructional activities in terms of the amount of time spent .......... 138

4.14 Percentage of time spent in teacher-centered, student-centered, and assessment activities in Patrick’s classroom .................................................. 140

4.15 Examples of questions on Patrick’s worksheet ........................................ 141

4.16 A comparison of John’s self-reported preferred and perceived classroom practice on the Constructivist Learning Environment Survey .................. 151

4.17 A comparison of John’s preferred, perceived, and observed classroom practice on the Constructivist Learning Environment Survey .................. 155

4.18 John’s instructional activities in terms of the amount of time spent .......... 157

4.19 Percentage of time spent in teacher-centered, student-centered, and assessment activities in John’s classroom .................................................. 162

4.20 Examples of problems in John’s classroom ............................................ 166

4.21 Summary of the individual case study results ........................................ 171

5.1 Highest and lowest component scores for preferred and perceived classroom practice on the Constructivist Learning Environment Survey across all 4 cases .......................................................... 176

5.2 Comparisons of observed classroom practice across all 4 cases ............... 179

5.3 Comparison of instructional activities in terms of the amount of time spent across all 4 cases ................................................................. 180

5.4 Patterns of time spent in teacher-centered, student-centered, and assessment activities across all 4 cases ...................................................... 182
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figures</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>A comparison of Kathy’s self-reported preferred and perceived classroom practice on the Constructivist Learning Environment Survey</td>
</tr>
<tr>
<td>4.2</td>
<td>Kathy’s instructional activities in terms of the amount of time spent</td>
</tr>
<tr>
<td>4.3</td>
<td>Percentage of time spent in teacher-centered, student-centered, and assessment activities in Kathy’s classroom</td>
</tr>
<tr>
<td>4.4</td>
<td>A comparison of Mike’s self-reported preferred and perceived classroom practice on the Constructivist Learning Environment Survey</td>
</tr>
<tr>
<td>4.5</td>
<td>Mike’s instructional activities in terms of the amount of time spent</td>
</tr>
<tr>
<td>4.6</td>
<td>Percentage of time spent in teacher-centered, student-centered, and assessment activities in Mike’s classroom</td>
</tr>
<tr>
<td>4.7</td>
<td>A comparison of Patrick’s self-reported preferred and perceived classroom practice on the Constructivist Learning Environment Survey</td>
</tr>
<tr>
<td>4.8</td>
<td>Patrick’s instructional activities in terms of the amount of time spent</td>
</tr>
<tr>
<td>4.9</td>
<td>Percentage of time spent in teacher-centered, student-centered, and assessment activities in Patrick’s classroom</td>
</tr>
<tr>
<td>4.10</td>
<td>A comparison of John’s self-reported preferred and perceived classroom practice on the Constructivist Learning Environment Survey</td>
</tr>
<tr>
<td>4.11</td>
<td>John’s instructional activities in terms of the amount of time spent</td>
</tr>
<tr>
<td>4.12</td>
<td>Percentage of time spent in teacher-centered, student-centered, and assessment activities in John’s classroom</td>
</tr>
<tr>
<td>5.1</td>
<td>Comparison of self-reported results on the preferred form of the Constructivist Learning Environment Survey across all 4 cases</td>
</tr>
</tbody>
</table>
5.2 Comparison of self-reported results on the perceived form of the Constructivist Learning Environment Survey across all 4 cases .................178

5.3 Comparison of observed classroom practice across all 4 cases ..................180

5.4 Comparison of instructional activities in terms of the amount of time spent across all 4 cases .............................................................................................181

5.5 Percentages of time spent in teacher-centered, student-centered, and assessment activities across all 4 cases ...........................................................183

6.1 A model showing the relationship between teacher beliefs and classroom practice ..............................................................................................................197
CHAPTER 1

INTRODUCTION


Constructivist learning principles assert that knowledge is not passively received but is actively constructed by the learner (Wheatley, 1991) and portray a completely different view of teaching and learning than the traditional didactic view. The constructivist view of teaching and learning suggests that teachers should be facilitators who help students construct their own understanding based on their existing knowledge. It also suggests that students should be active learners, questioners who are responsible for their own learning (Brooks & Brooks, 1999).
Therefore, reform in science education based on constructivist teaching and learning requires a radical shift in science classrooms. On the other hand, even though there has been an intensive call for instructional reform in science classrooms, research in science classrooms has suggested that change has not been extensive and teachers focus on the rote learning of facts and algorithms whereby students gain decontextualized content knowledge (Davis, 2003; Gallagher, 1991; Tobin & Fraser, 1989; Tobin & Gallagher, 1987; Weiss, 1997).

At the same time, teachers’ beliefs are receiving increased attention from the science education community. Many scholars consider teachers as action agents and highlight the importance of identifying teacher beliefs in order to successfully achieve any educational reform (Bybee, 1993; Haney, Czerniak, & Lumpe, 1996; Levitt, 2002; Nespor, 1987; Pajares, 1992; Tobin, Tippins, & Gallard, 1994). Therefore, the purposes of this study are to acquire new information with respect to science teacher beliefs and classroom practice related to constructivist teaching and learning and to identify factors that may affect teachers’ implementation of constructivism in their classrooms.

Theoretical Framework

For many years, philosophers, educators, and scientists have disputed the question of what represents reality. The traditional epistemological paradigm called positivism holds an objective view of reality. Reality exists outside the individual, is discovered, and is independent from the observer (Martin, 2000). According to the positivist view, reality is out there to be captured by following the unique approach of the scientific method. Ontologically, positivists believe that we do not make the world; the world is given, and we find the meanings which are already inherent in reality (Sipe & Constable, 1996).
An alternative view, called the constructivist paradigm, holds that individuals construct their own subjective reality; reality is constructed by the individual from his or her observations, reflections, and logical thought. This reality must be built by each individual for himself or herself. Constructivist’s initial ideas were proposed first by Giambattista Vico in 1710. von Glasersfeld (1989) stated that Vico’s notions about reality included the following:

1. Epistemic agents (people who know) can know nothing but the cognitive structures they themselves have put together.
2. God alone can know the real world, because He knows how and of what He has created it.
3. In contrast, the human knower can know only what the human knower has constructed. (p.123)

Constructivism can be defined as a set of beliefs about knowledge that begins with the assumptions that a reality exists but cannot be known as a set of truths because of the fallibility of human experience (Tobin et al. 1994; von Glasersfeld, 1989). There have been various types of constructivism discussed in the literature. Matthews (2000) lists three major constructivist traditions: educational constructivism, philosophical constructivism, and sociological constructivism. Only educational constructivism has many varieties including contextual, critical, dialectical, didactic, empirical, humanistic, information-processing, methodological, moderate, Piagetian (cognitive), post-epistemological, pragmatic, radical, realist, socio-historical, sociocultural, pragmatic social, and sociotransformative (Matthews). Even though there are a wide variety of constructivist models, this study is grounded in three fundamental constructivist theories: cognitive constructivism having its origin with Jean Piaget, radical constructivism having its origin with Ernst von Glasersfeld whose thinking has been strongly influenced by the
theories of Piaget, and social (sociocultural) constructivism which has its origin with Lev Vygotsky.

**Cognitive Constructivism**

Jean Piaget is one of the most prominent developers of a constructivist theory of learning in the 20th century. For Piaget, knowledge is never a copy of the real world (Piaget, 1964; von Glasersfeld, 1991). Piaget (1970a) viewed knowledge as a process of continual construction rather than a state.

For the genetic epistemologist, knowledge results from continuous construction, since in each act of understanding, some degree of invention is involved; in development, the passage from one stage to the next is always characterized by the formation of new structures which did not exist before, either in the external world or in the subject’s mind. (p.77)

According to Piaget (1970a, 1970b), knowing an object requires acting on the object, transforming it, assimilating it, and incorporating it into operational structures he called schemata.

Knowledge is derived from action, not in the sense of simple associative responses, but in the much deeper sense of assimilation of reality into the necessary and general coordination of action. To know an object is to act upon it and to transform it, in order to grasp the mechanisms of that transformation as they function in connection with the transformative actions themselves. To know is therefore to assimilate reality into structures of transformation. (Piaget, 1970b, pp. 28-29)

Piaget (1970a) asserts that actions lead to the development of operations, and operations in turn lead to the development of structures. For Piaget (1964), an operation is an interiorized action which modifies the object of knowledge and enables the knower to get at the structures of the transformation. Operations are internalized, reversible, conserved, and integrated with higher organizations (structures) and other operations. Structures (schemata) are the highest-order mental organizations (Wadsworth, 1978).
Piaget introduced the concept of equilibrium which refers to “a state in which epistemic agent’s cognitive structures have yielded and continue to yield expected results, without bringing to the surface conceptual conflicts or contradictions” (von Glasersfeld, 1991, p.120). Piaget described equilibration as an active process of self-regulated behavior balancing two intrinsic polar behaviors, assimilation and accommodation (Fosnot, 1996).

Assimilation and accommodation are key terms describing cognitive structure in Piaget’s theory. However, von Glasersfeld (1991, 1995b) warned that the meaning of these terms is often misinterpreted and used the same as their commonly used interchangeably in ordinary language. Assimilation has a different meaning in biology compared to cognitive theory; the operative processes are not physical transfer but perception or conception. According to von Glasersfeld (1995b), assimilation must be understood “as treating new material as an instance of something known” (p. 62). The cognitive organism assimilates only what it can fit into the structures it already has. In his book entitled “Structuralism,” Piaget (1970c) clarified the meaning of assimilation as follows:

Psychologically considered, assimilation is the process whereby a function, once exercised, presses toward repetition, and in “reproducing” its own activity produces a scheme into which the objects propitious to its exercise, whether familiar (“recognition assimilation”) or new (“generalizing assimilation”), become incorporated. So assimilation, the process or activity common to all forms of life, is the source of that continual relating, setting up of correspondences, establishing of functional connections, and so on, which characterizes the early stages of intelligence. And it is assimilation, again, which finally gives rise to those general schemata we called structures. But assimilation itself is not a structure. Assimilation is the functional aspect of structure formation, intervening in each particular case of constructive activity, sooner or later leading to the mutual assimilation of structures to one another, and so establishing ever more intimate inter-structural connections. (pp. 71-72)
For Piaget, assimilation is the organization of experience with one’s own logical structures or understandings. When new experiences foster contradictions to one’s present understandings, perturbing and disequilibrating the structure, they cause one to accommodate. Accommodation is comprised of reflective, integrative behavior that serves to change one’s own self and explicate the object in order for us to function with cognitive equilibrium in relation to it (Fosnot, 1996). Piaget (1964) criticizes learning based on stimulus-response schema. For Piaget, the stimulus is really a stimulus only when it is assimilated into a structure. von Glasersfeld (1989) explained Piaget’s view of learning in his article entitled “Cognition, Construction of Knowledge, and Teaching” by saying that

Cognitive change and learning take place when a schema, instead of producing the expected result, leads to perturbation and perturbation in turn, leads to accommodation that establishes a new equilibrium. As a result, human kind is a complex network of schemata which are intricately connected to each other in patterns completely unique to the individual. (p. 128)

Piaget’s theory has been criticized in that it ignores the effect of social interaction on learning (Santrock & Arends, 2001).

**Radical Constructivism**

Psychologist Ernst von Glasersfeld, whose thinking has been profoundly influenced by the theories of Piaget, is typically associated with radical constructivism. According to von Glasersfeld (1995a), there is an absolute reality but we have no way of knowing it. von Glasersfeld claims that “we can define the meaning of “to exist” only within the realm of our experiential world and not ontologically” (p. 7). Matthews (2000) summarized von Glasersfeld’s ontological/epistemological view as the following:
1. Knowledge is not about an observer-independent world.
2. Knowledge does not represent such a world; correspondence theories of knowledge are mistaken.
3. Knowledge is created by individuals in a historical and cultural context.
4. Knowledge refers to individual experience rather than to the world.
5. Knowledge is constituted by individual conceptual structure.
6. Conceptual structures constitute knowledge when individuals regard them as viable in relationship to their experience; constructivism is a form of pragmatism.
7. There is no preferred epistemic conceptual structure; constructivism is a relativist doctrine.
8. Knowledge is the appropriate ordering of an experiential reality.
9. There is no rationally accessible, extra-experiential reality. (pp. 172-174)

von Glasersfeld (as cited in Matthews, 2000) stated that for a radical constructivist,

Knowledge is not passively received either through the senses or by the way of communication. Knowledge is actively built up by the cognizing subject. The function of cognition is adaptive, in the biological sense of the term, tending towards fit or viability. Cognition serves the subject’s organization of the experiential world, not the discovery of an ontological reality. (p. 173)

According to von Glasersfeld (1993), knowledge is always the result of a constructive activity, and therefore cannot be transferred to a passive receiver. It has to be actively built by each individual knower. A teacher, however, can orient a learner in a general direction, and constraints can be arranged that prevent the learner from constructing in directions that seem unsuitable to the teacher. Thus, knowledge exists only in the mind of cognizing beings, where it is constructed, and is not to be found, for instance, in books or other traditional repositories of human knowledge which simply represent symbols open to a range of interpretation. Hence, there is no knowledge without a knower (Osborne, 1996). From a radical constructivist perspective, knowledge is not transferred directly from the environment or other persons into the learner, but has to be actively constructed within the individual mind. All knowledge is constructed for the purpose of enhancing survival through making experience meaningful; none of it tells
us anything certain about the world (Geelan, 1997). von Glasersfeld (1995a) criticizes behaviorist learning theory that has tended to focus attention on student performance rather than on the reasons that prompt them to respond or act in a particular way.

Social Constructivism

Social constructivist approaches emphasize the social contexts of learning and that knowledge is mutually built and constructed. Social constructivists believe that knowledge is situated and collaborative (Santrock & Arends, 2001). Vygotsky’s works have a significant effect on social constructivist views. According to Vygotsky (1978), social interaction is essential for cognitive development. Unlike Piaget, he stressed that learning occurs by interaction with others-first on the social level then on the individual level. In *Mind in Society*, Vygotsky (1978) stated:

> Every function in the child's cultural development appears twice: first, on the social level and, later on, on the individual level; first, between people (interpsychological) and then inside the child (intrapsychological). This applies equally to voluntary attention, to logical memory, and to the formation of concepts. All the higher functions originate as actual relationships between individuals. (p. 57)

Vygotsky argued that higher mental functions develop through participation in social activities; hence, the social context of learning is critical. At an early stage, children engage in instrumental thinking when manipulating physical objects. They also engage in social speech with others and learn to use signs in such talk (Bredo, 1997). Vygotsky emphasized the role of language as a means of communication between the child and the people in his environment. Vygotsky proposed the term “zone of proximal development” as an essential aspect of learning.

We propose that an essential feature of learning is that it creates the zone of proximal development; that is, learning awakens a variety of internal
developmental processes that are able to operate only when the child is interacting with people in his environment and in cooperation with his peers. Once these processes are internalized, they become part of the child’s independent achievement. (p. 90)

For Vygotsky, the zone of proximal development is “the distance between actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers” (p. 86). In the zone of proximal development, the student is cognitively prepared, but requires help and social interaction to fully develop (Phillips & Soltis, 2004).

In his article, Tappan (1998) summarized three claims that explain Vygotsky’s view. Unlike Piaget’s view about stages of children’s development, Vygotsky believed that a particular mental act cannot be viewed accurately in isolation but should be evaluated as a step in a gradual developmental process. His second claim is that language is the most important tool that mediates and shapes cognitive functioning. The third claim attributed to Vygotsky is that cognitive skills originate in social relations and culture and a child’s development is inseparable from social and cultural activities.

John Dewey is one of the first philosophers who emphasized the social nature of learning (Phillips & Soltis, 2004). Dewey highlighted that the school was a community and wanted schools to engage students in meaningful activities where they had to work with others on problems (Phillips & Soltis). In Democracy and Education, Dewey (1916) posited the role of communication in the construction of knowledge as follows:

It is that no thought, no idea, can possibly be conveyed as an idea from one person to another. When it is told, it is, to the one to whom it is told, another given fact, not an idea. The communication may stimulate the other person to realize the question for himself and to think out a like idea, or it may smother his intellectual
According to Prawat (2000), Dewey is the main proponent for activity-based, hands-on, or the learning-by-doing approach to teaching and learning. According to Piaget and Dewey, the key to the activity-based approach is to create opportunities for children’s engagement in situations that appeal to their natural curiosity and interest. Although Piaget and Dewey have similarities in their thinking, in his article, Prawat discussed Dewey’s social constructivist side and claimed that Dewey underwent a dramatic change in his thinking.

Glassman (2001) stated that Dewey and Vygotsky believe in similar ideas concerning the relationship of activity to learning/development, especially the roles that everyday activities and the social environment play in the educational process. However, according to Glassman, there are three key differences between Dewey’s and Vygotsky’s theories in terms of the relationship between process and goals in education. First, Glassman compared the two theorists on the role of social history and the tools it produces. Dewey sees social history as creating a set of malleable tools that are of use in present circumstances. Vygotsky believes that tools developed through history have a far more lasting impact on a social community. Second, the two theorists were compared in their views of experience/culture. Dewey sees experience as helping to form thinking whereas Vygotsky posits culture as the raw material of thinking. Third, the theorists are compared on their perspectives on human inquiry. Dewey sees the child as a free agent who achieves goals through her/his own interest in the activity. Vygotsky suggests there
should be greater control by a mentor who creates activity that will lead the child toward understanding.

Rogoff (1990) described similarities and differences between Vygotsky’s and Piaget’s theories. Rogoff summarized differences between the two theorists as follows:

1. While Piaget focuses on the individual as starting point, Vygotsky focuses on the social basis of mind.

2. Both theories highlight the importance of a common frame of reference, intersubjectivity, in social interaction. However, there are differences in the locus of intersubjectivity. In Piaget’s theory, social interaction is cooperation between equals who attempt to understand each other’s views through reciprocal consideration of alternative views. In Vygotsky’s view, social interaction is expected to foster development through the guidance provided by interaction with people who are more skilled.

3. Piaget and Vygotsky seem to be in opposition on the question of the age at which social influence contributes to cognitive development. For Piaget, development moves from the individual to the social while for Vygotsky, development moves from the social to the individual. According to Piaget, young children cannot benefit from social interaction until middle childhood because egocentricity blocks the establishment of cooperation in considering different point of views. In contrast, Vygotsky believed that the most important event in the development of the child’s thinking and speech occurs at approximately 2-years of age.

4. Piaget emphasized the importance of peer interaction and believed that children’s interactions with adults are unlikely to lead to cognitive structuring because of
their unequal power. For Vygotsky, ideal partners are not equal. Interaction with
either adults or peers can bring about cognitive growth.

Although there have been differences among constructivist theories, they have
common characteristics. In his article, Staver (1998) indicates similarities between radical
and social constructivism. First, knowledge is actively built up from within by each
member of a community and by a community itself. Second, social interactions between
and among individuals in a variety of community, societal, and cultural settings are
central to the building of knowledge by individuals as well as the building of knowledge
by communities and cultures. Third, the purpose of cognition and language is to bring
coherency to an individual’s world of experience and a community’s knowledge base.
According to Staver, the main difference between radical and social constructivism is
their foci. The focus of radical constructivism is cognition and the individual whereas the
focus of social constructivism is language and the group.

Statement of the Problem

Constructivist teaching practices are receiving increased attention from the
education community (Brooks & Brooks, 1999; Chiappetta 1997; Davis, Maher, &
Noddings, 1990; Duit & Confrey, 1996; Duit & Treagust, 1998; Gallagher, 1993; Piaget,
1950; 1964; 1970b; Prawat, 1992; Tobin et al., 1994; von Glasersfeld, 1989;1991; 1993;
1995a; 1995b; Vygotsky, 1978; Yager, 2000) and have been recommended by many of
the national science education reform documents and standards (NRC, 1996; Rutherford
& Ahlgren, 1990). The constructivist view has led to calls for a dramatic shift in
classroom environments away from the traditional transmission model of teaching toward
one that is much more complex and interactive (Prawat & Floden, 1994).
On the other hand, research shows that there has not been extensive change and teacher-centered activities are still dominant in science and mathematics classrooms (Davis, 2003; Weiss, 1997). An earlier study has been done by Hurd, Bybee, Kahle, and Yager (1980) on biology education in secondary schools. The authors summarized their findings in biology as follows:

In short, little evidence exists that inquiry is being used. And further, scant data support the contention that students in biology attain an understanding of scientific inquiry, or that they can use the skills of inquiry...biology teachers lecture more than 75% of the time, so little time is left for inquiry. (p.391)

According to this study, 8% of the primary, 90% of the intermediate, and 50% of all teachers base their instruction upon a single textbook and students are trained to seek the “right” answers from the textbook.

Moreover, Weiss’s (1997) survey provides considerable information about the status of science and mathematics teaching as they relate to the National Research Council (NRC) and the National Council of Teachers of Mathematics (NCTM) standards. Weiss found that traditional lecture/textbook methodologies continue to dominate science and mathematics instruction. Teachers in the survey reported instructional objectives that were consistent with the reform goals, but implemented class activities that were not very well aligned with the recommendations of the NRC and the NCTM. According to Weiss, the largest percent of time in science classes is devoted to lecture and discussion (38%), followed by hands-on/laboratory work (23%), individual seatwork (19%), nonlaboratory small group work (10%), and daily routines/noninstructional activity (10%).

In the 1999 U.S. Department of Education report (as cited in Windschitl, 2003) on student work and teacher practices in American schools, 69% of twelfth graders surveyed
indicated that they had “never” or “hardly ever” designed and carried out their own investigation. Thirty-seven percent and 32% of students surveyed in grades 8 and 12, respectively, reported that they did not “conduct science projects or investigations that took a week or more” (p.115).

Similarly, Haberman (1991) argued that urban teachers have tremendous constraints on their teaching, including large class sizes, inadequate preparation time, lower levels of training, inadequate classroom space, and outdated materials, and that often these constraints result in a “directive, controlling pedagogy” (p. 291) that he called the pedagogy of poverty. This pedagogy is characterized by teacher-directed activities such as giving information, tests, directions, and grades; monitoring seat work; settling disputes; and reviewing tests and homework. According to the author, this pedagogy includes a set of beliefs, such as “teachers are in charge and responsible” that often run counter to those that support inquiry science and those that motivated these individuals to become teachers in the first place. Haberman states that pedagogy-of-poverty teaching practices are common in urban classrooms.

Inquiry is one of the key instructional strategies consistent with constructivist teaching and learning and has been used widely by science educators (Anderson, 2002). Costenson and Lawson (1986) investigated the reasons why science teachers do not use inquiry, a component associated with constructivism in the science classroom. The authors conducted interviews with 12 experienced science teachers in the Phoenix area. The results indicated that there are 10 main reasons that teachers give for not using scientific inquiry: too much time and energy, too slow, reading too difficult, risk is too high, tracking, student immaturity, teaching habits, sequential material, discomfort, and
too expensive. Participants in this study were primarily concerned about the time necessary to use inquiry in their instruction.

The implementation of principles associated with the constructivist-based reform movement may be much more complex than initially thought; yet, teachers clearly play a significant role in implementing constructivist teaching and learning. According to Bandura (1986), an individual’s decisions throughout their lives are strongly influenced by their beliefs. Similarly, Pajares (1992) asserts that beliefs are the “best indicators of the decisions that individuals make throughout their lives” (p. 307). Teacher beliefs play a major role in teacher decision making about curriculum and instructional tasks (Nespor, 1987; Pajares). Therefore, educational researchers have advocated the need for closer examination and direct study of the relationship between teacher beliefs and educational practices (Pajares; Pomeroy, 1993).

The Purposes of the Study and Research Questions

The main purposes of this study are to gain an in-depth understanding of in-service science teacher beliefs and classroom practice related to constructivist teaching and learning and to identify factors that may influence teacher classroom decisions and practice. This study investigates the following questions:

1. What are the beliefs that teachers have regarding constructivist teaching and learning?

2. How do teachers embody their beliefs about constructivist teaching in science classrooms? Are these beliefs consistent with their classroom practice?

3. What factors influence teachers’ use of constructivism in their classrooms?
Significance of the Study

The findings of the study may have significant implications. First, the findings of the study could support science teachers while they are trying to implement constructivist teaching and learning reforms as recommended by the *National Science Education Standards* (NRC, 1996). Second, the findings of the study may provide science educators with ideas to plan workshops and seminars in which science teachers could develop their understanding and classroom practice associated with constructivist teaching and learning. Third, this study could lead educators to do further research based on the findings of the study. Fourth, policy makers and curriculum developers could benefit from the study as they make decisions about the curriculum in science education.

Limitations of the Study

One of the limitations of the study is lack of generalizability. Since it is a case study with a small number of participants, the findings from this study may not be generalized to other teachers. However, giving more detail and thick description of contexts allows readers to understand each teacher’s beliefs, practice, and school contexts so that they may be able to apply the findings of the study in similar settings.

In order to strengthen internal validity of the study, the researcher used a variety of data collection methods including surveys, interviews, classroom observations, and classroom artifacts. However, each method may have limitations. The surveys are self-reported by each participant in terms of their beliefs and actual practice related to a constructivist learning environment. Even though the interviews were intended to gain in-depth understanding of teacher beliefs and experiences related to constructivist teaching and learning, participants may have tended to give responses consistent with their
perceptions of researcher expectations or they may have inadequately remembered their experiences in response to the questions. The cultural differences between the researcher and the participants may have caused misinterpretations in the meaning of the interview questions and responses. In order to decrease these limitations, the researcher gave a copy of the interview transcriptions to each participant and asked for additional comments and modifications before analyzing the data.

Although there were 29-30 hours of classroom observations for each participant, and this may be an adequate time to understand and acquire detailed information about teacher practice, it is hard to generalize about practice in general based on just these observations. During the observations, the researcher may have missed some of the activities that the teachers use in their instruction at other times or may have observed some activities that the teachers did not frequently use. This could be considered a limitation of the study.

The study completely focuses on teacher beliefs even though students, administrators, and parents are other important elements of the school community. The findings of the study reflect the teacher’s point of view. However, students, principals, and parents may have different beliefs than those indicated by the teachers.

Definition of Terms

Brief definitions for the terms used in this study are summarized in alphabetical order.

Beliefs: As defined by Haney, Lumpe, and Czerniak (2003), beliefs are used as “one’s convictions, philosophy, tenets, or opinions about teaching and learning” (p. 367). In the current study, beliefs are associated with the teacher’s philosophy or opinion about teaching and learning and implications of constructivism in the science classroom.
For the current study, teacher beliefs about teaching and learning were categorized under five categories related to constructivism: didactic, transitional, emerging constructivist, progressing constructivist, and expert constructivist (see Appendix A; adapted from Teacher Pedagogical Philosophy Interview by Masene (2002) & Simmons et al. 1999). Didactic views focus on responses consistent with traditional teaching and learning. Transitional views include responses mainly consistent with the traditional view of teaching and learning along with some views consistent with constructivist teaching and learning. Emerging constructivist views include responses consistent with a mix of traditional and constructivist teaching and learning views. Progressing constructivist views include more responses based on constructivist teaching and learning. Expert constructivist views include responses mainly based on constructivist teaching and learning.

Classroom Practice: includes anything observed during the classroom period such as the instructional strategies; the interaction between the teacher and students, and interactions among students; decisions made by teachers and students; classroom management; and assessment strategies.

The Constructivist Learning Environment Survey (CLES) is a survey instrument designed to measure the extent to which teachers perceive and use constructivist approaches to teach school science and mathematics (Taylor, Fraser, & Fisher, 1997; Taylor, Fraser, & White, 1994). In the current study, the CLES used consists of two forms. The first form “preferred” of the CLES measures teacher perceptions of the classroom environment ideally liked or preferred (see Appendix B). The second form “perceived” of the CLES measures teacher perceived classroom practice (Taylor, Dawson, & Fraser, 1995; see
Appendix C. Both forms of the CLES, preferred and perceived, have five components: (a) Personal Relevancy/Learning About the World, (b) Scientific Uncertainty/Learning About Science, (c) Critical Voice/Learning to Speak Out, (d) Shared Control/Learning to Learn, and (e) Student Negotiation/Learning to Communication. However, Personal Relevance, Scientific Uncertainty, Critical Voice, Shared Control, and Student Negotiation were the terms most commonly used in the literature. Therefore, in this study, I used the terms: Personal Relevance, Scientific Uncertainty, Critical Voice, Shared Control, and Student Negotiation as defined by Taylor et al. (1997, p. 296).

**Personal Relevance:** This scale of the CLES focuses on the connectedness of school science to students’ out-of-school experiences, and with making use of students’ everyday experiences as a meaningful context for the development of students’ scientific and mathematical knowledge.

**Scientific Uncertainty:** This scale of the CLES is concerned with teachers' viewpoints on the nature of scientific knowledge.

**Critical Voice:** This scale of the CLES measures teachers' assessments of students' perceptions of the extent to which they are able to exercise a critical voice about the quality of their learning activities.

**Shared Control:** This scale of the CLES is concerned with students being invited to share with the teacher control of the learning environment, including the articulation of learning goals, the design and management of learning activities, and the determination and application of assessment criteria.
**Student Negotiation:** This component of the CLES measures the teacher's beliefs concerning the extent to which they believe students can interact verbally with other students for the purpose of building student scientific knowledge.

**Teacher-Centered:** In the literature, the term teacher-centered is characterized by a variety of terms such as traditional, chalk-and-talk, frontal teaching, tough minded, hard pedagogy, and mimetic (Cuban, 1990). In the current study, the terms “teacher-centered,” “traditional,” and “didactic instruction,” are interchangeably used to describe the classroom as described by Llewellyn (2002) in the following quote:

> In teacher-centered classrooms, students are often passive learners and receive information according to what the teacher feels they need to learn. Information is shared with students predominantly through reading and hearing. The students’ time is consumed with note taking, handouts, and worksheets that emphasize basic thinking skills. The teacher in this class often relies on a single textbook that along with lectures, serves to inform students of the body of knowledge that exists out there in the world of science. The activities and laboratory experiences serve as recipes to verify or confirm already stated knowledge and show how a set of scientific principles or truths apply to life. In the end, all students are expected to learn the same information. The unit test at the end relies on multiple-choice questions to inform the teacher about which facts and information the students have retained. (p. 29)

In teacher-centered classrooms, teachers focus on the content and most of the classroom time is spent on lectures, worksheets, and seatwork. According to Alton-Lee, Nuthall, and Patrick (as cited in Hendry, 1996), traditional teaching is one in which students are motivated through the use of rewards and grades to acquire knowledge given to them by a teacher or a textbook. During lessons, students typically are expected to listen, asked not to talk or discuss their interpretations privately, and are expected to speak in public only when questioned by the teacher.
Some teacher-centered instructional strategies include demonstration, drill and practice, and lecture. Demonstration is “a concrete experience that can be considered an advance organizer for structuring subsequent information and activities into a meaningful, instructional framework for students” (Chiappetta, Koballa, & Collette, 1998, p. 150). Teachers may use manipulatives, laboratory equipment, videos, or animations in order to demonstrate a concept. In the current study, both videos and animations were categorized as demonstration. Seatwork and worksheets are other terms used to describe drill and practice or classroom activity in which students solve problems, find the meaning of words, or fill in the blanks on the worksheet given by the teacher.

Drill and practice in this study was considered a teacher-centered instruction. Lecture is an instructional strategy in which the teacher explains the content and students usually listen and take notes. The teacher sometimes ask questions and students may give responses. The interaction among students is rarely seen. According to Chiappetta et al., lecture is “a traditional, teacher-centered method that involves didactic presentation of ideas and information” (p.136).

**Student-Centered:** In the literature, nontraditional, reform-based, standard-based, and constructivist-based instruction are some of the terms used for describing the classroom consistent with the national standards. In the current study, student-centered or constructivist-based teaching is the preferred term and the classroom is described by the following:

In a constructivist view of teaching, the acquisition of knowledge is an act of change in the pattern of thinking brought about by experiential problem-solving situations. This view assumes that meaningful learning occurs as a result of personal actions on data derived from active engagement in activities in which students discuss ideas and problems with their peers, manipulate equipment, work
independently, listen to the teacher in whole-class settings and respond to teacher questions. (Tobin, 1990, p. 34)

The teacher recognizes the importance of students’ prior knowledge, experience, interest, and needs related to their learning and provides an environment in which students are active learners, questioners, explorers, and take responsibility for their own learning. In a student-centered classroom, inquiry, social interaction and authentic assessments are encouraged.

Hands-on activities and inquiry are student-centered activities fundamental to the current study. Hands-on activity can be either a laboratory activity or classroom activity in which students use manipulatives to explore, observe, and develop understanding about a concept. Inquiry is one of the student-centered instructional strategies consistent with constructivist teaching and learning. According to the National Science Education Standards (NRC, 1996), inquiry can be defined as the activities of students in which they develop knowledge and understandings of scientific ideas as well as an understanding of how scientists study the natural world.
CHAPTER 2

LITERATURE REVIEW

Reform in science education in the United States calls for a new way of thinking about the teaching and learning of science. Constructivism provides the philosophical foundation for reform in science education (NRC, 1996) and stands in direct contrast to the traditional, dominant paradigm in science education, the behaviorist-positivist paradigm (Fosnot, 1996; Shapiro, 1994). As a result of the radical shift in teaching and learning from the traditional behaviorist-positivist paradigm to the constructivist paradigm, studies on constructivist teaching and learning compared to traditional teaching and learning are well documented in the literature (Brooks & Brooks, 1999; Gallagher, 1993). Therefore, the first part of this literature review compares traditional views and constructivist views of teaching and learning in order to describe the specifics of constructivist teaching and learning. The second part of the literature review discusses studies on teacher beliefs and classroom practices associated with constructivist teaching and learning.
Traditional Views of Teaching and Learning

For many cognitive psychologists, American pedagogy has been dominated by the behaviorist model (Yager, 1995). Behaviorists believe that knowing could be characterized only in terms of observational connections between stimuli and responses. Major behaviorist researchers including J. B. Watson, I. Pavlov, E. L. Torndike, and B. F. Skinner conducted their studies on animals and believed that experiences on animals would produce similar results on humans. When those experiences are applied to human learning, this issue for behaviorists is not “How is new knowledge acquired?” but instead “How is new behavior acquired?” Therefore, for behaviorists, learning means changes in behavior of an individual by reward or punishment. For behaviorists, learning can be achieved by an extrinsic motivation which means students learn for high grades, extra credits, and gold stars. Behaviorists introduced the terms positive and negative reinforcement to emphasize their view that rewards tend to strengthen particular responses whereas punishments weaken particular response tendencies. According to behaviorists, routine activities are effective for transmitting knowledge to the learner. Furthermore, they favor clear goals and reinforcements as teaching-learning strategies (Greeno, Collins, & Resnick, 1996).

The traditional, behaviorist-positivist view supports a transmission view of teaching in which knowledge can be transmitted to students’ minds via language, and students simply absorb transmitted knowledge (Hendry, 1996). Knowledge is viewed as a commodity to be transmitted to students, and learning is viewed as receiving and storing knowledge (Gallagher, 1993). Similarly, as Tobin et al. (1994) indicated, the traditional model assumed that an already developed body of knowledge, generally
accepted by the scientific community, can be transmitted to students through passive instructional means. In traditional classrooms, the teacher’s role is to convey effectively the prescribed content to the learner. As Wickens (1973) stated, the learner is expected to conform to the expectations for interest and achievement that the teacher establishes. The learner has no options in the initial selection of content.

<table>
<thead>
<tr>
<th>Traditional Classroom</th>
<th>Constructivist Classroom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strict adherence to fixed curriculum is highly valued.</td>
<td>Pursuit of student questions is highly valued.</td>
</tr>
<tr>
<td>Curricular activities rely heavily on textbooks and workbooks.</td>
<td>Curricular activities rely heavily on primary sources of data and manipulative materials.</td>
</tr>
<tr>
<td>Teachers generally behave in a didactic manner, disseminating information to students.</td>
<td>Teachers generally behave in an interactive manner, mediating the environment for students.</td>
</tr>
<tr>
<td>Teachers seek the correct answer to validate student learning.</td>
<td>Teachers seek the students’ point of view in order to understand students’ present conceptions for use in subsequent lessons.</td>
</tr>
<tr>
<td>Assessment of student learning is viewed as separate from teaching and occurs almost entirely through testing.</td>
<td>Assessment of student learning is interwoven with teaching and occurs through teacher observations of students at work and through student exhibitions and portfolios.</td>
</tr>
<tr>
<td>Students primarily work alone.</td>
<td>Students primarily work in groups.</td>
</tr>
</tbody>
</table>

Table 2.1: Characteristics of traditional and constructivist classrooms (Brooks & Brooks, 1999, p. 17).
Brooks and Brooks (1999) compared traditional and constructivist classrooms in terms of the role of students, the role of teachers, curriculum, and assessment as shown in Table 2.1.

Constructivist Views of Teaching and Learning

Constructivist teaching and learning is in sharp contrast to more traditional approaches (Ritchie & Cook, 1994). For constructivists, knowledge is not an objective representation of an observer-independent world. Knowledge refers to conceptual structures that individuals consider viable (Yager, 1995). Driver and Bell (1986) summarized a constructivist view of learning as follows:

1. Learning outcomes depend not only on the learning environment but also on the knowledge of the learner.
2. Learning involves the construction of meanings. Meanings constructed by students from what they see or hear may or may not be those intended. Construction of meaning is influenced to a large extent by our existing knowledge.
3. The construction of meaning is a continuous and active process.
4. Meanings, once constructed are evaluated and can be accepted or rejected.
5. Learners have the final responsibility for their own learning.
6. There are patterns in the types of meanings students construct due to shared experiences with the physical world and through natural language. (pp. 453-454)

Constructivist teaching and learning is student-centered (Duit & Confrey, 1996). According to Duit and Confrey, other approaches may claim this approach but constructivist approaches are student-centered in a specific way. They use subject-matter as a vehicle for interactive engagement with students. Ideas are embedded in student-oriented challenges and the classroom climate supports and encourages active exchange, debate, and negotiation of ideas. In constructivist classrooms, learning is negotiated between teacher and students, and the number of activities controlled by the teacher
decreases (Hand, 1996). Student autonomy, initiation, and leadership are encouraged and accepted in constructivist teaching and learning (Yager, 1995).

In constructivist teaching and learning, students are active learners. Contrary to the traditional approach, constructivism recognizes that, rather than being transferred from one individual to another, knowledge has to be constructed by each individual through his or her active engagement with the physical and/or social environment (Roth, 1993). Learning is accomplished by constructing and elaborating schemes based on experiences (Wheatley, 1991). In a constructivist classroom, students are encouraged to take responsibility for their own learning as they take on the role of an explorer (Wheatley).

Constructivists recognize that student prior knowledge and experiences play an important role in student learning. Duit and Treagust (1998) indicate that the learner actively constructs, even creates his or her knowledge, on the basis of the knowledge already held. Students try to make sense of experiences in terms of prior knowledge (Wheatley, 1991). In contrast to traditional classrooms, teachers in constructivist classrooms know that students bring a varied set of personal experiences, concepts, and understandings to the unit (Llewellyn, 2002). According to Ausubel (1968), “the most important single factor influencing learning is what the learner already knows; ascertain this, and teach him accordingly.” (p. iv)

As Saunders (1992) indicated, in constructivist classrooms, the active cognitive involvement of students is encouraged. Cognitive activities such as thinking out loud, developing alternative explanations, interpreting data, participating in cognitive conflict, and development of alternative hypotheses are given as some examples of activities
which activate constructivist learning and teaching. According to Duit and Confrey (1996), cognitive conflict seems to play a significant role in constructivist teaching. Cognitive conflict can be created by asking for students’ predictions and then contrasting these with the experimental results, by contrasting the ideas of the students and those of the teacher, and by contrasting the beliefs among students. Similarly, in a discrepant event, first, students are asked to predict what they expect to happen before a demonstration and explain why they think it should happen that way. Then, they observe what happens and are asked to modify their previous explanation (Gabel, 2003). A discrepant event puzzles students, causing them to wonder why the event occurred as it did. Puzzlement can stimulate students to engage in reasoning and the desire to find out (Piaget, as cited in Chiappetta, 1997).

Constructivist teaching and learning encourages social interaction not only between students and teacher but also among students. As Wilson (1995) stated, “a constructivist learning environment is a place where learners may work together and support each other as they use a variety of tools and information sources in their pursuit of learning goals and problem-solving activities” (p. 27). Students can construct their understanding by sharing ideas with each other in a small or a large group discussion. Saunders (1992) considered group work as one of the instructional strategies associated with constructivism in classrooms. Students could benefit from working groups not only in hands-on activities but also in the development of explanations, interpretation, and conclusions about phenomena under investigation. Saunders claimed that small group work tends to stimulate a higher level of cognitive activity among a larger number of students than does listening to lectures. According to Yager (2000), in constructivist
classrooms, group learning, where two or three students discuss approaches to a given problem with little or no interference from the teacher, is highly encouraged.

In constructivist teaching and learning, authentic assessment is encouraged. In constructivist classrooms, assessment of student learning is not separated from the classroom’s normal activities; rather it is embedded in the context of daily teaching (Brooks & Brooks, 1999). Saunders (1992) discussed higher level assessment as a characteristic of constructivist teaching and learning and supported assessment which taps higher level cognitive abilities for meaningful learning.

Inquiry is one of the key instructional strategies consistent with constructivist teaching and learning and has been used widely by science educators (Anderson, 2002). De Boer (1991) emphasized the importance of inquiry in science education in the following statement: “If a single word had to be chosen to describe the goal of science education during the 30-year period that began in the late 1950s, it would have to be inquiry” (p. 206). Welch, Klopher, Aikenhead, & Robinson (1981) defined inquiry as a general process by which human beings seek information or understanding. Broadly conceived, inquiry is a way of thought. Scientific inquiry, a subset of general inquiry, is concerned with the natural world and is guided by certain beliefs and assumptions.

According to the *National Science Education Standards* (NRC, 1996),

Inquiry is a multi-faceted activity that involves making observations, posing questions, examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations. Students will engage in selected aspects of inquiry as they learn the scientific way of knowing the natural world, but they also should develop the capacity to conduct complete inquiries. (p. 23)
The National Science Education Standards (NRC) state that inquiry teaching refers to the activities of students in which they develop knowledge and understandings of scientific ideas as well as an understanding of how scientists study the natural world. Inquiry means more than conducting laboratory experiments or hands-on activities, although both can be structured as inquiry experiences. Inquiry involves answering questions about the world in which we live. The essential features of classroom inquiry include engaging students through scientifically-oriented questions, obtaining evidence related to the questions, formulating explanations from the evidence, evaluating the explanations in light of other possible explanations, and communicating and justifying their explanations to others (Gabel, 2003).

Chiappetta (1997) defined two approaches to inquiry-based science teaching: general inquiry and scientific inquiry. General inquiry (teaching science by inquiry) does not specify the context or place limits on the approach while teaching science as inquiry (scientific inquiry) stresses active student learning and the importance of understanding a scientific topic. Then, the content becomes a critical aspect of the inquiry. Chiappetta listed some essential strategies for the inquiry process: asking questions, science process skills, discrepant events, inductive activities, deductive activities, gathering information, and problem solving.

Teacher Role in a Constructivist Classroom

The teacher role in a constructivist science classroom changes from someone who typically provides information on a certain topic to someone who organizes the environment and provides opportunities for students to create meaning through active and
relevant experiences (Brooks & Brooks, 1999). According to the *National Science Education Standards* (NRC, 1996), teachers should provide a learning environment where students interact and voice their ideas, as well as express and choose their individual approaches, and where students’ ideas are acknowledged and are incorporated into the problem-solving process. Brooks and Brooks listed the characteristics of constructivist teachers.

1. Constructivist teachers encourage and accept student autonomy and initiative.

2. Constructivist teachers use raw data and primary sources, along with manipulative, interactive, and physical materials.

3. When framing tasks, constructivist teachers use cognitive terminology such as classify, analyze, predict, and create.

4. Constructivist teachers allow student responses to drive lessons, shift instructional strategies, and alter content.

5. Constructivist teachers encourage students to engage in dialogue, both with the teacher and with one another.

6. Constructivist teachers encourage student inquiry by asking thoughtful, open-ended questions and encouraging students to ask questions of each other.

7. Constructivist teachers engage students in experiences that might engender contradictions to their initial hypotheses and then encourage discussion.

8. Constructivist teachers provide time for students to construct relationships and create metaphors.

9. Constructivist teachers nurture students’ natural curiosity through frequent use of the learning cycle model. (pp.103-118)

As Ritchie and Cook (1994) indicated, a change to constructivist teaching and learning involves much more than the application of a new method or recipe. It requires a change in beliefs about knowledge and student and teacher roles in the teaching and learning process. Since the teacher is a critical component in the teaching and learning
process, identifying teacher beliefs and practice is necessary to implement the tenets of the constructivist reform movement in the science classroom.

Teacher Beliefs and Classroom Practice

There has been a growing body of research on the definition of teachers’ beliefs and knowledge, and their influences on teachers’ classroom practice (Calderhead, 1996; Fang, 1996; Kagan, 1992; Nespor, 1987; Pajares, 1992; Richardson, 1996; Woolfolk-Hoy & Murphy, 2001). Although there is little agreement on the definition of beliefs, an understanding of this term is crucial in order to identify the relationship between beliefs and actions. Frank Pajares in his article entitled *Teachers’ Beliefs and Educational Research: Cleaning Up a Messy Construct*, discussed various definitions of beliefs which were articulated among the educators, and highlighted the confusion and the lack of an agreed upon definition.

As Pajares (1992) pointed out, beliefs are often disguised behind a variety of aliases, including attitudes, values, judgments, opinions, ideology, perceptions, conceptions, conceptual systems, dispositions, implicit theories, explicit theories, internal mental processes, action strategies, rules of practice, and perspectives. However, according to Pajares, the confusion focuses on the distinction between beliefs and knowledge.

**Definitions of Beliefs**

The term “beliefs” has been defined in the literature in a variety of different ways. Abelson (1979) defined beliefs in terms of people manipulating knowledge for a particular purpose or under a necessary circumstance. According to Brown and Cooney (1982), beliefs are dispositions to action and major determinants of behavior. Rokeach
(1972) defined beliefs as “any simple proposition, conscious or unconscious, inferred from what a person says or does, capable of being preceded by the phrase ‘I believe that’” (p. 113). Rokeach discussed three kinds of beliefs: descriptive or existential beliefs, evaluative beliefs, and prescriptive or exhortatory beliefs. In descriptive beliefs, the object of belief is described as true or false, correct or incorrect (e.g., I believe that the sun rises in the east). In evaluative beliefs, beliefs can be stated as good or bad (e.g., I believe this ice cream is good). In prescriptive or exhortatory beliefs, a certain action or a situation is advocated as desirable or undesirable (e.g., I believe it is desirable that children should obey their parents).

Rokeach (1972) suggested that all beliefs have three components: a cognitive component, an affective component, and a behavioral component. A cognitive component represents a person’s knowledge about what is true or false, desirable, or undesirable. An affective component of the belief is capable of arousing affect of varying intensity centering on the object of the belief, taking a positive or negative position in an argument. A behavioral component of the belief leads to action when it is activated. According to Rokeach, the nature of belief is somewhat similar to the structure of an atom in terms of the ways in which beliefs are organized. Rokeach claims that some of the beliefs (core beliefs) are more central, more connected to others (peripheral), and more resistant to change.

Moreover, Ackerman (1972) examined beliefs in four different categories as behavioral beliefs, unconscious beliefs, conscious beliefs, and rational beliefs. Behavioral beliefs are not distinguished simply because of the fixed behavioral patterns that anyone holding a certain belief will exhibit. Unconscious beliefs are rather long-standing beliefs
that can influence behavior over a long period of time, but resist recognition by the agent. Unlike behavioral beliefs, unconscious beliefs cannot be interpreted from behaviors. Behavioral beliefs, by contrast, will be thought of as non-conscious rather than unconscious. Behavioral beliefs are important in human action where the agent encounters no difficulty so that his beliefs do not require scrutiny at the consciousness level. Conscious beliefs are any beliefs a person has explicitly formulated and is aware of. Rational beliefs are defined as a philosophical idealization of actual belief structures.

Based upon a literature review on beliefs, Pajares (1992) defined belief as an “individual’s judgment of the truth or falsity of a proposition, a judgment that can only be inferred from a collective understanding of what human beings say, intend, and do” (p. 316). According to Richardson (1996), anthropologists, social psychologists, and philosophers have agreed upon a common accepted definition of beliefs that “beliefs are thought of as psychologically held understandings, premises, or propositions about the world that are felt to be true” (p.103). In educational settings, Haney et al. (2003) defined beliefs as “one’s convictions, philosophy, tenets, or opinions about teaching and learning” (p. 367).

**Definitions of Knowledge**

The definition of knowledge as a term can be traced back to the time of Socrates. Plato suggested that knowledge has three components: beliefs, truth, and justification (Woolfolk-Hoy & Murphy, 2001). In the traditional philosophical literature, knowledge depends on a “truth condition” that is being agreed upon in a community of people (Richardson, 1996). Based upon this definition, knowledge is a belief that meets two conditions: (a) the truth of what is believed and (b) the justification someone has for
believing it (Woolfolk-Hoy & Murphy). Alexander, Schallert, and Hare stated that beliefs are a category of knowledge and define knowledge as “encompasses all that a person knows or believes to be true, whether or not it is verified as true in some sort of objective or external way (as cited in Woolfolk-Hoy & Murphy, p. 146).

In educational settings, there have been different kinds of teacher knowledge. Subject knowledge, craft knowledge, and personal practical knowledge are some of the most common types of teacher’s knowledge debated in the teacher education literature. As Shulman (1986) suggested, teachers’ subject knowledge consists of three categories: subject matter content knowledge, pedagogical content knowledge, and curricular knowledge. Subject matter content knowledge refers not only to the facts of the discipline but also to how the facts are organized in the discipline and tested as acceptable and valid (Calderhead, 1996; Munby Russell, & Martin, 2001; Shulman). Pedagogical content knowledge refers to the knowledge that enables particular content to be taught (Calderhead; Shulman). Curricular knowledge refers to the programs designed for teaching particular subjects and the materials, ideas, and issues related to these programs (Shulman). Craft knowledge has been used to define “the knowledge that teachers acquire within their own classroom practice, the knowledge that enables them to employ strategies, tactics and routines that they do” (Calderhead, p. 717). According to Calderhead, craft knowledge is strongly shaped by teachers’ past experiences and personalities and personal practical knowledge of how teachers view teaching.

**Distinctions Between Beliefs and Knowledge**

Although the definitions for knowledge and beliefs have been widely debated, these terms have been used interchangeably in the literature. As Pajares (1992) stated, the
problem is associated with the difficulty of finding the border where knowledge ends and beliefs begin. A number of scholars have made the distinction between knowledge and beliefs. According to Calderhead (1996), beliefs generally refer to “suppositions, commitments, and ideologies while knowledge refers to factual propositions and the understandings that inform skillful action” (p. 715). Richardson (1996) distinguished knowledge from beliefs based on the notion of “truth condition.” In her definition, knowledge must satisfy “truth condition” or have some evidence but beliefs do not require a truth condition. Ernest (1989) proposed a distinction between knowledge and beliefs by identifying a case in which two teachers may have similar knowledge but one can teach mathematics with a problem-solving orientation, while the other has a more didactic approach because of different beliefs they hold.

Nespor (1987) suggested that four features of beliefs: (a) existential presumption, (b) alterativity, (c) affective and evaluative loading, and (d) episodic structure can be used to distinguish knowledge from beliefs. First, Pajares (1992) defined existential presumptions as “the incontrovertible, personal truths everyone holds” (p. 309). They are deeply personal and formed by chance, an experience, or an event. For example, a teacher may have beliefs about student “ability,” “maturity,” or laziness” which are labels for entities about the students rather than descriptive terms. Second, beliefs sometimes refer to “alternative worlds” or “alternative realities” which are different from reality (Nespor; Pajares). Third, belief systems depend on affective and evaluative components more than knowledge systems. Nespor suggested that feelings, moods, and subjective evaluation based on personal preferences may significantly influence one’s belief system. Unlike knowledge systems, belief systems do not require general consensus regarding the
validity and acceptability of beliefs. Individual beliefs do not even require internal consistency in the belief system. Finally, Nespor differentiated these two terms based on episodic structure. A knowledge system is stored in semantic networks whereas belief systems consist of episodically-stored material influenced by personal experiences or cultural and institutional sources.

Pajares (1992) synthesized the findings of research on beliefs in the literature as follows:

1. Beliefs are formed early and tend to be self-perpetuated, tend to be persistent against the contradiction caused by time, experience, reason, and schooling.

2. Epistemological beliefs play a key role in knowledge interpretation and cognitive monitoring.

3. Belief substructures, such as educational beliefs, must be understood in terms of their connections not only to each other but also to other, perhaps more central, beliefs in the system.

4. By their nature and origin, some beliefs are more incontrovertible than others.

5. The earlier a belief is incorporated into the belief structure, the more difficult it is to change.

6. Belief change during adulthood is a relatively rare phenomenon.

7. People’s beliefs strongly affect their behavior.

8. Beliefs cannot be directly observed or measured but must be inferred from what people say, intend, and do.

9. Beliefs about teaching are well established by the time a student attends college. (pp. 324-326)

Research on Teacher Beliefs and Practice

Many scholars consider teachers as important agents of change in implementing any reform movement (Bybee, 1993; Cuban, 1990; Prawat, 1992; Tobin et al., 1994). In the literature, the role of teacher beliefs about classroom practice is well documented
(Bandura, 1986; Nespor, 1987; Pajares, 1992). Therefore, a growing body of research studies has focused on the identification of the relationship between teacher beliefs and classroom practice in regard to a broad variety of issues: (a) Constructivism (Beck, Czerniak, & Lumpe, 2000; Haney et al., 2003; Haney & McArthur, 2002); (b) Curriculum (Cronin-Jones, 1991); (c) Goals of science education (Mcintosh & Zeidler, 1988); (d) Inquiry (Luft, 2001; Wallace & Kang, 2004); (e) Nature of science (Gess-Newsome & Lederman, 1995; Hashweh, 1996; Lederman, 1999; Lederman & Zeidler, 1987); (f) Reform strands (Haney et al., 1996; Roehrig & Kruse, 2005); (g) Science, Technology, and Society, (Lumpe, Haney, Czerniak, 1998); (h) Teaching and learning (Hancock & Gallard, 2004; Haney, Lumpe, Czerniak, & Egan, 2002; Laplante, 1997; Levitt, 2002; Lumpe, Haney, & Czerniak, 2000; Mellado, 1998; Porlan & del Pozo, 2004); and (i) Thematic units (Czernaik, Lumpe, & Haney, 1999). Although some studies (Cronin-Jones; Haney & McArthur; Haney et al., 1996, 2002; Hashweh; Levitt) found that teacher beliefs are consistent with classroom practice, others found that teacher beliefs do not necessarily influence classroom practice (Hancock & Gallard, 2004; Lederman; Lederman & Zeidler; Mellado). Although the relationship between teacher beliefs and practice is controversial; regardless, beliefs ultimately connect to teaching practice (Richardson, 1996; Roehrig & Luft, 2004).

Hashweh (1996) conducted a study with 35 Palestinian science teachers in order to identify the relationship between their epistemological beliefs and classroom practices. Data obtained through the use of a three-part questionnaire consisted of critical incidents, direct questions about teacher strategies for conceptual change, and ratings of the use and importance of specific teaching strategies. The author characterized teachers as learning
constructivists, learning empiricists, knowledge constructivists, and/or knowledge empiricists. Learning constructivist teachers emphasized the active role of the learner in constructing knowledge to understand the world and acknowledged that learning science is a conceptual change process. In contrast, learning empiricists emphasized the role of external reinforcement in learning and were not aware of the existence of alternative conceptions. Knowledge constructivist teachers believed that the aim of science was to develop theories to understand the world, testing theories against experience was more important than their origins, scientific knowledge was tentative. In contrast, knowledge empiricists believed that the aim of science was to collect facts about the world, scientific knowledge was objective, permanent, and discovered. He found that differences in epistemological beliefs influenced classroom teaching. According to the findings of his study, teachers holding learning constructivist and knowledge constructivist beliefs are more likely to detect student alternative conceptions, have a richer repertoire of teaching strategies, use potentially more effective teaching strategies for inducing student conceptual change, and report more frequent use of effective teaching strategies compared with teachers having empiricist beliefs.

Haney and McArthur (2002) constructed case studies for four prospective science teachers in order to identify teacher constructivist beliefs and classroom practices. Participants were purposively selected as a result of their scores on the Classroom Learning Environment Survey ([CLES] Taylor, et al., 1994). The CLES instrument has five subcategories that were viewed as critical to the formation of a constructivist classroom environment: (a) Personal Relevance, (b) Scientific Uncertainty, (c) Critical Voice, (d) Shared Control, and (e) Student Negotiation. Other data sources came from
classroom assignments, semi-structured interviews conducted after observations, and classroom observations. However, each participant was only observed teaching a self-selected constructivist lesson.

In their study, Haney and McArthur (2002) analyzed teacher beliefs as either core beliefs or peripheral beliefs. Core beliefs are defined as those beliefs that are both stated and enacted while peripheral beliefs are defined as constructivist beliefs that are stated, but are not enacted. The study showed that teachers’ core beliefs (constructivist, conflict, and emerging) were stable and resistant to change. Teachers’ beliefs regarding Personal Relevance, Scientific Uncertainty, and Student Negotiation were constructivist core beliefs that were consistent with their practices. However, Shared Control was a peripheral belief for three teachers who stated that they would like to implement it but they found it both difficult and frustrating to incorporate. The authors suggested that the belief in the need to cover the existing local science curriculum was evident as an obstacle for all participants.

Beck et al. (2000) conducted a study consisting of 203 teachers having different backgrounds, teaching experiences, and race. The purpose of the study was to identify the factors influencing K-12 science teachers’ implementation of constructivism in their classrooms. The authors used an open-ended questionnaire and the Classroom Learning Environment Survey (Taylor et al. 1994) as instruments. In general, the teachers possessed positive attitudes about teaching for Personal Relevance, but teachers with Bachelor’s and Master’s degrees had a more positive attitude toward teaching for Personal Relevance than teachers with Doctoral degrees. Middle level teachers expressed their intent to teach for Personal Relevance more than primary teachers. Significant
differences were found between teachers’ intent to implement and their gender. Female teachers were more likely to implement the targeted behavior than male teachers for both Critical Voice and Student Negotiation. Middle level teachers were the most likely to implement Student Negotiation while primary teachers had the most positive attitude about teaching for Student Negotiation. Generally, the teachers believed that teaching for Personal Relevance, Scientific Uncertainty, Critical Voice, Shared Control, and Student Negotiation in the classroom can motivate students, help students understand the limitations and imperfections in science, that science changes over time, and involve students in their own learning. On the other hand, they also indicated that they were concerned with the amount of time it takes, student misuse of Critical Voice, the immaturity and inexperience of students in the use of Shared Control, and classroom management problems.

Haney et al. (1996) identified teacher beliefs and intentions regarding the implementation of science education reform strands. Data was obtained through structured interviews and questionnaires. Four questionnaires related to the reform strands of inquiry, knowledge, conditions, and applications were developed by the authors from the structured interviews conducted using a sample of 13 teachers representing a diverse population. The questionnaires were mailed to 800 teachers, randomly selected from a listing of all Ohio public schools. Multiple regression and analysis of variance techniques were used for statistical analyses. Results indicated that teacher beliefs were significant predictors of behavioral intentions to implement all four strands of reform. Findings indicated that women were more likely to intend to implement reforms strands than were men. The primary teachers held more favorable
beliefs toward the implementation of science education reform strands than did the middle-level or high school teachers. Teacher familiarity was another component that influenced teacher intentions. Teachers in this study did not believe that they had the ability to bring about educational change. They believed that barriers such as lack of effective staff development opportunities, available resources, and administrative support impeded their ability to implement educational reform.

Cronin-Jones (1991) conducted two case studies of middle grades teachers implementing a constructivist-based curriculum. Data was collected from a total of 93 sets of field notes for both teachers, three formal interviews, and more than 20 informal interviews. In both cases, four major belief categories appeared to influence curriculum implementation. These beliefs are beliefs about how students learn, a teacher’s role in the classroom, the ability levels of students in a particular age group, and the relative importance of content topics. Both teachers believed that the most important student outcome is factual knowledge, that middle-grade students learn through repeated drill and practice, and that middle school students require a great deal of direction. Even though some components of both teachers’ belief structures enhanced the success of curriculum implementation, overall their existing belief structures were inconsistent with the philosophy of the intended curriculum, thus impeding successful implementation.

In his study, Dharmadasa (2000) analyzed the views of 6 third-grade teachers in six elementary schools in a Southeastern state prior to a proposed implementation of a constructivist curriculum. Prior to the implementation of constructivism, data from interviews indicated that teachers viewed a constructivist approach to teaching as a challenge and a concept that is difficult to grasp in a short time period. Two of the
teachers agreed to implement a constructivist curriculum designed by the investigator. In this curriculum, physical knowledge teaching and learning materials and a series of activities were developed for six areas: push, pull, hit, balance, swing, and balance for children to experiment and problem solve. After implementing the constructivist approach, the two teachers were supportive of the curriculum but were not confident about providing appropriate materials, promoting experimentation, and initiating children’s construction of knowledge. The teachers who implemented the constructivist curriculum stated that the greatest challenge for them was to ask probing questions to promote students’ thinking to higher levels and to maintain classroom management at the same time. This study indicated that teachers who hold certain deep beliefs about teaching and learning are unlikely to change dramatically.

Levitt (2002) conducted a study in order to identify the beliefs of elementary teachers regarding the teaching and learning of science and the extent to which the teachers’ beliefs were consistent with constructivism, underlying science education reform. Sixteen teachers from two school districts involved in a local systemic project for science education reform participated in the study. Although data was collected via semi-structured interviews and classroom observations, each teacher was only observed teaching a single lesson from the program.

Levitt (2002) analyzed teacher beliefs associated with the recommendations for the teaching and learning of science as described in the *National Science Education Standards* (NRC, 1996). She categorized teacher beliefs into three groups: traditional, transitional, and transformational. Traditional beliefs are the least consistent with the recommendations of science education reform. Although teachers who express traditional
beliefs may exhibit elements of recommended practices, in general, the belief statements and practices of the teachers in this category greatly differ from the recommendations for teaching science. Transitional beliefs are those expressed beliefs that are moving toward the recommendations for reform. Teachers in this category seem to embrace aspects of the philosophy of reform yet inconsistencies between their belief statements and actions exist, or stated constraints inhibit implementation and adoption of reform beliefs. Classroom practices for this group of teachers also are beginning to align with reform, but the teacher still exhibits some traditional beliefs and/or practices. Teachers espousing transformational beliefs are those whose belief statements and classroom practices demonstrate the closest alignment with the recommendations for science education reform as well as consistency between espoused beliefs and classroom practices.

According to the findings of the study (Levitt, 2002), five patterns of teacher responses supported the characterization of teacher beliefs that teaching and learning should be student centered. First, the teachers expressed belief in engaging students in hands-on activities. Second, teachers expressed belief in students as active participants in learning science. They described the role of students as a worker, an experimenter, an investigator, a gatherer of information, an observer, a discoverer, and a helper. Third, teachers expressed the belief that the learning of science should be personally meaningful to students. Fourth, teachers expressed belief that science education should foster positive attitudes toward science. Fifth, teachers expressed belief that the role of the teacher changes to accommodate a focus on the students.

Levitt (2002) also concluded that although gaps still exist between the teacher beliefs and the principles of reform, the implication of teacher beliefs is that the teachers
are moving in a direction consistent with science education reform. The author described teacher beliefs as incomplete when compared to the philosophy of teaching and learning underlying science education reform. On the other hand, the findings of the study could not give in-depth information regarding teacher classroom practices due to few classroom observation hours.

A more recent study was done by Roehrig and Kruse (2005) in order to understand the impact of a reform-based chemistry curriculum, *Living By Chemistry* (*LBC*), on teachers’ classroom practices and to identify the effects of teacher beliefs and knowledge on their implementation of the curriculum. Twelve high school chemistry teachers participated in the study. Qualitative and quantitative data were collected through interviews and classroom observations from the field test of the curriculum prior to full implementation. The interview protocol was adapted from the Teachers’ Pedagogical Philosophy Interview developed by Richardson & Simmons. Participant responses were categorized as traditional, instructive, transitional, responsive, or reform-based and then given a numerical value from 1 (traditional) to 5 (reform-based) in order to do statistical analyses. In addition, each teacher was observed teaching non-LBC lessons at least twice prior to the field test of LBC and observed weekly, totaling four to seven observations per teacher. The observations were coded using a modified Reformed Teaching Observation Protocol ([RTOP] Sawada, Piburn, Judson, Turley, Falconer, Benford, & Bloom, as cited in Roehrig & Kruse). The findings of the study revealed that teachers’ classroom practices became more reform-based as a result of the presence of the new curriculum. This study is also consistent with the idea that teaching beliefs have a significant influence on classroom practices. Experienced, out-of-discipline teachers
with transitional or student-centered teaching beliefs exhibited the most growth in reform-based teaching practices. Although the study offered insightful information related to teacher beliefs and practices in implementation of the reform-based curriculum, it lacks evidence related to teacher content knowledge since teacher content knowledge was not directly measured in the study.

Unlike studies previously discussed, there have been some studies that suggest that there may be an inconsistency between teacher beliefs and classroom practices. Mellado (1998) conducted a study with 4 student teachers in Spain to investigate the relationship between pre-service teacher conceptions of science teaching and learning and their classroom practices. The data gathering procedures included a questionnaire and interviews, both analyzed by means of cognitive maps and classroom observations during the participants’ practice teaching. Each participant was observed teaching the same subject for one or two classroom sessions. The authors could not find any clear relationship between the teachers’ conceptions about teaching and learning of science and their classroom practices. The finding of the study revealed that although participants had received training, they were incapable of transferring much of the knowledge of science teaching which they had acquired into the classrooms. The authors believe that the reason could be due to the fact that the knowledge the teachers received concerning science education was theoretical, impersonal, and static with little relationship to the practical knowledge needed in the classroom.

Similarly, Hancock and Gallard (2004) conducted a study with 16 pre-service teachers in an undergraduate science education methods course that involved observation and teaching experiences in K-12 classrooms in order to understand the impact of field
experiences on the beliefs developed by pre-service science teachers. Data was gathered through drawings representing beliefs and in-depth interviews with 5 participants selected by the authors depending on complexity of their beliefs. The findings of the study revealed that field experiences both reinforce and challenge the beliefs held by pre-service teachers.

One of the studies that showed an inconsistency between teacher beliefs and classroom practices was done by Simmons et al. (1999) as a part of the Salish I Research Project. Nine university research sites selected 10 beginning teachers who were graduates of the participating university. A total of 116 beginning teachers participated in the study. Data were collected from responses to the Teacher’s Pedagogical Philosophy Interview developed by Richardson & Simmons; classroom observation protocol, Secondary Teacher Analysis Matrix developed by Gallagher & Parker; and the Constructivist Learning Environment Survey developed by Taylor et al. The authors categorized teacher beliefs as student-centered beliefs or teacher-centered beliefs. Teachers with student-centered beliefs place the responsibility for acquiring and processing scientific knowledge on the student; in other words, students actively construct their own knowledge. In contrast, teachers who have teacher-centered beliefs consider it to be the teacher’s responsibility to organize scientific knowledge for students. Although many beginning teachers hold student-centered beliefs, only 10% of first-year teachers implemented student-centered, inquiry-based instruction.

In addition, identifying the beliefs of the school community as well as those of teachers is important for successfully implementing reform in schools. Haney et al. (2003) focused on a constructivist learning environment not only from the teacher’s
perspective but also from that of the administrator, parent, community member, and student. Seventy-two participants of a year-long Eisenhower-funded project were purposively selected for this study. The participants represented school community groups: 35 teachers, 9 administrators, 18 parents/community members, and 10 students. The Beliefs About Learning Environments (BALE) Instrument developed by Varrella and Burry-Stock was used as a theoretical model for constructivist belief identification and comparison. The BALE consists of a single open-ended statement for participants to complete: “My perception of the relationship between students and teachers in the learning environment is ...” Responses were rated using the BALE rubric, which consists of a 1 to 5 point system with 5 representing the highest constructivist response, and then they were analyzed by a multivariate analysis of variance. The findings of this study indicated that even though both administrators and teachers significantly held more positive beliefs than did the parent/community members, constructivist teaching ideas did not dominate their beliefs regarding successful teaching. Constructivist beliefs especially related to curriculum, use of instructional strategies, and assessment techniques seemed to be lacking. Administrators reported significantly higher constructivist beliefs than did the parents/community members or students regarding the “teaching for understanding” construct including teacher as facilitator, student preconceptions and relevance, higher order thinking skills, demonstration of understanding, and construction of student conceptual understanding. This finding is somewhat contradictory to the findings of previous studies (Haney et al. 1996) that teachers do not have administrative support while trying to implement constructivist reform. One reason for this discrepancy could be the administrators in this study were involved in science professional development
projects. This study reveals that the beliefs of the school community might be another factor that may affect teacher classroom practices.

Tobin and McRobbie (1996) investigated the enacted science curriculum and factors that impede reforms in secondary science classes. In their study, data was collected from a chemistry teacher and his eleventh-grade students using the Classroom Environment Survey developed by Tobin, classroom observations, and interviews. The authors identified four cultural myths that were supported by both the teacher and students including the transmission of knowledge, being efficient, maintaining the rigor of the curriculum, and preparing students to be successful on examinations. The transmission myth views the teacher as a transmitter of knowledge and students as receivers of knowledge. The efficiency myth expresses the beliefs that teachers have control of students and covering content is more important than student learning. The myth of rigor includes the beliefs that the teacher’s role is to identify the content to be learned and decide what tasks are appropriate for students. Tests and examinations are focused on in the enacted curriculum and result in an emphasis on low cognitive-level types of engagement by students. The authors discussed that these beliefs are obstacles to the reform of science education and should be addressed to facilitate the implementation of reform in science classrooms.

In their study, Tobin and Gallagher (1987) investigated academic work in high school science classrooms in order to develop an understanding of the forces which mould the implemented curriculum. The researcher believed that higher cognitive-level outcomes were an important goal for a high school science curriculum and that students learned by constructing their own knowledge as a result of active engagement in learning
tasks. Fifteen science teachers from two co-educational high schools in Australia participated in the study. The data collection process included classrooms observations and interviews with students and teachers that occurred in three phases. In the first phase, 9 teachers from a private school were observed by two observers for a period of 6 weeks. For the initial 3 weeks, five grade-8 classes were observed by two observers for 8 to 12 lessons during a physical science topic while additional observations were conducted for 3 weeks in grade-9 general science classes and in grade-11 elective studies in chemistry, physics, physical science, biology, and human biology. In the second phase, the study consisted of observations of 6 volunteer teachers from a public school. Unlike the first part, the observations in the public school were focused on a specific teacher rather than a selected grade level. In the last phase, formal interviews with all 15 teachers and 86 students were conducted. But, no students were interviewed from the public school. Overall, the authors described the activities using four major categories: whole-class interactive, whole-class non-interactive, individual student work, and small group work. Whole-class interactive activities that included teachers presenting content in a lecture mode but with frequent questions being asked of students to increase their engagement were the most predominant type and occurred in most classes for more than 50% of the time allocated to science. Whole-class non-interactive activities, including introduction to a new topic or summary of the topic at the end of the unit, were used less than 20% of the total instructional time. Individual seatwork activities were also common and tended to have low cognitive demand and occurred near the end of each period. Small group activities occurred most often when students worked in teams to collect data in the laboratory. The authors summarized the results regarding academic work. The assessment
system, teacher expectations for student performance and achievement, and the need to cover the curriculum in the prescribed time significantly affected the implemented curriculum. Algorithms and procedures were used to reduce the cognitive demands of the work. The cognitive demands of the work were low. Students were concerned with getting the work done, obtaining correct responses, and getting good grades.

Based upon Tobin and Gallagher’s study (1987) previously discussed, Tobin and Fraser (1989) investigated the implemented and perceived curriculum in two grade-10 science classes at a school in which the main goal was to learn in a hands-on and minds-on manner in Southside High, Australia. Two science teachers teaching at the tenth grade were selected as above average as a result of a nomination process and volunteered to participate in the study. Data were collected through classroom observations, interviews with teachers and students, working with students during class time, student notebooks and test papers, and the surveys including the Individualized Classroom Environment Questionnaire developed by Fraser and the Classroom Environment Scale developed by Moos & Trickett for measuring student perceptions of the classroom environment. A total of 20 lessons were observed by one of the researcher teams. The authors found that both teachers conceptualized their roles in terms of metaphors which influenced the way in which they taught. Teacher beliefs had a major impact on the way in which the curriculum was implemented. Teacher knowledge limitation caused an emphasis on students learning facts and completing exercises in workbooks rather than learning science with understanding. The learning environment perceived by students was related to teacher knowledge and beliefs. Teacher expectations of and attitudes toward individuals were reflected in student perceptions of the learning environment.
Roehrig and Luft (2004) investigated the constraints that beginning secondary science teachers experienced in the implementation of inquiry-based lessons while they participated in a science-focused induction program, Alternative Support for Induction Science Teachers (ASIST), developed by university educators in order to foster inquiry-based environments in secondary science classrooms. During the study, the 14 teachers who participated in ASIST were in their first, second, or third years of teaching secondary science. Data were collected via multiple sources including demographic information, open-ended and semi-structured interviews about teaching beliefs, monthly classroom observations, and a nature of science questionnaire. Teacher beliefs were captured using an open-ended interview at the beginning and end of the school year. The interview protocol used included questions from the Teacher’s Pedagogical Philosophy Interview [TPPI] developed by Richardson and Simmons. Participants’ responses to each question from the TPPI were categorized as didactic, transitional, conceptual, early constructivist, experienced constructivist, or constructivist inquiry beliefs. Didactic and transitional responses represent teacher-centered beliefs, while early constructivist, experienced constructivist, or constructivist inquiry responses represent student-centered beliefs. Each teacher was observed at least seven times during the school year by project staff. The authors categorized three broad groupings that emerged to represent the experiences, knowledge, beliefs, and practices of these teachers: inquiry teachers, process-oriented teachers, and traditional teachers. According to these results, four teachers were described as inquiry teachers as they implemented inquiry in their classrooms. Two of the teachers believed that science class consisted predominantly of
activities and laboratories for students to learn science process skills. Eight teachers fell into the traditional group.

The results showed that none of the factors including teachers’ content knowledge, views on the nature of science, teaching beliefs, and pedagogical knowledge in isolation were found to be predictive of the implementation of inquiry-based instruction. Strong content knowledge combined with student-centered beliefs and a contemporary view of the nature of science increased the possibility that inquiry would be implemented in the classroom. Other constraints to implementing inquiry instruction became evident as the beginning science teachers were observed and interviewed during post conferences. The most prevalent self-reported constraint among the beginning teachers was low student ability and motivation. Another constraint reported in this study was the management risk of science as inquiry.

Summary

The first part of the literature review summarizes the similarities and differences between traditional and constructivist views of teaching and learning. Based on this comparison, a fundamental principle of constructivist teaching and learning is that constructivist teaching and learning is student-centered. Constructivist teaching and learning is student-centered. Therefore, students’ prior knowledge, interest, and motivation should be recognized. In addition, constructivist teaching and learning offers an opportunity for students to be active learners, questioners, and explorers and take responsibility for their own learning. Relevancy to students’ daily experiences, authentic assessment during the instruction, student inquiry, and social interaction are encouraged in constructivist classrooms. Finally, teachers have a different role than that in traditional
teaching and learning; rather than transmitting knowledge, teachers should act as guides
to help students understand science.

The second part of the literature focuses on studies related to teacher beliefs and
classroom practice. The relationship between teacher beliefs and classroom practice has
been widely discussed. While some studies (Beck et al., 2000; Cronin-Jones, 1991;
Levitt, 2002; Roehrig, & Kruse, 2005) found that teacher beliefs have a significant
relationship with classroom practice, others (Mellado, 1998; Simmons et al., 1999) did
not find a clear relationship between teacher beliefs and practice. Although there has been
more research related to student teachers and beginning teachers, research with in-service
teachers in classroom settings seem to be relatively sparse. In addition, most of the
research with in-service science teachers collected self-reported data through surveys
regarding their classroom practice (Beck et al., Haney et al., Hashweh) without classroom
observations. The current study intends to fill this gap by combining survey information
with classroom observations.

Moreover, other factors affecting teacher beliefs and classroom practices are well
documented in the literature. Cultural myths including the transmission of knowledge,
being efficient, maintaining the rigor of the curriculum, and preparing students to be
successful on examinations (Tobin & McRobbie, 1996), existing curriculum (Haney &
McArthur, 2002), lack of administrative support (Haney et al., 1996), school community
including parents and students (Haney et al. 2003), teacher content knowledge (Roehrig
& Luft, 2004), teacher education programs (Mellado, 1998), teacher’s epistemological
beliefs (Hashweh, 1996; Roehrig & Luft), and teacher’s beliefs about student ability
(Cronin-Jones, 1991; Roehrig & Luft) are some of the factors that play a significant role in teacher classroom practice.
CHAPTER 3

METHODOLOGY

The purpose of this study was to obtain an in-depth understanding of science teacher beliefs and classroom practice related to constructivist teaching and learning, and factors that may affect their teaching strategies. The researcher purposively selected four science teachers in a Midwestern urban school system to participate in this study.

Qualitative research methodology was employed in order to identify science teacher beliefs and classroom practice related to constructivist teaching and learning, and other factors that may affect their classroom practice. Qualitative research involves an interpretive, naturalistic approach to the world. Qualitative researchers study things in their natural settings, attempting to make sense of, or to interpret, phenomena in terms of the meanings people bring to them (Denzin & Lincoln, 2000). Merriam (1998) defined qualitative research as “an umbrella concept covering several forms of inquiry that help us understand and explain the meaning of social phenomena with as little disruption of the natural setting as possible” (p. 5). In education, five types of qualitative research are commonly used: (a) the basic or generic qualitative study, (b) ethnography, (c) phenomenology, (d) grounded theory, and (e) case study.
In the current study, there are two reasons why a case study design seems to be more appropriate than any other research methods in order to gain a deeper understanding of teacher beliefs and practice related to constructivist teaching and learning. First, a case study has distinct advantages for answering “how” and “why” questions (Yin, 1989). Second, a case study is particularly appropriate if the researcher is interested in process rather than outcome (Merriam, 1998).

Case study has been defined by several authors. According to Yin (2003), a case study is “an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident” (p. 13). Merriam (1998) defined a qualitative case study as an intensive description and analysis of a single instance, phenomenon, or social unit. Case study is an “in-depth exploration of a bounded system such as an activity, event, process, or individuals based on extensive data collection” (Creswell, 2005 p. 439). Berg (2004) stated that case study methods involve systematically gathering enough information about a particular person, social setting, event, or group to allow the researcher to effectively understand how the subjects operate.

Although the definitions of case study are slightly varied, all focus on a detailed examination of one setting, or a single subject, a single depository of documents, or one particular event (Bogdan & Biklen, 1998). The main purpose of a case study is to gain an in-depth understanding of the situation and meaning for those involved (Merriam, 1998). According to Merriam, depending on the overall intent of the study, there are three types of case studies: (a) descriptive, (b) interpretive, and (c) evaluative. A descriptive study in education focuses on a detailed account of the phenomenon under study. An interpretive
case study contains rich, thick description. Evaluative case studies involve description, explanation, and judgment. This study is interpretative since the purpose of the study is to obtain a deeper understanding of science teacher beliefs and classroom practice related to constructivist teaching and learning.

Case studies can be categorized either as a single case study or multiple case studies. Multiple case studies, when a researcher conducts a study using more than one case, can be identified as collective case studies, cross-case studies, multicase or multisite studies, or comparative case studies (Merriam, 1998). As the current study includes more than one case, it is a multiple, cross-case study.

Participants

In this study, 4 science teachers in different school settings selected based upon the following criteria: (a) willingness to participate, (b) two science teachers from public high schools, (c) two science teachers from private middle schools, and (d) approval by the school system. Both genders were also expected to be represented in this sample. The teachers were contacted by telephone and in person. Pseudonyms were chosen for each participant to ensure confidentiality. Kathy and Mike volunteered to participate in the study. Both were teaching in a public high school. John and Patrick who were working in a private middle school also agreed to participate in the study. Table 3.1 represents the participants’ demographic characteristics. First, the researcher conducted her research with Kathy and Mike. Upon completion of data collection at the public high school, the researcher conducted her research with Patrick and John at the private middle school setting.
<table>
<thead>
<tr>
<th>Participant’s Name</th>
<th>Age</th>
<th>School</th>
<th>Subjects</th>
<th>Grade</th>
<th>Undergraduate Degree</th>
<th>Major (BSc)</th>
<th>Master’s Degree</th>
<th>Teaching Exp</th>
<th>Mostly Taught in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kathy</td>
<td>32</td>
<td>Public High</td>
<td>Environmental Science</td>
<td>10-12</td>
<td>Miami University College of Education</td>
<td>Biology, Biological Science</td>
<td>M.A. student in Science Education at The Ohio State University</td>
<td>9</td>
<td>Urban</td>
</tr>
<tr>
<td>Mike</td>
<td>36</td>
<td>Public High</td>
<td>Physics</td>
<td>10-12</td>
<td>University of Dayton Arts &amp; Science</td>
<td>Biology</td>
<td>M.A., The Ohio State University 2000</td>
<td>9</td>
<td>Urban</td>
</tr>
<tr>
<td>Patrick</td>
<td>38</td>
<td>Private Middle</td>
<td>General Science</td>
<td>6</td>
<td>Ottenberg College U.S. Air Force Clinical Laboratory Technical School</td>
<td>Middle School Math &amp; Science</td>
<td>--</td>
<td>4</td>
<td>Suburban</td>
</tr>
<tr>
<td>John</td>
<td>60</td>
<td>Private Middle</td>
<td>General Science</td>
<td>8</td>
<td>University Of Wittenberg Arts &amp; Science</td>
<td>Biology Major &amp; Chemistry Minor</td>
<td>M.Ed. Wright State University Elementary Administration 1971</td>
<td>13 years teaching and 26 years administrative experience</td>
<td>Rural, Suburban, Urban</td>
</tr>
</tbody>
</table>

Table 3.1: Demographic characteristics of participants.
School Context

*The Public High School*

The school in which two participants of the study, Kathy and Mike, worked was a public high school that opened in 1976. At the onset of the study, there were 824 students attending this school, 52% male and 48% female. It had a very diverse student population representing over 25 nations. Forty-six percent of the student population was White, 43% Black, 4% Hispanic, and 13% of the students required special education. Roughly 46% of the students in this school received free or reduced lunch and 18% of them came from other countries. Thirty-two percent of the students were in the ninth grade, 27% in tenth grade, 22% in eleventh grade, and 19% in twelfth grade. The school had a large library that provided students with a place to study, check out materials, and use computers. The library also had 38 computers to use that could be reserved by teachers for a specific classroom period. There were a total of seven science teachers working in this school. Kathy and Mike volunteered to participate in this study. Each class period was 51 minutes.

*The Private Middle School*

The school in which other two participants of the study, Patrick and John, worked was a private, co-educational, independent Pre K-12 school. It was founded in 1982 as the first independent day school in the central area of the state. The school has earned a position as one of the most highly respected and distinguished independent schools in the region. The school opened with 132 students and 14 faculty.

At the onset of the study, the private school had 619 students and 82 teachers, a few of whom were part-time. The student population represented the cultural, economic,
racial, and ethnic diversity found in this region. The tuition varied by grade level from $7,700 to $15,800 for the 2005-2006 academic year.

The school had an unusual time schedule. Each day on the schedule was identified by different letters A, B, C, D, E, and F, in order to provide each class at the same grade level with an equal amount of classroom hours. The regular class time was 42 minutes but the class time sometimes changed depending on the school schedule. For example, on advisory days, the class time was 37 minutes. In January, every Friday was a ski day and all students participated so there was no class on those days. However, in February, there were no ski days so the classrooms were observed five times a week.

Data Collection Methods

There were four major sources of data for this study including surveys, semi-structured interviews, classroom observations, and documents. The process of data collection took 4 months.

Survey

The first major means of collecting data was through the Constructivist Learning Environment Survey ([CLES] Taylor et al., 1994). The original version of the CLES was designed in 1991 by Taylor and Fraser (as cited in Taylor, Fraser, & Fisher, 1997). The revised versions of the CLES (Taylor, Dawson, & Fraser, 1995; Taylor et al. 1997; Taylor et al., 1994) were developed based on the first version (Taylor & Fraser, as cited in Taylor et al., 1997) with additions related to key dimensions of a critical constructivist learning environment. In the current study, the CLES used consists of two forms: the Preferred and the Perceived (see Appendices B and C). The first form “preferred” of the CLES measures teacher perceptions of the classroom environment ideally liked or
preferred. The second form “perceived” of the CLES measures teacher perceived classroom practice (Taylor et al., 1995). Both forms of the CLES, preferred and perceived, have five components: Personal Relevance/Learning About the World, Scientific Uncertainty/Learning About Science, Critical Voice/Learning to Speak Out, Shared Control/Learning to Learn, and Student Negotiation/Learning to Communicate. The Personal Relevancy scale is concerned with teacher perceptions of the relevancy of school science to their students’ out-of-school lives. The Scientific Uncertainty scale is concerned with teacher viewpoints on the nature of scientific knowledge. The Critical Voice scale measures teacher assessments of student perceptions of the extent to which they are able to exercise a critical voice about the quality of their learning activities. The Shared Control scale is concerned with teacher perceptions of sharing control of the classroom learning environment with students in relation to the design and management of learning activities, determining and applying assessment criteria, and negotiating social norms in the classroom. The Student Negotiation scale measures teacher beliefs concerning student perceptions of the extent to which they interact verbally with other students for the purpose of building their scientific knowledge within classrooms (Taylor et al. 1995). The survey was distributed in person to each participant during classroom observations and collected after a week. The demographic questionnaire was distributed to identify teacher demographic characteristics such as age, subjects and grade levels that they were teaching, undergraduate and master’s degrees, majors, teaching experiences and school contexts where they had teaching experience (see Appendix D) and collected after a week with the CLES.
Interviews

An interview can be defined as a conversation with a purpose (Dexter, as cited in Lincoln & Guba, 1985). Lincoln and Guba categorized interviews by their degree of structure, either structured or unstructured. In the structured interview, the questions are developed by the interviewer and the responses rest with the respondent. In the unstructured interview, both questions and answers are provided by the interviewee. An unstructured interview is sometimes called a guided conversation (Bogdan & Biklen, 1998). In this case, the researcher encourages the interviewee to talk about specific areas of interest and probes more deeply on the issues the interviewee initiates (Bogdan & Biklen). The semi-structured interview is in the middle of the spectrum between the structured and unstructured interviews. In this case, the interviews may still remain open-ended and assume a conversational manner. Yet, the researcher follows a set of questions derived from the case study protocol (Yin, 2003).

In the current study, a semi-structured interview was employed with each participant. Two different sets of interview questions were developed and used by the researcher. Some of the interview questions were adapted from the Teacher’s Pedagogical Philosophy Interview ([TPPI] Richardson & Simmons, as cited in Simmons et al. 1999). The first set of interview questions dealt with general teaching and learning, including curriculum, instruction, and assessment (see Appendix E). The second set of interview questions specifically addressed constructivist teaching and learning in science education (see Appendix F). Additional questions based on the interviewee’s responses were asked spontaneously during the interview. Table 3.2 displays the interview time
schedule for each participant. The interview schedules were made based on the availability of each participant.

<table>
<thead>
<tr>
<th></th>
<th>Date for Interview 1</th>
<th>Date for Interview 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kathy</td>
<td>12/10/2005</td>
<td>02/10/2006</td>
</tr>
<tr>
<td>Mike</td>
<td>01/09/2006</td>
<td>02/10/2006</td>
</tr>
<tr>
<td>Patrick</td>
<td>02/02/2006</td>
<td>02/24/2006</td>
</tr>
<tr>
<td>John</td>
<td>02/14/2006</td>
<td>02/21/2006</td>
</tr>
</tbody>
</table>

Table 3.2: Interview schedule for each participant.

Interviews mostly were conducted in the teacher’s lounge or in another place more appropriate for the interviewee such as an empty room available at that time. The interview session took approximately 30-45 minutes. A digital voice recorder was used during the interview sessions. After all of the interviews were conducted, the researcher had the interviews transcribed. Then, the researcher listened to all audiotapes to ensure the accuracy in the interview transcripts.

Classroom Observations

The third major means of collecting data was through classroom observations. A major advantage of direct observation is that it provides here-and-now experience in depth (Lincoln & Guba, 1985). During the classroom observations, the researcher took field notes. Field notes can be defined as “the written account of what the researcher hears, sees, experiences, and thinks in the course of collecting and reflecting on the data in a qualitative study” (Bogdan & Biklen, 1998, p. 108). The role of the researcher during observation can be changed from completely participant to completely observer.
A participant observer is an observational role adopted by researchers when they participate in activities in the setting they observe. On the other hand, a non-participant observer is an observer who visits a site and records notes without becoming involved in the activities of the participants (Creswell, 2005). The role of the researcher in the current study was that of a non-participant observer. Therefore, the researcher did not participate in activities in the classrooms. The researcher observed classrooms of each participant five times a week for 7 weeks. A “Classroom Observation Chart” (see Appendix G) was developed by the researcher in order to keep a record of each observation. The Classroom Observation Chart included the observation time and date, the teacher code, the school code, the description of the classroom, the number of students for each classroom period, and researcher comments. Additionally, the “Classroom Observation Report Chart” adapted from the Mathematics and Science Classroom Observation Profile System ([M-SCOPS] Stuessy, Parrott, & Foster 2003; see Appendix H) was used during classroom observations in order to take more consistent and accurate field notes during each visit. The Classroom Observation Report Chart included general information for the classroom observations such as the teacher code, the school code, the subject, the lesson, the grade level, the date, the time, and the description of learning goals. The Classroom Observation Chart also included specific information such as the beginning and the ending time of each activity; the student and the teacher’s behaviors during the activity; the content that was taught for that time period; teaching strategies such as lectures, group works, questioning, discussion, hands-on activities, etc; and researcher comments.
Documents

Documents are another source of data. Lincoln and Guba (1985) listed several reasons for using documents: a stable source of information, always available, and a rich source of information. In the current study, lesson plans, handouts/worksheets, and assignments delivered to students in classes were collected in order to triangulate with other sources of data. The researcher did not collect and analyze any documents and records related to student work and grades. All documents used in the normal course of teaching such as worksheets, textbooks, laboratory activities, and homework assignments were analyzed by the researcher.

Data Management

One of the requirements of a good analysis is efficient management of the data (Dey, 1993). Data management is essential especially for qualitative researchers since the data generated by qualitative methods are voluminous (Miles & Huberman, 1994; Patton, 1990). Merriam (1998) suggests three options for organizing data. The first option is to organize data by hand. The second option is to use a computer software program designed for qualitative research. The third option is a mix of manual and computer management. The data for this study were organized by a mix of manual and software program methods. All data sources were organized for analysis in a number of ways. First, the interviews were transcribed and listened to several times in order to ensure accuracy. All interview transcripts were entered into a software program, NVivo (QSR International, 2002). Second, classroom observations were organized based on the amount of time spent for each activity and entered into an Excel file to create figures. Descriptive observation notes were entered into NVivo. Third, classroom documents
were organized depending on the content for each case. Fourth, the CLES results were entered into an Excel file to create figures. Data corpus including interview transcripts, classroom observation reports, surveys, and classroom documents were put in a color-coding folder for each case and a case study data base was created as suggested by Yin (2003). Each participant had a pseudonym name and also a color-coding. In the same way, a different folder for each participant was created to keep electronic backup copies of the data on the computer.

Data Analysis

Data analysis is the process of bringing order, structure, and meaning to the mass of collected data (Marshall & Rossman, 1995). There are several ways to approach the analysis of qualitative data. The inductive analysis approach was used to evaluate the data. An inductive analysis involves discovering patterns, themes, and categories in one’s data (Patton, 2002). More simply, Lincoln and Guba (1985) define inductive data analysis as “a process for making sense of field data” (p. 202). The constant comparative method is one way to conduct an inductive analysis of qualitative data (Lincoln & Guba). The constant comparative method of analyzing qualitative data combines inductive category coding with a simultaneously comparison of all units of meaning obtained (Glaser & Strauss, as cited in Maykut & Morehouse, 1994). As each new unit of meaning is selected for analysis, it is compared to other categories. If it does not fit with any other category, then a new category is created. Merriam (1998) stated several important guidelines in the formation of data categories in qualitative research:

- Categories should reflect the purpose of the research.
- Categories should be exhaustive. All relevant data should fit into a category.
• Categories should be “mutually exclusive.” A particular unit of data should fit into only one category.

• Categories should be sensitizing. The naming of the category should be as sensitive as possible to what is in the data.

• Categories should be “conceptually congruent.” This means that the same level of abstraction should characterize all categories at the same level. (pp. 183-184)

In addition to general guidelines for analyzing qualitative data, there are also some specific strategies for analyzing case studies. In case study analysis, all the information including interview transcripts, field notes, and documents about the case should be brought together (Merriam, 1998). This data base is sometimes called a case study data base (Yin, 2003) or a case record (Patton, 2002). This case record includes all the major information that was used to conduct the case analysis. In a multiple case study, there are two stages of analysis including within-case analysis and cross-case analysis. For the within-case analysis, each case is first treated as a comprehensive case in and of itself. For the individual case analyses, reported patterns were based upon a majority (2/3) of observations within the individual case. Once the analysis of each case is completed, cross-case analysis begins (Merriam). For the cross-case analyses, reported patterns were based upon a majority (3/4) of observations across the 4 cases. For both the individual and case-study analyses, frequency was associated with pervasive observations over time. After organizing and reading all data corpus, data analysis was begun with the first case. The NVivo software program was used to code and analyze interview transcripts. From specific cases or quotations, a general pattern was formed within the
case. Once themes and patterns appeared from the data, an analytic outline was built for
the study based on the coding and categorization. Then, the data was interpreted through
analyzing and connecting the codes and categories. Each participant’s beliefs related to
constructivist teaching and learning were categorized based on constructivist categories
related to didactic, transitional, emerging constructivist, progressing constructivist, and
expert constructivist (see Appendix A). Interview transcripts were triangulated with the
self-reported results of the preferred and perceived forms of the Constructivist Learning
Environment Survey in order to answer the first research question.

In order to answer the second research question, classroom observation data and
classroom documents in addition to interview transcripts and the responses on the CLES
were analyzed. Classroom observation data were analyzed in two ways. First, each
teacher’s classroom practice was sorted into constructivist categories: didactic,
transitional, emerging constructivist, progressing constructivist, and expert constructivist.
Field notes taken during classroom observations were analyzed in order to describe the
activities. Second, data from the Classroom Observation Report Charts were analyzed in
terms of the percentage of time spent for each activity. Activities were categorized using
two main classification schemes: The first scheme categorized all activities as teacher-
centered, student-centered, or assessment depending on the nature of the activity. For
example, similar types of activities such as lectures, worksheets, and
videos/demonstrations were categorized as teacher-centered activities since the teacher
had the primary responsibility for presenting the content to the students. Activities like
projects, presentations, hands-on activities, and group discussions were categorized as
student-centered activities since the students had more responsibility for their own
learning and were actively involved in activities. The time spent for quizzes and tests was also calculated as assessment time for each classroom. For the second categorization scheme, all activities were grouped into four subcategories: whole-class, group work, individual student work, or other. Whole-class activities included lectures, worksheets, videos/demonstrations, and hands-on activities directed by the teacher and involving all students. Group work included activities in which students worked together in groups either to discuss ideas or to do activities. Individual student work included activities in which each student was individually assigned to do activities. After these categorizations, all data were entered into an Excel file and figures were created to effectively communicate the patterns. Interview transcripts and classroom observation data were also analyzed to answer the third research question. The same process was used for each participant and the findings were compared.

Ethical Issues

The teachers and school principals were provided with a copy of the dissertation proposal with detailed information about the purpose of the project including a description of the project and its duration, data collection and analysis procedures, and a description of the measures to be taken to protect and ensure confidentiality. The teachers were informed that their participation was voluntary and they were free to withdraw from participation at any time during the study. A recruitment letter and a support letter were given to the principal of the school for his/her signature of consent (see Appendices I and J). Also, a recruitment letter and support letter were given to each of the teachers for their signature of consent (see Appendices K and L). Information presented on audiotapes was only heard by the researcher for the purpose of identifying patterns or themes related
to teaching practice. The teachers and school principals had been informed that the study did not have any risks for the teachers and students, and that the results may help to support teachers as they try to implement constructivist-based reforms as recommended by the *National Science Education Standards* (NRC, 1996).

**Trustworthiness**

Trustworthiness is the term used by Lincoln and Guba (1985) to refer to the believability of a researcher’s findings. The common criteria for trustworthiness are internal validity, external validity or generalizibility, reliability, and objectivity. Validity refers to the “correctness” or “precision” of research findings (Lewis & Ritchie, 2003). Internal validity deals with the question of how research findings are congruent with reality (Merriam, 1998). External validity or generalizability is “referring to whether the findings of a particular study hold up beyond the specific research subjects and the setting involved” (Bogdan & Biklen, 1998, p. 32). In qualitative research, Guba proposed new terms including “credibility” (in place of internal validity), “transferability” (in place of external validity), “dependability” (in place of reliability), and “confirmability” (in place of objectivity) that have a better fit with naturalistic inquiry (as cited in Lincoln & Guba). In a qualitative study, researchers are interested in having consistent findings with the data obtained from the study rather than replication of the findings (Lincoln & Guba; Merriam, 1998).

**Credibility**

In order to establish credibility, some methods suggested in the literature include prolonged engagement and persistent observation, triangulation, peer debriefing, negative
case analysis, and member checking (Lincoln & Guba, 1985; Merriam, 1998). Prolonged engagement and persistent observation were used to establish credibility in the current study. Prolonged engagement is defined as “the investment of sufficient time to achieve certain purposes” (Lincoln & Guba, p. 301). According to Lincoln and Guba, prolonged engagement requires that the researcher be involved with a site sufficiently long to detect distortions that might creep into data and to build trust. The purpose of persistent observation is to identify characteristics in the situation relevant to the research questions. Lincoln and Guba clarified the difference between these terms- prolonged engagement provides scope and persistent observation provides depth. In the current study, each participant’s classes were observed for over 2 months, for a total of 29-30 classroom periods which was assumed to be long enough to build trust and to better understand the classroom context.

Triangulation is another common way to increase credibility. Four kinds of triangulation can contribute to verification and validation of a qualitative analysis.

1. Methods triangulation: Checking out the consistency of findings generated by different data collection methods.
2. Triangulation of sources: Checking out the consistency of different data sources within the same method.
3. Analyst triangulation: Using multiple analysts to review findings.

In the current study, multiple data sources (methods triangulation) including the CLES, interviews, classroom observations, and classroom documents were used in order to
triangulate the findings (triangulation of sources). Peer review and debriefing is another way to establish credibility. The data and findings were shared with an experienced researcher and one Ph.D. student in order to provide different perspectives (analyst triangulation).

Negative-case analysis is another way to increase credibility. Lincoln and Guba defined negative-case analysis as “process of revising hypotheses with hindsight” (p. 309). In the current study, negative cases and unconfirming evidence were found in order to increase credibility.

Member check is the most crucial technique for establishing credibility. Member checking can be defined as “a process in which the researcher asks one or more participants in the study to check the accuracy of the account” (Creswell, 2005, p. 252). In order to establish credibility based on member check, a copy of the interview transcripts were given to each participant in order to ensure that their beliefs and ideas were represented accurately.

Transferability

The establishment of transferability different from the establishment of external validity is impossible (Lincoln & Guba, 1985). According to Lincoln and Guba, qualitative researchers cannot specify the external validity of an inquiry. They can only provide the thick description to enable readers, interested in making a transfer, to reach a conclusion if transfer can be considered. According to Merriam (1998), the purpose of the researcher in qualitative research is “to understand the particular in depth, not to find out what is generally true of the many” (p. 208). In the current study, the setting and the
participants were described with detailed explanation along with comprehensive and multiple quotations in order to help the reader understand the context.

Confirmability and Dependability

The major technique for establishing confirmability is the external audit. In the current study, the process and findings of the study were shared with an experienced researcher in order to examine whether the findings, interpretations, and conclusions were supported by the data.

Researcher Role and Subjectivity

The role of the researcher in qualitative research is important because of being an actual instrument of the study (Merriam, 1998). Gold (as cited in Bogdan & Biklen, 1998) has discussed the spectrum of possible roles for observers to play. At one extreme is the complete observer. The researcher does not participate in activities at the setting. At the other end is complete involvement at the site, with little discernible difference between the observer’s and the subject’s behaviors. The role of the researcher in the current study was complete observer. Researcher subjectivity is one of the important concerns of qualitative research studies. In order to decrease this concern, the researcher should develop awareness of his/her subjectivity and monitor it (Glesne, 1999). In the current study, the researcher tried to monitor her biases and subjectivity by keeping a journal and writing down any biases, beliefs, and experiences.

Researcher Background and Biases

The researcher has a B. S. degree in Chemistry and a M. Ed. degree in Science Education. She earned a bachelor’s degree at Ankara University in Turkey. After completing an undergraduate degree, she started to teach general science in grades 6-8
and chemistry in grades 9-11 in Turkey. After 4 years of her teaching experience, she began her Master’s Program in Science Education at the University of Missouri-Columbia and graduated in 2002. She has been a doctoral student at a large Midwest university since 2002.

At the beginning of her teaching experiences, she mainly possessed traditional teaching and learning beliefs. However, although she was not a strong believer in constructivism and had not received formal instruction related to constructivist teaching and learning, she believed in the importance of hands-on activities and laboratory experiments to improve student learning of science. However, she did not have much opportunity to do laboratory activities in her classroom since the school where she worked did not have a science laboratory, equipment, or a library. Sometimes she did demonstrations by using available resources such as water, sugar, and salt. In addition to the lack of equipment and resources, the large number of students in her classes was another constraint that affected her teaching. Consequently, she was a traditional teacher who primarily lectured with questioning although she realized that lecturing was not a very effective way to increase student motivation and interest. However, she was effective at transmitting a large amount of information to students in order to cover the curriculum. In particular, at the high school level, her teaching strategy was completely focused on student preparation for the Nationwide University Entrance Exam. Students were required to pass this exam in order to continue their education and to select their majors based on their scores on the exam. Therefore, she tried to cover all the information that the students needed for the exam and had them solve numerous problems that would help them to understand the concepts. The exam was the most
influential factor affecting her teaching practice since it was extremely important to her students.

When she was first introduced to constructivist teaching and learning, she was skeptical about the successful implementation of constructivism in schools. However, throughout her master and doctoral study, her beliefs related to teaching and learning significantly changed from traditional to constructivist. Her beliefs related to teaching and learning are mostly consistent with constructivism and she believes that constructivist teaching and learning can provide meaningful learning for students. On the other hand, implementation of constructivist teaching and learning is not an easy process. Teacher beliefs related to constructivist teaching and learning is one of the most influential factors that may affect teacher classroom practice. She thinks that a teacher who holds only traditional teaching and learning beliefs is less likely to effectively implement constructivist teaching and learning in his/her classroom. Although teacher beliefs are one of the key factors to successfully implement constructivist teaching and learning, other factors may affect teacher classroom practice. She believes that one of the important factors could be teacher preparation. Although she did not have an opportunity to use constructivist teaching methods in her classes, she doubt that she would have felt comfortable using them, even if she had a chance, since she had not been prepared to teach in that way.

Teachers should be prepared to develop and organize a constructivist learning environment for students and should be introduced to new teaching methods, materials, and ideas so that they can try to implement them in their classrooms. Workshops and
inductive programs for in-service teachers should be designed to help teachers to adapt to new roles based upon the tenets of constructivism.
The purpose of this study was to identify in-service science teacher beliefs and classroom practice related to constructivist teaching and learning, as well as factors that may have influenced their classroom practice. As described in Chapter 3, four different case studies were developed for science teachers in two different school settings and different grade levels for over 4 months. This chapter presents the description of each case, the analysis, and the findings in order to respond to the following research questions:

1. What are the beliefs that teachers have regarding constructivist teaching and learning?
2. How do teachers embody their beliefs about constructivist teaching in science classrooms? Are these beliefs consistent with their classroom practice?
3. What factors influence teachers’ use of constructivism in their classrooms?

Each case is described individually in detail in terms of classroom context, preferred and perceived teacher beliefs, observed classroom practice, factors that influenced teacher classroom practice, and finally, a summary.
The First Case: Kathy

Kathy was a 32-year old, Caucasian science teacher with 9-years teaching experience. Kathy received her Bachelor’s of Science degree in Biological Science Education and was seeking her Master’s of Arts degree in Science Education at a Midwestern university. Kathy was teaching Environmental Science for grades 9 through 12 and Physical Science for grade 9. She had taught mostly in urban schools. It was her seventh year of teaching in the same school. She had National Board Certification in Adolescent and Young Adult Biology. As a teacher, she was eager to improve her teaching and her student achievement in science and sincerely cared about her students. She was interested in not only student achievement in her class but also in their lives and problems outside of school. She believed that her level of interaction with the students was one of her greatest strengths as a teacher.

Classroom Context

At the time of the study, Kathy had four different Environmental Science classes and one Physical Science class. I observed her Environmental Science class five times a week for over 2 months, for a total of 30 classroom periods. Each classroom period was 51 minutes. The same class session, the third period, with the same students was regularly observed throughout the research in order to follow the activities over time and to develop an in-depth understanding of the classroom context. This classroom session was suggested by Kathy considering my time schedule for observations.

Students who were enrolled in the Environmental Science class were at different grade levels, varying from grades 10 through 12. The student population was diverse in terms of socioeconomic status and ethnic and religious background. One of the apparent
characteristics of the students in this class was the lack of motivation and interest. In addition, there was a significant drop-out rate. The number of students in this class was 31 at the beginning of the academic year and at the time of the observations, it was 19 including 6 girls and 13 boys. However, by the time I interviewed Kathy, during the middle of the academic year, it was down to 13 students. She gave several reasons for student attrition.

Some of the students have been expelled; other students have chosen to leave and finish high school at North Adult which allows them more flexibility in their schedules. Others have chosen to go to the new Virtual High School where they can take their classes using the computer. One was expelled for running at a student with scissors. One was expelled for having drugs on the school grounds. One was expelled for getting in a very violent fight on school grounds and so it is heartbreaking to see there are only 13 that are attending. (Interview 2)

She also stated that their school was dealing with similar problems that were in every other school.

The classroom had two computers, one printer, an LCD projector, an empty fish tank, a board, several visually-stimulating posters on the walls, and five large tables surrounded by chairs. Students usually sat as a group at each table in a U shape according to the plan developed by the teacher. This seating plan seemed to be very flexible for group work. However, since the classroom was very small, it was hard for Kathy to move around tables to check student work. In addition, it was not large enough to do experiments. There were only three sinks on one side of the classroom with a narrow counter. Although there was a window, the classroom was not naturally well lit. The lights were always on during classroom times except for lectures in which she used the overhead projector.
Kathy’s Beliefs Related to Constructivist Teaching and Learning

Kathy’s constructivist beliefs related to teaching and learning were at the expert level. Data from the interviews and the Constructivist Learning Environment Survey revealed that Kathy held expert constructivist beliefs related to teaching and learning. Data from the interviews suggested that Kathy viewed constructivism as “a great equalizer” and believed that “constructivism is a great way for students to learn” (Interview 2). Kathy defined constructivism as “where the students are given the tools to build the knowledge for themselves” and stated that she felt constructivism provided an equal opportunity for all students. She said,

I think that constructivism is a great equalizer. It is a great way for all kids to learn, to have experience, and rebuild the knowledge for themselves and it helps them internalize it in ways that make sense for them. (Interview 2)

On the other hand, Kathy also believed that she could not fully implement constructivism in her classroom. In the first interview, Kathy described her teaching philosophy as “a mixed bag of reality and idealism” in order to express the discrepancy between her beliefs and classroom practice.

As shown in Table 4.1, data from the self-reported results of the two forms of the Constructivist Learning Environment Survey confirmed that Kathy was aware of the differences between her preferred and her perceived classroom practice related to four of the constructivist components: Personal Relevance, Scientific Uncertainty, Shared Control, and Student Negotiation. For all four of these components, her preferred practice scores were greater than her perceived practice scores.
Table 4.1: A comparison of Kathy’s self-reported preferred and perceived classroom practice on the Constructivist Learning Environment Survey.

<table>
<thead>
<tr>
<th></th>
<th>Preferred</th>
<th>Perceived</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Relevance</td>
<td>25</td>
<td>17</td>
</tr>
<tr>
<td>Scientific Uncertainty</td>
<td>20</td>
<td>14</td>
</tr>
<tr>
<td>Critical Voice</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Shared Control</td>
<td>21</td>
<td>15</td>
</tr>
<tr>
<td>Student Negotiation</td>
<td>23</td>
<td>17</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>114</strong></td>
<td><strong>98</strong></td>
</tr>
</tbody>
</table>

Note. PR=Personal Relevance. SU=Scientific Uncertainty. CV=Critical Voice. SC=Shared Control. SN=Student Negotiation.

Figure 4.1: A comparison of Kathy’s self-reported preferred and perceived classroom practice on the Constructivist Learning Environment Survey

As shown in Figure 4.1, the biggest difference between preferred and perceived practice on the CLES was related to Personal Relevance. As the results of the CLES revealed, Kathy was a strong believer in Personal Relevance but she did not believe that she was able to implement this in her practice. Data from the interviews confirmed the
results of the CLES related to Kathy’s strong belief in Personal Relevance. Kathy always tried to connect the content to student experiences outside of school. Kathy stated that she tried “to help them find real-world examples of what they were talking about because once they find real-world examples then it [content] becomes more meaningful to them” (Interview 1). Kathy emphasized several times that her goal for student learning was “to try and find connections between what it is that they’re learning and their daily lives” (Interview 2). Therefore, Kathy always provided local examples rather than simply lecturing about the content. Also, she encouraged students to think about the content and identify their own real-world examples related to what they were learning. In order to achieve this goal, Kathy stated that she tried to use outside resources and materials including case studies, local examples, science articles, and videos.

I’ve been working very hard at trying to find local things particularly … local examples, local case studies that are more relevant to the students and allow them to get, kind of wrap their head around, what it is that we’re talking about. (Interview 2)

Kathy believed that her preferred and perceived classroom practice also were different in terms of the following components of constructivism: Scientific Uncertainty, Shared Control, and Student Negotiation. For each of these components, her preferred beliefs were greater than her perceived classroom practice. With regard to Scientific Uncertainty, data from interviews confirmed that Kathy viewed science as a process and wanted her students to understand science both as a concept and a process. Kathy defined science as “process where …we try to find the patterns, explanations, or things that are going on in our world” (Interview 1).
Shared Control was another component of the CLES for which her preferred classroom practice was greater than her perceived classroom practice. Kathy wrote the curriculum for this Environmental Science course for her school district. Kathy planned her instruction based on national and state standards and her personal expectations in terms of what content she thought was useful for students. Kathy indicated her goals for student learning were as follows:

For all students, to gain an awareness and understanding of what it is that they’re supposed to know - based on national standards, state standards, and my own personal expectations. (Interview 2)

Kathy strongly felt the need to cover the curriculum as much as she could and indicated that she wished she had the time to move on to the next concept only when her students completely understood the current concept. But she stated that she could not do this due to the fact that she had limited time. Kathy said that she tried to “… find the best way to help our students understand the large volume of content that they are expected to know, understand …” by searching for a variety of resources (Interview 1).

Student Negotiation was another constructivist component for which the responses on the CLES revealed that Kathy’s preferred practice was greater than her perceived classroom practice. For Kathy, students should be able to form opinions based on content they learned and apply it to different situations. Kathy explained her view by giving the following example.

For example, if we discuss water pollution, and they read a newspaper article 6 months later about water pollution, can they understand the article? Do they know what it’s talking about? Could they have a discussion with someone about it and have some insights as to what is that they’re talking about. (Interview 2)
Kathy indicated that she wanted her students to share and discuss their ideas with their peers.

Critical Voice was the only constructivist component for which Kathy believed that she could translate a strong belief into her classroom practice; her preferred beliefs were equal to her perceived classroom practice. According to the CLES, Kathy indicated that it was acceptable for students to ask the question “Why do I have to learn this?” They could question the way she was teaching, complain about activities that were confusing or prevented them from learning, and express their opinions.

*Kathy’s Observed Classroom Practice*

Kathy’s observed classroom practice demonstrated the characteristics of an emerging constructivist, a mix of traditional and constructivist teaching and learning. Kathy’s self-reported responses of preferred and perceived classroom practice on the CLES were re-examined in light of the observed practice data. Table 4.2 shows the similarities and differences between Kathy’s perceived classroom practice and observed classroom practice.

<table>
<thead>
<tr>
<th></th>
<th>Preferred</th>
<th>Perceived</th>
<th>Observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Relevance</td>
<td>25</td>
<td>17</td>
<td>19</td>
</tr>
<tr>
<td>Scientific Uncertainty</td>
<td>20</td>
<td>14</td>
<td>10</td>
</tr>
<tr>
<td>Critical Voice</td>
<td>25</td>
<td>25</td>
<td>23</td>
</tr>
<tr>
<td>Shared Control</td>
<td>21</td>
<td>15</td>
<td>8</td>
</tr>
<tr>
<td>Student Negotiation</td>
<td>23</td>
<td>17</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>114</td>
<td>98</td>
<td>70</td>
</tr>
</tbody>
</table>

Table 4.2: A comparison of Kathy’s preferred, perceived, and observed classroom practice on the Constructivist Learning Environment Survey.
As shown in Table 4.2, Kathy’s observed classroom practice was less than her perceived practice in terms of four components of the CLES: Scientific Uncertainty, Critical Voice, Shared Control, and Student Negotiation. The biggest differences between Kathy’s perceived classroom practice and observed classroom practice were for Shared Control and Student Negotiation.

According to data from the classroom observations, Shared Control was the least implemented component in Kathy’s classroom. Kathy wrote the curriculum for this Environmental Science course for her school district. She followed the curriculum and decided what to teach, how to teach, and how to assess student learning. Students did not have much responsibility for deciding the content, activities or the assessments.

For Student Negotiation, Kathy’s observed classroom practice was less than her preferred classroom practice. Most of the time, Kathy was not able to implement Student Negotiation in her classroom. As seen in Table 4.3, Kathy spent most of the time in whole-class activities (55%) in which the teacher-student interaction was more dominant than the student-student interaction. Moreover, Kathy allocated 28% of classroom time to individual student work such as seat work in which students responded to prompt questions posed by Kathy at the beginning of each class, studied case studies in the textbook, identified meanings for vocabulary words, or worked on individual projects.

Kathy also had difficulty implementing the constructivist component of Scientific Uncertainty. Sometimes Kathy planned and implemented modeling activities in which students could experience science as a process. For example, Kathy used a modeling hands-on activity entitled “Estimating Wild Animal Populations” in which students used
beans as animals and then calculated their estimated populations (Classroom Observation, December 06, 2005). However, the historical and cultural aspects of science were not observed in Kathy’s classroom.

<table>
<thead>
<tr>
<th>Instructional Activities</th>
<th>Number of Minutes</th>
<th>Time (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole-Class</td>
<td>837</td>
<td>55</td>
</tr>
<tr>
<td>Group Work</td>
<td>145</td>
<td>9</td>
</tr>
<tr>
<td>Individual Student Work</td>
<td>424</td>
<td>28</td>
</tr>
<tr>
<td>Other</td>
<td>124</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>1530</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 4.3: Kathy’s instructional activities in terms of the amount of time spent.

Figure 4.2: Kathy’s instructional activities in terms of the amount of time spent.

According to Figure 4.2, in comparison to whole-class activities, Kathy allocated approximately half as much class time for group work activities which provide an
opportunity to stimulate student negotiation. The following vignette is a good example of small group discussions in which student negotiation was encouraged in Kathy’s classroom.

Kathy distributed copies of various science articles from the Internet (http://evolution.berkeley.edu) related to the human impact on evolution such as using an antibiotic on chickens and pigs, discovery of “superweed,” and the avian flu. She divided the class into five groups consisting of three or four students in each group. Students in each group read different articles. She highlighted that they needed to read carefully and try to understand the article so that they could have an in-depth discussion. While reading the article, she wanted them to think about the following questions: Do you think it is a problem? If so, how do we change it? Are we influencing evolution? After students read the articles, Kathy had them discuss their articles with the other students in their group. However, just a couple of students expressed their opinions and mostly students did not want to participate in discussions.

Critical Voice and Personal Relevance were the constructivist components that showed relatively small differences between Kathy’s perceived and observed classroom practice. Critical Voice was encouraged in Kathy’s classroom, although her preferred score was slightly greater than her observed score on the CLES. Data from classroom observations suggested that Kathy always encouraged students to ask questions about anything confusing and/or difficult for them to understand related to the content, activities, or assessments. She cared about her students and talked to them to in order to understand how their problems and their lives outside of school might affect their learning.
Personal Relevance was the only component for which Kathy’s observed classroom practice score was greater that her perceived classroom practice. Data from classroom observations confirmed data from the interviews that Kathy tried to implement Personal Relevance in her classroom as much as possible. Several times during the classroom observations, Kathy used a lot of outside resources such as Internet articles and videos/computer animations in order to provide real-life examples of the concept that she was teaching. For example, when she was teaching about invasive species, Kathy gave local examples such as Honeysuckle around the school that students probably saw everyday (Classroom Observation, January 13, 2006). Kathy used the local example of Highbanks Woods on the Columbus map to show how humans had the ability to change their environment through population growth (Classroom Observation, November 15, 2005). Another time, Kathy gave a local example of how fire changes the environment by showing changes in the map of the city (Classroom Observation, November 21, 2005). However, Kathy could not always give examples directly related to student experiences. Kathy sometimes used real-world examples even though students did not directly experience them in their lives. For example, she used a video related to using inadequate treatment for TB in Russian prisons to show how the misuse of antibiotics can affect the evolution of disease-causing bacteria (Classroom Observation, November 17, 2005). Another time, Kathy distributed an article related to the avian (bird) flu in order to have students discuss it (Classroom Observation, November 18, 2005). All of these examples did not seem enough for Kathy since she seemed to want to give more examples from student lives to make student learning more meaningful and more relevant.
Data from classroom observations suggested that Kathy used a variety of instructional strategies in order to enhance student learning and a variety of assessment methods to identify what students know and can do. Table 4.4 shows the amount of the classroom time spent on activities in Kathy’s classroom.

<table>
<thead>
<tr>
<th>Classroom Activities</th>
<th>Number of Minutes</th>
<th>Time (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher-Centered</td>
<td>909</td>
<td>59</td>
</tr>
<tr>
<td>Student-Centered</td>
<td>497</td>
<td>33</td>
</tr>
<tr>
<td>Assessment</td>
<td>124</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>1530</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 4.4: Percentage of time spent in teacher-centered, student-centered, and assessment activities in Kathy’s classroom.

![Figure 4.3: Percentage of time spent in teacher-centered, student-centered, and assessment activities in Kathy’s classroom](image)

Figure 4.3: Percentage of time spent in teacher-centered, student-centered, and assessment activities in Kathy’s classroom.
As shown in Table 4.4, 59% of class time was devoted to teacher-centered activities while student-centered activities occurred for 33% of classroom time. Kathy spent 8% of classroom time in assessment activities such as quizzes and tests. According to Figure 4.3, there appears to be a considerable difference between the percentage of time spent in teacher-centered activities and student-centered activities in Kathy’s classroom.

According to data from the classroom observations, Kathy spent 59% of classroom time in teacher-centered activities such as lectures with questioning and discussion, individual seat work, and videos/demonstrations. Based on classroom observations, lecture with questioning and discussion was one of the most frequent teacher-centered activities observed in Kathy’s classroom. During the lectures, Kathy frequently used an LCD projector in order to show students the main ideas, questions, and other representations such as tables, graphs, and diagrams from the textbook. During these sessions, Kathy always turned off the lights in order to increase student visibility of projections. Rather than lecturing on the content alone, Kathy asked many questions in order to encourage student discussion and provide opportunities for students to express their opinions about the content. Kathy prepared written outlines for students in order to help them quickly take notes and hopefully increase their participation during the class. Kathy always encouraged students to identify their own real-world examples related to what they were discussing. For example, in the first interview, Kathy said,

I have printed out good enough outlines of the notes … almost just fill in the blanks, so they are spending the time listening and then I put little mini questions in between meant to create a list for discussion … to help them find real-world examples of what we are talking about. (Interview 1)
The following vignette from the November 14, 2005 Classroom Observation describes Kathy’s typical classroom lecture.

Kathy started to review the concepts taught the previous week, including survival of the fittest, evolution, and natural selection. She asked questions in order to have students think about and reflect on the concepts. The questions were on the board: “What does survival of the fittest mean?” “How does it relate to evolution?” Kathy reviewed evolution and natural selection. Kathy was speaking and asking questions while students were listening to her, but few of the students responded to Kathy’s questions. Kathy asked the question “How do humans influence evolution?” She used the LCD projector and listed six factors: habitat destruction, extinction, global warming, medication/antibiotics, genetic engineering, and pesticides. The first three factors were provided by the students. The others were listed by the teacher. Then, Kathy asked students to find an example for each factor. Kathy gave 4 minutes to each pair of students to find examples for each factor. A few students suggested a couple of examples, but others did not appear to find examples. So, Kathy gave most of the examples since students did not give any more examples. Then, Kathy instructed the students to open their textbooks and read the definition of pesticides. Kathy distributed a handout about pesticides and projected a copy for students to see. Kathy asked students to respond to the first four questions but with little student response, she gave the responses for each question. Then, Kathy continued on to the next six questions. Students searched for responses to these questions in the textbook. Again, Kathy ended up giving the responses for questions 5 through 10. Then, Kathy said “Do your best on the next three to four questions.”
As can be seen from the vignette previously discussed, Kathy and the textbook were the main resources for the science content. Several times, Kathy had students individually read the information from the textbooks. Kathy also sometimes used other resources including articles from the Internet or videos related to the content she was teaching.

Another teacher-centered activity observed in Kathy’s classroom was individual seat work. Almost every day, Kathy allocated 5-15 minutes of classroom time for students to work individually on prompt questions, case studies, worksheets, or vocabulary words. For example, at the beginning of each classroom session, Kathy posed prompt questions or assigned case studies in order to promote student thinking and discussion of opinions related to the particular issue they were studying (See Table 4.5.) Students responded in writing to the prompt questions and turned in their work at the end of the class. Kathy graded student work and gave them to the students the next day.
Questions

What does survival of the fittest mean and how does it relate to evolution?
How are humans influencing evolution?
Explain what co-evolution is. Provide your own example.
Over 1000 years, a pond becomes a forest. Is this primary/secondary [succession]?
Explain.
What kinds of things affect the size of a population?
What are the challenges that sea turtles face during their lifetime?
What does carrying capacity mean? Give an example of a natural and an human effect on it.
How are populations regulated? (at least 2 ways)
What is competition? If it is a negative-negative relationship, why is it so common in nature?
What patterns did you see in the issues between the biomes (by type and in general)?
How might you (scientists) measure the biodiversity of an ecosystem?
How do humans cause extinctions?

Table 4.5: Examples of Kathy’s prompt questions.

Kathy gave special attention to the use of visual representations in her teacher-centered activities and tried to show videos, computer animations, or pictures in order to facilitate student learning. The following excerpts from interviews demonstrate Kathy’s view that visual representations would be helpful for students to better understand abstract concepts.

I think that for all of them seeing, being able to make something tangible to them, so that even if it is just a very slight relationship, being able to see examples of the process that they are talking about is very useful. Experiencing it through a lab is really important. And if you don’t experience it or see it through a lab, seeing some kind of a video or animation or something, because so many concepts are abstract, that being able to actually see it makes a big difference. (Interview 1)

I like to take advantage of the fact that I have the document camera with an LCD projector to show them pictures out of the textbook, out of the newspaper, pictures from web pages, … newspaper articles, and things from here and there. (Interview 2)
Classroom observations confirmed that Kathy tried to bring many visual representations to the class in order to help students understand abstract concepts. For example, when teaching biodiversity, Kathy showed pictures of species taken in her field trip to Costa Rica (Observation Observation, January 10, 2006).

In summary, Kathy spent 59% of class time in teacher-centered activities including lectures with questioning and discussion, seat work, and videos/demonstrations. Although Kathy made a great effort to encourage students to express their ideas, respond to questions, ask questions, and have discussions, during most of the classroom time, students in Kathy’s classroom were passive, sitting and listening to her, watching videos, and responding to class assignments. Therefore, Kathy was very active in talking; explaining; giving examples; and showing videos, pictures, and animations during most of the class time.

As seen in Table 4.4, Kathy spent 33% of classroom time in student-centered activities including hands-on modeling activities, projects, and group discussions. Hands-on modeling activities were among Kathy’s favorite instructional strategies. Kathy believed that students learned science best through hands-on modeling activities in which students can experience the concept.

For environmental science, there are a lot more modeling activities as they are not very tangible, to pick an ecosystem up and stick it down in your classroom … For example, beans where we’re pretending like the beans are real animals and we’re counting how many there are back and forth. And so for this part, … a lot of those activities especially if they are studying a real skill or able to see a real process. (Interview 1)

The following vignette is a good example of a hands-on modeling activity used by Kathy.
Kathy explained that they were going to do a lab activity. She distributed the handout for the lab activity. She asked questions to stimulate student identification of some factors that may affect sea turtles. She had students think about and on their handouts write a list of challenges that sea turtles face during their lifetime. Then, Kathy started reading aloud the text related to background information and instructions for the activity. The students continued to read the remainder of the text silently. Kathy explained the rules of the activity by showing the diagram in the handout on the LCD projection. Kathy warned that the students should follow the rules and not cheat during the game as the previous class did. One student asked how they cheated. She said that they did not follow the rules. Then, they went to the hall downstairs. Kathy divided the students into two large groups: turtles and limiting factors. Limiting factors consisted of two subgroups: (a) on-land predators such as raccoons, dogs, ghost crabs, foxes, gulls, human egg collectors, and shore-line development and (b) in-sea predators such as sharks, killer whales, fishing gear entanglements, plastic litter, and illegal killings by humans. Kathy distributed a bag of beans to the students who were going to be sea turtles. Each turtle started with 50 beans in their bag. Turtles were supposed to hatch, cross the beach, and spend 10 years in open sea before returning to their nesting site to lay eggs. Each bean represented a baby turtle. Kathy distributed index cards to the students that were limiting factors. Limiting factors were instructed to try to tag turtles. Each time a turtle was tagged, they lost 10 beans to the limiting factor. The activity ended when all turtles were either dead or all safely returned to the nesting area. The activity took 15 minutes. All of the students participated in the activity and seemed to enjoy the game. Then they cleaned up and went to the classroom (Classroom Observation,
December 01, 2005 and Classroom Documents). In this modeling activity, Kathy had students act like sea turtles and understand how their lives could be affected by on-land and in-sea predators. This activity was related to the concept of evolution and survival of the fittest of a population.

Kathy believed that this type of modeling activity motivated students but took too much time. Kathy always spent time before this type of activity to prepare students for the activity and after the activity to discuss the activity in terms of what they did and what they learned. She said,

I think that if you don’t spend time … debriefing with the students, talking about what it is that they saw, why it happened, why they choose to do things the way that they did, potential error, how things could have been different, what if you modified this, what if you modified that, and asking them to demonstrate their knowledge in a couple of different ways, explain it to another student, write about it, draw a picture that … well, they’ve had that experience; they’ve not put it into their knowledge base. It hasn’t fully infiltrated down into their consciousness. And so I think one of the big pieces is having the time, not only to actually go through the activity but to follow through and make sure that they really do gain an understanding. (Interview 2)

Classroom observations confirmed that Kathy encouraged students to discuss before and after activities to ensure student learning. For example, after the Sea Turtle Activity previously described, Kathy asked how many turtles died. She asked them to raise their hands if they lost all their beans. Five students raised their hands. She said that five out of nine lost their babies after 5 years. Then she described how this activity was related to the survival of the fittest of the population and the concept of evolution which she taught the previous week. She asked them to answer the four open-ended questions in the handout as an assignment for the next day. The first two questions were knowledge-level questions that students could easily answer. But, the last two questions required
higher-level thinking and personal decision making to increase the successful reproduction and survival of sea turtles (Classroom Observation, December 01, 2005, and Classroom Documents).

Data from classroom observations indicated that Kathy assigned two projects during a period of 2 months: the creation an Invasive Species Brochure Project and the Biome Project. During this period, students were allowed to individually study on the computer in the library to find information for their projects or construct their projects such as brochures or poster presentations. During these projects, Kathy was a facilitator and helped students to find information related to their project.

The Biome Project was an assignment for Christmas break (Classroom Observation, January 04, 2006). However, Kathy allocated several classroom periods to assign biomes based on student preferences and to help students prepare for their projects before the Christmas break. After the Christmas break, Kathy explained more about the Biome Project. She said that it would be fine if most of the resources were websites. She explained the chart and added, “Each square needs to be filled.” She also explained that the students need to find information about latitude, precipitation, and temperature. One student asked to clarify the assignment. Kathy explained that they had two different tasks. The first part was the same general information for everybody, but the second part was specifically their part assigned before the break. She showed the size of poster to the students. Kathy said that the poster must be a “regular” size.

On the next class after Christmas break, Kathy pointed out that students should focus on environmental problems for their Biome Project. They went to the library to complete their project that was due the next day. The students who needed help came to
her and asked their questions. For example, Kathy talked to one of the students and helped him decide what kind of environmental problems he needed to research. Another student asked for help in searching the websites. One student asked how to show the references for the images. She gave her a couple of choices: either put it under the picture or give it a number and refer to it in the bibliography.

All of the students were working on the computer except one student who had already finished the project. Kathy went to the computers to check the students and help them. During preparation for the Biome Project, Kathy was always ready to help students and give them guidance. After completing their projects, students presented their work as a poster presentation. At this time, she gave each student a sheet of a paper so that they could evaluate each others’ projects. After the presentation, she spent a classroom period reviewing the projects and clarifying patterns they found.

As previously discussed, Kathy encouraged students to discuss the content that they were learning in pairs. For Kathy, students should be able to form opinions based on knowledge they learned and apply it to different situations (Interview 2). Classroom observations confirmed that Kathy encouraged students to think critically and discuss their ideas related to the concept that she was teaching.

In conclusion, Kathy spent a total of 33% of classroom time in student-centered activities in which students were engaged in modeling activities or developing and presenting a project showing what they learned. During this time period, Kathy was a facilitator and helped students “construct” their understanding based on experience through activities or discussions.
Kathy used a variety of assessment strategies including student homework, class work, hands-on activities, projects, presentations, tests, and quizzes. Data from classroom observations suggested that Kathy allocated 8% of classroom time for assessment. She gave periodic quizzes for every other section of each chapter and one test for a chapter. She asked various types of questions on the quizzes and tests including multiple-choice, essays, and vocabulary definitions (fill in the blank).

**Factors That Influenced Kathy’s Classroom Practice**

Kathy identified the following factors that influence her classroom practice: student behavior and background, time, state testing, and her own creativity. Kathy had a diverse student population in terms of socioeconomic, ethnic, and religious background. Student misbehavior was frequently seen in Kathy’s classroom. Classroom observation notes showed that most of the students did not pay attention during class and tended to put their heads down on the table. According to Kathy, the students did not have good parenting and lacked basic skills. When student misbehavior occurred, Kathy encouraged them to change their behaviors by talking with them.

Being that they are 16-17-18- years old, I expect that they understand when it is polite, when it is impolite to take care of pencil sharpening, side conversations, and checking for homework with somebody else. I try to trust them that they understand when those things are appropriate, when they are not. And once they are not doing it correctly, I would first try to encourage them to change their behavior or you know have a discussion with them. “Did you know this is kind of rude?” such and such because a lot of times bad habits are modeled at home so it is a way of helping to teach them what is expected in terms of behavior. And I tend to be a lot more forgiving than some people because for me I’d rather have that student in my class than … in the office or suspended not getting anything at all. (Interview 1)

Another characteristic of Kathy’s students was lack of participation and motivation.

Although she encouraged them to participate in discussions, only a few students seemed
eager or even willing to participate. Kathy stated that the reason for this problem was that students did not want to give wrong answers, although there was no correct answer.

They just want a worksheet where they can read something and answer some questions and be done. When they have to process that knowledge and share their personal opinions or share or think about it at the deeper level of what, for example, what might the implications be for a broader society? They tend to be more resistant to that kind of thinking because it involves more risks for them ….. They feel like there’s more of a wrong answer. Well, there’s not necessarily a wrong answer. The wrong answer is not answering it. But they are much more hesitant to develop their thoughts and put them into place and so some of them are more frustrating lessons. (Interview 2)

According to Kathy, students usually did not want to get challenged to think at a higher level and so she has modified her instructional strategies to predominantly use guided-inquiry.

You have to do a lot more guided-inquiry than what you had planned. In terms of inquiry instruction, that’s where the biggest stumbling block is. … They want to know what the answer is. They don’t want to have to think. (Interview 2)

According to Kathy, another reason for the lack of participation was that students may not have enough experience to discuss environmental issues.

The students have got to have some background about what it means to live in different countries around the world because we’re talking about rapid population growth and its impact on the environment. And in order for them to understand what that looks like in other countries, like India or Kenya, they have to understand a little bit about what that culture is and what it means to live in those countries. For them to be able to discuss it, and they have such a limited awareness of what goes on in the rest of the world, then I have to take time to do some social studies and teach them about the country so that they can start to talk about it. And so one of the things I did today was mostly discussion-based. “How would you feel if your family had to dig a hole in the ground outside and that is where you went to the bathroom and it contaminates your water supply?” … It’s so outside of their realm of their experience so it is very difficult for them to picture it and form an opinion about it. And so a lot of what I wanted to do was going to be based on their ideas, their discussions, but they didn’t have many ideas for discussion so you end up in a position where you are talking to them more than they end up doing on their own because they don’t have much experience with this. (Interview 2)
In conclusion, Kathy most frequently identified the following major challenges: student misbehavior, student lack of participation and motivation, and student limited experiences. These challenges influenced her selection of classroom activities in a significant way. For example, Kathy felt the need to explain the content and use the lecture method since students did not entirely participate in the discussions and activities.

Kathy indicated that time was another influential factor that challenged and affected her classroom practice. For Kathy, time was required not only to do the activities but also to prepare and discuss what students learned. According to Classroom Observations, Kathy spent 14% of her classroom time in preparation and reflection activities in order to facilitate student understanding. Kathy believed that hands-on, modeling activities required more classroom time than the lecture and discussion-type activities and were most effective for high-ability students. Kathy stated that it was difficult to implement hands-on, modeling activities in her classroom.

I think that it [constructivism] requires a lot of classroom time that we are very resistant to do due to the large breath of materials that we’re expected to cover. I think that it makes sense to cover things in a more experiential way, true constructivism. In the context of the current classroom in the United States, it’s difficult to make it a reality unless you are dealing with a group of high-level students in a high income area where you don’t need to spend as much time on basic skills. (Interview 2)

State testing was another influential factor that impacted Kathy’s classroom practice.

There is a lot of pressure for state testing and so this year is the first year I started to feel the pressure much more intensely because of the new graduation test … It is a much more difficult test. Any students who do not pass this test will be coming to my class with the expectation that I will go back and teach them what they didn’t learn the first time. And so after this year, my class is very much going to become remedial science going back over. They are going to keep calling it
Environmental Science but it is going to become--here is where you go learn all the stuff you should have learned the last 10 years. (Interview 1)

According to Kathy, her creativity was another challenge that affected her choice of classroom strategies and activities.

There’s a limit to my creativity. I have to actually, you know, a lot of times I will look around, find examples of lessons, activities, things that other teachers have done or that are in another curriculum and then modify them to meet my needs. … One of my biggest limitations is creativity, actually coming up with the idea and having the time to develop it, develop it in a thoughtful way so that it provides quality instruction. (Interview 2)

**Summary of Kathy’s Case**

Data from the preferred form of the CLES and the interviews suggested that Kathy expressed expert constructivist teaching and learning beliefs. However, Kathy also indicated that she had difficulty implementing constructivism in her classroom. Personal Relevance and Critical Voice were the most preferred components in Kathy’s classroom practice while Scientific Uncertainty was the least preferred component in her preferred classroom practice. The only constructivist component for which there was no difference between her preferred and perceived classroom practice was that of Critical Voice, a constructivist component for which Kathy believed that she could translate a strong belief into her perceived classroom practice.

For Kathy, the biggest gap between her preferred and perceived classroom practice was for the constructivist component of Personal Relevance. Her preference for this component was greater than her perceived implementation. Other differences between her preferred and perceived classroom practice were for the constructivist components of Scientific Uncertainty, Shared Control, and Student Negotiation. For these three components, her preference was greater than her perceived implementation.
Classroom observations suggested that Kathy’s classroom practice demonstrated the characteristics of an emerging constructivist, a mix of traditional and constructivist teaching and learning. The biggest gaps between Kathy’s perceived and observed classroom practice were for the constructivist components of Shared Control and Student Negotiation. Shared Control and Student Negotiation were not observed at the same level in Kathy’s classroom compared to what Kathy perceived was happening in her classroom. A similar pattern was observed for Scientific Uncertainty; Kathy’s perceived practice score was greater than her observed classroom practice score. Critical Voice was the most implemented component in Kathy’s observed classroom practice and she perceived this as well as a frequent component in her perceived practice. Interestingly, Personal Relevance was the only constructivist component that was observed more frequently than Kathy perceived as happening in her classroom. Shared Control was the least implemented component in Kathy’s observed classroom practice; again, her perceived score was greater than her observed score.

Kathy used a number of instructional strategies and assessment methods, many of which were traditional in nature. Kathy spent more class time in teacher-centered activities (59%) such as lecture including questioning and discussion, videos/demonstrations, and individual student seat work than in student-centered activities (33%) including student presentations, projects, and group discussions that required active student involvement and student responsibility for their own learning. Assessments including class work, homework, hands-on activities, presentations, projects, quizzes and tests made up 8% of class time. According to Kathy, student
behavior and background, time, state testing, and Kathy’s own creativity were some of the influential factors that affected her classroom practice.

The Second Case: Mike

Mike was a 36-year-old science teacher of Asian descent with 9-years teaching experience. Mike received his Bachelor’s of Science in Biology and Master’s of Arts degree in Science Education from a Midwestern university. Mike was working in the same public high school as Kathy. It was his fifth year in the school. Mike was teaching AP Physics, Physics, and Chemistry classes for grades 10 through 12. Mike received the Presidential Award for Excellence in Mathematics and Science Teaching (PAEMST) administered by the National Science Foundation. Mike believed that his strengths as a teacher were the huge amount of time he spent planning and correcting student mistakes on papers, giving students a second chance, and caring about their problems and lives.

Classroom Context

I observed Mike’s Physics class five times a week for over 2 months, for a total of 29 class hours. Each classroom period was 51 minutes. Using the same observation protocol and the same class session (the fifth period) with the same students, enabled me to regularly observe one Physics class throughout the research in order to have an in-depth understanding of the classroom context. The content of the Physics course included physical quantities, measurement, data interpretation and graphic analysis, force and motion, waves, and electricity. During the observation time, Mike was teaching force and motion and then started teaching waves at the culmination of the classroom observations.

Twelve students including 3 girls and 9 boys in grades 9 through 12 attended this Physics class. The number of the students in this class was much smaller compared to the
number of students in Kathy’s classroom. Therefore, the physical classroom size seemed to be larger even though it was exactly the same classroom as Kathy’s. In this class, students were allowed to sit wherever they wanted. Although it was a small-sized class, student misbehavior was a common characteristic in Mike’s classroom as in Kathy’s classroom. Most of the students did not demonstrate much motivation nor interest in the Physics content.

Mike’s Beliefs Related to Constructivist Teaching and Learning

Mike expressed emerging constructivist beliefs related to teaching and learning. Data from the interviews and the results of the preferred and perceived forms of the CLES revealed that Mike had a mix of traditional and constructivist beliefs related to teaching and learning. Data from interviews revealed that Mike’s understanding of constructivism focused on using a variety of teaching strategies and resources. In his words, Mike explained constructivism as follows:

I think constructivism uses a lot of hands-on project work; using a variety of teaching styles and materials to teach their students, not just one lecture, not just one type. They may be incorporating technology so you want to use a different variety of resources to build the way that you deliver your materials, build the way that you test, and you ask questions; that’s what constructivism is to me. (Interview 2)

Then, Mike added that he used constructivism in his classroom all the time.

I use it all the time. I learned about the theory my first year of teaching. To me, I think it works the best because it’s put together to construct rather than use things all separately. So, you want to use different ways of teaching the materials to build on their knowledge so that they can understand the different ways. (Interview 2)

According to the results of the preferred and perceived forms of the CLES (see Table 4.6), there was not much difference between Mike’s preferred and perceived
classroom practice related to the three components of constructivism: Personal
Relevance, Shared Control, and Student Negotiation. Moreover, there was no difference
between Mike’s preferred and perceived practice for Critical Voice on the CLES (see
Figure 4.4). Mike reported that it was okay for students to ask the question “Why do I
have to learn this?” Also, they could question the way he was teaching, complain about
activities that were confusing and anything that prevented them from learning, and
express their opinions. Mike indicated that students should give feedback to him about
his teaching.

Do you think I am covering enough [content]? If you think I am not covering
enough, then you need to push me. I need feedback from them, too. So, feedback
is very important. (Interview 1)

<table>
<thead>
<tr>
<th></th>
<th>Preferred</th>
<th>Perceived</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Relevance</td>
<td>22</td>
<td>20</td>
</tr>
<tr>
<td>Scientific Uncertainty</td>
<td>20</td>
<td>13</td>
</tr>
<tr>
<td>Critical Voice</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Shared Control</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>Student Negotiation</td>
<td>25</td>
<td>23</td>
</tr>
<tr>
<td>Total</td>
<td>95</td>
<td>81</td>
</tr>
</tbody>
</table>

Table 4.6: A comparison of Mike’s self-reported preferred and perceived classroom
practice on the Constructivist Learning Environment Survey.

As seen in Figure 4.4, the largest difference between Mike’s preferred and
perceived classroom practice was for Scientific Uncertainty. Mike viewed science as a
process of discovering new things, a component that he preferred but he didn’t perceive
as happening in his classroom as much as he wished.
Science to me is the process of discovering, learning new ideas about the things around us, being able to solve problems, being able to predict. And science to me is just being able to write well, read well, using math to learn more about ourselves and about the world. And that is science to me. And when a student learns science and they’re able to discover and invent and do better things. But they do need that basic knowledge to get them started to build on. (Interview 2)

Mike wanted his students to know the fundamental concepts in science and appreciate and like science. Mike stated “I want them to know at least the main concepts taught in physics and chemistry. I want them to appreciate science and want to learn more about science after they had me” (Interview 1).

![Figure 4.4: A comparison of Mike’s self-reported preferred and perceived classroom practice on the Constructivist Learning Environment Survey](image)

*Note. PR=Personal Relevance. SU=Scientific Uncertainty. CV=Critical Voice. SC=Shared Control. SN=Student Negotiation.*

However, Mike believed that inquiry was for high-level students and indicated that he wanted his students to create their own labs if they were high-level students. He said,
If I have really, really great students, I want them to make up their own labs. This is what we are learning today, this is kinetic energy. You need to go and find a lab that describes [the experiment] to me and you need to write that lab, hypothesis, procedures, and test it. That would be the ideal— a group of students that I’d want, more inquiry based, more them putting effort and work than me doing the work for them. (Interview 1)

Mike believed that hands-on laboratory activities helped students learn the concepts and equations better after a lecture on the content, a relatively traditional sequence of instruction.

I like do a lot of labs. I think if you give them a lecture and you do a lab that reinforces what they learned, they can practice more equations, what equations actually mean, use equations, and then perform it. They can understand the calculations more. (Interview 1)

The second biggest difference between Mike’s preferred and perceived classroom was practice on the CLES for Shared Control. As seen in Table 4.6, Shared Control was the least preferred and the least perceived component among the five components of constructivism. According to data from the interviews, Mike focused on the content that students needed to know and felt a strong need to cover the curriculum. For Mike, the content was most important and his role was to help students learn the content that they were expected to know and to develop life-long skills. According to Mike, teaching was

… to educate students so they can have a better knowledge and understanding of what’s required by the state such as be proficient in math, science, history, reading--be proficient in the content so they can use that knowledge to either go to college or use it … have that skill for the rest of their lives to solve problems, to think. (Interview 2)

Based on this expectation, Mike viewed his role as helping students to understand the content. Mike stated,

My role as a teacher is to help students understand the curriculum, the content to be successful at that grade level or above. … They need to know some basic
knowledge to move on and also to make them enjoy science. I think I will make them understand, enjoy science, and appreciate science. (Interview 1)

Mike decided what to teach mainly based on the local curriculum guide and national and state standards. However, Mike also indicated that he adjusted his schedule depending on his perception of the importance of the content and depending on student level. He stated,

A lot of it comes from our curriculum guides. We have national standards that we have to follow so … I can be somewhat flexible in deciding what I feel is important but we need to follow those standards. (Interview 1)

A lot of times, we have to plan according to the curriculum, what we’re supposed to teach each 9 weeks. I follow that and then I also plan it based on what the students know. If I’m moving too fast, I slow down a little bit and review. If they know the stuff, then I can move on. I also plan it based on activities, labs. If this lab goes well with this content, then I’ll use the lab with the lesson. If the project does well with this topic, then I’ll use that. Yeah. I plan it - on a weekly basis. (Interview 2)

Although Mike stated that he considered student level in planning his instruction, he also indicated that the results of tests and quizzes and students’ responses to his questions during instruction were important indicators to assess student learning and to determine when to move on to the next concept. There was little evidence of student input into curriculum or instructional decisions.

I give a lot of quizzes, I ask questions, I grade them. If the majority, 70% of the kids, understand the material, then I move on. I move on and I don’t go back. (Interview 1)

As shown in Figure 4.4, Personal Relevance and Student Negotiation were the components that indicated relatively small differences between Mike’s preferred and perceived classroom practice. Mike’s understanding of Student Negotiation focused on
group work. For Mike, students could learn from each other and also needed each other to do laboratory activities due to the limited equipment and the nature of the activities.

I like them to work in small groups. And, one student has a lot of strengths. They can help someone that may not be as good --push them up-- so I do not have to constantly help everybody at the same time. So, if they can work in groups together, they can learn from each other. If one person gets it wrong, maybe they do not understand my way, the teacher’s way. Maybe the other students will explain better than [my way]. (Interview 1)

I do like group work. They say they learn a lot from each other. Sometimes it is impossible just to do it in a lab by yourself. … You cannot do it by yourself and I do not have enough equipment so you have to share. (Interview 1)

Mike’s Observed Classroom Practice

Mike’s observed classroom practice demonstrated the characteristics of transitional teaching and learning. Mike’s self-reported responses related to preferred and perceived classroom practice on the CLES were re-examined in light of the observed practice data. Table 4.7 shows the similarities and differences among Mike’s preferred classroom practice, perceived classroom practice, and observed classroom practice.

<table>
<thead>
<tr>
<th></th>
<th>Preferred</th>
<th>Perceived</th>
<th>Observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Relevance</td>
<td>22</td>
<td>20</td>
<td>9</td>
</tr>
<tr>
<td>Scientific Uncertainty</td>
<td>20</td>
<td>13</td>
<td>9</td>
</tr>
<tr>
<td>Critical Voice</td>
<td>16</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td>Shared Control</td>
<td>12</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Student Negotiation</td>
<td>25</td>
<td>23</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>95</td>
<td>81</td>
<td>50</td>
</tr>
</tbody>
</table>

Table 4.7: A comparison of Mike’s preferred, perceived, and observed classroom practice on the Constructivist Learning Environment Survey.

As shown in Table 4.7, Mike’s observed classroom practice was different from his perceived practice in terms of all five components of the CLES: Personal Relevance,
Scientific Uncertainty, Critical Voice, Shared Control, and Student Negotiation. The biggest difference between Mike’s perceived and observed classroom practice was for Student Negotiation. Since Mike’s understanding of Student Negotiation was based on group work, he believed that he implemented Student Negotiation more as reflected in his perceived classroom responses. On the other hand, classroom observations could not confirm the data from the interviews and the CLES related to Student Negotiation. Data from classroom observations and classroom documents revealed that group work activities involved students working together during laboratory activities where students had to share the equipment and follow the procedures outlined by the teacher. The laboratory activities were usually very structured hands-on activities in which students were given a procedure to follow in order to get the desired results. Mike usually had students start the activity by having them read the instructions individually, one-by-one, and then he responded to student questions regarding the activity. The following vignettes demonstrate the nature of student group work in laboratory activities in Mike’s classroom.

November 18, 2005 was a laboratory day focusing on centripetal acceleration. Mike had the students individually read aloud the procedures one-by-one to the class. However, many of the students did not appear to be listening and appeared inattentive. For example, one was having his lunch and one was putting his head on the table. Then, Mike demonstrated what they were to do. He had the students work in pairs. Although Mike demonstrated everything that the students were supposed to do, some students still did not know what they should do and asked the researcher what they were going to do.
January 09, 2006 was another laboratory day focusing on power. First, Mike distributed the handouts and one student started reading the text related to the content. Mike explained the relationship between horsepower and watts and between pound and Newtons. Another student read the objectives of the experiment that they were going to do. Then, another student read the procedures. Mike reminded students that they needed to measure in metric. He divided students into groups. Each group consisted of 2 or 3 students and was selected based on student choice. In this laboratory activity, students were supposed to measure the power output of a person by measuring the time it took a person to run up a flight of stairs of known height. Students were supposed to measure the height of one step of the staircase and multiply by the number of steps and record what they found. Then, while one student ran up the stairs as fast as possible, the other student was watching the time. Students recorded the times after repeating the procedure for a couple of trials. At the end of the activity, students were supposed to make a line graph or bar graph to illustrate individual trials and group averages for weight, height of stairs, time and horsepower. After all the instructions were received, the class went to the stairs to do the activity. Mike first demonstrated and ran up the stairs while one student recorded the time. The other students did the same thing and recorded their time. Three of the students in the class already measured the time and were calculating what they found.

From the vignettes previously described, the laboratory activities did not seem to help students learn. However, students usually enjoyed the laboratory activities since they felt free to chat with each other and have fun. There was lack of classroom control so most of the students did not seem to be aware of what they were doing. These activities provided little evidence of Student Negotiation.
Table 4.8: Mike’s instructional activities in terms of the amount of time spent.

Although Mike indicated that he frequently allowed students to work in groups and always during lab activities. Table 4.8 indicates that Mike spent 16% of class time in group work. Further inspection of Table 4.8 reveals that Mike spent 50% of class time in whole-class activities (50%) and 22% of class time in individual student work.

Figure 4.5: Mike’s instructional activities in terms of the amount of time spent

As shown in Figure 4.5, Mike spent more class time in whole-class activities including lectures, whole-class worksheets, and videos/demonstrations. In comparison, he
allocated approximately half as much class time to individual student activities including individual worksheets and projects. Group work was mostly during laboratory activities and observed the least amount of class time.

The second biggest difference between Mike’s perceived and observed classroom practice was seen for the constructivist component of Personal Relevance. Classroom observations could not confirm the data for Mike’s responses from the perceived form of the CLES related to Personal Relevance. The only data that supported Mike’s preferred and perceived belief in Personal Relevance was Mike’s description of a project in which students were allowed to make a flashlight. Mike said,

> After waves, we do electricity, and then they need to make their own flashlight with on and off switches. I only give them five materials but they need to come up with how to build a flashlight to make it work, to make it look like a flashlight. (Interview 1)

Personal Relevance was rarely observed in Mike’s classroom practice. The following vignette demonstrates a typical lesson in Mike’s classroom and confirms the lack of Personal Relevance in his observed practice.

Mike started a new chapter on work and power. Mike put a slide on the overhead projector so that students could see the definitions, formulas, and units for work and power. He explained each concept and started to solve problems by explaining them using overhead slides. (Classroom Observation, December 12, 2005). Table 4.9 illustrates some of the problems used in Mike’s classroom which provide little evidence of Personal Relevancy.
Questions

How much work is done on a vacuum cleaner pulled 7.9m by a force of 180.5N at an angle of 33 degrees above the horizontal?
A girl weighs 565N and runs up a 14.5 flight of stairs that is 30 degrees in 12.6s. What is her power running up the stairs?
An apple fell from a tree and hits Newton on the head. If a 200g apple fell 7.0m before hitting Newton, what was its change in potential energy during the fall?
A ball of mass (x) is flung off a 0.68m high table, and the ball hits the floor with a speed of 6m/s. How fast was the ball moving when it left the table?

Table 4.9: Examples of problems solved in Mike’s classroom.

Another large difference between Mike’s perceived and observed classroom practice was for the constructivist component of Scientific Uncertainty. Data from classroom observations provide little evidence of Mike’s attention to Scientific Uncertainty in his classroom practice. For example, Mike sometimes played videos related to the content or a scientist who was important in a particular field. For example, Mike used a video related to Isaac Newton during the time he was teaching force and motion (Classroom Observation, December 08, 2005).

Mike assigned an individual project in which students were responsible for finding information and preparing a power point presentation related to the lives, discoveries, and inventions of 10 scientists including Avogadro, Bohr, Boyle, Curie, Dalton, Einstein, Faraday, Lavoisier, Newton, and Volta. For the project presentation, a slide for each scientist was to include one to two important discoveries or inventions. Therefore, the power point presentation should have approximately 12 slides with a cover page and a timeline for the last slide. Mike allocated almost half of five classroom
periods to this project so that students could go to the library and search for information about the scientists on the Internet and prepare their PowerPoint slides. Each student was allowed to work individually. During these time periods in the library, Mike checked student work and suggested some books for their projects. After all the students completed their projects, they were supposed to present to the class. Mike modified an evaluative rubric from the Internet and shared the expected criteria with the students prior to the presentations. During student presentations, Mike kept questioning students in order to evaluate if they understood the information related to their scientists. However, even though students worked on their projects for weeks, most of the students were not able to respond to Mike’s questions. They did not seem to have enough knowledge about the scientists.

As shown in Table 4.7, Shared Control was the least implemented constructivist component observed in Mike’s classroom. There was not much difference between Mike’s perceived classroom practice and observed classroom practice related to Shared Control but the perceived score was higher than the observed score. All data supported the assumption that Mike did not strongly believe in the importance of Shared Control. For Mike, the content was most important and his role was to help students learn the content that they were expected to know. Mike was the main person who decided content, activities, and assessment criteria for students.

Mike’s observed classroom practice indicated that Critical Voice was the only component that Mike seemed to frequently implement in his classroom. Several times, Mike conducted demonstrations that elicited positive student reactions and he used this
feedback to make instructional decisions. The following vignette describes one of the “explosion” demonstrations in Mike’s classroom.

All students went to the chemistry laboratory to watch the demonstration done by one of the chemistry teachers and Mike. Mike and his colleague prepared the equipment. They used methyl alcohol and strontium. They turned off the lights and showed an exciting explosion. Students got excited and asked them to do it again. The activity took 20 minutes and then students went back to their respective classrooms (Classroom Observation, November 18, 2005). After this demonstration, Mike did a similar demonstration a couple of times in his own classroom since students always wanted him to do it again.

Mike valued a variety of teaching approaches to address all students’ needs and learning styles.

I think that all students learn in different ways so I try, like I said, different ways of addressing-- worksheets, labs, projects, presentations, quizzes, and tests. So if they can’t do it using one type, they can do it better, so they can learn it in another way. (Interview 1)

<table>
<thead>
<tr>
<th>Classroom Activities</th>
<th>Number of Minutes</th>
<th>Time (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher-Centered</td>
<td>805</td>
<td>55</td>
</tr>
<tr>
<td>Student-Centered</td>
<td>492</td>
<td>33</td>
</tr>
<tr>
<td>Assessment</td>
<td>182</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>1479</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 4.10: Percentage of time spent in teacher-centered, student-centered, and assessment activities in Mike’s classroom.

Mike used a variety of teaching strategies including lectures and worksheets, videos/demonstrations, group work/hands-on activities, individual projects, individual
seatwork/worksheets, and student presentations. Table 4.10 shows that Mike scheduled 55% of class time for teacher-centered activities.

As shown in Figure 4.6, there was an apparent difference between Mike’s classroom activities in terms of teacher-centered and student-centered activities. He spent approximately half as much time in student-centered activities compared to teacher-centered activities.

Figure 4.6: Percentage of time spent in teacher-centered, student-centered, and assessment activities in Mike’s classroom

Teacher-centered activities in which students were mostly sitting, taking notes, and following directions were common activities in Mike’s classroom. According to classroom observations, the most frequently used activity was lecture with questioning and problem solving on worksheets. Mike always lectured about the content and solved problems on worksheets distributed to the students before each class. When students
came to class, they already had the worksheets on their desks. During the lectures, Mike
turned off the lights to enhance student visibility of the overhead slides. He showed how
to solve the problems on overhead slides on which he wrote the formulas and equations.
The following vignette illustrates a typical teacher-centered activity in Mike’s classroom.

Mike distributed the handout entitled “Forces and Motion.” Mike asked one
student to read the text in the handout aloud to the class. Then, the students took turns
reading. One student asked the difference between mass and weight while another student
read from the text. Mike explained the difference between mass and weight to the
individual student but not to the whole class. [He might have thought that it was already
in the text they were reading.] However, the reading time was not productive for the
students since they did not seem to be listening and two of the students were chatting. He
put a problem about friction on an overhead slide. He also said that there would be a lab
about friction the next week. After Mike gave the definition of friction, a student asked
the meaning of Fs and Fk. Mike explained about static friction and kinetic friction by
using two objects: a remote control and a piece of paper. One student asked if friction is a
force. Mike said, “Yes.” Mike continued to solve the problem using a slide on the
overhead projector. One student asked whether Mike would provide the equation on the
test. He said that he would. Mike reviewed the concepts he taught: Forces Fx, Fy, and
Fnet; Newton’s laws, 1st inertia, 2nd F=ma, 3rd equal and opposite force; Friction Fk=µk
(mg) and Fs=µs (mg). One student asked a question related to the problem that was solved
the previous day. She said that she could not understand why they calculate Fx and Fy.
Mike made up a problem to help answer her question that he solved on a slide on the
overhead projector (Classroom Observation, December 01, 2005).
Another teacher-centered activity frequently observed in Mike’s classroom was seatwork. Mike usually preferred solving problems on the slides on the overhead projector as a whole class as previously described. However, he also allowed students to individually solve problems as seatwork after explaining how to solve them. Mike sometimes distributed samples of tests and quizzes to the students in order to encourage students to prepare themselves for exams. During this time, if a student asked a question, then Mike responded to that question. At the end of the class, Mike collected student worksheets in order to assess them. The following vignette is a typical example of Mike’s use of seatwork.

Mike distributed a worksheet related to Fs and Fk to the class and asked the students to solve the problems on the worksheet. He collected the “Force Notes” sheet from the students. Students started solving the problems on the worksheet. One student asked how they could calculate $\mu_k$. As usual, he explained the solution on a slide on the overhead (Classroom Observation, December 02, 2005).

Videos/demonstrations were very common activities in Mike’s classroom. For example, Mike showed a video from the Internet related to weight and energy (Classroom Observation, January 06, 2006). In order to encourage students to carefully watch the video, Mike also administered a video quiz in which students responded to short-answer questions.

Mike allocated 33% of classroom time for student-centered activities such as student presentations and projects. Mike indicated that he tried to assign at least one project for each chapter, approximately every two months. For example, as he had done
in previous years, Mike was planning to assign a project in which students needed to
make their own flashlights for the upcoming chapter on electricity.

Mike used a variety of assessment methods including quizzes, tests, projects,
presentations, class work, and homework. In the first interview, Mike stated,

Tests and quizzes are the standard types of assessment. You can ask them
[students] questions. You can walk around the room and just look at what they are
doing--if it is correct. You can have them do projects. You can have them talk in
front of the class to explain, like a presentation. You can have them do a lab. You
can have them solve problems--many types. I used various assessments; I don’t
stick to one. (Interview 1)

However, Mike predominantly used tests and quizzes since he believed that they helped
students prepare for their future education.

I think tests and quizzes are very important because when they go to college that
is what they do. They are evaluated on what they know, so they need a lot of
practice on that. (Interview 1)

Mike spent 12% of classroom time for quizzes and tests to keep students on task.

Classroom observations revealed that Mike always offered extra credit to the students if
they got the work done during the classroom activities.

Factors That Influenced Mike’s Classroom Practice

Mike identified the following factors that influenced his classroom practice:
student knowledge and behavior, standardized testing, and the school resources. For
Mike, one of the biggest factors that influenced his classroom practice was student
knowledge. Mike believed that student background in science and mathematics
significantly affected not only his teaching practice but also student learning. Therefore,
Mike was concerned about the different grade levels of the students in his classroom and
the differences in
… their background knowledge, what they bring into my classroom, what did their teachers teach them the other grade before? Did they understand math? Because when we teach physics, we use a lot of math and a lot of students still do not know algebra. I do a lot of math, I have to … reassess, recover with the students. … Some students in calculus have better math skills than others. That is one thing. Some students are in different grade levels. I have tenth, eleventh, and twelfth grade students in there so obviously grade-12 students have more science knowledge background than the tenth-grade ones and more math background than younger students so what they bring in is a factor. (Interview 1)

In order to handle this problem, Mike indicated that he kept questioning and re-teaching if necessary in order to have students understand the new content.

Usually what I do is--we do notes. I ask questions and if lots of students understand what I am talking about, then I move on. If they do not understand what I am talking about, then I go back and especially in math, I go back and review. (Interview 1)

According to Mike, student behavior and interactions with each other could be an obstacle for him, especially if he was conducting inquiry-based activities. Mike also was concerned that students may not follow directions and may do something wrong if they do not understand the content.

Sometimes you give up control in the classroom. It’s up to the students and you may have one set agenda. If the group doesn’t do what you want them to do, the teacher may get frustrated. So I mean-I think it’s a good thing for them to learn how to work together and sometimes certain groups don’t like to work together and that probably is the main reason that I don’t use inquiry every day because I don’t think it’s helpful every time for a certain lesson. Sometimes they may go the wrong path. They may think they’re doing something right but they don’t. And then, if you don’t stop them, then they may do wrong stuff, go in the wrong direction. And so that’s why sometimes you need, like I said, all different ways, lecture, notes, tests. So that way they know--this is, these are the facts. This is the content and you need to build on what you learned in class to use this type of inquiry because the students that come to my class you can’t just go here, do this. They need that background. They need that knowledge first before they can use inquiry to solve problems. (Interview 2)

During a number of times in the interviews, Mike indicated the importance of standardized testing such as the ACT and the Ohio Graduation Test (OGT) that students
need to take. State testing was a significant factor that affected Mike’s classroom practice. As a result of this belief, he gave special attention to the content that was related to these tests. He also used tests and quizzes as a way to prepare his students for their future education in college.

According to Mike, another factor that influenced his classroom practice was his colleagues. Mike believed that an exchange of ideas among colleagues was beneficial to improve classroom practice. Mike also added that workshops were helpful to learn new strategies but he also indicated that sometimes he cannot implement them due to lack of equipment or materials in his classroom.

If something is successful to other teachers, I try to use their strategies. If I go to a workshop and they have a great lab and then they show us how to do it at the workshop, and if I can do it, I have some materials, and yeah, I’ll use them in my classroom--A lot of times when teachers do stuff that we don’t have in our classroom, even though it’s great, I know it is good--if we don’t have the equipment--we don’t have like gas in our buildings--so it’s hard to do some of this stuff to try to implement some of the hands-on activities that some of these other teachers do. (Interview 2)

**Summary of Mike’s Case**

Data from the preferred form of the CLES and the interviews suggested that Mike expressed emerging constructivist teaching and learning beliefs. For Mike, the biggest gap between his preferred and perceived classroom practice was for the constructivist component of Scientific Uncertainty. His preference for this component was greater than his perceived implementation of it. Other differences between his preferred and perceived classroom practice were for the constructivist components of Personal Relevance and Student Negotiation. Again, his preference was greater than his perceived implementation. For Mike, Shared Control was the least preferred and least perceived
component reported on the CLES. There was no difference between Mike’s preferred and perceived classroom practice related to Critical Voice.

Classroom observations suggested that Mike’s classroom practice exhibited the characteristics of transitional teaching and learning. The largest difference between Mike’s perceived and observed classroom practice was for the constructivist component of Student Negotiation. The second largest difference between Mike’s perceived and observed classroom practice was for the constructivist component of Personal Relevance. Observed classroom practice suggested that Scientific Uncertainty and Shared Control were other constructivist components that were observed less compared to Mike’s reported perceived classroom practice. Critical Voice was the most frequently observed component among the five constructivist components on the CLES in Mike’s classroom. Shared Control was the least observed constructivist component in his classroom.

Mike used many instructional strategies as stated in his interviews. However, Mike spent more than half of the class time in teacher-centered activities (55%) such as lectures including worksheets and questioning, videos/demonstrations, and individual seat work. Mike allocated 33% of classroom time to student-centered activities including student projects, presentations, and laboratory activities. Mike used a variety of assessment methods including quizzes, tests, projects, presentations, and homework. Mike indicated that student knowledge and behavior, standardized testing, and the school resources were the most influential factors affecting his classroom practice.

The Third Case: Patrick

Patrick was a 38-year old, African-American science teacher with 4-years of teaching experience. He graduated from the Clinical Laboratory Technical School and
did not have a Master’s degree. He mostly taught in suburban schools. Patrick was teaching General Science for grades 6 through 8 and Mathematics for grade 5 and grade 6 in a private middle school. He had good communication with the students. Patrick indicated that most of his students saw him as a “dad.” Patrick believed that everybody could learn science and encouraged all students to try to learn science rather than give up.

In the first interview, Patrick indicated

Prior to me, they hated science and they probably still don’t like it very much but to keep from disappointing me, they work harder at learning what they need to learn. And they find out “Oh, this isn’t as bad as I thought it was going to be.” So it opens the door. So I’m one part instructor and I’d say one part dad, absolutely. (Interview 1)

Patrick’s good communication with his students was one of his most notable strengths as a teacher. Patrick wanted his students not only to have fun but also to gain self-confidence in their ability to learn science.

Classroom Context

Patrick was teaching sixth-grade General Science to three different classrooms and I visited the sixth-grade General Science class four or five times a week for 2 months, for a total of 30 classroom periods. The same class session, the seventh period, with the same students was regularly observed throughout the research in order to have an in-depth understanding of the classroom context. The regular classroom time was 42 minutes but the classroom time sometimes changed depending on the school schedule. For example, on advisory days, the classroom time was 37 minutes. On laboratory days, Patrick did his classes as a double period, 87 minutes with a few minutes break. Patrick had six laboratory sessions during the time period of the classroom observations.
There were 18 students, including 10 girls and 8 boys. Three or four of the students sat together at each table. Students usually sat at the same table since the seating plan was arranged by Patrick at the beginning of the year based on student social preference. Students seemed to be well-behaved and motivated to learn, and attended classes regularly. Student misbehavior did not seem to be an issue in Patrick’s classroom.

The classroom was a well-lit, large classroom with five large tables for students, two desks at the back of the class, and one desk in front of the white board for the teachers. There were two teacher desks at the back of the room because Patrick shared this classroom with a fifth-grade science teacher. A Smart board and four computers were available for use by students and Patrick. Both sides of the classroom had counters with sinks for experiments. There was also a hamster in a cage and posters on the walls.

**Patrick’s Beliefs Related to Constructivist Teaching and Learning**

Patrick expressed expert constructivist teaching and learning beliefs. Data from interviews suggested that Patrick’s understanding of constructivism was based on hands-on project activities in which students were encouraged to construct their own knowledge based upon previous knowledge and show what they know and can do. According to Patrick, constructivism is “giving them [students] knowledge about a subject and having them construct their understanding of it, putting it together somehow” (Interview 2).

Patrick provided some examples from his classroom in order to explain his understanding of constructivism.

For instance, like I said, in the water study, they had to put something together that showed me what they know. The project that they’re all working on now—the diseases—they’re putting together what they know, how this disease, if it takes place, how it affects this portion of the nervous system. If it affects the nervous system, how is it going to affect the muscles? If it affects the muscles, how is it
going to affect the rest of the body? They’re starting to use what they know and build upon it. That’s how I view constructivism. (Interview 2)

As stated in the previous excerpt, Patrick encouraged students to make connections among concepts to facilitate meaningful learning. Although Patrick expressed his perception of constructivism as classroom applications like hands-on project activities, data from the CLES indicated that Patrick’s constructivist teaching and learning beliefs were more comprehensive.

As shown in Table 4.11, Patrick expressed expert constructivist beliefs with higher numbers on the preferred version of the CLES. On the other hand, data from interviews and the perceived form of the CLES suggested that Patrick did not think that he implemented all of his beliefs into his practice. Patrick indicated that “At times I do implement constructivism, at times I cannot” (Interview 2).

<table>
<thead>
<tr>
<th></th>
<th>Preferred</th>
<th>Perceived</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Relevance</td>
<td>25</td>
<td>16</td>
</tr>
<tr>
<td>Scientific Uncertainty</td>
<td>24</td>
<td>20</td>
</tr>
<tr>
<td>Critical Voice</td>
<td>19</td>
<td>22</td>
</tr>
<tr>
<td>Shared Control</td>
<td>21</td>
<td>14</td>
</tr>
<tr>
<td>Student Negotiation</td>
<td>25</td>
<td>18</td>
</tr>
<tr>
<td>Total</td>
<td>114</td>
<td>90</td>
</tr>
</tbody>
</table>

Table 4.11: A comparison of Patrick’s self-reported preferred and perceived classroom practice on the Constructivist Learning Environment Survey.

As shown in Figure 4.7, the biggest difference between Patrick’s preferred and perceived classroom practice was for the constructivist component of Personal
Relevance. Patrick always wanted to implement Personal Relevance in his classroom but this did not always happen in his perceived practice. In the first interview, Patrick said,

I also use a lot of examples and stories so they can relate to what I’ve said. Sixth graders love stories. They’ll sit down and listen to every story you have to tell and they categorize it. ... That’s how they remember it and it’s like “Oh yeah,” so I’m applying it to real-life scenarios for them. (Interview 1)

![Figure 4.7: A comparison of Patrick’s self-reported preferred and perceived classroom practice on the Constructivist Learning Environment Survey](image)

*Note. PR=Personal Relevance. SU=Scientific Uncertainty. CV=Critical Voice. SC=Shared Control. SN=Student Negotiation.*

The second largest differences between Patrick’s preferred and perceived classroom practice were for the constructivist components of Shared Control and Student Negotiation. Patrick indicated that he considered students’ understanding and coherence regarding the subject when planning his instruction but he did not solicit student input. For example, Patrick said,
A lot of times I come in. I have a set plan. I know where I’m going with this. But I do a lot of improvisation. Like yesterday, they were asking questions about this paper that’s coming up. So I backed up and I went through the paper again with them because obviously they had questions about it. They didn’t understand it. Why am I going to ignore that when I’m just setting them up for failure? (Interview 1)

Patrick suggested that group work provided a good way for students to interact with each other. The following excerpt describes Patrick’s beliefs about group work.

It’s interesting to watch how they work together because you have the strong person who is going to try to do everything. They always break down this way. I’ve noticed. You’ve got one person who wants to do everything. One person doesn’t want to do anything, and the mediator who gets the person who doesn’t want to do anything involved and the one who wants to do everything to settle down. As long as they can figure out their roles in about the first three days, there’s never a problem. Sometimes it lasts longer. … So there have been occasions where you get one person who just doesn’t fit into a group. I won’t let them get out of the group. I’ll have them work on some part of that whole project by themselves but they’re still contributing to the group and it’s teaching group interaction. (Interview 1)

Another difference between Patrick’s preferred and perceived classroom practice was for the constructivist component of Scientific Uncertainty. Patrick indicated that he wanted to implement Scientific Uncertainty in his classroom but once again he did not perceive this as happening in his classroom to the extent that he wished. Patrick wanted his students to ask questions since he believed that science was about asking questions.

They need to ask questions. Students have to ask questions. Science is about asking questions. It’s a matter of letting them know they can ask their questions. From kindergarten through fifth grade they’re told, “This is how it’s done.” This is why it’s done that way and most of the time, not all of the time, but most of the time, they are never allowed to say “why or why not.” (Interview 2)

Patrick was distressed that students often said “this happens because the teacher said so.” Instead, Patrick wanted students to think for themselves, ask in-depth questions, and develop a passion to learn science.
As a middle school class teacher, it’s my job to teach them how to ask questions and expose them to science. Show them it’s not all textbook, read it, learn the facts, learn the numbers, learn the names of these big chemicals that are running through your body. This is fascinating if you look at it from a different perspective and think about it. So I want to give them that hunger for science, hunger for learning. (Interview 2)

Patrick tried to increase student confidence by encouraging them and letting them know that making mistakes was okay and a way of learning science.

I tell them you can do this. All you have to do is to try in the labs. It’s a participation lab. Because if the lab doesn’t work, as a scientist you know not every lab is going to work. “Why didn’t it work?” Analyze what went wrong and could you do it differently the next time. That’s learning science. That’s how you get involved in science. (Interview 1)

When students asked questions, Patrick mostly preferred to encourage them to think instead of giving them the answer.

They’ll ask me questions and sometimes I’ll say, “I don’t know. What? Why is this?” which makes them start to think, which lets them know it’s okay to ask questions and they start asking more questions. (Interview 2)

According to Patrick, it was important to encourage students to ask “why” questions and have them search for answers. Patrick added,

They know that once they’ve asked me that question, I’m expecting to see it as a project. And they’re like “Okay, fine.” That’s pushing them along. That’s one way I’ve learned to do it, but I haven’t figured out the key to saying why. You know “Go find out why.”--getting them to empower themselves to go find out why. (Interview 2)

The unusual difference between Patrick’s preferred and perceived classroom practice was for the constructivist component of Critical Voice. Unlike the other components, Patrick’s score related to the constructivist component of Critical Voice reported for his perceived classroom practice was higher that reported for his preferred classroom practice. In the first interview, Patrick indicated that students should be
comfortable in their surroundings. Therefore, he always asked for student opinions; for example, to arrange student seats and choose lab partners.

They have to be comfortable in their surroundings. … They know that sitting next to somebody means that is your lab partner. So, when we do something, you’ll be working with that person. That’s why I ask them “Is this okay with you?” “Is this comfortable for you?” Eventually they’re going to have to learn to get along with each other no matter who they sit next to so I’m just breaking them in by giving them the option. (Interview 1)

**Patrick’s Observed Classroom Practice**

Patrick’s observed classroom practice demonstrated characteristics of progressing constructivist teaching and learning. Patrick’s self-reported responses for his preferred and perceived classroom practice on the CLES were re-examined in light of the observed practice data.

<table>
<thead>
<tr>
<th></th>
<th>Preferred</th>
<th>Perceived</th>
<th>Observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Relevance</td>
<td>25</td>
<td>16</td>
<td>22</td>
</tr>
<tr>
<td>Scientific Uncertainty</td>
<td>24</td>
<td>20</td>
<td>14</td>
</tr>
<tr>
<td>Critical Voice</td>
<td>19</td>
<td>22</td>
<td>20</td>
</tr>
<tr>
<td>Shared Control</td>
<td>21</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>Student Negotiation</td>
<td>25</td>
<td>18</td>
<td>16</td>
</tr>
<tr>
<td>Total</td>
<td>114</td>
<td>90</td>
<td>84</td>
</tr>
</tbody>
</table>

Table 4.12: A comparison of Patrick’s preferred, perceived, and observed classroom practice on the Constructivist Learning Environment Survey.

Table 4.12 shows the similarities and differences among Patrick’s preferred, perceived, and observed classroom practice. According to Table 4.12, the biggest differences between Patrick’s perceived and observed classroom practice were for the constructivist components of Personal Relevance and Scientific Uncertainty. Personal
Relevance was the only component implemented more often in Patrick’s observed classroom compared to his perceived classroom. Personal Relevance was the most frequently observed component in Patrick’s classroom. Patrick used many real-world examples and stories related to the content he was teaching. Patrick showed videos that were directly relevant to the lives of students outside of class. For example, Patrick used a video related to healthy nutrition. After the video, Patrick encouraged the students to discuss about food and commercials. Patrick suggested that students eat healthy foods in order to keep their heart healthy. Patrick was planning to show the videotape *Body Story: Puberty* related to adolescence. According to classroom observations, all projects assigned by Patrick were related to student daily life. For example, Patrick created an activity for students to locate and measure their heart beats and their blood pressure. The following is an example of a hands-on activity in Patrick’s class that was relevant to student daily life.

Patrick brought a stethoscope and a Sphygmomanometer to the class (January 25, 2006). He said the names of the instruments and asked students to repeat them. All students gathered around him. He had one student sit on the table. He took her blood pressure. All students got excited. He had the students take each other’s blood pressure. Sometimes they listened to their heart rates. He also explained what mmHg means and showed mmHg on the Sphygmomanometer. He asked how the stethoscope works. He explained they could hear their breath. He had them listen to their breath by taking a deep breath in and out.

Classroom observations suggested that Patrick encouraged students to understand the scientific process. However, his perceived belief was less than his observed practice
related to Scientific Uncertainty. The following is an example of a project that was relevant to student daily life as well as illustrative of the scientific process. Patrick provided a handout about a new project, entitled “Heart Rate Project” (Classroom Observation, January 05, 2006). Patrick showed students how and helped them to locate and take their pulses. Then, Patrick asked students to get comfortable and relaxed. At first, students were surprised and then they all found a comfortable place to lie down. Some of them laid down on the table. Patrick turned off the lights and started to tell a story to them. Some started giggling and then they all quieted down and relaxed. After all the students relaxed, Patrick asked them to find their pulse and count the heart beats when he said start. Then, Patrick asked them to record those numbers on their handouts. For the second activity, Patrick sent students to the hallway in order to do another activity. He had them do 25 jumping jacks. Then, he asked them to take their pulses when he said start. Patrick kept time and students recorded their numbers. The students returned to the class and Patrick asked them to multiply these numbers by 4 in order to calculate their pulses in a minute. Students did the calculations and recorded the new numbers in their handouts. Patrick asked students to state their own hypothesis and find eight more different activities to calculate their heart rate to test their hypothesis. Patrick explained about a hypothesis, and warned students to pick safe activities. He also reminded students not to pick passive activities like playing video games. Other than these rules, students were free to pick activities based on their hypothesis and record their data to test the hypothesis. Students asked a lot of questions regarding the project and Patrick responded. Students were instructed to list the activities with their hypothesis and turn them in the next day. Based on student activities that they picked, Patrick gave feedback to students
before having them to do their activities. Patrick allocated several classroom periods to help students do their projects. On another day, Patrick helped students to enter their data into an Excel file and construct their graphs in the computer laboratory. Students asked a lot of questions and Patrick helped them, sometimes individually and mostly as a whole class. Patrick also spent a couple of classroom periods in which students wrote their laboratory reports including an introduction, their hypothesis, data table, graph of their data, and conclusions. This project enabled students to not only understand science as a process but also to make connections to their personal lives.

The other differences between Patrick’s perceived and observed classroom practice were for the constructivist components of Critical Voice, Shared Control, and Student Negotiation, all of which Patrick perceived as happening more than was observed by the researcher. Critical Voice was the only component implemented more often in Patrick’s observed classroom compared to his preferred classroom. Students in Patrick’s classroom were allowed to express their opinion related to anything that appeared to impede or promote their learning. For example, one of the students complained about an annoying smell coming from the sink next to her seat (Classroom Observation, January 05, 2006). Patrick also had students engage in many hands-on activities since they enjoyed doing these kinds of activities.

Shared Control was the least perceived and least observed component in Patrick’s classroom. In the school in which Patrick worked, the science curriculum for all grades was decided by Patrick and his colleagues based on the National Science Education Standards (NRC, 1996), state standards, and student needs. However, all teachers were free to make modifications. For example, Patrick re-organized the sixth-grade science
curriculum based on the coherence of the topics. As a result of this modification, the sixth-grade science curriculum started with tiny organisms and microscopes, cells, tissues, organs, organ systems, bones, muscles, the circulatory system, the reproductive system, and then continued on to the sun, the moon, and the solar system. Since Patrick wanted to gather all the content related to the body system, he was planning to make more changes between the fifth-grade and the sixth-grade science curriculum.

I teach a lot of the body system and the only two that are in our curriculum that I don’t teach are respiratory and digestion which is taught in fifth grade. But I re-teach respiratory when I teach circulatory so we’re working on me pulling digestion and circulatory into my curriculum and since the fifth-grade instructor teaches a lot of earth science, giving her my space unit. (Interview 1)

Patrick had autonomy to modify the curriculum and instruction based on student needs. In addition, the parents of students sometimes were involved in decisions about classroom activities. For example, Patrick asked for parent permission before showing a video related to puberty and having discussions with students about it. However, students did not have much direct input to decide what they learn, what kinds of activities they do, and how they are assessed. Patrick sometimes gave students options to form their groups for projects or self-evaluate their individual performance and group performance during the projects they studied. The following vignette is a good example of how students had the option to form their own groups for the Disease Project.

At the beginning of the class, Patrick delivered the research packet. He gave students two options: “Do you want to make your groups or do you want me to make your groups?” Students wanted to make their groups by themselves. Then Patrick helped students form groups. For example, Patrick gave a suggestion to a couple of students who could not decide on the person they wanted to join their group. Each group had 3-4
students. Patrick explained the disease presentation in detail (Classroom Observation, February 13, 2006). At the end of the projects and presentations, Patrick asked students to complete a self-evaluation (Classroom Observation, March 02, 2006).

Patrick’s perceived practice also was greater than his observed classroom practice for the constructivist component of Student Negotiation. Data from classroom observations suggested that Patrick tried to encourage students to listen to each other’s ideas, a highly preferred component of constructivism. Students were encouraged to share their life experiences with their classmates related to the content they were learning. However, most of the time, the interaction between the teacher and students was more common than the interaction among students. The student-student interaction was encouraged especially during the group projects where students needed to negotiate with each other to find the information related to their projects. For example, the Disease Project is a good example of Student Negotiation in group work implemented in Patrick’s observed classroom.

After dividing students into groups, Patrick explained the disease presentation in detail. Students would be investigating one of the diseases for two weeks. Then, students needed to make a presentation to the class. They were free to pick a presentation tool including PowerPoint, poster presentation, and/or video. However, Patrick warned the students that making a video did not necessarily mean that they would get an A. Patrick allowed students to start working on their project and all students were excited and working. Some students conducted searches using different computers. Patrick delivered a piece of blank paper to each group and asked students to write their names and the disease they picked for their presentation. However, only one group decided on their
disease. Patrick encouraged students to work on their projects for two more weeks and eventually students prepared wonderful presentations and demonstrated adequate knowledge about the disease they picked. Students investigated their topics and demonstrated responsibility for their own learning. Patrick acted as a guide to help them to do their projects.

In contrast to the benefits of the Disease Project, classroom observations suggested that group work was not as common as much as whole-class activities in Patrick’s classroom.

<table>
<thead>
<tr>
<th>Instructional Activities</th>
<th>Number of Minutes</th>
<th>Time (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole-Class</td>
<td>795</td>
<td>64</td>
</tr>
<tr>
<td>Group Work</td>
<td>308</td>
<td>25</td>
</tr>
<tr>
<td>Individual Student Work</td>
<td>50</td>
<td>4</td>
</tr>
<tr>
<td>Other</td>
<td>84</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>1237</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 4.13: Patrick’s instructional activities in terms of the amount of time spent.

As shown in Table 4.13, Patrick allocated 64% of classroom time to do whole-class activities, including lectures with questioning and discussion, videos/demonstrations, worksheets, and hands-on activities. Patrick spent 25% of classroom time in group work activities while he spent 4% of classroom time in individual student work such as individual student projects.
As shown in Figure 4.8, whole-class activities were the most common types of activities in Patrick’s classroom. Whole-class activities were conducted more than two times as much as group work activities and 16 times as much as individual student work. Individual student work activities were the least common type of instruction in Patrick’s classroom.

There was a variety of activities observed in Patrick’s classroom, including teacher-centered activities such as lecture, worksheets, and videos and student-centered activities such as hands-on activities, projects, and presentations. However, as shown in Table 4.14, Patrick spent 42% of classroom time in teacher-centered activities while 51% of class time was spent in student-centered activities.
<table>
<thead>
<tr>
<th>Classroom Activities</th>
<th>Number of Minutes</th>
<th>Time (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher-Centered</td>
<td>520</td>
<td>42</td>
</tr>
<tr>
<td>Student-Centered</td>
<td>633</td>
<td>51</td>
</tr>
<tr>
<td>Assessment</td>
<td>84</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>1237</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 4.14: Percentage of time spent in teacher-centered, student-centered, and assessment activities in Patrick’s classroom.

Teacher-centered activities in Patrick’s classroom included lectures, worksheets, and videos. Patrick usually gave an assignment to the students before lecturing on the content. Patrick indicated,

I first start giving a straight quick down and dirty homework assignment, learn the definitions, write out the definitions as you work with them. That way when I mention photosynthesis, you know what I’m talking about. I don’t have to go back and say photosynthesis is—you’ve already seen it. (Interview 2)

As Patrick indicated in his interviews, he always lectured about the content along with questions and discussion. He frequently used the Smart board during his instruction. He used models and diagrams in order to facilitate student learning. The following vignette is an example of a typical lecture in Patrick’s classroom.

Patrick reviewed the vocabulary from a handout entitled “Circulatory System Guided Reading” that was previously assigned to the students (Classroom Observation, January 04, 2006). He asked about “active transport.” One student read the definition of active transport from the book. Then, Patrick threw a ball to one of the students and said that this is an active transport. Patrick displayed a heart diagram on the computer screen. He drew blue lines coming from the body to the lungs. He also showed the model of the
heart. One student asked the difference between heart failure and heart attack. He explained about a heart attack and bypass surgery on the heart diagram.

Data from classroom documents (e.g., worksheets) suggested that Patrick posed many questions for students to answer. However, Patrick also focused on vocabulary words that students needed to know such as atrium, ventricle, coronary circulation, pulmonary circulation, artery, vein, capillary, diffusion, active transport, organ, tissue, aorta, blood pressure, systolic, and diastolic.

**Questions**

Where is your heart located?
What are the three types of circulation?
What supplies the heart with nutrients and oxygen?
What causes a heart attack?
How does the blood change in the lungs?
Where does the blood go after it leaves the lungs?
Where are the capillaries located?
What is blood pressure?
What is the average blood pressure?
What is the average pulse rate for adults and children?
Why it is important to have consistent blood pressure?
What causes heart failure?

---

Table 4.15: Examples of questions on Patrick’s worksheet.

In addition, Table 4.15 provides an example of the type of questions on Patrick’s worksheets. Patrick used diagrams that helped student visual learning on the worksheets. For example, Patrick distributed a paper that had two drawings including the heart and
the lungs along with a listing of vocabulary words. During one classroom period, students colored both drawings and labeled the vocabulary words on the drawings.

Sometimes Patrick used videos related to the content he was teaching. When he told the students that they were going to watch a video, students always got excited. When Patrick was teaching about the circulatory system, he used a video prepared by the National Geographic Society. The video took 17 minutes and summarized the parts of the circulatory system, described the main components of blood and their functions, and explained the exchange of gases in the lungs.

Data from interviews and classroom observations revealed that Patrick provided many hands-on, student-centered activities to create a constructivist learning environment for students. Patrick used the term “get our hands dirty” to describe the best way to learn science.

I learned science, believe it or not, in sixth, seventh and eighth grade by sitting and reading a book and it drove me nuts. It wasn’t until high school chemistry--my chemistry instructor made us get our hands dirty with it and I’ve loved it ever since. (Interview 1)

As shown Figure 4.9, Patrick spent approximately half of the classroom time involving students in student-centered activities, projects, and presentations, and slightly less than half of the time in teacher-centered activities. As Patrick indicated a number of times, he believed that science cannot be learned just by reading books.

Science is one that you learn by doing, math also. I teach a math class as well but science is something I believe you learn by doing. So the more participation you get out of the students, the more they’ll learn by doing it instead of just reading in a book and saying okay, “We will be tested over it.” (Interview 1)
Patrick always encouraged students to get involved in the activities. For example, in order to explain circulation through capillaries, he had all students participate in the following activity.

Patrick asked everybody to stand up. He separated two tables by a small distance. Then he asked students to pass through, between the tables. He said that the open area was a capillary. It was narrow and difficult to pass through. Each student passed through. Then he put pink cards, waste products coming from the cell, on the table. Each student picked up one pink card while passing through the capillary. Then he put yellow cards on another table. After passing through the capillaries, each student went to this table, the lung, and dropped off the pink cards (waste) and picked up the yellow cards (oxygen). This was a model of the circulatory system. He asked questions in order to advance

Figure 4.9: Percentage of time spent in teacher-centered, student-centered, and assessment activities in Patrick’s classroom
student learning. All students had fun and seemed to understand what they were doing (Classroom Observation, January 19, 2006).

Patrick also assigned a project in which students had to construct their knowledge based on their own investigations. Patrick explained the Disease Project as follows:

So far we’ve studied cells, bone structure, muscular structure, and a circulatory system. Now they’re going to come up with a disease state that affects one or all of those and they have to present it to the class and show me what they know. (Interview 1)

Patrick used various type of assessment including student presentations, projects, hands-on activities, homework, quizzes, and tests. During the first interview, Patrick indicated that he did not want his students to merely repeat facts to him but rather wanted them to understand the content. Patrick said,

… not just regurgitate it back to me and say—“Oh well this definition is this.” But the questions on the quizzes are starting to move them toward understanding. What would happen if there was a problem with this aspect of the body? What do you think would happen? … One of the questions I gave them was “What would happen if you contracted some virus that attacked the mitochondria?” And they [students] had to think what the mitochondria does. Without that your cells would be lacking energy. They wouldn’t want to do anything and that would affect you because the cell would die. Therefore, you’d die. (Interview 1)

During classroom observations, Patrick spent 7% of classroom time on quizzes and tests. Data from classroom documents suggested that quizzes and tests consisted of various types of questions including multiple-choice, open-ended, and fill-in-the blanks.

Factors That Influenced Patrick’s Classroom Practice

Patrick identified the following factors that influenced his classroom practice: content, student levels, and parental involvement. For Patrick, content was one of the factors that influenced his teaching practice. He believed that his ability to implement constructivism in his classroom depended on the content he was teaching and whether a
laboratory was appropriate and doable. For example, Patrick gave an example of a Water Study Project assigned at the beginning of the school year. During this open-ended project, as a group, students were assigned to create a representation of a wetland and an animal that lived in that wetland. Patrick was impressed by his students’ work since they went beyond what he thought they were going to do. However, for Patrick, it was hard to do laboratory activities related to genetics or other body systems. Patrick stated,

Like when I’m teaching … why we have different blood types. I’d love to be able to bring in the reagents and have my blood drawn and the kids’ blood drawn but you have a problem with the kids’ blood drawn. You have a problem with the kids having their blood drawn, you have problems with blood-borne pathogens and disease and stuff. Okay, these are the rigid standards--I can’t do that any more. Giving them--sometimes you have to just give the information as it is and that’s hard for me because I learn better by hands-on and some of the students do. But whenever possible, yes, I do, give them something to build and learn by.

(Interview 2)

Patrick added that he generally encouraged students to do a research paper/project related to content that he could not do as a laboratory. According to Patrick, students start asking more “why” questions once they start exploring the content. He said “Find out what you’re researching about which is going to spark them to say why is this, why is that.” However, Patrick was not happy that students tended to use the Internet to find information and did not want his students to solely rely on all the information that they found on the Internet. Patrick added “Unfortunately, they rely on the Internet a lot and not all the sites on the Internet are accurate. So, if it’s easy for them to Google it, they take it for gospel” (Interview 2).

The second factor that influenced Patrick’s classroom practice was the nature of students at this grade level. Patrick believed that sixth-grade students did not want to do open-ended projects since they were used to having everything spelled out for them. As
Patrick indicated and data from classroom observations confirmed, students wanted to see examples of the completed assignments to see what the assignment should look like. For example, as discussed in the Heart Rate Project, each student was responsible for generating their own hypothesis. During the classroom sessions, students asked many questions about the kind of hypothesis that they could investigate even though Patrick showed several examples to them. Patrick also believed that the sixth-grade students want to find the simplest answer. Patrick stated,

They’re just now learning about the human body in depth. They ask the questions but I don’t send them off, find out why, find out why because they’re sixth graders. And the sixth grade is--they’re looking for the easiest way to get the easiest answer so they don’t have to work with this any more. Unfortunately, so they will do the minimum to answer the question and that’s it. (Interview 2)

Parental involvement was another factor that seemed to influence Patrick’s classroom practice since the school in which Patrick worked was a private independent school.

Being in an independent school, a lot of times there is parent involvement. How are the parents going to receive how I’m teaching something? The parents, if they like it, if their kids are excited about it, the parents are excited about it. If the kids don’t like the class, and you’re answering to the parents all the time, that’s a factor, that is a big factor. (Interview 2)

According to Patrick, parents would be happy if the kids were happy. So, Patrick picked activities that students would enjoy as well as provide opportunities to learn. For Patrick, most of the students enjoyed and learned from hands-on activities, so he preferred to do them in his classroom.

Parents were also a factor influencing the content that he taught. For example, Patrick indicated that some of the parents who were doctors told him that the content that he was teaching was more complex. As his students were sixth graders, Patrick felt that
although the content was complex, his instruction needed to be appropriate for the grade level.

It’s a matter of teaching to the sixth-grade level. Everything that I’m teaching is a lot more complex than what I’m teaching. I give them the basics. As I say, the basic sixth-grade response to what’s going on in the human body. Later on, or early next week, we’re going to start talking about blood banking--immune hematology. I’m teaching them blood types A, B, AB, and O. That’s it. It’s a lot more complex than that. Some of these kids have doctors for parents and I’ve been written to on several occasions saying, “Well, the circulatory system is more complex than that and then actually you have all these different types.” And I told them, “This is sixth grade. This is not anatomy--this is not like Gray’s Anatomy. I can’t.” So I just give them the basics. (Interview 1)

Although Patrick followed the curriculum decided by the science teachers in the school and he was the person who decided what to teach and how to teach in his classroom, he did appear to consider the influencing factors when planning his instruction.

Summary of Patrick’s Case

Data from the preferred and perceived forms of the CLES and the interviews suggested that Patrick expressed expert constructivist teaching and learning beliefs. Moreover, Patrick indicated that he could not always implement constructivism in his classroom. For Patrick, the biggest difference between his preferred and perceived classroom practice was for the constructivist component of Personal Relevance. Similarly, Patrick’s preferred score was greater than his perceived classroom practice score for Shared Control and Student Negotiation. Scientific Uncertainty also displayed the same pattern related to Patrick’s preferred and perceived classroom practice. Critical Voice was the least preferred component in Patrick’s preferred classroom practice. Patrick’s perceived classroom practice had a greater score for Critical Voice compared to his preferred classroom practice score.
In contrast to his self-reported expert beliefs, classroom observations suggested that Patrick’s observed classroom practice demonstrated characteristics of progressing constructivist teaching and learning. The biggest differences between Patrick’s perceived and observed classroom practice were for Personal Relevance and Scientific Uncertainty. Interestingly, Personal Relevance was observed more than perceived. All the examples of stories, videos, and projects in his classroom were directly related to student lives outside of school. However, Scientific Uncertainty was observed less than perceived. Patrick encouraged students to view science as both content and process but the historical and cultural aspects of science were not dominant in Patrick’s observed classroom. For Critical Voice, Shared Control, and Student Negotiation, Patrick’s perceived practice was greater than his observed classroom practice. Shared Control was the least observed constructivist component in Patrick’s classroom.

Patrick used a variety of instructional and assessment strategies. Patrick spent more class time in student-centered activities (51%) including hands-on activities, student projects, and presentations than in teacher-centered activities (42%) including lectures, worksheets, and videos. Assessments included quizzes, tests, presentations, projects, and student homework. Patrick indicated that content, student levels, and parental involvement were some factors that influenced his classroom practice.

The Fourth Case: John

John was a 60-year-old science teacher working in the same school with Patrick. He received his Bachelor’s of Science degree in Biology as a major and Chemistry as a minor. He had a Master’s of Education degree in Elementary Administration. He had 13-years teaching experience and 26-years administrative experience. He had teaching
experience in rural, suburban, and urban schools. John had taught Mathematics, Science, and Health classes for grades 5 through 8. He was teaching the seventh- and eighth-grade General Science classes. One of the most significant strengths of John was his role as a coach. John highly encouraged students to ask questions and try to find answers by themselves with his guidance. John also was the teacher that actually started doing hands-on science and experiments in his school district.

*Classroom Context*

At the onset of the study, John was teaching seventh-grade General Science and eighth-grade General Science to three different classes. I observed one of his eighth-grade General Science classes four or five times a week for 2 months, for a total of 29 classroom periods. The same class session, the sixth period, with the same students was regularly observed throughout the research in order to have an in-depth understanding of the classroom context. The regular classroom time was 42 minutes but the classroom time sometimes changed depending on the school schedule. For example, on advisory days, the classroom time was 37 minutes. Unlike Patrick, John did not have double periods for laboratories.

The number of the students in John’s class was 15, including seven girls and eight boys. There were five tables in the classroom and three or four students sat together at each table. Students appeared to be well-behaved and motivated to learn, and attended classes regularly. Student misbehavior was not a concern in John’s classroom.

The classroom was very similar to Patrick’s classroom. At the back of the class, there was a desk between the shelf for equipment and the shelf for textbooks. Another
teacher desk was located near the board and there were sinks on both sides of the classroom. On the counter, there was one computer and a printer.

John’s Beliefs Related to Constructivist Teaching and Learning

John expressed progressing constructivist teaching and learning beliefs. For John, constructivism was based on a hands-on approach to science. John’s understanding of constructivism also included in-depth questioning to promote student thinking.

Educators always have to come up with new words to describe things. Constructivism in science is nothing different than the old hands-on approach to science. Here’s what you can do. How are you gonna do this? Develop a plan to come up with this and why did it happen that way? At least, that’s my concept of it—not having been formally instructed in constructivism which is what they do now in school. (Interview 2)

John also perceived constructivism as the thoughtful application of learning to answer what and why questions.

Like, we’ll be doing something about melting ice into water and seeing what that does and recording some of that. We’ll have to grasp some of that and there’s certain things that happen at certain temperatures that may surprise them. And see, if they can figure out why it’s, what’s going on, what has happened here with that? You know they’d expect—they always hear that water boils at 212°. But it does not boil at 212° here. It boils like at 209° or 210°. “Why?” And let them see if they can figure it out. What would they [students] predict? That’s always good to predict what you’re going to see. That is, people call it constructivism. I call it—it’s more like an application. (Interview 2)

John considered himself as a teacher in the middle of a continuum with regard to constructivism and criticized being at either end of the continuum. For John, “There’s a happy medium for kids and they need both sides of that” (Interview 2).

Something more or less I’ve been trying to look at myself and see what I think there is. My big gripe with education is [that] education always springs from this end to this end. Education never takes a good balance. We’re either here or we’re here. Why can’t we be here? There are good points to all parts of it. And why can’t we do a blending of all of that? … I don’t think I’d do it [constructivism] completely—no, because here again I’ll go back to what I just said. I think you
don’t need to be on one end of the pendulum or on the other end of the pendulum.
(Interview 2)

However, John added that he leans more to the application side associated with
constructivism because even though individuals may have a lot of scientific knowledge,
they may be unable to apply the scientific knowledge in real-world situations.

Especially in science, I think I would lean more to the constructivism side, the
application end of it. Why do we have to wear seatbelts? Why is it important to
wear a seat belt in the car and what happens to you if you don’t? Why a girl gets
killed this morning--she wasn’t wearing a seat belt and she hit a tree. What law
did she defy? That is what happens when you defy those laws because – [she is]
going to be in motion until acted upon by another force. (Interview 2)

Data from the CLES were consistent with John’s interview responses. As shown
in Table 4.16, John generally did not perceive that he was implementing constructivism
in his classroom as much as he preferred.

<table>
<thead>
<tr>
<th></th>
<th>Preferred</th>
<th>Perceived</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Relevance</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>Scientific Uncertainty</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>Critical Voice</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>Shared Control</td>
<td>17</td>
<td>12</td>
</tr>
<tr>
<td>Student Negotiation</td>
<td>19</td>
<td>16</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>89</strong></td>
<td><strong>75</strong></td>
</tr>
</tbody>
</table>

Table 4.16: A comparison of John’s self-reported preferred and perceived classroom
practice on the Constructivist Learning Environment Survey.
Figure 4.10: A comparison of John’s self-reported preferred and perceived classroom practice on the Constructivist Learning Environment Survey

As shown in Figure 4.10, the biggest differences between John’s preferred and perceived classroom practice on the CLES were seen for the constructivist components of Personal Relevance and Shared Control. For both components, his preference score was greater than his perceived score. Related to his Personal Relevance beliefs, John indicated that he designed his teaching to incorporate real-world situations and events.

I like to give information and I like to give it in relative terms, things that they can relate to, examples that they can relate to. Like I was talking about my father-in-law and laser surgery, and what that’s all about and what part that is. How they see things. Giving examples in seventh grade of going through the current events and seeing what’s happening in some places. And we had some great ones this year because certain volcanoes erupted. We had tsunamis. We had all sorts of things happening in specific places of the world. And being able to say why did this happen. (Interview 2)
John wanted his students to ask questions with respect to the news that they were aware of from the media. For example, in the first interview, John stated that “I want them to know--be able to hear something happening on the news--that there was a volcano up in the Alutian Islands and know why, know why that happened” (Interview 1).

With regard to Shared Control, data from John’s interviews were consistent with his CLES responses. He preferred Shared Control more than he perceived he was able to implement it. John indicated that he was very flexible in planning his instruction and was guided by student understanding.

I plan things out about what I think I want to do, but my plan has always been pretty flexible. And I can pretty much change things in mid-stream, fairly easily depending on where they are. You know and if I see that - you get to the point where you just know looks on their face that they’re getting it or they’re not or you look for non-verbals--that tells you what’s happening and so you’ve got to change some things to bring them back. (Interview 1)

On the other hand, John indicated that the curriculum decided by John and his colleagues was based on standards and state testing.

There are certain things that tenth graders are going to be tested on in order to get their diplomas so the OGT, the Ohio Graduation Test, is one of the things along with the national science standards that kind of dictate where we need to be and what we need to cover. That is why we have moved more physical science down into the middle school where we used to be more predominantly on life sciences down there. Well, they get life science in the ninth grade. They wouldn’t get any physical science. They really don’t get any physics until the eleventh grade which is after the test is all done anyway. And so we had to reconfigure things a little bit when we went as a whole department and we went through all the different strands on the OGT as to who would cover what, when, and where and so that’s what’s kind of been driving that. (Interview 2)

On the CLES, John’s preferred classroom practice was somewhat greater than his perceived classroom practice for the constructivist components of Scientific Uncertainty and Student Negotiation. John viewed science as “the process of gaining knowledge.”
John stated that the best thing for students is “to learn to do things and processes because they can take the same process and apply it in other areas and it still works. So, they can understand what the process is, just like the process they do in simple machines” (Interview 2). For John, students should be able to explain why things happened rather than only knowing facts. John indicated that “I want them to go beyond knowing just facts. They have to be able to put facts together and come up with explanations of why things happen in this world” (Interview 1). John added that “Just like, here’s a current event that happened. Why? What do you know that you can put together that explains why this shouldn’t be a surprise to you?” According to John, students should be able to synthesize to explain the big picture. John said “I think you have to know some facts. I think you have to know not the isolated facts. I think you have to be able to put all those things into the big picture” (Interview 2). John indicated that he preferred to do inquiry-type lessons although he did not do them frequently and tended to use lectures, questioning, and discussions most of the time.

I would prefer to try to do it more using a laboratory or inquiry-type basis rather than lecture notes. Lecture notes--I mean I almost feel I do too much of that now anyway. (Interview 1)

With regard to Student Negotiation, John believed that students should be encouraged to work together but he added that he did not always allow students to work together. John said,

I think it’s pretty good when you can give them each a specific kind of a problem to solve or to come up with a solution to it where they [students] have a chance to sit and talk about it, those kinds of things. I’m not real hot on it for general information. (Interview 1)
An unusual result was observed for John’s responses on the CLES for Critical Voice. John’s score for perceived Critical Voice was greater than his score for preferred Critical Voice. John indicated that he preferred that students should be free to talk, be skeptical, and be questioners related to the content they were learning. John believed that skepticism can provide an environment for student discussion and dialogue. He believed in dialogue or discourse to encourage students to question and think.

I would actually like to see them be questioners. “Why does this happen?” Or challenge [me as a teacher]—“I don’t agree with you” or “I don’t understand that.” “Explain that.” Well, I think it’s this way and get into a dialogue because I think when you get into dialogues, you get more learning than you do if you just listen. Because you are thinking--you are trying, you’re putting your mind through a process versus just listening and gaining information. (Interview 1)

*John’s Observed Classroom Practice*

John’s classroom practice was consistent with his beliefs and demonstrated characteristics of progressing constructivist teaching and learning. John’s self-reported responses for his preferred and perceived classroom practice on the CLES were re-examined in light of the observed classroom practice data.

<table>
<thead>
<tr>
<th></th>
<th>Preferred</th>
<th>Perceived</th>
<th>Observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Relevance</td>
<td>20</td>
<td>15</td>
<td>21</td>
</tr>
<tr>
<td>Scientific Uncertainty</td>
<td>15</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Critical Voice</td>
<td>18</td>
<td>20</td>
<td>19</td>
</tr>
<tr>
<td>Shared Control</td>
<td>17</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>Student Negotiation</td>
<td>19</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>89</strong></td>
<td><strong>75</strong></td>
<td><strong>79</strong></td>
</tr>
</tbody>
</table>

*Table 4.17: A comparison of John’s preferred, perceived, and observed classroom practice on the Constructivist Learning Environment Survey.*
Table 4.17 shows the similarities and differences between John’s perceived and observed classroom practice. As shown in Table 4.17, the biggest difference between John’s perceived and observed classroom practice was for the constructivist component of Personal Relevance. Interestingly, his observed score was greater than his perceived score. According to classroom observations and classroom documents, Personal Relevance was a significant part of John’s observed classroom practice. Data from classroom observations suggested that John frequently gave many real-world examples related to the content that he was teaching. For example, when John was teaching electromagnetic waves, he asked students to find examples of the use of each wave such as radio, micro, radar, infrared, visible, and ultraviolet in their daily lives. When he was teaching chemistry, he focused heavily on food chemistry related to nutrition, saturated fat, and unsaturated fat which was personally relevant to students.

The second biggest difference between John’s perceived and observed classroom practice was for the constructivist component of Shared Control. For this component, his perceived score was greater than his observed score. As previously discussed, Shared Control was the least observed component in John’s classroom practice. John exercised autonomy in planning instruction, deciding the content that he taught, and developing assessments. Student input was not solicited for these decisions.

There was a very small difference between John’s perceived and observed classroom practice for both Critical Voice and Student Negotiation (perceived>observed). There was no apparent difference between John’s perceived and observed classroom practice related to Scientific Uncertainty. Most of the time students were encouraged to express their opinions related to instruction and activities. Student Negotiation was
sometimes seen in John’s classroom. John encouraged students to express their opinion and ask questions about the content. John sometimes encouraged students to work together to do a specific project. During projects, students had an opportunity to discuss with their peers and make decisions about their projects.

<table>
<thead>
<tr>
<th>Instructional Activities</th>
<th>Number of Minutes</th>
<th>Time (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole-Class</td>
<td>513</td>
<td>45</td>
</tr>
<tr>
<td>Group Work</td>
<td>453</td>
<td>40</td>
</tr>
<tr>
<td>Individual Student Work</td>
<td>30</td>
<td>3</td>
</tr>
<tr>
<td>Other</td>
<td>133</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>1129</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 4.18: John’s instructional activities in terms of the amount of time spent.

As shown in Table 4.18, John spent 45% of class time in whole-class activities including the use of lectures and worksheets. During whole-class activities, interactions between the teacher and students were more prevalent than interactions among students. Individual student work activities where Student Negotiation was limited occupied 3% of class time.

As shown in Figure 4.11, John spent considerably more class time in whole-class activities and group student work activities than in individual student work activities. John allocated nearly the same amount of class time for group work activities compared to whole-class activities. In the group work projects, students were encouraged to discuss their ideas and make decisions related to their projects.
For example, John assigned a Simple Machines Project in which students were supposed to design, build, and test either a catapult or a trebuchet. John distributed a one-page handout explaining the requirements in terms of size, materials, and journals. Size should be no bigger than 8 cubic feet. Materials could be standard building materials that could have been available at the time of these war machines. Each student was required to keep an individual journal explaining his/her process in detail even though they worked in a group. Journals were to be open-ended and describe specific details about what students thought and did each day. In addition to these requirements, students who were building a catapult were supposed to hit a target as accurately as possible in three tries. Students who were building a trebuchet were supposed to throw a projectile as far as possible. After three measured throws of a projectile, the average was taken to determine the distance. The following vignettes illustrate student engagement and construction of knowledge associated with the Simple Machine Project.
It was a construction day (January 18, 2006). At the beginning of the class, John reminded students that classroom work was a part of their grade and he encouraged them to stay on task. Most of the students were struggling with how to convert the unit, inch, to get 8 cubic feet. John explained that 8 cubic feet did not necessarily have to be 2 by 2 by 2. He said that 4 by 2 by 1 was still 8 cubic feet but just rectangular rather than cubic. All students were trying to figure out how to design their projects. One student was measuring the catapult exhibited in the class to get some ideas about 8 cubic feet. One student turned on the computer and started searching catapult on the Internet. They kept discussing about the size. Most of the students had a reference book called *The Art of Catapult*. They were looking at it and trying to find information about catapults. One student was writing her journal. At the end of the class, John asked students to put their initials on their construction and collected their work to be continued on the next day.

January 19, 2006 was another construction day. The students continued working on their projects. One student worked on the computer. Two more students went to the library. Two of the students measured the catapult. Two girls returned from the library with a large piece of white paper. They put it on the table and drew their designs on it. Three of the students were trying to convert the dimensions.

The following week was another construction day (January 26, 2006). The classroom was very noisy and messy. It looked like a carpentry shop rather than a classroom. Two girls were screwing the wood pieces together. Since there was a gap between the pieces of wood, John helped them to fix it. One student asked for help to cut the wood. One girl was reading a book. Several times, students came to John to ask questions related to their project but John did not give them direct answers and instead
asked the students questions to help them to think and discover the answers by themselves. The following dialogue between John and one student is a good example showing not only how John guided student learning but also how the student constructed their own understanding. One student came to John and asked him how to increase the height of the trebuchet. John asked him how to calculate the volume. The student said to multiply height, width, and length. Then the student measured the width and length of the trebuchet. The student multiplied these two numbers which resulted in 405. He divided 13,824 by 405 and got 34 inches. John said that he could use a height of no more than 34 inches. The student again asked John what to do in order to increase the height. John asked him to think about the dimensions of the volume. Then, the student realized that he could decrease the length in order to increase the height.

When the students tested their projects, all the students were happy and excited especially, the two students whose trebuchets hurled the balls the farthest distance (48’ and 69.4’). Students discussed why the second trebuchet hurled the ball the farthest distance. The student who constructed the first trebuchet said that, “His project had twice as much weight as ours. Ours is 20 pounds and his is 40 pounds.” John summarized the discussion. The trebuchet that had more weight and shorter arms could hurl the ball the furthest.

Students were active learners and were searching for information in order to design their projects. They were supposed to use not only science knowledge but also mathematics, including measurement and geometry, as well as art. After all the students completed their projects by the due date, February 06, 2006, John explained that the most important part of the projects were their journals that they kept during the process rather
than the machine itself since it showed their thinking and decisions. John showed one catapult that had an adjustable angle and said that he has never seen one like that before. John added that it was good to see different constructions.

According to Table 4.16, there was no difference between John’s perceived and observed classroom practice related to Scientific Uncertainty. John encouraged students to use the scientific process rather than just learning facts. As previously discussed, John assigned the Simple Machine Project in order to encourage students to become actively involved in the scientific process. However, historical and cultural aspects of science were not commonly seen in John’s classroom. Data from classroom observations revealed that John wanted his students to be questioners and skeptics. However, he also believed that there were times that students needed to listen and gain basic information. John frequently encouraged students to ask questions and to make connections to develop a meaningful understanding of why things happen.

Generally, there seemed to be some differences between John’s preferred and perceived classroom practice. However, data from interviews and classroom observations revealed that there was little difference between John’s perceived and observed classroom practice and generally John was able to implement most of his beliefs into classroom practice. John indicated that he planned his instruction depending on the outcome he wanted. John stated,

If I want them to get a certain amount of specific facts then I am going to approach it one way. If I want them to take those facts and do something with them then I’m going to approach it in another way. If I wanted them to have certain facts but I don’t want them to know what those facts are, I want them to figure them out for themselves and then I’ll do it in another way. (Interview 2)
Classroom observations documented that John used various instructional and assessment strategies in his classroom. Table 4.19 shows John’s classroom practice with regard to teacher-centered and student-centered activities.

<table>
<thead>
<tr>
<th>Classroom Activities</th>
<th>Number of Minutes</th>
<th>Time (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher-Centered</td>
<td>543</td>
<td>48</td>
</tr>
<tr>
<td>Student-Centered</td>
<td>453</td>
<td>40</td>
</tr>
<tr>
<td>Assessment</td>
<td>133</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>1129</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 4.19: Percentage of time spent in teacher-centered, student-centered, and assessment activities in John’s classroom.

As shown Figure 4.12, John spent nearly the same amount of class time in teacher-centered (48%) and student-centered activities (40%). Teacher-centered activities consisted of lectures with questioning and discussion, worksheets, and problem solving using the Smart board. The student-centered activities included student projects and presentations.
Data from classroom observations suggested that lectures, worksheets, and problem solving using the Smart board were the main types of teacher-centered activities observed in John’s classroom. During the lectures, John asked many questions. John always asked students for their explanations for the examples or events that they were talking about to ensure that students could synthesize what they knew. The following vignette is a good example of how John encouraged students to think and understand why things happened using their prior knowledge.

The lesson was on sound waves. John took a helium tube and a balloon. Students suggested that the tube would explode. John said that it was a helium tube and asked students what they knew about helium. Most of the students said that it was a noble gas. Then John asked for their prediction if the balloon filled with helium, will it explode or not. Students were supposed to apply what they knew about inert gases in order to
respond to his question. Some students said that since helium was an inert gas, it did not react with anything and would not explode. John added that this was the reason why helium is used in balloons. While this discussion was going on about helium, John blew the balloon up with helium gas and inhaled the helium. He started to talk and all the students were surprised because of the change in John’s voice. John started asking a lot of questions about why his voice became different. John added that he did not try to change his voice. One student quietly said that he thought John’s voice changed because molecules vibrated faster. John asked him to repeat his explanation. The student said that because helium was lighter than oxygen. John added that helium was lighter than air. John continued to probe and asked additional questions. John suggested that students think about density and the resistance of helium and air. John also warned students not to do this experiment by themselves since it could create a problem (Classroom Observation, January 24, 2006).

According to data from classroom observations, John always asked questions to encourage students to think more rather than give the students a single answer. The following excerpt from interview 1 supports this view of John.

I don’t - I rarely give them a straight answer. I always ask them a question because that’s what they want to do. They want you to answer the question for them. And I try not to answer the question for them. You heard me, they were asking me questions on all of these. And I never really did give them the answer most of the time.

All data seemed to suggest that John viewed himself as a coach that helped students learn. John’s own words are explicit with regard to his view of his role as a coach.

I’m more like a coach. And that’s how I coach, I teach. When I teach, I coach. … Show them the ways which they can do it, but they are the ones who have to do it. So that’s--I guess that’s how I see it. A teacher is one who doesn’t do things
for people, but has them do it for themselves and is able to get them to know how to do it for themselves and motivate them to do for themselves. (Interview 1)

Worksheets and problem solving using the Smart board were another type of teacher-centered activity observed in John’s classroom. John continuously asked questions related to formulas and next steps while he was solving the problems. The following vignette describes a typical worksheet and problem-solving based activity in John’s classroom.

The lesson was on work (January 12, 2006). All students had the worksheet related to work problems. There were 10 questions on the worksheet. John asked one student the equation for work. Each time, John asked one student for a response to his question that he wrote on the Smart board. John took a book and walked around with it and asked whether he did work or not. All students said “No.” John asked why he was not doing work. A few students suggested that John had force on the book in a vertical direction, but he was moving in a horizontal direction. John approved of their responses. John asked for the power formula which he wrote down on the Smart board. John solved all of the problems by questioning the students and writing the solutions on the Smart board. Table 4.20 shows some examples of problems in John’s classroom. As shown in Table 4.20, the problems solved in John’s classroom were somewhat related to the students’ daily lives.
Problems

You are walking from your science class to your math class. Your book bag weighs 30N. You walked 25m. down the hallway, down a 3m. flight of stairs, and finally another 25m. to the math class. What is the total work performed on your books walking to math class and returning to the science room for study hall the next period?

A train performs 100,000N-m of work pulling a box car filled with Doritos a distance of 50m. What was the force of the train?

If an ant does 2.0N-m of work dragging a piece of sugar a certain distance using a force of .04N, how far did the ant drag the piece of sugar?

If a man riding a bike performs 24,000 joules of work peddling a bike for 30 seconds, how much power did the bicyclist produce?

Table 4.20: Examples of problems in John’s classroom.

Data from interviews and classroom observations suggested that John encouraged students to be active learners and have responsibility for their own learning in student-centered activities. John believed that students should be at the center rather than him. He indicated,

It would be more of them [students] at the center and I’m behind the scenes and asking questions and coaching, more or less. And that’s the way I would actually see something being much more effective is where kids get to be doing things more without me. (Interview 2)

Classroom observations supported John’s belief in promoting active student engagement in their own learning. As shown in Table 4.19, John spent 40% of the classroom time in student group projects and presentations in which students were active learners. The Simple Machine Project previously described is a good example of one of John’s student-centered activities.

John used various assessment strategies to evaluate student learning. Classroom observations, questioning, quizzes and tests, student projects, presentations, and journals
were used to assess student learning in John’s classroom. John indicated that questioning and observation of students were his favorite assessment strategies although most parents found these assessments subjective.

A lot of them are observations where I’ll look at a kid, even read non-verbals with them. Some try not to give you non-verbals. … And I found that out. All you have to do is to ask a question. And then I know they don’t get it. I try not to ask a question of a student that I don’t think they would know. Or I’ll try to lead them through to the right answer. If I have to do a lot of leading, then I know they really don’t have it. I will go back and ask questions about things that they have had previously. Not just for this unit but in a previous unit. “Who can tell me about this?” because I’m looking not for short-term retention but long-term retention. I get more out of a question and the answer part and the observation than I do necessarily the paper-and-pencil test. But that winds up being very subjective and most parents don’t like subjective assessments. (Interview 1)

John also used tests and quizzes. There were several types of questions on his tests and quizzes including multiple-choice, open-ended, blanks to fill in, and true or false. John spent 12% of classroom time on tests and quizzes.

Factors That Influenced John’s Classroom Practice

John identified the following factors that influenced his classroom practice: nature of students, parental involvement, and standards. The nature of the students was one of the most significant factors that influenced John’s classroom practice. John encouraged students to think critically and be questioners. Classroom observations demonstrated that he devoted a great deal of effort to develop activities to promote inquiry-type learning. John also recognized that students do not always want to get challenged or stimulated to think. In the first interview, John explained, I am working on trying to do more inquiry type--where you give them a problem and they have--you don’t give them the solution that you help them work their way through. That’s, I like that, but I’ve always found it kind of challenging because students will give up too easily. They really don’t want to do the work. It’s there
--you know it. They just don’t want to go through the hard work to do it. But I think a lot of them learn a little bit more this way. (Interview 1)

During the Simple Machines Project, John reviewed student journals in order to see their “thinking” and monitor their progress. However, John was not very happy about their journals since most of them did not provide much information about what they did each day.

Most of them are rather incomplete. There’s a few of them that are more complete than the others. But just saying, “Working on my project today” is not very much of a journal entry. It tells me nothing. (Interview 1)

Although students were supposed to have an individual journal that explained his/her own thinking, decisions, and actions, the students who worked in the same group gave almost the same journal other than the use of a different pronoun.

In fact some of them [students] didn’t even get that they were supposed to have their own individual ones even though it was said repeatedly. “You each must have an individual journal. That you tell me about what happened--in relation to you in this project where you can share with me who did the work on what and who didn’t.” … Some of them just changed the pronoun or the name and they’re almost identical. (Interview 1)

Parental involvement was another factor that influenced John’s classroom practice since the school where John was working was a private school.

I think the parental aspect has a lot to do with it. In private schools, you’re not going to send a child here for $15,000 a year and not be involved and expect something from your child plus pay the taxes, whatever it is to your home school. (Interview 2)

John also indicated that as a school they were driven by standards and the Ohio Graduation Test (OGT).

State standards and OGT--[they] are the main things that are driving us here. In the public school system, it is pretty much the standardized testing that drives them because that’s how they get their report card and if they don’t show well on that report card, people aren’t going to be very happy with them. (Interview 2)
However, the teachers in the private school seemed to have more autonomy than those in the public schools. For John, there were not many outside factors that affected his teaching practice. John said,

In a private school, there aren’t a whole lot of factors that affect how you do things because you have a lot more autonomy to do things. You may be a little bit more limited in supplies, in the equipment than you would in the public school. But in the public system, you’re pretty much required to stick to a specific curriculum. (Interview 2)

**Summary of John’s Case**

Data from the preferred and perceived forms of CLES and the interviews suggested that John had progressing constructivist teaching and learning beliefs. John linked constructivism to the application of learning and considered himself a constructivist with regard to this view. John’s responses on the CLES were consistent with data from his interviews. The biggest differences between John’s preferred and perceived classroom practice were for the constructivist components of Personal Relevance and Shared Control. Other differences between John’s preferred and perceived classroom practice included the constructivist components of Scientific Uncertainty and Student Negotiation. An unusual difference between John’s preferred and perceived classroom practice was found for the constructivist component of Critical Voice. For John, Critical Voice had a greater score for his perceived classroom practice than for his preferred classroom practice.

Classroom observations confirmed that John’s observed classroom practice had the characteristics of progressing constructivist teaching and learning. The biggest difference between John’s perceived and observed classroom practice was for the
constructivist component of Personal Relevance. Personal Relevance was observed more frequently in John’s classroom practice compared to what John perceived was happening in his classroom. A small difference between John’s perceived and observed classroom practice (perceived>observed) was revealed for Shared Control, which was also one of the least observed components in John’s observed classroom practice. Other small differences, with the same pattern of perceived classroom practice greater than observed classroom practice, were found for Critical Voice and Student Negotiation. Interestingly, John’s perceived classroom practice was the same as his observed classroom practice for Scientific Uncertainty. Generally, John’s perceived and observed classroom practice revealed similar patterns.

John used a lot of instructional and assessment strategies in his observed classroom practice. John spent 48% of classroom time in teacher-centered activities including lectures, questioning, worksheets, and problem solving using the Smart board. John also spent 40% of classroom time in student-centered activities including student projects and presentations. John also used several assessment strategies including classroom observations, questioning, quizzes and tests, student projects and presentations, and journals. John allocated 12% of classroom time to assessment such as quizzes and tests. John indicated that the nature of students, parental involvement, and standards were the main factors that influenced his classroom practice.
Table 4.21: Summary of the individual case study results.

Table 4.21 presents the summary of the results for the individual case studies. Kathy expressed expert constructivist teaching and learning beliefs. However, Kathy’s observed classroom practice had characteristics of emerging constructivist teaching and learning. Critical Voice had the highest score for Kathy’s preferred (along with Personal Relevance), perceived, and observed classroom practice on the Constructivist Learning Environment Survey. Scientific Uncertainty had the lowest score for Kathy’s preferred and perceived classroom practice while Shared Control had the lowest score for Kathy’s preferred and observed classroom practice. Kathy spent more class time in whole-class activities.

<table>
<thead>
<tr>
<th>Classroom Practice</th>
<th>Kathy</th>
<th>Mike</th>
<th>Patrick</th>
<th>John</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expressed Constructivist Beliefs</td>
<td>Expert</td>
<td>Emerging</td>
<td>Expert</td>
<td>Progressing</td>
</tr>
<tr>
<td>Observed Constructivist Practice</td>
<td>Emerging</td>
<td>Transitional</td>
<td>Progressing</td>
<td>Progressing</td>
</tr>
<tr>
<td>Highest Preferred</td>
<td>PR, CV</td>
<td>SN</td>
<td>PR, SN, SU</td>
<td>PR, SN</td>
</tr>
<tr>
<td>Highest Perceived</td>
<td>CV</td>
<td>SN</td>
<td>CV</td>
<td>CV</td>
</tr>
<tr>
<td>Highest Observed</td>
<td>CV</td>
<td>CV</td>
<td>PR</td>
<td>PR</td>
</tr>
<tr>
<td>Lowest Preferred</td>
<td>SU, SC</td>
<td>SC</td>
<td>CV</td>
<td>SU</td>
</tr>
<tr>
<td>Lowest Perceived</td>
<td>SU</td>
<td>SC</td>
<td>SC</td>
<td>SU, SC</td>
</tr>
<tr>
<td>Lowest Observed</td>
<td>SC</td>
<td>SC</td>
<td>SC</td>
<td>SC</td>
</tr>
<tr>
<td>Instructional Activities</td>
<td>W&gt;I&gt;G/O</td>
<td>W&gt;I&gt;G&gt;O</td>
<td>W&gt;G&gt;O&gt;I</td>
<td>W/G&gt;O&gt;I</td>
</tr>
<tr>
<td>Classroom Activities</td>
<td>T&gt;S&gt;A</td>
<td>T&gt;S&gt;A</td>
<td>S&gt;T/A</td>
<td>T/S&gt;A</td>
</tr>
</tbody>
</table>

activities than in individual student work. Group work and other activities were not common in Kathy’s observed classroom. Kathy also spent more class time in teacher-centered activities than in student-centered activities.

Mike expressed emerging constructivist teaching and learning beliefs. However, Mike’s observed classroom practice was transitional. Although there was no pattern on any component that had the highest score, Shared Control had the lowest score for Mike’s preferred, perceived, and observed classroom practice. Mike spent more class time in whole-class activities than in individual student work. Group work and other activities were not prevalent in Mike’s observed classroom.

Patrick expressed expert constructivist teaching and learning beliefs. However, Patrick’s observed classroom practice was progressing constructivist teaching and learning. Personal Relevance had the highest score for Patrick’s preferred and observed classroom practice. Shared Control had the lowest score for Patrick’s perceived and observed classroom practice. Patrick spent more class time in whole-class activities than in group work. Individual student work and other activities were not dominant in Patrick’s observed classroom practice. Patrick spent more class time in student-centered activities than in teacher-centered activities.

John was the only teacher whose constructivist teaching and learning beliefs and observed classroom practice was consistent. John had progressing constructivist teaching and learning beliefs and classroom practice. Personal Relevance had the highest score for John’s preferred and observed classroom practice. Scientific Uncertainty had the lowest score in John’s preferred and perceived classroom practice. Shared Control had the lowest score in John’s perceived and observed classroom practice. John spent almost
equal amounts of class time in whole-class and group work activities. Individual student work and other activities were not dominant in John’s observed classroom practice. John also spent almost equal amounts of class time in teacher-centered and student-centered activities.
CHAPTER 5

CROSS-CASE STUDY RESULTS

The purpose of the study was to identify science teacher beliefs and classroom practice related to constructivist teaching and learning and factors that may affect teacher classroom practice. As described in Chapter 3, four different case studies were developed for science teachers in two different school settings and different grade levels for over 4 months in order to respond the following research questions:

1. What are the beliefs that teachers have regarding constructivist teaching and learning?
2. How do teachers embody their beliefs about constructivist teaching in science classrooms? Are these beliefs consistent with their classroom practice?
3. What factors influence teachers’ use of constructivism in their classrooms?

In Chapter 4, each case was described individually in detail in terms of classroom context, teacher preferred and perceived beliefs, observed classroom practice, factors that influenced teacher classroom practice, and a summary. This chapter addresses the research questions, presents a cross-case analysis to compare all 4 cases in terms of their
Research Questions

Research Question 1

Research question 1 is “What are the beliefs that teachers have regarding constructivist teaching and learning?” According to data from the interviews and the preferred and perceived forms of the CLES, teacher beliefs related to constructivist teaching and learning varied from emerging constructivist to expert constructivist teaching and learning. According to data from the interviews, teachers expressed a variety of beliefs related to constructivism. However, most of their beliefs about constructivism were centered on hands-on activities and projects. Kathy viewed constructivism as “a great equalizer” and believed that “constructivism is a great way for all kids to learn” and that it “helps them internalize in ways that make sense for them.” But she also believed that it was “hard to make it a reality” (Interview 2). Mike defined constructivism as “using a variety of teaching styles and materials particularly hands-on projects” (Interview 2). Then, Mike added that he used it all the time. For Patrick, constructivism was “giving them [students] knowledge about a subject and having them construct their understanding of it, putting it together somehow” (Interview 2). Patrick’s example of constructivism was based on meaningful learning by making connections among concepts. However, Patrick added that “at times I do implement it, at times I cannot” (Interview 2). According to John, constructivism was “nothing different than the old hands-on approach to science” (Interview 2). John used the term application rather than constructivism and considered himself to be closer to this view of constructivism. John said “I think I would lean more to the constructivism side, the application end of it”
However, John did not perceive that he would totally implement constructivism in his classroom.

In summary, data from the CLES and interviews suggested that Kathy and Patrick expressed expert constructivist teaching and learning beliefs. Mike expressed emerging constructivist teaching and learning beliefs and John expressed progressing constructivist teaching and learning beliefs.

<table>
<thead>
<tr>
<th>Classroom Practice</th>
<th>Kathy</th>
<th>Mike</th>
<th>Patrick</th>
<th>John</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preferred</td>
<td>PR (SU)</td>
<td>SN (SC)</td>
<td>PR (CV)</td>
<td>PR (SU)</td>
</tr>
<tr>
<td></td>
<td>CV (SC)</td>
<td></td>
<td>SN</td>
<td>SN</td>
</tr>
<tr>
<td></td>
<td>SN</td>
<td></td>
<td>SU</td>
<td></td>
</tr>
<tr>
<td>Perceived</td>
<td>CV (SU)</td>
<td>SN (SC)</td>
<td>CV (SC)</td>
<td>CV (SU)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(SC)</td>
</tr>
</tbody>
</table>

*Note. PR=Personal Relevance. SU=Scientific Uncertainty. CV=Critical Voice. SC=Shared Control. SN=Student Negotiation. Italics in parentheses indicate the lowest scores.*

Table 5.1: Highest and lowest component scores for preferred and perceived classroom practice on the Constructivist Learning Environment Survey across all 4 cases.
As shown in Table 5.1 and Figure 5.1, Personal Relevance and Student Negotiation were the most frequently preferred components of constructivism across all 4 teachers based upon a comparison of the five components of Personal Relevance, Scientific Uncertainty, Critical Voice, Shared Control, and Student Negotiation on the CLES. Interviews confirmed that all participants believed that school science should be relevant to student lives outside of school. They also believed that students could learn from each other by discussing ideas and concepts. Although there was no discernible pattern with regard to the least preferred constructivist component of classroom practice, both Scientific Uncertainty and Shared Control were among the least preferred components across the 4 cases.
Figure 5.2: Comparison of self-reported results on the perceived form of the Constructivist Learning Environment Survey across all 4 cases

Data from the perceived form of the CLES revealed that the teachers did not seem to implement all of their beliefs into classroom practice. As shown in Table 5.1 and Figure 5.2, Critical Voice was the most perceived constructivist component. Interestingly, Critical Voice was the only component for Patrick and John that they perceived in their classroom practice more than they preferred while Kathy and Mike equally perceived and preferred Critical Voice in their classroom practice. A possible explanation may be related to school type. Since Patrick and John worked in a private school, they may have felt the need to implement Critical Voice in their classroom more than they preferred. Across all 4 teachers, Shared Control was the least frequently perceived constructivist.
component in their classrooms. Data from the interviews confirmed that all teachers decided what they teach, which activities they do, and how they evaluate based upon the standards and their choices. All teachers felt the need to follow the curriculum based upon standards. They were the main people who had autonomy to decide what to teach and how to teach.

Research Question 2

Research question 2 is “How do teachers embody their beliefs about constructivist teaching in science classrooms? Are these beliefs consistent with their classroom practice?” Teacher self-reported responses for their preferred and perceived classroom practice on the CLES were re-examined in light of the observed classroom practice data.

<table>
<thead>
<tr>
<th></th>
<th>Kathy</th>
<th>Mike</th>
<th>Patrick</th>
<th>John</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed</td>
<td>CV (SC)</td>
<td>CV (SC)</td>
<td>PR (SC)</td>
<td>PR (SC)</td>
</tr>
</tbody>
</table>

*Note. PR=Personal Relevance. SU=Scientific Uncertainty. CV=Critical Voice. SC=Shared Control. SN=Student Negotiation.*

Table 5.2: Comparison of observed classroom practice across all 4 cases.
As shown in Table 5.2 and Figure 5.3, there was no discernable pattern with regard to the most frequently observed constructivist component. However, Critical Voice was observed most of the time in Kathy’s and Mike’s classrooms and Personal Relevance was observed most of the time in Patrick’s and John’s classrooms. Shared Control was the least frequently implemented constructivist component by all of the teachers.

Table 5.3: Comparison of instructional activities in terms of the amount of time spent across all 4 cases.

<table>
<thead>
<tr>
<th>Instructional Activities</th>
<th>Kathy</th>
<th>Mike</th>
<th>Patrick</th>
<th>John</th>
</tr>
</thead>
<tbody>
<tr>
<td>W&gt;I&gt;G</td>
<td></td>
<td></td>
<td>W&gt;G&gt;I</td>
<td>W/G&gt;I</td>
</tr>
</tbody>
</table>

Note. PR=Personal Relevance. SU=Scientific Uncertainty. CV=Critical Voice. SC=Shared Control. SN=Student Negotiation.

Figure 5.3: Comparison of observed classroom practice across all 4 cases.
Figure 5.4: Comparison of instructional activities in terms of the amount of time spent across all 4 cases

All of the teachers used a variety of instructional strategies. However, as shown in Table 5.3 and Figure 5.4, according to data from classroom observations, all of the teachers most frequently spent class time in whole-class activities. However, Patrick and John allocated more of their class time to do group work activities and Kathy and Mike spent more of their class time in individual student work activities. A possible explanation is the nature of the students in the different school settings. Student misbehavior in Kathy’s and Mike’s classrooms may have been a factor affecting their choice of using individual student work over group work. On the other hand, Patrick and John may have chosen more group work because they did not have concerns about student behavior. Data from interviews confirmed that Kathy and Mike were concerned about student misbehavior and selection of group members. For example, Kathy said,

There are certain students who do not want to talk to certain students. If they can pick their group, they want to pick certain people. Even science kids want to pick certain people to be in their group. (Interview 1)
Mike also indicated a similar concern about group work. Mike stated,

I like group work a lot but if they get distracted by talking, then I switch them or tell them “Next time you talk and you do not work, then you are not going to work together.” (Interview 1)

For Patrick, students had different personalities which sometimes created a problem in group work. However, Patrick believed that group membership problems could be solved in a few days and that students needed to learn to work together.

According to data from classroom observations, teacher-centered activities included lectures, questioning, discussions, worksheets, and videos/demonstrations. Student-centered activities included student projects, presentations, and hands-on activities. Both teacher-centered and student-centered activities were observed in all 4 teachers’ classrooms. Table 5.4 shows the patterns of class time spent in teacher-centered, student-centered, and assessment activities across all 4 cases.

<table>
<thead>
<tr>
<th>Classroom Activities</th>
<th>Kathy</th>
<th>Mike</th>
<th>Patrick</th>
<th>John</th>
</tr>
</thead>
<tbody>
<tr>
<td>T&gt;S&gt;A</td>
<td>T&gt;S&gt;A</td>
<td>S&gt;T/A</td>
<td>T/S&gt;A</td>
<td></td>
</tr>
</tbody>
</table>

Table 5.4: Patterns of time spent in teacher-centered, student-centered, and assessment activities across all 4 cases.
As shown in Table 5.4 and Figure 5.5, three teachers spent more time in teacher-centered activities than student-centered activities in their classrooms. Only Patrick allocated more class time to student-centered activities than teacher-centered activities. An average of approximately 10% of class time was allocated to assessments including quizzes and tests.

In summary, teacher expressed beliefs were not consistent with their classroom practice. Teacher preferred and perceived beliefs varied from emerging to expert constructivist teaching and learning. However, observed classroom practice varied from transitional to progressing constructivist teaching and learning.

**Research Question 3**

Research question 3 is “What factors influence teachers’ use of constructivism in their classrooms?” Teacher beliefs appear to be a strong influential factor but may not be
the only factor that influences classroom practice. In the current study, the most widespread self-reported factor that influenced teacher practice was the nature of students and student ability. According to data from the interviews, all 4 teachers indicated their concerns about the nature of students and their ability to do activities. Kathy believed that students wanted to do worksheets so that they could be easily and quickly done rather than do inquiry activities that would require more time and a higher level of thinking.

They just want a worksheet where they can read something and some questions and be done. ... They want to know what the answer is. They don’t want to have to think. (Inquiry 2)

Kathy also indicated that it is difficult to implement constructivism in classrooms that do not have high-level students.

It’s difficult to make it [constructivism] a reality unless you are dealing with a group of high-level students in a high income area where you don’t need to spend as much time on basic skills. (Interview 2)

Similarly, Mike believed that inquiry-type lessons associated with constructivism were especially appropriate for high-level students. He also was concerned that students during inquiry activities would give up or proceed down the wrong path. Mike believed that students need lectures and notes to understand some content and learn facts. In the second interview, Mike said,

Sometimes they may go the wrong path. They may think they’re doing something right but they’re not. And then, if you don’t stop them, then they may do wrong stuff, go in the wrong direction. (Interview 2)

Although Patrick assigned open-ended projects to the students, he also indicated that his students as sixth graders disliked open-ended projects because they were coming out of fifth grade and were used to being spoon-fed everything. Patrick also added that his students tended to want to find answers in the easiest way.
And the sixth grade is--they’re looking for the easiest way to get the easiest answer so they don’t have to work with this any more. Unfortunately, they will do the minimum to answer the question and that’s it. (Interview 2)

Similarly, John indicated that students wanted to get an answer rather than be challenged.

Students will give up too easily. They really don’t want to do the work. It’s there. … They just don’t want to go through the hard work to do it. (Interview 1)

According to the teachers, the students did not want to get challenged and wanted to get answers without too much thinking or effort.

School type such as public versus private and grade level were other factors that strongly influenced teacher practice. Kathy and Mike were teaching in the public school and the district curriculum and standardized testing seemed to have more of an impact on their practice compared to Patrick and John who taught in the private school; although, they all cited these influential factors. Patrick and John were teaching in the private school and had more autonomy to modify their curriculum and instruction as needed. On the other hand, Patrick and John reported more parental influence on their curriculum and instruction since the school where they worked was a private school. There may be a pattern that indicates that the higher the grade level, the less likely the teachers will use student-centered activities. Kathy and Mike were teaching in a high school and tended to use more teacher-centered activities such as lectures, worksheets, and videos/demonstrations in their classrooms. In contrast, Patrick and John were teaching in a middle school and tended to use more student-centered activities such as projects and presentations in their classrooms. Moreover, there may be some interaction with the public-private school setting as well.
Summary

Data sources for the cross-case analyses included interviews and responses to the preferred, perceived, and observed Constructivist Learning Environment Survey. For all data sources, cross-case patterns were reported based upon a majority (3/4) across the 4 cases. These emergent patterns were aligned with the research questions. Chapter 6 will use these patterns to identify specific findings aligned with the research questions and discuss the findings in relationship to the literature, implications, and future research.
CHAPTER 6

CONCLUSIONS AND DISCUSSION

This chapter consists of three main parts. The first part of the chapter presents a brief description and summary of the study. The second part of the chapter discusses the overall findings of the study in terms of the research questions and comparisons with other research studies in the literature as described in Chapter 2. The last part of the chapter provides implications for teacher education programs and policy makers and curriculum developers along with suggestions for further research in science education.

Summary of the Study

Constructivist teaching and learning is the current reform movement recommended by the National Science Education Standards (NRC, 1996; Rutherford & Ahlgren, 1990) and supported by the literature in science education (Brooks & Brooks, 1999; Dewey, 1916; Duit & Treagust, 1998; Fosnot, 1996; Gallagher, 1993; Piaget, 1950, 1964, 1970a, 1970b; von Glasersfeld, 1995a, 1995b; Vygotsky, 1978; Wadsworth, 1978; Yager, 2000). This new way of teaching and learning requires a major shift in the activities used in science classrooms. On the other hand, although there has been an intensive call for the implementation of the constructivist reform movement, the research
suggests that there has not been a significant change in science classroom activity (Davis, 2003; Gallagher, 1991; Tobin & Fraser, 1989; Tobin & Gallagher, 1987; Weiss, 1997).

At the same time, the research related to teacher beliefs and classroom practice has received significant attention by the education community. Many scholars believe that teacher beliefs are one of the key factors in successfully implementing any reform movement (Bybee, 1993; Haney, et al., 1996; Levitt, 2002; Nespor, 1987; Pajares, 1992; Tobin et al., 1994).

This study was an exploratory case study of teacher beliefs and classroom practice related to constructivist teaching and learning. The main purposes of the study were to identify in-service science teacher beliefs and classroom practice related to constructivist teaching and learning and to examine factors that may influence their classroom practice in different school settings. In order to answer the following research questions, individual case and cross-case analyses with four science teachers were conducted.

1. What are the beliefs that teachers have regarding constructivist teaching and learning?
2. How do teachers embody their beliefs about constructivist teaching in science classrooms? Are these beliefs consistent with their classroom practice?
3. What factors influence teachers’ use of constructivism in their classrooms?

As described in Chapter 3, four different science teachers in two different school settings and different grade levels were purposively selected for the study. Two of the teachers were teaching science in a public high school while the other two teachers were teaching science in a private middle school. The data collection process took more than 4 months and data was collected through the Constructivist Learning Environment Survey.
(Taylor et al., 1994), interviews, classroom observations, and classroom documents. Data were collected, organized, and then analyzed in two ways as suggested by Merriam (1998): individual case analysis and cross-case analysis. The findings of the study as related to other literature will be discussed in the next part of the chapter.

Discussion of the Study in Relationship to the Literature

As discussed in Chapter 2, studies related to the relationship between teacher beliefs and classroom practice are well documented in the literature. Although some studies (Cronin-Jones, 1991; Haney & McArthur, 2002; Haney et al., 1996, 2002; Levitt, 2002) found that teacher beliefs are consistent with classroom practice, others found that teacher beliefs do not necessarily influence classroom practice (Hancock & Gallard, 2004; Lederman, 1999; Lederman & Zeidler, 1987; Mellado, 1998). Although the relationship between teacher beliefs and practice is controversial; in either case, beliefs ultimately connect to practice (Richardson, 1996; Roehrig & Luft, 2004).

The findings of the current study offer important insights related to the literature about the relationship between teacher beliefs and classroom practice. The overall findings of the current study along with a discussion of each finding follows:

1. Teachers generally reported that they held constructivist teaching and learning beliefs.

2. Teachers generally reported that they implemented constructivist teaching and learning beliefs in their classrooms but not as much as they preferred.

3. Teachers generally perceived their implementation of constructivist teaching and learning to be greater than their observed classroom practice.
According to the findings of the study, 3 of the 4 teachers had difficulty incorporating their beliefs into classroom practice. For example, Kathy and Patrick reported expert constructivist teaching and learning beliefs. Yet, Kathy’s observed classroom practice demonstrated emerging constructivist teaching and learning while Patrick’s classroom practice demonstrated progressing constructivist teaching and learning. Mike expressed emerging constructivist teaching and learning beliefs, but his classroom practice had the characteristics of transitional teaching and learning. These finding are consistent with studies that indicate inconsistency between teacher beliefs and classroom practice (Mellado, 1998; Simmons et al., 1999). Only one teacher demonstrated consistency between his expressed beliefs and his observed classroom practice. John was the only teacher who seemed to be able to incorporate his beliefs into classroom practice. John’s reported preferred and perceived beliefs and observed classroom practice were more consistent compared to the other teachers. He expressed progressing constructivist teaching and learning beliefs and these progressing constructivist teaching and learning beliefs were implemented in his classroom. His extensive years as a teacher and as an administrator in varied settings may have enabled him to more successfully implement his constructivist teaching and learning beliefs into classroom practice.

4. Personal Relevance and Student Negotiation were the most frequently preferred components of constructivism.

Three of the teachers stressed the importance of Personal Relevance in science classrooms in the preferred form of the CLES. In the interviews, Kathy, Patrick, and John emphasized that school science should be relevant to student lives outside of school to foster positive attitudes toward science and to promote student science understanding.
This finding is consistent with the findings of Levitt’s (2002) study. In her study, elementary teachers believed that the learning of science should be personally meaningful to students and that science education should foster positive attitudes toward science.

Generally, Kathy, Patrick, and John were able to implement Personal Relevance in their classrooms. However, Personal Relevance was not generally observed in Mike’s classroom.

5. Critical Voice was the most perceived component of constructivism in science classrooms.

There was no difference between Kathy’s and Mike’s preferred and perceived classroom practice regarding Critical Voice. Both of the teachers highlighted the importance of Critical Voice and implemented it in their classroom. On the other hand, an unusual result was seen between Patrick’s and John’s preferred and perceived classroom practice with regard to Critical Voice. They indicated that they implemented Critical Voice more frequently than they preferred. The reason for this situation may be related to the school setting for Patrick and John. Since the school was a private school, they may have felt more of a need to implement Critical Voice to meet parental and student expectations.

6. Shared Control was one of the least preferred and was the least frequently perceived and the least frequently implemented component of constructivism in science classrooms.

Teachers in the current study expressed their need to follow the existing science curriculum, similar to the teachers in the studies conducted by Haney and McArthur (2002) and Tobin and Gallagher (1987). Haney and McArthur categorized teacher beliefs as either core beliefs or peripheral beliefs. Haney and McArthur found Shared Control to
be a peripheral belief that teachers were unable to implement due to the belief in the need to stick to the existing local science curriculum. Their finding is supported by the findings of the current study. Moreover, in the current study, teachers also expressed their belief in the need to prepare students to be successful on standardized, state-level tests and that the teacher’s role was to identify the content to be learned and align instructional activities with the test demands. This finding is consistent with the research of Tobin and McRobbie (1996) who identified cultural myths such as maintaining the rigor of the curriculum and preparing students to be successful on examinations as obstacles to implementing reform in science classrooms.

7. Whole-class activities were most frequently observed in all science classrooms. Whole-class activities included lecture, worksheets, videos/demonstrations, and hands-on activities directed by the teacher and involving all students. In whole-class activities, the interaction between the teacher and students was more dominant than the interaction among students. Teachers working in the private middle school tended to spend more class time in group work than those working in the public high school. According to Brooks and Brooks (1999) and Yager (2000), group learning, where two or three students discuss approaches to a given problem with little interference from the teacher, is highly encouraged in constructivist classrooms. However, group work was occasionally observed in the science classrooms in the public high school. Teachers working in the public high school tended to devote more class time to individual student work than those in the private middle school. Yet, teachers in the public high school indicated that they preferred to do group work and wanted students to work in groups. A possible explanation for this discrepancy between beliefs and practice in the public high school
may stem from teacher concerns related to classroom management. Since Kathy and Mike had more student misbehavior and student drop-out in their classrooms, they did not seem to provide much opportunity for students to work in groups compared to Patrick and John.

8. The teachers working in the private middle school tended to use more student-centered activities in their classrooms while teachers working in the public high school tended to use more teacher-centered activities in their classrooms. Almost all of the teachers expressed student-centered teaching and learning beliefs. However, not all of them were able to incorporate their beliefs into classroom practice. Student-centered activities where students have more responsibility for their own learning and are actively engaged in activities such as hands-on activities, projects, presentations, and student group discussions were more dominant in science classrooms in the private middle school. On the other hand, teacher-centered activities where the teacher had the primary responsibility to deliver instruction to students through activities such as lectures, worksheets, and videos/demonstrations were more prevalent in science classrooms in the public high school. This pattern may be due to the difference between private and public school or the difference between grade levels or the difference based upon both type of school and grade level. Patrick and John indicated that they had more autonomy to decide activities and modify the curriculum since they were working in a private school. Patrick and John indicated that in a private school, parental involvement was a significant factor that influenced their classroom practice, including the expectation for more student-centered activities. They indicated that they felt the need to select activities that were enjoyable to students so that parents were satisfied.
Also, there seems to be a pattern that indicates the higher grade level that teachers teach, the less likely they are to use student-centered activities. One of the reasons for this pattern may come from the fact that teachers in high schools may feel more pressure to prepare students to be successful on the high-stake exams such as Ohio Graduation Test. But teachers at lower grades in middle schools may not feel the same need to prepare students for high-stake exams. Kathy and Mike more frequently stated that standardized testing was a significant factor that influenced their practice in the high school. Thus, school type (private vs. public) and grade level seem to be a combination of factors that may influence teacher practice with regard to the use of teacher-centered and student-centered activities.

9. The most frequently self-reported challenge to implementing constructivist teaching and learning beliefs was the nature of students and student ability. All of the teachers indicated that the nature of students and student ability were factors that influenced their classroom practice. Kathy and John indicated that students did not want to think and get challenged, but wanted teachers to provide the answers so that they could quickly complete their work. Kathy also indicated that low student motivation and student diversity in terms of background, ability, and achievement affected her implementation of constructivist teaching and learning. Patrick indicated that sixth-grade students were used to being spoon-fed everything and they needed direction to do activities. Both Kathy and Mike indicated that inquiry-type teaching and/or constructivism was for higher-level students. This finding is also supported by the literature. For example, in the Cronin-Jones (1991) study, teacher beliefs about the ability of students in a particular age group influenced the implementation of a standard-based
curriculum which was grounded in constructivist teaching and learning. The teachers in the Cronin-Jones study believed that middle school students require a great deal of direction and this belief was reflected in their classrooms. Roehrig and Luft (2004) conducted a study to understand factors that impacted the inquiry-based instruction of 14 beginning secondary science teachers who were enrolled in an induction program designed to assist beginning secondary teachers. In this study, 8 of 14 teachers held traditional beliefs. One of the constraints reported was teacher concerns about management and student ability. Low student ability and motivation were reported as the most prevalent constraints among the beginning teachers.

10. Teachers used various assessment strategies in their classrooms but they were primarily traditional types of assessments.

According to the findings of the current study, teachers primarily used traditional assessment strategies such as quizzes, tests, worksheets, class work, and homework. Some alternative assessment strategies such as projects and presentations were also used but to a lesser extent. Most of the assessment strategies were interwoven with teaching strategies as indicated by Brooks and Brooks (1999). Teachers spent approximately 10% of class time in assessment such as quizzes and tests.

In conclusion, although teachers frequently expressed constructivist teaching and learning beliefs, they had difficulty incorporating their beliefs into classroom practice. Shared Control was the least implemented component of constructivism while Critical Voice was the most perceived component of constructivism in science classrooms. Whole-class activities were the most common type of activity observed in all classrooms. Group work and student-centered activities were more commonly observed in the private
middle school science classrooms compared to the public high school science classrooms. All teachers used a variety of assessment strategies in their science classrooms but they predominantly used traditional quizzes and tests.

There appears to be several factors that influenced teacher classroom practice. One of the most prevalent self-reported obstacles that influenced classroom practice was teacher beliefs about student ability and student motivation. Teacher beliefs appear to be a strong factor but may not be the only factor that influences classroom practice. For the current study, school type (public vs. private) and grade level appear to be overarching factors that influence teacher classroom practice.

Based upon the literature and the findings of the current study, Figure 6.1 provides a model showing the relationship between teacher beliefs and classroom practice. According to this model, teacher beliefs can be shaped by teacher education, teacher prior experiences, and teacher content and pedagogical content knowledge. Teacher beliefs may also be influenced by school type (public vs. private) and grade level. Finally, teacher beliefs may be filtered through many factors such as the nature of students, student misbehavior and background, student knowledge and levels, time, standards, content, state testing, standardized testing, parental involvement, school resources, and teacher creativity that eventually may affect classroom practice.
In light of the findings of the current study, there may be several key implications for teacher education programs. Since one of the main findings was that teachers had difficulty in incorporating their beliefs related to constructivist teaching and learning into classroom practice, teacher education programs should provide teachers with methods and opportunities to implement constructivist teaching and learning in their classrooms. Pre-service teacher education programs should focus on more opportunities for pre-
service teachers to experience constructivist teaching and learning in their university content and method courses. Teacher education programs also could provide in-service teachers with opportunities for workshops and inductive programs where they could engage in and experience how to incorporate constructivist teaching and learning beliefs into classroom practice. During these experiences and as follow-up, collaboration between teachers and teacher educators can help teachers solve problems that may arise in their classrooms as they implement constructivist teaching and learning. Teacher education programs also can provide both pre-service and in-service teachers with instructional materials and curriculum packages based on principles of constructivist teaching and learning. This would provide teachers with more teaching ideas and resources to implement constructivist teaching and learning in their classrooms.

According to the findings of the current study, classroom management and student drop-out seemed to be a major concern for teachers especially for those with a diverse student population in their classroom. Apparently, teachers are not well prepared to deal with student misbehavior and student drop-out and they are unsure of how to provide a safe learning environment. Teacher education programs should provide pre-service teachers with course work and field experiences and in-service teachers with workshops and inductive programs on how to solve problems associated with diverse student backgrounds, low student motivation, and low student achievement as well as strategies, methods, and resources to provide equal opportunities for all students. Since science should be for all students, it is very crucial to prepare teachers for classrooms of diverse students.
Policy Makers and Curriculum Developers

There may be some significant implications for policy makers and curriculum developers. According to the findings of the current study, curriculum, state testing, and time were reported by teachers as significant factors that may influence their classroom practice. Since constructivist teaching and learning focuses on learners rather than content, teachers should be empowered to adjust curriculum based on student interest and need. However, in the current study teachers, especially those working in the public school did not have much autonomy to adjust curriculum based on student interest and needs due to state testing and content standards. Teachers seemed to be in conflict between achieving content standards and implementing constructivist teaching and learning. Policy makers and curriculum developers should modify curriculum and give teachers more autonomy to adjust the curriculum and their teaching practice based on student background, needs, and interests.

Suggestions for Further Research

There are some limitations associated with the current study. One of the limitations of the study is lack of generalizability. Since it is a case study design with a small number of participants, the findings from this study may not be generalized to other teachers. Since the current study included two science teachers from a private middle school and two science teachers from a public high school, further research should be designed with two teachers from a public middle school and two teachers from a private high school in order to understand how school type (public versus private and/or grade levels) may influence teacher classroom practice.
This study completely focuses on teacher beliefs even though students, administrators, and parents are other important elements of the school community. The findings of the study reflect the teacher’s point of view. However, students, principals, and parents may have different beliefs than those indicated by the teachers. Therefore, case studies focusing on not only teachers but also students, principals, and parents perspectives could be designed in order to better understand school context and school climate while implementing constructivist teaching and learning.

In addition, this study investigates only teacher beliefs related to constructivist teaching and learning. However, there may be other factors that may influence teacher classroom practice while implementing constructivist teaching and learning such as teacher content knowledge, teacher pedagogical content knowledge, and teacher views of the nature of science. These factors were not considered in the current study. Further research could focus on the relationship between teacher beliefs and classroom practice along with these other potential factors.

Moreover, in this study, data from the interviews suggested some factors such as school type (public versus private), grade levels, nature of students and student ability, state standards and state testing, time, school resources, parental involvement, content, and teacher creativity that may affect teacher classroom practice. However, this study could not provide evidence beyond self-reported data as to which factor(s) significantly impacted teacher classroom practice. In addition to these factors indicated in the current study, other potential factors such as teacher age and experience, gender, and subjects being taught could be considered for further researcher. Therefore, further research could
be designed in order to understand which factors may significantly affect classroom practice.

The findings of the current study also raise other questions for educators to consider and investigate. What do students think about constructivist teaching and learning? How do teachers implement constructivist teaching and learning in diverse classroom settings? How does constructivist teaching and learning affect student learning? Educators should investigate these areas to help improve science teaching and learning at all levels, pre K-16.
LIST OF REFERENCE


APPENDIX A

CONSTRUCTIVIST CATEGORIES
<table>
<thead>
<tr>
<th>Questions</th>
<th>Didactic</th>
<th>Transitional</th>
<th>Emerging Constructivist</th>
<th>Progressing Constructivist</th>
<th>Expert Constructivist</th>
</tr>
</thead>
<tbody>
<tr>
<td>How do you define learning?</td>
<td>• Recall definitions and equations.</td>
<td>Most of teacher responses fall under didactic views and only one response fall under expert constructivist views</td>
<td>Teacher responses are a mix of didactic and expert constructivist views.</td>
<td>Most of teacher responses fall under expert constructivist views.</td>
<td>• Build their understanding by using prior knowledge and experiences.</td>
</tr>
<tr>
<td></td>
<td>• Follow a particular procedure to solve a problem.</td>
<td></td>
<td></td>
<td></td>
<td>• Make judgments about ideas.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Use a concept in a new situation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Find real-world examples.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Integrate problems with other disciplines.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Make connections among concepts.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Not only recall knowledge but also comprehend the meaning of the task.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Design own investigation.</td>
</tr>
<tr>
<td>How do you define teaching?</td>
<td>• Transmit scientific knowledge to students.</td>
<td>Most of teacher responses fall under didactic views and only one response fall under expert constructivist views</td>
<td>Teacher responses are a mix of didactic and expert constructivist views.</td>
<td>Most of teacher responses fall under expert constructivist views.</td>
<td>Provide an environment in which students</td>
</tr>
<tr>
<td></td>
<td>• Controlling student homework.</td>
<td></td>
<td></td>
<td></td>
<td>• Take own responsibility for their learning.</td>
</tr>
<tr>
<td></td>
<td>• Prepare students for exams.</td>
<td></td>
<td></td>
<td></td>
<td>• Question ideas.</td>
</tr>
<tr>
<td></td>
<td>• Maintain quiet classroom environment.</td>
<td></td>
<td></td>
<td></td>
<td>• Offer multiple solutions to a problem.</td>
</tr>
<tr>
<td></td>
<td>• Follow the curriculum and guidelines.</td>
<td></td>
<td></td>
<td></td>
<td>• Make decisions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Ask and investigate questions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Be creative/skeptical and curious.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Communicate with others.</td>
</tr>
<tr>
<td>How do you believe your students learn best science?</td>
<td>• Lectures, demonstration</td>
<td>Most of teacher responses fall under didactic views and only one response fall under expert constructivist views</td>
<td>Teacher responses are a mix of didactic and expert constructivist views.</td>
<td>Most of teacher responses fall under expert constructivist views.</td>
<td>• Active student involvement</td>
</tr>
<tr>
<td></td>
<td>• Notes, worksheets, books</td>
<td></td>
<td></td>
<td></td>
<td>• Take responsibility for their learning.</td>
</tr>
<tr>
<td></td>
<td>• Drill and Practice</td>
<td></td>
<td></td>
<td></td>
<td>• Hands-on Activities</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Projects</td>
</tr>
<tr>
<td>What is the student role in the classroom?</td>
<td>Presentations</td>
<td>Group work and discussions</td>
<td>Engage in real-life problems</td>
<td>High-level questioning</td>
<td></td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>---------------</td>
<td>---------------------------</td>
<td>----------------------------</td>
<td>-----------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Follow the instruction and rules</strong></td>
<td><strong>Be questioners, explorer</strong></td>
<td><strong>Be creative and skeptic</strong></td>
<td><strong>Work collaboratively with peers</strong></td>
<td><strong>Ask questions and seek an answer to questions</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Be well-behaved</strong></td>
<td><strong>Control student misbehavior</strong></td>
<td><strong>Apply concepts to real-life situations</strong></td>
<td><strong>Form opinions and discuss ideas</strong></td>
<td><strong>Take the responsibility for their learning</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Listen to the teacher</strong></td>
<td><strong>Be facilitator</strong></td>
<td><strong>Encourage student inquiry</strong></td>
<td><strong>Encourage students to ask questions and discuss their ideas</strong></td>
<td><strong>Identify student prior knowledge and adjust the schedule based on student level</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Do assignments</strong></td>
<td><strong>Lecture</strong></td>
<td><strong>Student presentations</strong></td>
<td><strong>Projects</strong></td>
<td><strong>Inquiry</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Worksheets</strong></td>
<td><strong>Problem solving</strong></td>
<td><strong>Discussion and questioning</strong></td>
<td><strong>Student presentations</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Video</strong></td>
<td><strong>Group work</strong></td>
<td><strong>Group work</strong></td>
<td><strong>Hands-on activities</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Questioning</strong></td>
<td><strong>Hands-on activities</strong></td>
<td><strong>Hands-on activities</strong></td>
<td><strong>Hands-on activities</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>What is the role of teacher during instruction?</th>
<th>Most of teacher responses fall under didactic views and only one response fall under expert constructivist views</th>
<th>Teacher responses are a mix of didactic and expert constructivist views.</th>
<th>Most of teacher responses fall under expert constructivist views.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Deliver knowledge to students</strong></td>
<td><strong>Be facilitator</strong></td>
<td><strong>Encourage student inquiry</strong></td>
<td><strong>Encourage students to ask questions and discuss their ideas.</strong></td>
</tr>
<tr>
<td><strong>Maintain a quiet environment</strong></td>
<td><strong>Encourage student autonomy and initiative</strong></td>
<td><strong>Identify student prior knowledge and adjust the schedule based on student level</strong></td>
<td><strong>Identify student prior knowledge and adjust the schedule based on student level</strong></td>
</tr>
<tr>
<td><strong>Control student misbehavior</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Prepare students for exams</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Provide materials and resources</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>What are your favorite teaching strategies?</th>
<th>Lecture</th>
<th>Worksheets</th>
<th>Video</th>
<th>Questioning</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lecture</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Worksheets</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Video</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Questioning</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>How do you decide what you teach?</th>
<th>The Curriculum timeline</th>
<th>Personal decision of the students</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The Curriculum timeline</strong></td>
<td><strong>Student interest</strong></td>
<td><strong>Students prior knowledge</strong></td>
</tr>
<tr>
<td><strong>Personal decision of the students</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Tools and materials you use most often in your classroom</td>
<td>Different assessment methods you use?</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>----------------------------------------------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>teach and what not to teach?</td>
<td>importance of concepts</td>
<td>one response fall under expert</td>
</tr>
<tr>
<td></td>
<td>- Covering materials</td>
<td>constructivist views.</td>
</tr>
<tr>
<td>How do you decide when to move from one concept to another?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Curriculum Timeline</td>
<td>Most of teacher responses fall</td>
</tr>
<tr>
<td></td>
<td>- Personal Decisions</td>
<td>under didactic views and only</td>
</tr>
<tr>
<td></td>
<td>- Quizzes and tests</td>
<td>one response fall under expert</td>
</tr>
<tr>
<td></td>
<td></td>
<td>constructivist views.</td>
</tr>
<tr>
<td>What are the different assessment methods you use?</td>
<td>Quizzes and tests</td>
<td>Most of teacher responses fall</td>
</tr>
<tr>
<td></td>
<td>Facial expression</td>
<td>under didactic views and only</td>
</tr>
<tr>
<td></td>
<td>Verbal expression</td>
<td>one response fall under expert</td>
</tr>
<tr>
<td></td>
<td></td>
<td>constructivist views.</td>
</tr>
<tr>
<td>Could you describe a lesson that you were pleased with?</td>
<td></td>
<td>Most of teacher responses fall</td>
</tr>
<tr>
<td></td>
<td>- Student understanding the main concepts</td>
<td>under didactic views and only</td>
</tr>
<tr>
<td></td>
<td>- Safe learning environment</td>
<td>one response fall under expert</td>
</tr>
<tr>
<td></td>
<td>- Student motivation</td>
<td>constructivist views.</td>
</tr>
<tr>
<td>What are the tools and materials you use most often in your classroom?</td>
<td>- Textbooks</td>
<td>Most of teacher responses fall</td>
</tr>
<tr>
<td></td>
<td>- Worksheets</td>
<td>under didactic views and only</td>
</tr>
<tr>
<td></td>
<td></td>
<td>one response fall under expert</td>
</tr>
<tr>
<td></td>
<td></td>
<td>constructivist views.</td>
</tr>
<tr>
<td>Anything that helps students learn to concepts including</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Textbooks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Science Magazines</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- News</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- The Internet</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Softwares</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Videos</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Samples</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Science Equipments</td>
<td></td>
</tr>
</tbody>
</table>
| What is science?               | **•** Science is about the facts.  
|                               | **•** Science is to discover the truth.  
| Most of teacher responses fall under didactic views and only one response fall under expert constructivist views | Teacher responses are a mix of didactic and expert constructivist views.  
| Most of teacher responses fall under expert constructivist views. | **•** Science is a process of learning about the world.  
| **•** Science is part of social and cultural traditions.  
| **•** Scientists are creative.  
| **•** Science is questioning and trying to find answers.  
| **•** Science is an attempt to explain natural phenomena.  
| **•** Science is a collaborative process. |

| How do you want your students to view by the end of the school years? | **•** Positive attitudes toward science.  
| **•** Know main concepts in science.  
| **•** Science is doing experiments. | Most of teacher responses fall under didactic views and only one response fall under expert constructivist views  
| Teacher responses are a mix of didactic and constructivist views. | Most of teacher responses fall under expert constructivist views.  
| Most of teacher responses fall under expert constructivist views. | **•** Science is questioning and searching for answers.  
| **•** Science is a collaborative process of testing and interpreting ideas.  
| **•** There is no single scientific method.  
| **•** Scientific knowledge is tentative.  
| **•** Science is exciting. |

| What is inquiry?  
How do you implement inquiry in your classroom? | Students verify known scientific principles by following a given procedure.  
| Students verify known scientific principles by following a given procedure but teacher also encourage students to use other procedures. | Teacher presents a question for which the students do not know the answer, and students are given a procedure to follow in order to complete the inquiry.  
| Teachers provide students with a problem to investigate but the methods for resolving the problem are completely left to the students. | **•** Problems posed by students based on their interest  
| **•** Students design their own investigation |

| What are your goals for student learning? | **•** Know main concepts and equations.  
| **•** Be successful on state tests. | Most of teacher responses fall under didactic views and only one response fall under expert constructivist views.  
| Teacher responses are a mix of didactic and constructivist views. | Most of teacher responses fall under expert constructivist views.  
| **•** Promote student problem solving skills.  
| **•** Promote decision-making skills.  
| **•** Encourage lifelong learning.  
| **•** Encourage sharing ideas, asking questions, and being skeptical, curious, and creative. |

Adapted from Teacher Pedagogical Philosophy Interview by Simmons et al. (1999) and by Masene, R. S. (2002).
APPENDIX B

CONSTRUCTIVIST LEARNING ENVIRONMENT SURVEY

PREFERRED FORM
What I wish happened in my science classroom

DIRECTIONS

1. Purpose of the Questionnaire
   This questionnaire asks you to describe important aspects of the science classroom which you are in right now. There are no right or wrong answers. Your opinion is what is wanted. Your answers will enable us to improve future science teaching.

2. How to Answer Each Question
   On the next few pages you will find 30 sentences. For each sentence, circle only one number corresponding to your answer. For example:

<table>
<thead>
<tr>
<th>Almost Always</th>
<th>Often</th>
<th>Sometimes</th>
<th>Seldom</th>
<th>Almost Never</th>
</tr>
</thead>
</table>
   In this class I wish that . . .
   8 I asked the students questions. | 5 | 4 | 3 | 2 | 1 |

   • If you think that you almost always ask the students questions, circle the 5.
   • If you think that you almost never ask the students questions, circle the 1.
   • Or you can choose the number 2, 3 or 4 if one of these seems like a more accurate answer.

3. How to Change Your Answer
   If you want to change your answer, cross it out and circle a new number. For example:

   8 I ask the students questions. | 5 | 4 | 3 | 2 | 1 |

4. Course Information
   Please provide information in the box below. Please be assured that your answers to this questionnaire will be treated confidentially.

   a. Name:   b. School:
   c. Grade/Year-level:   d. Sex:  male /female (please circle one)

5. Completing the Questionnaire
   Now turn the page and please give an answer for every question.
<table>
<thead>
<tr>
<th>Learning about the world</th>
<th>Almost Always</th>
<th>Often</th>
<th>Sometimes</th>
<th>Seldom</th>
<th>Almost Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>In this class I wish that . . .</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Students learned about the world outside of school.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Students' new learning started with problems about the world outside of school.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Students learned how science can be part of their out-of-school life.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In this class I wish that . . .</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Students got a better understanding of the world outside of school.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Students learned interesting things about the world outside of school.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learning about science</td>
<td>Almost Always</td>
<td>Often</td>
<td>Sometimes</td>
<td>Seldom</td>
<td>Almost Never</td>
</tr>
<tr>
<td>In this class I wish that . . .</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Students learned that science has changed over time.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Students learned that science is influenced by people's values and opinions.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In this class I wish that . . .</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 Students could learn about the different sciences used by people in other cultures.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 Students could learn that modern science is different from the science of long ago.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 Students could learn that science is about <strong>inventing</strong> theories.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learning to speak out</td>
<td>Almost Always</td>
<td>Often</td>
<td>Sometimes</td>
<td>Seldom</td>
<td>Almost Never</td>
</tr>
<tr>
<td>In this class I wish that . . .</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 It was OK for students to ask me &quot;why do I have to learn this?&quot;</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 It was OK for students to question the way I'm teaching.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 It was OK for students to complain about activities that are confusing.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In this class I wish that . . .</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 It was OK for students to complain about anything that prevents them from learning.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 It was OK for students to express their opinions.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learning to learn</td>
<td>Almost Always</td>
<td>Often</td>
<td>Sometimes</td>
<td>Seldom</td>
<td>Almost Never</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------</td>
<td>-------</td>
<td>-----------</td>
<td>--------</td>
<td>--------------</td>
</tr>
<tr>
<td>In this class I wish that . . .</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 Students could help me to plan what they're going to learn.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17 Students could help me to decide how well they are learning.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18 Students could help me to decide which activities are best for them.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In this class I wish that . . .</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19 Students could help me to decide how much time they spend on activities.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 Students could help me to decide which activities they do.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Learning to communicate</th>
<th>Almost Always</th>
<th>Often</th>
<th>Sometimes</th>
<th>Seldom</th>
<th>Almost Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>In this class I wish that . . .</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21 Students got the chance to talk to other students.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22 Students could talk with other students about how to solve problems.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23 Students could explain their ideas to other students.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In this class I wish that . . .</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 Students could ask other students to explain their ideas.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 Students could listen carefully to each other’s ideas.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX C

CONSTRUCTIVIST LEARNING ENVIRONMENT SURVEY

PERCEIVED FORM
What happens in my science classroom?

DIRECTIONS

1. **Purpose of the Questionnaire**
   This questionnaire asks you to describe important aspects of the science classroom which you are in right now. There are no right or wrong answers. Your opinion is what is wanted. Your answers will enable us to improve future science teaching.

2. **How to Answer Each Question**
   On the next few pages you will find 30 sentences. For each sentence, circle only one number corresponding to your answer. For example:

<table>
<thead>
<tr>
<th></th>
<th>Almost Always</th>
<th>Often</th>
<th>Sometimes</th>
<th>Seldom</th>
<th>Almost Never</th>
</tr>
</thead>
</table>
   In this class . . .
   8   I ask the students questions.       5   4   3   2   1

   • If you think that you *almost always* ask the students questions, circle the 5.
   • If you think that you *almost never* ask the students questions, circle the 1.
   • Or you can choose the number 2, 3 or 4 if one of these seems like a more accurate answer.

3. **How to Change Your Answer**
   If you want to change your answer, cross it out and circle a new number. For example:

   8   I ask the students questions.       5   4   3   2   1

4. **Course Information**
   Please provide information in the box below. Please be assured that your answers to this questionnaire will be treated confidentially.

<table>
<thead>
<tr>
<th>a. Name:</th>
<th>b. School:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>c. Grade/Year-level:</th>
<th>d. Sex:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>male /female</td>
</tr>
<tr>
<td></td>
<td>(please circle one)</td>
</tr>
</tbody>
</table>

5. **Completing the Questionnaire**
### Learning about the world

<table>
<thead>
<tr>
<th>In this class . . .</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Students learn about the world outside of school.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Students' new learning starts with problems about the world outside of school.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Students learn how science can be part of their out-of-school life.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>In this class . . .</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Students get a better understanding of the world outside of school.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Students learn interesting things about the world outside of school.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Learning about science

<table>
<thead>
<tr>
<th>In this class . . .</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 Students learn that science has changed over time.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Students learn that science is influenced by people's values and opinions.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>In this class . . .</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 Students learn about the different sciences used by people in other cultures.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 Students learn that modern science is different from the science of long ago.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 Students learn that science is about inventing theories.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Learning to speak out

<table>
<thead>
<tr>
<th>In this class . . .</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 It's OK for students to ask me &quot;why do I have to learn this?&quot;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 It's OK for students to question the way I'm teaching.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 It's OK for students to complain about activities that are confusing.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>In this class . . .</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 It's OK for students to express their opinions.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Learning to learn

<table>
<thead>
<tr>
<th>In this class . . .</th>
<th>Almost Always</th>
<th>Often</th>
<th>Sometimes</th>
<th>Seldom</th>
<th>Almost Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 Students help me to plan what they're going to learn.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17 Students help me to decide how well they are learning.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18 Students help me to decide which activities are best for them.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19 Students help me to decide how much time they spend on activities.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 Students help me to decide which activities they do.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Learning to communicate

<table>
<thead>
<tr>
<th>In this class . . .</th>
<th>Almost Always</th>
<th>Often</th>
<th>Sometimes</th>
<th>Seldom</th>
<th>Almost Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 Students get the chance to talk to other students.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22 Students talk with other students about how to solve problems.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23 Students explain their ideas to other students.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 Students ask other students to explain their ideas.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 Students listen carefully to each other's ideas.</td>
<td>5 4 3 2 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX D

DEMOGRAPHICS QUESTIONNAIRE
TEACHER CODE:

1. Gender:  Female □  Male □

2. Birthdate: _____________

3. Graduated from the University of ______________________________
   College of Education □  Arts and Sciences □
   Other □ (Please specify) ______________________________

4. Major:
   Biology □  Chemistry □  Earth Science □
   Physics □  Science □  Other □ (Please specify) _________

5. Master’s Degree?  No □  Yes □
If yes,
   Name of Institution ______________________________
   Year of Graduation ______________________________
   Type of Degree: M.Ed. □  M.A. □  Other □ (Please specify) ______

6. Doctoral Degree?  No □  Yes □
If yes,
   Name of Institution ______________________________
   Year of Graduation ______________________________
   Type of Degree: Ed.D. □  Ph.D. □  Other □ (Please specify) ______

7. Mostly, I have taught in:
   Rural Area □  Suburban Area □  Urban Area □

8. Number of years teaching science __________________

9. Current Grade(s): ________________  Grade(s) Taught: ________________

10. Current Subject(s): ________________  Subject(s) Taught: ________________
1. How do you define teaching?

2. How do you define learning?

3. How do you think students best learn science?

4. What are your goals for student learning?

5. How do you plan your instruction?

6. How do you decide what you teach and what not to teach? How do you decide when to move from one concept to another?

7. What are the different assessment methods you use? Give me examples.

8. What kinds of teaching strategies do you use most often? Why do you use those most often? Could you give me an example?

9. How would you describe the characteristics of an ideal learning environment?

10. Could you describe a lesson that you were pleased with?

11. Could you describe a lesson that you were not pleased with and please talk about your experiences?

12. What are the tools and materials that you use most often in your classroom?

Adapted from Teacher Pedagogical Philosophy Interview by Simmons et al. (1999) and by Masene (2002).
APPENDIX F

INTERVIEW QUESTIONS II
1. What are your goals for student learning in science education?

2. How do you plan your lesson according to these goals?

3. Could you define constructivism as a learning theory? What is your understanding of this theory?

4. How committed are you to this theory? Do you feel implement this theory entirely in your classroom? Could you give me an example of ways you implement this theory?

5. How do you feel about students’ social interactions?

6. What is the student role in the classroom?

7. How do you view your role as a teacher?

8. How do you feel about your curriculum?

9. Could you define inquiry in the classroom?

10. Have you implemented any inquiry lessons in the classroom?
    
    If yes, describe these lessons.
    
    If no, why not?

11. What are the most important factors that affect the way you teach?

12. Are there any factors that influence the way you teach? What are some examples of this? (a) at the school level (b) at the state levels

13. What is science?

14. How do you want your students to view science by the end of the school year?

Adapted from Teacher Pedagogical Philosophy Interview by Simmons et al. (1999) and by Masene (2002).
APPENDIX G

CLASSROOM OBSERVATION CHART
<table>
<thead>
<tr>
<th>Date/ Time</th>
<th>Teacher Code</th>
<th>School Code</th>
<th>Classroom Description (Physical)</th>
<th>No. of Students</th>
<th>Comments:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX H

CLASSROOM OBSERVATION REPORT CHART
<table>
<thead>
<tr>
<th>S</th>
<th>E</th>
<th>G</th>
<th>Time</th>
<th>Beg</th>
<th>End</th>
<th>No.</th>
<th>Min</th>
<th>%</th>
<th>What the teacher is doing</th>
<th>What the students are doing</th>
<th>Information (Content)</th>
<th>Teaching Strategies:</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Whole-Class (W)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Group Work (G)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Individual Student Work (IW)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lecture (L)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Questioning (Q)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Discussion (D)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hands-On Activities (HOA)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Inquiry (I)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Problem Solving (PS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Worksheet (WS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Demonstration (Demo)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Video (V)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Tests, Quizzes (Assess.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This form was adapted from Mathematics and Science Classroom Observation Profile System (M-SCOPS) presented by Stuessy, C. L., Parrott, J. A., & Foster, A. S. at the School Science and Mathematics Association Annual Meeting, Columbus, OH, October, 2003.
Dear Principal,

My name is Funda Savasci. I am a PhD candidate majoring in Science Education at The Ohio State University. I am interested in investigating “Science Teacher Perceptions and Classroom Practice Related to Constructivist Teaching and Learning.” I am asking for your consent to participate in this study, which will help me understand science teacher perceptions related to constructivist teaching and learning and implications for science classrooms.

This study intends to (a) document science teacher perceptions related to constructivist teaching and learning and (b) understand how these strategies are applied in science classrooms. In order to do this, I am going to interview one of your science teachers, Ms. / Mr. _______________, at three different times and observe his/her classroom five times a week for 7 weeks. I am asking for your permission to go into Ms./ Mr. ________________’s classroom to observe his/her teaching strategies used in science classrooms.

I will provide you a copy of my dissertation proposal in which detailed information can be found about the purpose of the project; a description of the project, including duration; brief description of the subjects; data collection and analysis procedures; interview questions; and a description of the measures to be taken to protect and ensure confidentiality.

If you agree to support this project, please sign the support letter form. Your support for this project is voluntary, and you are free to withdraw your support at any time during the project.

If you have any questions related to this project, please feel free to contact me at (614) 260-3206.

Sincerely,

__________________________________________
Funda SAVASCI
Co-Investigator
College of Education
The Ohio State University

__________________________________________
Dr. Donna F. BERLIN
Major Advisor / Principal Investigator
College of Education
The Ohio State University
APPENDIX J

PRINCIPAL SUPPORT LETTER
I support the Ph.D. dissertation study entitled “Science Teacher Perceptions and Classroom Practice Related to Constructivist Teaching and Learning” to be conducted in __________________________ classroom.

Dr. Donna F. Berlin, the Principal Investigator, and her authorized representative and the Co-Investigator, Funda Savasci, have provided a written proposal detailing the purpose of the study; a brief description of the study; including duration; a brief description of the participants; data collection and analysis procedures; copies of the interview questions; and a description of the measures to be taken to protect and ensure confidentiality. Possible benefits of the study have been described, as have alternative procedures, if such procedures are applicable and available.

I acknowledge that I have had the opportunity to obtain additional regarding the study and that any questions I have raised have been answered to my full satisfaction. Furthermore, I understand that I am free to withdraw my support at any time.

Finally, I acknowledge that I have read and fully understand the support form. I sign it freely and voluntarily. A copy has been given to me.

<table>
<thead>
<tr>
<th>Date:</th>
<th>Signed: ___________________________</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Principal)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date:</th>
<th>Signed: ___________________________</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(OSU Faculty Advisor and Principal Investigator)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date:</th>
<th>Signed: ___________________________</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Co-Investigator)</td>
</tr>
</tbody>
</table>
APPENDIX K

TEACHER RECRUITMENT LETTER
Dear ____________

My name is Funda Savasci. I am a PhD candidate majoring in Science Education at The Ohio State University. I am interested in investigating “Science Teacher Perceptions and Classroom Practice Related to Constructivist Teaching and Learning.” I am asking for your consent to participate in this study, which will help me understand science teacher perceptions related to constructivist teaching and learning and classroom implications in science classrooms.

This study intends to (a) document science teacher perceptions related to constructivist teaching and learning and (b) understand how these strategies are applied in science classrooms. In order to do this, I will interview you at three different times, audiotape your responses for purposes of accuracy, and observe your teaching strategies five times a week for 7 weeks.

If you agree to participate, please sign the consent form. Your participation in this study is voluntary, and you are free to withdraw from participation at any time during the study.

All information will be kept strictly confidential by assigning a pseudonym that will substitute for your name on all materials. No actual names will be used in any report of the research. The audio tapes will be used for research purposes only and they will be kept in a secure place and destroyed upon completion of the study.

If you have any questions related to this study, please feel free to contact me at (614) 260-3206.

___________________________________________________________________________

Funda SAVASCI
Co- Investigator
College of Education
The Ohio State University

Dr. Donna F. BERLIN
Major Advisor / Principal Investigator
College of Education
The Ohio State University
APPENDIX L

TEACHER CONSENT FORM
I consent to participating in the Ph.D. dissertation study entitled “Science Teacher Perceptions and Classroom Practices Related to Constructivist Teaching and Learning.”

Dr. Donna F. BERLIN, the Principal Investigator, or her authorized representative, Funda Savasci has explained the purpose of the study, the procedures to be followed, and the expected duration of my participation.

I acknowledge that I have had the opportunity to obtain additional information regarding the study and that any questions I have raised have been answered to my full satisfaction. Furthermore, I understand that I am free to withdraw consent at any time and to discontinue participation in the study without prejudice to me.

Finally, I acknowledge that I have read and fully understand the consent form. I sign it freely and voluntarily. A copy has been given to me.

Date: ________________________________  Signed: ________________________________

(Teacher)

Date: ________________________________  Signed: ________________________________

(School Principal)

Date: ________________________________  Signed: ________________________________

(Principal Investigator or his/her authorized representative)