ACCEPTANCE

This dissertation, PRESERVICE SCIENCE TEACHERS’ EXPERIENCES WITH REPEATED, GUIDED INQUIRY, by AMY B. SLACK, was prepared under the direction of the candidate’s Dissertation Advisory Committee. It is accepted by the committee members in partial fulfillment of the requirements for the degree Doctor of Philosophy in the College of Education, Georgia State University.

The Dissertation Advisory Committee and the student’s Department Chair, as representatives of the faculty, certify that this dissertation has met all the standards of excellence and scholarship as determined by the faculty. The Dean of the College of Education concurs.

Lisa Martin-Hansen, Ph.D.  Julie Dangel, Ph.D.
Committee Chair  Committee Member

Amy Lederberg, Ph.D.  Edward Lomax, Ph.D.
Committee Member  Committee Member

Date

Christine Thomas, Ph.D.
Associate Chair, Department of Middle-Secondary Education and Instructional Technology

Ronald P. Colarusso, Ed.D.
Dean, College of Education
AUTHOR’S STATEMENT

By presenting this dissertation as a partial fulfillment of the requirements for the advanced degree from Georgia State University, I agree that the library of Georgia State University shall make it available for inspection and circulation in accordance with its regulations governing materials of this type. I agree that permission to quote, to copy from, or to publish this dissertation may be granted by the professor under whose direction it was written, by the College of Education’s director of graduate studies and research, or by me. Such quoting, copying, or publishing must be solely for scholarly purposes and will not involve potential financial gain. It is understood that any copying from or publication of this dissertation that involves potential financial gain will not be allowed without my written permission.

______________________________________________
Amy B. Slack
VITA

Amy B. Slack
908 Tuxworth Circle
Decatur, GA 30033

EDUCATION:
- Ph.D. 2007 Georgia State University
  Teaching and Learning
- Ed.S. 2005 Georgia State University
  Science Education
- M.Ed. 2000 Georgia State University
  Science Education
- M.S. 1999 Georgia State University
  Biology
- B.S. 1996 Centre College
  Biology

PROFESSIONAL EXPERIENCE:
- 2006-Present Teacher of Science
  Parkview High School, Lilburn, GA
- 2004-2006 Clinical Instructor
  Georgia State University, Atlanta, GA
- 2000-2004 Teacher of Science
  Brookwood High School, Snellville, GA

PRESENTATIONS AND PUBLICATIONS:


**PROFESSIONAL SOCIETIES AND ORGANIZATIONS:**

- 2005-Present
  - Association for Science Teacher Education
- 2004-Present
  - National Association for Research in Science Teaching
- 2004-Present
  - National Science Teachers’ Association
- 2004-Present
  - Southeastern Association for Science Teacher Education
- 2000-Present
  - Georgia Science Teachers’ Association
- 2004-Present
  - Doctoral Fellows, Georgia State University
ABSTRACT

PRESERVICE SCIENCE TEACHERS’ EXPERIENCES WITH REPEATED, GUIDED INQUIRY
by
Amy B. Slack

The purpose of this study was to examine preservice science teachers’ experiences with repeated scientific inquiry (SI) activities. The National Science Education Standards (National Research Council, 1996) stress students should understand and possess the abilities to do SI. For students to meet these standards, science teachers must understand and be able to perform SI; however, previous research demonstrated that many teachers have naïve understandings in this area. Teacher preparation programs provide an opportunity to facilitate the development of inquiry understandings and abilities.

In this study, preservice science teachers had experiences with two inquiry activities that were repeated three times each. The research questions for this study were (a) How do preservice science teachers’ describe their experiences with repeated, guided inquiry activities? (b) What are preservice science teachers’ understandings and abilities of SI?

This study was conducted at a large, urban university in the southeastern United States. The 5 participants had bachelor’s degrees in science and were enrolled in a graduate science education methods course. The researcher was one of the course instructors but did not lead the activities. Case study methodology was used. Data was
collected from a demographic survey, an open-ended questionnaire with follow-up interviews, the researcher’s observations, participants’ lab notes, personal interviews, and participants’ journals. Data were coded and analyzed through chronological data matrices to identify patterns in participants’ experiences.

The five domains identified in this study were understandings of SI, abilities to conduct SI, personal feelings about the experience, science content knowledge, and classroom implications. Through analysis of themes identified within each domain, the four conclusions made about these preservice teachers’ experiences with SI were that the experience increased their abilities to conduct inquiry, increased their understanding of how they might use SI in their classroom, increased their understanding of why variables are used in experiments, and did not increase their physics content knowledge. These conclusions suggest that preservice science teachers having repeated, guided experiences with inquiry increase their abilities to conduct SI and consider how inquiry could be used in their future science classrooms.
PRESERVICE SCIENCE TEACHERS’ EXPERIENCES WITH
REPEATED, GUIDED INQUIRY
by
Amy B. Slack

A Dissertation

Presented in Partial Fulfillment of Requirements for the
Degree of
Doctor of Philosophy
in
Teaching and Learning
in
the Department of Middle-Secondary Education and
Instructional Technology
in
the College of Education
Georgia State University

Atlanta, Georgia
2007
ACKNOWLEDGMENTS

I would never have survived this long journey if not for the wonderful people in my life. First, I’d like to thank my family who provided me love and support throughout this process. Special acknowledgment goes to my father who acted as editor and to my mother who always listened. I’d also like to thank the many friends who stuck with me through this.

I had a wonderful committee - thanks for all your time, input, and effort. Dr. Martin-Hansen provided support and discussions about inquiry throughout the execution of this study. Dr. Dangel’s help with the methodology and results section were invaluable. Dr. Lederberg’s class inspired this project, and I appreciate her input and positive words. Dr. Lomax agreed to be on this committee at the last minute, and I am thankful for his additions and willingness to join the committee.

I’d especially like to thank Dr. Hanna and Dr. Lucy, who began this journey with me but were unable to finish it. They were always there in spirit. I began my foray into science education with Dr. Hanna, and she provided the role model for the kind of teacher I want to be. Dr. Lucy pushed me to think outside the box and challenged me. He also acted as my guide and mentor throughout the entire Ph.D. program.

I never could have completed this program if not for my fellow doctoral students. I enjoyed the seminars together, debating current topics, the feedback I received about my prospectus, and the general sense of camaraderie. GSU is truly a special place because of the relationships between the students. I especially want to thank Melissa and Price for their input and support.

Finally, I’d like to thank Max, who sat patiently by my desk throughout the writing process. He missed out on many walks because of this program and got old and grey in the process. His wags brightened my days and he always reminded me to take a break every now and again.
### TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>List of Tables</td>
<td>v</td>
</tr>
<tr>
<td>List of Figures</td>
<td>vi</td>
</tr>
<tr>
<td>Abbreviations</td>
<td>vii</td>
</tr>
<tr>
<td>Chapter 1 INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Statement of the Problem</td>
<td>1</td>
</tr>
<tr>
<td>Significance of the Problem</td>
<td>7</td>
</tr>
<tr>
<td>Philosophical Framework</td>
<td>9</td>
</tr>
<tr>
<td>Conceptual Framework</td>
<td>11</td>
</tr>
<tr>
<td>Theoretical Framework</td>
<td>24</td>
</tr>
<tr>
<td>Rationale</td>
<td>26</td>
</tr>
<tr>
<td>Overview of the Methodology</td>
<td>28</td>
</tr>
<tr>
<td>Summary</td>
<td>29</td>
</tr>
<tr>
<td>Chapter 2 REVIEW OF THE LITERATURE</td>
<td>31</td>
</tr>
<tr>
<td>Introduction</td>
<td>31</td>
</tr>
<tr>
<td>Learning Through Experience</td>
<td>31</td>
</tr>
<tr>
<td>Scientific Inquiry: Definitions and Standards</td>
<td>36</td>
</tr>
<tr>
<td>Scientific Inquiry in the Classroom</td>
<td>40</td>
</tr>
<tr>
<td>Assessing Views of Scientific Inquiry</td>
<td>45</td>
</tr>
<tr>
<td>An Explicit Approach to Scientific Inquiry</td>
<td>47</td>
</tr>
<tr>
<td>Microgenetic Method</td>
<td>53</td>
</tr>
<tr>
<td>Summary</td>
<td>58</td>
</tr>
<tr>
<td>Chapter 3 METHODOLOGY</td>
<td>60</td>
</tr>
<tr>
<td>Introduction</td>
<td>60</td>
</tr>
<tr>
<td>Qualitative Research</td>
<td>61</td>
</tr>
<tr>
<td>Participants</td>
<td>61</td>
</tr>
<tr>
<td>Description of the Inquiry Experience</td>
<td>65</td>
</tr>
<tr>
<td>Data Collection</td>
<td>69</td>
</tr>
<tr>
<td>Data Analysis</td>
<td>80</td>
</tr>
<tr>
<td>Trustworthiness of Qualitative Research</td>
<td>82</td>
</tr>
<tr>
<td>Human as Instrument</td>
<td>84</td>
</tr>
<tr>
<td>Summary</td>
<td>86</td>
</tr>
</tbody>
</table>
4 RESULTS ..............................................................................................................88
   Introduction .......................................................................................................88
   Understandings and Abilities of Scientific Inquiry ........................................89
   Participants’ Experiences with Scientific Inquiry ...........................................95
   Participants’ Description of Scientific Inquiry Experiences ........................128
   Participants’ Science Content Knowledge ......................................................130
   Classroom Implications .................................................................................133
   Summary ..........................................................................................................138

5 SUMMARY, CONCLUSION, AND DISCUSSION .............................................141
   Preservice Teachers’ Descriptions of Their Experiences with Repeated Scientific Inquiry .................................................................142
   Preservice Teachers’ Understandings and Abilities of Scientific Inquiry ....145
   Effectiveness of the Case .................................................................................155
   Conclusions .....................................................................................................163
   Implications for Science Education .................................................................165
   Future Modifications to the Scientific Inquiry Experience ..........................169
   Future Research .............................................................................................171
   Summary .........................................................................................................172

References ........................................................................................................174

Appendixes .....................................................................................................185
LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Inquiry as an Evolutionary Process</td>
</tr>
<tr>
<td>2</td>
<td>Schedule of Participants’ Inquiry Experiences</td>
</tr>
<tr>
<td>3</td>
<td>Data Collection</td>
</tr>
<tr>
<td>4</td>
<td>Postactivity Interview Questions</td>
</tr>
<tr>
<td>5</td>
<td>Reflection Questions for the SI Activities</td>
</tr>
<tr>
<td>6</td>
<td>Understanding of SI Demonstrated by Participants</td>
</tr>
<tr>
<td>7</td>
<td>A Comparison of Understandings by Schwarts et al. (2001) with Understandings Demonstrated by Participants</td>
</tr>
<tr>
<td>8</td>
<td>Abilities Demonstrated by Participants with Corresponding Abilities of SI Presented by NSES (NRC, 1996)</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Data Matrix for Noemie</td>
<td>88</td>
</tr>
<tr>
<td>2</td>
<td>Data Matrix for Tracy</td>
<td>104</td>
</tr>
<tr>
<td>3</td>
<td>Data Matrix for Pearl</td>
<td>111</td>
</tr>
<tr>
<td>4</td>
<td>Data Matrix for Mischa</td>
<td>117</td>
</tr>
<tr>
<td>5</td>
<td>Data Matrix for Anna</td>
<td>123</td>
</tr>
</tbody>
</table>
ABBREVIATIONS

AAAS  American Association for the Advancement of Science
NOS   Nature of Science
NRC   National Research Council
NSES  National Science Education Standards
SI    Scientific Inquiry
VNOS  Views of Nature of Science
VOSI  Views of Science Inquiry
VOSI-M Views of Science Inquiry—Modified
CHAPTER 1

INTRODUCTION

Statement of the Problem

Scientific inquiry is one aspect of the current reform effort in science education (American Association for the Advancement of Science [AAAS], 1990, 1993; National Research Council [NRC], 1996). The National Science Education Standards (NRC, 1996) stress that science students of all ages should be able to understand inquiry and possess the abilities needed to do scientific inquiry (SI). For students to meet these standards, they must have valid experiences in the science classroom. Factors such as an open curriculum, caring and prepared teachers, and adequate time for inquiry-based lessons must occur in the classroom to facilitate these experiences. However, one important factor is that science teachers are able to understand SI and possess the abilities to conduct SI in the same manner as is expected of the students. Because teachers first need to comprehend what comprises inquiry abilities and understanding, one of the goals of teacher preparation programs should be to facilitate this development.

In this study, I examined a teacher preparation program that uses SI with its preservice teachers. The guiding research questions were as follows:

1. How do preservice science teachers’ describe their experience with repeated, guided inquiry activities in their coursework?

2. What are preservice science teachers’ understandings and abilities of SI throughout experiences involving scientific inquiry and reflection?
These questions were explored by research with a group of preservice science teachers who were graduate students studying science education and earning teaching certificates for broad-field science in grades 6-12. Participants were interviewed, completed a questionnaire, kept experimental notes, and reflected about their experiences with provided post-activity questions. Analysis of this data and my observations are used to describe preservice teachers’ experiences with inquiry and their understandings and abilities of SI.

The National Research Council (1996) stressed in the National Science Education Standards (NSES) that teaching science through inquiry promotes scientific literacy, an opinion that is maintained in this research project. Scientific inquiry and its associated terminology can be a tenuous concept. It often has different terms, such as inquiry, scientific inquiry, and inquiry learning, associated with its use. Multiple definitions exist for the same concepts and semantics play a part in defining inquiry; therefore, it is necessary to define the terms to be used throughout this paper.

In the NSES, (NRC, 1996), SI is defined as the way scientists explore the natural world and propose explanations based on evidence from their work. SI also refers to students’ activities as they gain knowledge of scientific ideas and understand how scientists study the natural world. SI is found in Content Standard A of the NSES for grades K-12, which states: “As a result of activities in grades K-4 (or 5-8 or 9-12), all students should develop: abilities necessary to do scientific inquiry and understandings about scientific inquiry” (NRC, pp. 121, 143, 173). Thus, the NSES stress that SI includes both understanding and abilities. Therefore, in this study SI is defined as students having an understanding of scientific knowledge and how scientists conduct their research.
Additionally, SI involves students having the *abilities* to conduct SI; these abilities involve the work done by students, of any age or ability, as they try to understand the natural world through open-ended activities that mimic the work done by scientists. This use of the term SI recognizes that students conduct investigations in different ways from scientists, yet acknowledges that for students, the investigations are novel.

Although Gunstone, Loughran, Berry, and Mulhall (1999) claim that scientific inquiry is a restrictive term used along the lines of “the scientific method,” for the purpose of this study, SI is considered to be different from the “scientific method” that is often taught to students. The scientific method suggests a rigid, step-by-step approach to doing science (NRC, 1996) and is usually described as a fixed set of steps that all scientists follow in a specific sequence when conducting research (Schwartz, Lederman, & Thompson, 2001). Students are often expected to memorize the scientific method and asked to repeat it in cookbook-like lab procedures. Although engaging in SI consists of abilities that are performed logically and often in sequence, it also requires students to take part in “high-level reasoning [and] applying their existing understanding of scientific ideas,” thus leading to a more open, less rigid experience than the step-by-step methods of the scientific method (NRC, p. 145). Reform efforts that advocate SI emphasize there is no one scientific method; instead, approaches to answering scientific questions vary within and across scientific fields (Schwartz et al.).

Because SI is an important topic in the field of science education (AAAS, 1990, 1993, NRC, 1996), the purpose of this research study was to examine preservice science teachers’ experiences with inquiry activities and describe their SI understandings and abilities. For this study, the understandings of SI are those described by Schwartz et al.
(2001) and are based upon the descriptions of SI found in both the *NSES* (NRC, 1996) and the AAAS’s *Benchmarks for Science Literacy* (1993). These understandings are

- Knowledge of methods used to conduct investigations instead of one “scientific method”;
- Understanding the role of investigations within research agendas;
- Recognition of assumptions involved in designing and conducting scientific inquiries;
- Recognition of limitations of data collection and analysis;
- Recognition and analysis of alternative explanations and models;
- Understanding the reasons for using controls and variables in experiments;
- Understanding the distinction between data and evidence;
- Understanding the relationship between evidence and explanations;
- Understanding the role of communication in the development and acceptance of scientific information.

The six abilities of SI described in the *NSES* Content Standard A for grades K-12 are used in this study. Because the participants in this research study are preservice science teachers earning certification for grades 6-12, the 9-12 standards form the basis of the abilities that were assessed in participants. The six abilities of SI as described in the *NSES* for grades 9-12 as established by the NRC (1996) are

- Identify questions and concepts that guide scientific investigations;
- Design and conduct scientific investigations;
- Use technology and mathematics to improve investigations and communications;
• Formulate and revise scientific explanations and models using logic and evidence;
• Recognize and analyze alternative explanations and models;
• Communicate and defend a scientific argument.

Much educational research has occurred in the field of scientific inquiry. Research has been conducted about both students’ and teachers’ views of scientific inquiry (Schwartz et al., 2001; Wallace & Kang, 2004), how to teach inquiry (Schwartz & Crawford, 2003), and why inquiry is not being implemented in the classroom (Costenson & Lawson, 1986; Welch, Klopfer, Aikenhead, & Robinson, 1981). The results of these studies have contributed valuable information about SI in education, such as what constitutes valuable experiences of inquiry for students and how to prepare teachers, both pre- and in-service, to use SI in their classrooms. One troubling outcome of much of this research is that practicing teachers do not have adequate understandings of SI and do not implement SI in the classroom (Costenson & Lawson; Muscovici, 2000; Wallace & Kang). Even those who understand SI often do not implement it into the classroom (Marlow & Stevens, 1999; Wallace & Kang). Providing preservice science teachers with SI activities might allow them to develop the abilities needed to do inquiry and deepen their understandings of the concepts associated with inquiry.

Some preservice teacher programs teach SI through the use of authentic science experiences by having students conduct scientific research (Brown & Melear, 2006; Melear, Goodlaxson, Warne, & Hickok, 2000; Wilson, 2003). These studies demonstrate authentic science experiences facilitate understanding of SI and help preservice teachers value SI. However, it may not be possible for every student to take a science class that
offers an authentic research experience. It seems contradictory for educators of science teachers, the group who stresses the importance of inquiry in the classroom, to leave the teaching of science inquiry to scientists alone. Therefore, exposing preservice teachers to SI in their methods courses provides teacher educators an opportunity to facilitate a development of the understandings and abilities of SI. Having inquiry experiences that are similar to those conducted by K-12 students in a science classroom might be adequate exposure to increase preservice teachers’ understandings and abilities of inquiry, as well as demonstrate how SI might appear in a classroom. Although much of the research into teachers practicing SI is with students conducting research with a scientist or in a science classroom (Brown & Melear; Melear et al., 2000; Schwartz & Crawford, 2003; Schwartz, Lederman, & Crawford, 2000; Wilson), I studied the outcomes of preservice teachers engaging in inquiry-based activities such as those found in a K-12 science classroom.

Students entering a science teacher preparation program come to the program with different skills, abilities, experiences, and understandings. The way preservice science teachers’ understandings and abilities of SI change and are shaped by experiences with inquiry is not well understood. Therefore, in this research project, a group of preservice science teachers experienced repeated, guided scientific inquiry activities in a methods course, and their descriptions of their experience with inquiry are examined. Guided SI involves supplying the students with materials or a problem but allows the students to ask further questions and design the procedures they will use to answer their questions.

In addition to the experiences with inquiry, preservice teachers made explicit connections between their activities and SI through reflection about their experiences in a
Explicit connections involve purposeful and planned linkage of their activities with the characteristics of SI through the use of questions that evoke these connections (Gess-Newsome, 2002). Their journal entries are used to describe their experiences with inquiry and their understandings and abilities of SI.

Significance of the Problem

Currently in most K-12 science classrooms, science is treated as a large body of knowledge that students must possess in order to pass a standardized test. While the tests vary from state to state, much classroom time is often devoted to test preparation, and rote memorization of science “facts” and content is often characteristic of science education throughout the country. Too often science teaching emphasizes recall of factual content with little focus on knowledge generation (McComas, Clough, & Almazroa, 1998). Most of the adults in U.S. society “learned” science in a classroom that used memorization, with the result that they have a very poor understanding of science, especially as it relates to their lives in the everyday world. As a result, much of our current population could be termed “scientifically illiterate,” having little or no understanding of the ways in which science affects the world. The American Association for the Advancement of Science (1990, 1993) and the NRC (1996) advocate a movement towards a scientifically literate population. Examples of science literacy in individuals include understanding there are consequences to throwing away a glass jar instead of recycling it; consciously pondering news items dealing with supposed science and questioning their claims; and holding oneself and his or her political representatives responsible for issues dealing with scientific issues, such as stem cell research, drilling for oil in Arctic National Wildlife Refuge, or ratifying the Kyoto protocol. For U.S.
society to be scientifically literate, its citizens must start with their young students, relating science to them not as a body of facts, but as an enterprise that is tentative, creative, inquiring, empirical, and subjective in its search for an understanding of natural phenomena (AAAS, 1990, 1993; NRC).

Although the vast majority of K-12 students will be in science classrooms that stress fact over action, process, or critical thinking, since the 1950s there has been a movement away from regurgitation of facts, and many teachers attempt to break away from this model. Organizations such as AAAS, NRC, and the National Science Teachers Association (NSTA) have put forth statements and documents emphasizing the importance of scientific literacy. These groups consist of scientists, science teachers, psychologists, teacher educators, and other representatives of the science and education communities who are interested in the learning and teaching of science. Thus, the documents they published are well researched and representative of the current knowledge of the best practices in science teaching. Although there are many scientists and organizations that emphasize the importance of scientific literacy, there is a debate about it among some social scientists (Nisbet, 2003). This group argues there is too much emphasis placed on scientific literacy by the scientific community. Even though there is a small movement that questions the importance of scientific literacy, the position taken in this paper is that it is an important component of educating students in the sciences.

To increase science literacy in the United States, AAAS created Project 2061 with funding from the National Science Foundation. Under Project 2061, AAAS published several documents that describe their stance, such as *Science for all Americans* (1990), *Benchmarks of Science Literacy* (1993), and the *Atlas of Science Literacy* (2001). These
documents contain guidelines and standards for science educators. The NSES, published by the NRC (1996), encourage increased scientific literacy in the classroom and define scientific literacy as

the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity . . . [as well as] specific types of abilities. (p. 22)

*Science for All Americans* puts forth similar assertions and states there are three areas of knowledge involved in scientific literacy: scientific worldview, scientific inquiry, and the scientific enterprise (AAAS, 1990). Scientific worldview encompasses the basic beliefs and attitudes that scientists share about their work. Scientific inquiry involves understanding the tools, processes, and methods used by scientists. Scientific enterprise recognizes the individual, social, cultural, and institutional aspects involved in doing science. SI is thus an important aspect of scientific literacy, can be used in science classrooms, and may be emphasized in preparing science teachers. This study contributes to the field of scientific literacy research by examining the area of scientific inquiry, specifically, preservice teachers’ descriptions of their experiences with SI and their understandings and abilities of SI.

**Philosophical Framework**

This study is guided by a constructivist paradigm. Guba and Lincoln (1994) describe constructivism as one of the four research paradigms that guide qualitative inquiry. Each of the four paradigms represents the researcher’s worldview for a particular study. Constructivist thinking suggests that “realities are apprehendable in the form of multiple, intangible mental constructions [and] socially and experientially based” (Guba & Lincoln, p. 110). Furthermore there is no absolute truth and the real world remains