5-2018

Theory of Planned Behavior Applied to High School Science Teachers Implementing Next Generation Science Standards

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THEORY OF PLANNED BEHAVIOR APPLIED TO HIGH SCHOOL SCIENCE TEACHERS IMPLEMENTING NEXT GENERATION SCIENCE STANDARDS

A Thesis Submitted in Partial Fulfillment
of the Requirements for the Degree of
Master of Science

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College of Natural and Health Sciences
Department of Chemistry and Biochemistry
Chemistry: Education Emphasis

May 2018

This Thesis by: Anna Pierce

Entitled: *Theory of Planned Behavior Applied to High School Science Teachers Implementing Next Generation Science Standards*

has been approved as meeting the requirements for the Degree of Master of Science in College of Natural and Health Sciences in Department of Chemistry and Biochemistry, Program of Chemistry: Education

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ABSTRACT

Pierce, Anna. *Theory of Planned Behavior Applied to High School Science Teachers Implementing Next Generation Science Standards*. Published Master of Science thesis, University of Northern Colorado, 2018.

The high demand for a scientifically literate society and workforce led to the creation of the Next Generation Science Standards (NGSS) and their release in April 2013. NGSS are based on a call to improve science education at the primary and secondary levels and emphasize the importance of a more conceptual and hands-on approach to science. The purpose of this mixed methods research study was to examine, through the use of Ajzen's theory of planned behavior, the factors involved in teachers' intentions to implement the NGSS in high school science courses. Semi-structured interviews were performed with nine teachers and experts in the field who were asked for their opinions regarding the implementation and changes they have made in their lessons and pedagogy in order to accommodate NGSS. From this, salient beliefs were identified and used to develop a survey using the theory of planned behavior. Factors influencing high school science teachers' (*N*=238) intentions to implement NGSS were identified through backward elimination multiple regression and independent samples *t*-tests. From the results, suggestions were provided on how to improve the adoption of NGSS and the effectiveness of professional development.
Keywords: Next Generation Science Standards, NGSS, implementation, science standards, high school, science teacher, theory of planned behavior

ACKNOWLEDGEMENTS

I wish to express my appreciation to my research advisor, Dr. Corina Brown, who was supportive and encouraging throughout this process. I am also grateful for the guidance of my committee members: Dr. Richard Hyslop and Dr. Robert Reinsvold.

My research would not have been possible without the many participants in my qualitative and quantitative studies and I am extremely appreciative for their willingness to participate. I would like to acknowledge the work of Icek Ajzen who proposed the theory of planned behavior, which guided much of my research. I am grateful for the advice on the finer points of grammar and usage from Marty Pierce and the helpful statistics discussions with Alan Arakkal.

TABLE OF CONTENTS

CHAPTER

I. INTRODUCTION.......... 1

Purpose of the Study.......... 2
Significance of the Study.......... 3
Research Questions.......... 4

II. REVIEW OF LITERATURE.......... 5

Next Generation Science Standards.......... 5
Theoretical Framework.......... 9

III. METHODOLOGY.......... 18

Research Questions.......... 19
Part 1: Semi-structured Interviews (Elicitation Study) 19
Part 2: Pilot Study with Questionnaire.......... 23
Part 3: Full Study with Questionnaire.......... 29

IV. RESULTS AND DISCUSSION.......... 40

Part 1: Semi-structured Interviews (Elicitation Study) 40
Part 2: Pilot Study with Questionnaire.......... 51
Part 3: Full Study with Questionnaire.......... 56

V. CONCLUSION AND IMPLICATIONS.......... 81

Limitations.......... 82
Future Research.......... 83
Implications.......... 84

REFERENCES.......... 87

APPENDIX

A SEMI-STRUCTURED INTERVIEW QUESTION.......... 93

B PILOT STUDY QUESTIONNAIRE.. 95

C INSTITUTIONAL REVIEW BOARD APPROVAL FOR QUALITATIVE RESEARCH... 103

D INSTITUTIONAL REVIEW BOARD APPROVAL FOR QUANTITATIVE RESEARCH.. 105

E FULL STUDY QUESTIONNAIRE.. 107

F ASSUMPTIONS FOR MULTIPLE LINEAR REGRESSION........ 115

LIST OF TABLES

TABLE

3.1.	Elicitation Study Participant Demographics and Background Information	20
3.2.	Response Types	31
3.3.	Demographics and Other Characteristics of Teachers	32
4.1.	Direct Construct Mean Score with Standard Deviation	52
4.2.	Indirect Construct Mean Score with Standard Deviation	52
4.3.	Simple Bivariate Correlations for Direct and Indirect Scores	54
4.4.	Direct Construct Mean Score with Standard Deviation	56
4.5.	Indirect Construct Mean Score with Standard Deviation	57
4.6.	Means and Standard Deviations for Indirect Salient Beliefs	58
4.7.	Means and Standard Deviations for Indirect Salient Beliefs Measuring Subjective Norm	60
4.8.	Means and Standard Deviations for Indirect Salient Beliefs Measuring Perceived Behavioral Control	61
4.9.	Simple Bivariate (Pearson's) Correlations for BI with Direct and Indirect Constructs	61
4.10.	Simple Bivariate (Pearson's) Correlations with Direct and Indirect Constructs	62
4.11.	Confirmatory Factor Analysis Theory of Planned Behavior Model Fit Results	63
4.12.	Standardized Results for Variances from Confirmatory Factor Analysis	64

4.13. Squared Multiple Correlations from Confirmatory Factor Analysis.. 65

4.14. Final Regression Model for BI as Dependent Variable as Predicted by the ABd, SNd, PBCd, Gender, Years of Experience, and Familiarity with NGSS... 66

4.15. Regression Analysis for the Direct Construct as Dependent Variable as Predicted by the Indirect Construct................................ 69

4.16. Attitude toward Behavior Salient Beliefs Independent Samples *t*-test Comparing Low Intenders and High Intenders BI Score........... 70

4.17. Subjective Norm Salient Beliefs Independent Samples *t*-test Comparing Low Intenders and High Intenders BI Score.................. 73

4.18. Perceived Behavioral Control Salient Beliefs Independent Samples *t*-test Comparing Low Intenders and High Intenders BI Score......... 74

LIST OF FIGURES

FIGURE

2.1.	Theory of planned behavior (Ajzen, 1991)	13
4.1.	Scatter plot of bivariate correlations of ABi with ABd and PBCi with PBCd...	54
F.1.	Scatter plot between studentized residual and standardized residual...	116
F.2.	Partial regression plot between BI and familiarity.........................	116
F.3.	Partial regression plot between BI and years of experience...........	117
F.4.	Partial regression plot between BI and gender..............................	117
F.5.	Partial regression plot between BI and ABd..................................	118
F.6.	Partial regression plot between BI and SNd..................................	118
F.7.	Partial regression plot between BI and PBCd................................	119
F.8.	Histogram of studentized residuals..	119
F.9.	Normal P-P plot of regression standardized residuals....................	120
F.10.	Normal Q-Q plot of studentized residuals......................................	120
F.11.	Studentized residuals with the unstandardized predicted values for familiarity..	121
F.12.	Studentized residuals with the unstandardized predicted values for years of experience..	121
F.13.	Studentized residuals with the unstandardized predicted values for gender...	122

F.14. Studentized residuals with the unstandardized predicted values for ABd.. 122

F.15. Studentized residuals with the unstandardized predicted values for SNd.. 123

F.16. Studentized residuals with the unstandardized predicted values for PBCd.. 123

CHAPTER I

INTRODUCTION

The United States is trailing other industrialized nations in math and science, ranking 29th and 22nd, respectively, out of 34 nations, according to the U.S. Department of Education (2013). There is a "need for a highly trained scientific workforce, and a scientifically literate citizenry has become imperative to the U.S." (Bodner, 2011, p. 1). To address this need in the science field, the National Research Council (NRC) established a committee to create the Next Generation Science Standards (NGSS). The NGSS are education standards adopted by multiple states in order to give all students a globally competitive science education. These standards are meant for science to be taught conceptually and are likely to cause teachers to teach differently (Cooper, 2013). Researching the implementation of the NGSS by teachers can help lead to an understanding of the current state of NGSS adoption and lead to appropriate professional development on how to improve use of the standards in the classroom.

In order to create the NGSS, the NRC collaborated with the National Science Teachers Association (NSTA), the American Association for the Advancement of Science (AAAS), Achieve, and 26 states with the following goal in mind:

> By the end of the 12th grade, students should have gained sufficient knowledge of the practices, crosscutting concepts, and core ideas of science and engineering to engage in public discussions on science-related issues, to be critical consumers of scientific information related to their everyday lives, and to continue to learn about science throughout their lives. (National Research Council, 2012, p. 24)

This worthwhile goal requires further research in order to determine if it is truly being attained. One step to achieving this goal is to investigate the teacher attitudes that can lead to or prevent reform in science education. Many prior studies supported this statement: Bybee (1993), Crawley & Koballa (1991), Cuban (1990), Fullan & Miles (1992), Gess-Newsome et al. (2003), Haney, Czerniak, & Lumpe (1996), Smith & Southerland (2007), and Thompson (1992). All of these studies are at least a decade old and thus have not dealt with the recent NGSS. The present study is aimed to research the attitudes and intentions of high school science teachers who are required by their state to implement NGSS.

Purpose of the Study

The purpose of the present study was to examine, through the use of Ajzen's theory of planned behavior, the factors involved in teachers' intentions to implement the NGSS in high school science courses. In the first part of this study, I interviewed experts in the field of science education in order to obtain salient beliefs about the implementation of NGSS in high school classrooms. Experts included university professors of science education and secondary science teachers who are implementing NGSS. The experts were questioned about their opinions of NGSS and how they believe the standards have affected their teaching and their students. The interview responses were analyzed for common themes. I then used this information to create a questionnaire, using Ajzen's theory of planned behavior, to investigate the implementation of NGSS in the high school science classroom.

Significance of the Study

Teacher attitudes may be partly responsible for teachers' decisions regarding NGSS implementation. Teachers may or may not be correctly implementing the NGSS in their classroom. The aforementioned studies, which occurred before the NGSS were created, reported that teacher beliefs and attitudes influence the implementation of reform. Those researchers observed that positive attitudes can promote reform while negative attitudes may inhibit reform. By researching teacher beliefs about the implementation of NGSS, barriers to change can be identified and addressed in order to promote reform. Depending on teachers' opinions and attitudes about NGSS, they may or may not be changing their lessons. Some teachers might be using previous science standards in the classroom although they are required to use the new NGSS. Therefore, students are unable to receive the proposed benefits of the new standards.

Understanding the salient beliefs of high school science teachers can help educators and administrators identify ways to increase the correct adoption of NGSS and provide appropriate professional development for teachers (Jones-King & Musselman, 2013). While there is novel research cited in the following literature review on implications of NGSS in the science classroom, there is a lack of research discussing the implementation of these science standards in the classroom. The most recent comprehensive study to investigate teachers' behavioral intention and attitudes toward the implementation of science education standards was done over two decades ago with Ohio's Competency Based Science Model strands (Haney et al., 1996). This research may provide educators and administrators information about barriers to NGSS implementation, which they can then use to help improve professional development for teachers.

Research Questions

The first research question (Q1) was used for the semi-structured interviews (elicitation study), which was the first part of the research. The second (Q2) and third (Q3) research questions guided the full study with the questionnaire.

Q1 What are experts' opinions regarding Next Generation Science Standards in high school and their implementation?

Q2 What are the salient reasons that teachers do or do not intend to implement NGSS in their high school science classroom?

Q3 What are the relationships between attitude toward implementing NGSS, subjective norm, perceived behavioral control and intention to implement the NGSS?

CHAPTER II

REVIEW OF LITERATURE

In order to understand the purpose of the current study and the theoretical framework that was used, a discussion of the present state of NGSS research is provided followed by a description of the theory of planned behavior and its application in this study.

Next Generation Science Standards

Elementary, middle, and high school teachers must follow educational standards in every core subject area. These are either widely used standards such as the Common Core and NGSS or standards set and followed by the state or school district (Gross et al., 2013; Cooper, 2013). However, not all teachers implement the standards in the same manner. The present study is concerned with the Next Generation Science Standards (NGSS) and their implementation in high school science classrooms across the United States.

NGSS were released in April 2013 and have been adopted by 19 states in the U.S. and Washington, D.C. as of November 2017, and many other states have shown interest in adopting them (NGSS Lead States, 2013). The NGSS were written as performance expectations that describe what the student should know and be able to do in order to demonstrate mastery of a certain standard in an assessment. Prior to the release of NGSS, “A Framework for K-12 Science Education” was released in 2011 by the NRC, which developed three dimensions for learning science: crosscutting concepts, disciplinary core ideas, and science and engineering practices. The NGSS also use these three dimensions as a framework for the standards. These dimensions are meant to promote integration of content throughout science learning (Bodner, 2011). Assessments need to include all three dimensions when implemented correctly (Cooper, 2013; NGSS Lead States, 2013).

Adoption and implementation of NGSS require states, schools, and teachers to make many changes. Implementation does not usually happen immediately and may take three to four years (Pruitt, 2014). Local communities have a variety of paths and timelines toward the complete implementation of the standards, according to a report by Simpson et al. in 2017. Despite the different paths, common themes have emerged: "communication, capacity/network building, professional learning for all stakeholders, examination of instructional learning materials, development of an assessment system, and state and local policy development" (p. 2). In general, all of these big changes are taking longer than the four years initially estimated to implement these standards (Simpson et al., 2017). Pruitt (2014) warned that if the timeline takes longer than originally predicted, "the sense of urgency is lost" (p. 155). One reason that this process is taking longer than expected might be due to teachers' attitudes and beliefs toward implementation of NGSS, which my research attempted to address.

Schools are making several necessary changes such as the creation of new curricula and assessments as well as training for pre-service and in-service teachers, according to Cooper (2013). Pre-service teachers need to learn to teach science in a way that engages critical thinking, not just through lectures that promote passive learning and rote memorization. Teachers have to be prepared to understand science conceptually and be able to answer the complex questions this new approach to learning may inspire in their students (Cooper, 2013). Similarly, Hanuscin and Zangori (2016) have five recommendations for pre-service teacher education: 1) mastery of content knowledge, 2) understanding the NGSS and the Framework, 3) providing successful examples of NGSS in the classroom, 4) practice with implementing NGSS in the classroom, and 5) collaboration with peers. Rodger Bybee (2014), a well-known science education expert, agreed that the field of science education needs to change how teachers are taught in order to reflect the educational shifts seen at the K-12 level when implementing NGSS. One example of a shift is that students are now asked to explain natural phenomena instead of learning facts. The implication of this shift is that "students develop models and make sense of the natural world by using evidence to develop explanations" (Bybee, 2014, p. 217). Lack of training in this new method of teaching or lack of time to be able to change lessons could be barriers for teachers implementing NGSS.

The transition to NGSS has not been without controversy. The Fordham Institute, a critic of NGSS, released a report evaluating each state's standards and compared them to the NGSS using criteria that focused on content, rigor, and clarity of expectations. They gave the NGSS a "C" letter grade. Thirteen states, including Washington, D.C., earned higher grades than NGSS, 12 earned Cs like NGSS, and 26 states received a D or F. For the latter, Fordham Institute believed adopting NGSS would be an upgrade (Gross et al., 2013). However, schools who received a higher grade than the NGSS might actually be depreciating their existing curriculum by adopting the new and potentially inferior standards. Teachers who believe their previously-used science standards were better than NGSS may be less likely to implement NGSS.

Changes in assessments need to be made by teachers using NGSS, according to an article by Sondergeld, Peters-Burton, and Johnson (2016). They noted that many assessments need to change to use an essay or short answer format instead of multiple choice in order to allow students to provide evidence of learning. Advantages of self-constructed responses include students being more creative, not guessing the answer, being required to use higher levels of integrated thinking, and being able to assess multiple objectives at a time (Sondergeld et al., 2016). Disadvantages include a longer time for completion of assessments, a longer time for teachers to grade, and more subjectivity in teacher grading (Sondergeld et al., 2016). These advantages and disadvantages possibly reflect beliefs that either promote or inhibit teachers correctly implementing NGSS.

There is currently very limited quantitative research dealing specifically with the implementation of NGSS. One quantitative report was based on American schools using NGSS in the Middle East and North Africa (MENA), which surveyed teachers about the current implementation of the standards (Simpson, Sunder, Gabler, & KDSL Global, 2017). They found that teachers attending trainings in the MENA region who were new to NGSS had uneasiness about the implementation of the standards and how it would affect their classroom. However, 30 minutes into the training, teachers realized that the goal of NGSS aligned with their own goals of what they want to see happening in their classrooms. As reported in the MENA, simple changes in professional development may improve teachers' opinions of the standards here in the United States.

In the report's survey of 75 teachers in the MENA region (Simpson et al., 2017), 84% believed that NGSS will lead to improved student learning, a majority have a plan for transitioning to NGSS at their school, only 11% felt unprepared to teach using NGSS, and half of participants had participated in professional development and trainings on NGSS. One challenge that MENA region teachers face is that they are mainly non-native English speakers, but the emphasis on using science practices increased the accessibility of content despite the language challenges of NGSS being written in English. Overall, in part due to teacher beliefs, the transition for teachers and schools appeared to be positive in the MENA region.

While there is research evaluating NGSS (Gross et al., 2013) and predicting what teachers need to know in order to implement the standards (Bodner, 2011; Bybee, 2014; Cooper, 2013; Sondergeld et al., 2016), there is no research detailing how the implementation of NGSS is progressing in the classrooms across the United States or how teachers' attitudes and beliefs might affect the implementation. The purpose of the current study is to determine salient beliefs, both positive and negative, held by high school science teachers about the implementation of NGSS under the framework of the theory of planned behavior.

Theoretical Framework

Theory of Planned Behavior

By using the theory of planned behavior as a theoretical framework, it can be determined which salient beliefs prevent or promote teachers' implementation of NGSS in high school science classrooms. Ajzen (1985) proposed the theory of planned behavior, which uses the idea that humans behave using goals and plans to direct their behavior. Social psychologists agree that humans act based on their intentions to act, although not all intentions are acted upon.

These general concepts allow for the theory of planned behavior to predict and explain a behavior in certain contexts. A person's intent to behave in a certain way is the immediate determinant of that behavior. The immediate determinants to intention are identified as the attitude toward the behavior, the subjective norm, and the perceived behavioral control (Ajzen, 1985). The attitude toward the behavior is the degree of positive or negative assessment given to the behavior. The subjective norm is the social pressure to perform or not perform that behavior. The perceived behavioral control is the level of difficulty or ease with performing the behavior based on various obstacles or aids. Each of these variables might have more or less of a weight depending on the behavior (Ajzen, 1991).

A person's attitude toward behavior (*AB*) is defined as a personal belief that performing a specific behavior is either positive or negative, which is depicted in Equation 1 (Ajzen, 1985).

$$AB \; \alpha \; \sum_{i=1}^{n} b_i e_i \tag{1}$$

In the equation, the strength of the salient behavioral belief (b) is multiplied by the outcome evaluation (e) of the belief (either positive or negative). These values are summed for the number of (n) salient beliefs. A person's attitude toward the behavior (*AB*) is directly proportional (α) to the summative belief index shown in Equation 1. It is important that the salient beliefs are truly salient instead of selected beliefs that were thought to be important (Ajzen, 1991). For example, a high school science teacher might believe that implementing NGSS will increase student engagement in learning science, which indicates a positive attitude toward the behavior.

Belief strength (*b*) is best assessed on a 7-point scale, such as likely to unlikely, while evaluation of a belief (*e*) can be measured using a 7-point evaluative scale, such as good and bad (Ajzen, 1991). Multiple items are needed in order to assess belief strength and evaluation of a belief. The 7-point scales can be unipolar (1 to 7 or 0 to 6) or they can be bipolar (-3 to +3). It is thus reasonable that the belief strength can be measured with a 1 to 7 scale while the evaluative scale uses a -3 to +3 scale. It is beneficial to use scales in this manner because the interpretation of scores is easier when the midpoint of the scale is zero, clearly showing if the final score represents an attitude for or against implementing NGSS. This was the practice used in the present research design.

A person's subjective norm is defined as the social pressures perceived by a person to perform or not perform a specific behavior. People who see a behavior as positive and believe that others think it is important tend to perform that behavior (Ajzen, 1985). Teachers might be influenced by their administrators, other teachers, or students' parents, thus affecting their implementation of the standards. A similar equation to Equation 1 can be derived for subjective norm (*SN*) where the strength of the normative belief (*n*) is multiplied by the person's motivation to comply (*m*) to the individual or group in question as shown in Equation 2. The subjective norm is directly proportional (α) to the sum of the products for the number of *n* salient individuals or groups (Ajzen, 1991).

$$SN \ \alpha \ \sum_{i=1}^{n} n_i m_i \qquad (2)$$

Prior researchers (Ajzen, 1991) have concluded that using a unipolar measure for motivation to comply and a bipolar measure for the strength of normative beliefs results in optimal scoring and was used in the present research design.

A person's perceived behavioral control takes into account time, opportunity, and dependence on others in order to perform the behavior because each of these factors may make changes to a person's intentions. High school teachers might not feel they have control over the available resources, which could limit their implementation. Equation 3 is used to determine perceived behavioral control (*PCB*) where each control belief (c) is multiplied by the control power (p) of that salient control factor which might inhibit or promote performance of that behavior. The summed products for the number of *n* salient control beliefs is proportional to the perceived behavioral control (Ajzen, 1991).

$$PCB\ \alpha\ \sum_{i=1}^{n} c_i p_i \qquad (3)$$

In the present study, to score perceived behavioral control, a unipolar scale was used for the strength of control belief, while a bipolar scale was used for the control power so that a neutral score was zero.

The variables of attitude toward the behavior, subjective norm, and perceived behavioral control can be weighted more or less as shown in the multiple linear regression analysis, which was performed in the full study. The regression coefficients from these analyses are weights (*w)* of these variables. The theory of planned behavior can be summarized by Equation 4 where the behavior (*B*) can be predicted by the behavioral intent (*BI*), which can be estimated by the weighted contributions of attitude toward behavior, subjective norm, and perceived behavioral control (w_1, w_2, w_3).

$$B\sim BI\sim(AB + SN + PBC) = w_1 AB + w_2 SN + w_3 PBC \qquad (4)$$

The relationships between the variables in the theory of planned behavior are shown in Figure 2.1 (Ajzen, 1991). For each of the direct variables (attitude toward behavior, subjective norm, and perceived behavioral control), there is a proportional indirect measure (behavioral beliefs X outcome evaluations, normative beliefs X motivation to comply, and control beliefs X control power) as described in Equations 1, 2, and 3.

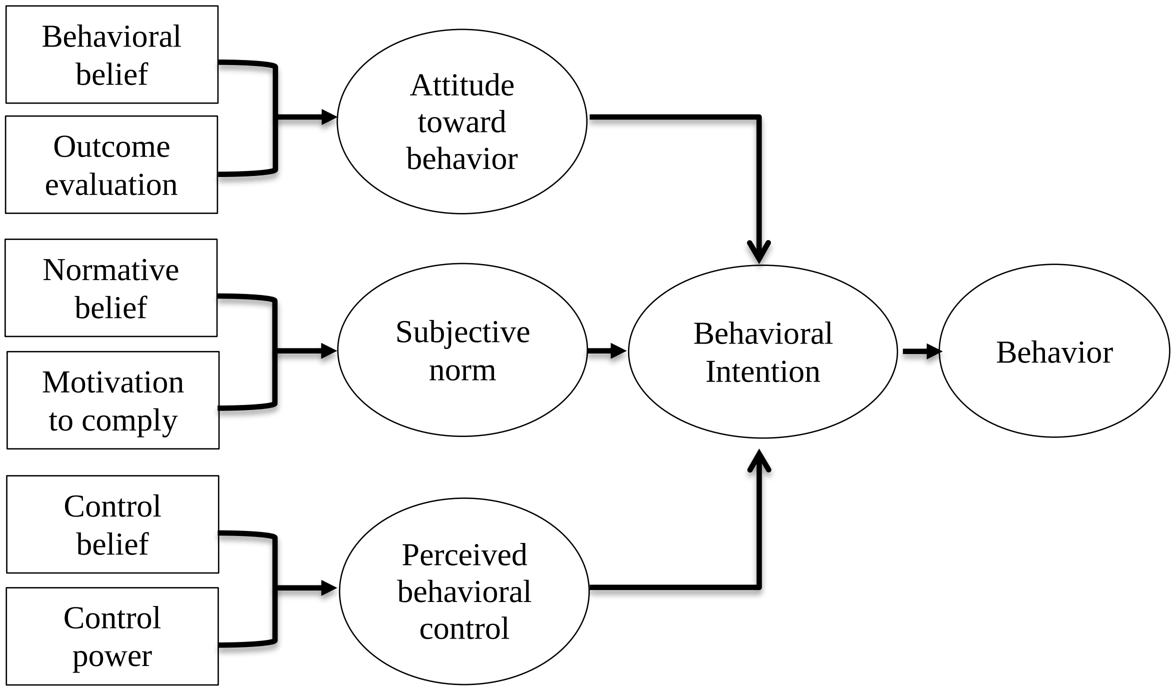

Figure 2.1. Theory of planned behavior (Ajzen, 1991)

The correlations between intention and behavior as well as the correlations between direct and indirect measures should be reported when possible. The latter was reported in the present study, since behavior was not measured. In a sample of research findings in the health and social science fields, these major relationships among the variables in the theory of planned behavior were found to have strong intention-behavior correlations that exceed 0.70 (Ajzen, 1985). The correlations between intention-attitude toward behavior and intention-subjective norm were also all highly accurate predictions of intentions, which support the use of the theory of planned behavior in the health and social science disciplines (Ajzen, 1985).

There are three requirements in order to accurately predict a behavior using the theory of planned behavior (Ajzen, 1991). First, the behavior that is being predicted needs to be compatible with the measures used for intention and perceived behavioral control. Second, the perceived behavioral control needs to accurately reflect actual control. If the items on the questionnaire are not applicable, then they will not be helpful in predicting if the behavior is taking place. Third, the time between assessment and observation of the behavior must be stable. For example, a teacher's responses to the questionnaire may no longer be valid if he or she attends professional development about NGSS shortly after taking the questionnaire.

Time is one factor that might cause changes in a person's intention and behavior. Thus, the passing of time can cause multiple issues with the theory. One issue is with the salience of beliefs. As the performance of a behavior, such as the implementation of NGSS, becomes closer in time, the person might have more negative beliefs about that behavior, which might ultimately prevent the person from performing that behavior. For example, a teacher might not implement NGSS as time goes on due to other obligations that need to be met before he or she has time to work on changing lesson plans. Another issue is the opportunity to learn new information over time that might change a person's beliefs. When new information about the behavior becomes available, a person's beliefs may change, thus affecting his or her intent to perform the behavior. In general, if a person has strong intentions to perform the behavior, he or she will likely still continue with the plan despite new information, and the opposite would be true of someone with weak intentions (Ajzen, 1985; Francis, 2004).

Applications of Theory of Planned Behavior in Science Education

Several cases show how the theory of planned behavior can be used successfully in the field of science education (Crawley, 1988; Crawley & Koballa, 1991; Haney, Czerniak, & Lumpe, 1996; Jones-King & Musselman, 2013; Listman & Kapila, 2016). Although the findings in those studies do not necessarily apply to the findings of the present study, they were helpful in the creation of the present study's methodology. These cases also help support the use of the theory of planned behavior in the context of the present study.

The application of the theory of planned behavior is demonstrated by Crawley and Koballa's (1991) study of Hispanic-American student enrollment in a high school chemistry course. The authors wanted to learn what salient beliefs were held by students which either led them to enrolling or not enrolling in chemistry. All relationships between indirect (behavioral, normative, and control beliefs) and direct (attitude, subjective norm, and perceived behavioral control) constructs were analyzed. Crawley and Koballa observed that the students rely on their attitude about chemistry and not what others want them to do. The students were also somewhat influenced by personal perceptions of control and potential barriers that they believe exist. The use of the theory of planned behavior was supported by their findings.

The theory of reasoned action, a modification to the theory of planned behavior that does not use perceived behavioral control as a variable, was explored by Crawley in 1988 with the intent to understand and predict science teaching behavior. In Crawley's study, 42 teachers enrolled in a summer professional development class about implementing physical science were asked to respond to an open-ended questionnaire and a final questionnaire from which Crawley was able to determine salient beliefs of teachers. He observed that the teachers' attitude toward the science teaching behavior strongly influenced their use of investigative methods when teaching physical science, whereas social pressure had little influence on teachers. From these studies, one can predict that teacher attitudes, which I explored in my research, will have a stronger influence than the subjective norm.

Additionally, Listman and Kapila (2016) used the theory of reasoned action, the modified version of the theory of planned behavior, to explain student and classroom attitudes toward science, technology, engineering, and mathematics (STEM) subjects and how the attitudes relate to "student behaviors of engagement, performance, and persistence in STEM subjects and subsequent choice of a STEM career" (p. 2). Their goal was to foster positive attitudes about STEM among students using a specific curriculum, so a pre- and post-test methodology was used.

A study exemplifying the methodology for pilot research was performed by Jones-King and Musselman (2013). They conducted a study using the theory of planned behavior as their theoretical framework to explore factors that would promote high quality professional development for science and math teachers. Their pilot study consisted of 18 participants and a 60 question survey. Using Cronbach's alpha and factor analysis, they were able to estimate internal consistency reliability and determine if any questions should be excluded from their questionnaire. The purpose of their analysis was to validate the use of instrumentation, which was supported. However, some of the items did not fully align with the theory of planned behavior, but the authors believed that it was due to the small sample size and planned to continue to use those items for a full study with a larger sample size. Their methodology was used and adapted for the present research.

The study by Haney, Czerniak, and Lumpe (1996) was used as a model in the present research design. The purpose of their study was to use Ajzen's theory of planned behavior in order to determine which factors influence teachers' intentions to implement the four strands of Ohio's Competency Based Science Model: inquiry, knowledge, conditions, and applications. Haney et al. found that attitudes toward the behavior had the strongest influence on Ohio teachers' intent to implement the science standards. Similarly, in the present study, I will investigate the attitudes and intentions of high school teachers in the implementation of the NGSS. There has not been a study using the theory of planned behavior with science standards since the research of Haney et al. The present research will potentially lead to the improved adoption of these standards and improved professional development for teachers using NGSS.

In this chapter, the literature relating to the NGSS, the theory of planned behavior, and applications of the theory were considered. The application of the theory of planned behavior in the context of this study will be further discussed in the next chapter.

CHAPTER III

METHODOLOGY

This chapter presents the methods employed in conducting the study, including the research questions, research design, data collection, and instrumentation. A multi-method approach to data collection was used and the research was conducted in several stages starting with semi-structured interviews (Part 1), then a pilot study (Part 2), followed by the full study (Part 3).

Guidelines for conducting a study (Ajzen, 1985; Ajzen 1991) and constructing a questionnaire (Francis et al., 2004) using the theory of planned behavior were followed. Part 1 of the study consisted of semi-structured interviews (Appendix A) that were conducted in order to identify salient beliefs held by teachers regarding the implementation of NGSS. The findings of the semi-structured interviews were used, in Part 2 of the study, to develop the items in the questionnaire (Appendix B) related to the direct measures (attitude toward behavior, subjective norm, perceived behavioral control) and indirect measures (behavioral beliefs X outcome evaluations, normative beliefs X motivation to comply, and control beliefs X control power). This questionnaire was piloted (Part 2) with a small sample size. Following this, any errors in the questionnaire were addressed before completing a full study (Part 3) with a larger sample size (see Appendix E for full study questionnaire).

Research Questions

The first research question (Q1) guided the first part of the research, which was the semi-structured interviews (elicitation study). The second (Q2) and third (Q3) research questions guided the full study with the questionnaire.

Q1 What are experts' opinions regarding Next Generation Science Standards in high school and their implementation?

Q2 What are the salient reasons that teachers do or do not intend to implement NGSS in their high school science classroom?

Q3 What are the relationships between attitude toward implementing NGSS, subjective norm, perceived behavioral control and intention to implement the NGSS?

Part 1: Semi-structured Interviews (Elicitation Study)

Through semi-structured interviews, the first research question was addressed. This research question was intentionally kept broad due to the exploratory nature of this study. The findings from the interviews were analyzed to create the questionnaire used in the pilot study and full study.

Participants

The participants for the elicitation study consisted of nine professors of science education and secondary science teachers located in the U.S. West and Midwest. In order to be included in the study, participants needed to have familiarity with NGSS and/or K-12 science education. Three of the participants were middle or high school teachers who have been working to implement NGSS in their classrooms. Four of the participants were university professors of science education or education. Two of the participants were not professors or teachers, but have extensive experience with the process of implementation of NGSS due to the organizations with which they are affiliated. A summary of the participant demographics and background are given in Table 3.1.

Table 3.1. Elicitation Study Participant Demographics and Background Information

Participant Code	**Gender**	**Role in Education**	**Years of Experience in the Field of Education**	**Are you familiar with NGSS? (Yes, No, Somewhat)**
1	M	Professor of Biology who teaches biology and pre-service education	>15 years	Yes
2	F	University administrator who works with graduate level science education	>15 years	Yes
3	F	Science representative for a state Department of Education who previously taught pre-service teacher education, chemistry, and biology	>15 years	Yes
4	M	Professor of Chemistry who teaches chemistry and pre-service teacher education	>15 years	Somewhat
5	F	High school chemistry teacher	10-15 years	Yes
6	F	High School chemistry, biology, and earth science teacher	<2 years	Yes
7	M	Professor of Chemistry and Chemistry Education	>15 years	No
8	F	Professor of pre-service teacher education	10-15 years	Yes
9	M	Middle school science teacher	<2 years	Yes

Data Collection

In-depth interviews were used in order to understand the experiences of science education experts. This type of interview is one of the most common qualitative methods and is “optimal for collecting data on individuals’ personal histories, perspectives, and experiences” (Mack, Woodsong, MacQueen, Guest, & Namey, 2005). During the in-depth interviews, I considered myself the student seeking knowledge on the topic of implementation of NGSS while the interviewee was the expert sharing their experiences; this mindset is an essential part of the in-depth interview (Mack et al., 2005). Institutional Review Board (IRB) approval was obtained from the University of Northern Colorado (Appendix C)--IRBNet ID: 957989-2.

Participants were interviewed either in person, by phone, or by written communication. A demographic form, including information such as role in education, years of experience, and familiarity with NGSS, and a consent form were completed before the interview. The administration of the interview, which contained 13 semi-structured questions (see Appendix A), took 30-60 minutes. Phone and in-person interviews were audio recorded and later transcribed. A written record was kept for participants who chose to answer the questions via a word document.

Trustworthiness and Rigor

To ensure trustworthiness in the elicitation study, an external person with expertise in qualitative research and I discussed and were in complete agreement with the resulting themes. To show consistency and trustworthiness in the results, a triangulation was used by comparing the interviews of secondary teachers to professors of science education in which similar themes among both groups of participants were observed.

Personal Stance of the Researcher

My interest in studying NGSS arose because I will soon be a high school science teacher implementing these science standards. I have had the opportunity to create several lessons and units using NGSS. This experience has created an interest in learning about teachers' perspectives on how implementation is going in their classrooms. I have had an overall positive experience using NGSS in the classroom, but I was interested to hear both positive and negative opinions of these standards.

Theoretical Stance

Approaching this study through a social constructionist theoretical stance allowed the participants and me to identify the perceptions of these science standards and how they are implemented in schools. Social constructionism acknowledges that we are social beings who construct knowledge through interactions with each other and our world (Creswell, 2013). All participants had their own ideas and opinions of the standards due to their unique experiences. Furthermore, I wanted to ensure an interview environment in which they felt comfortable voicing their opinions. Their reality of using the science standards is dependent on the participants' classroom and life experiences, thus representing a social constructionism theoretical stance.

Data Analysis

The interview transcripts were analyzed for common themes and patterns employing NVivo Pro 11 software using thematic analysis procedures (Creswell, 2013). "Thematic analysis is a method for identifying, analyzing, and reporting patterns (themes) within data" (Braun & Clarke, 2006, p. 6). The transcripts were organized and categorized into concepts and keywords commonly discussed in the interviews. Data were connected using themes to show how concepts were interrelated. Based on the results of the analysis, a quantitative questionnaire was created to send to high school science teachers.

Part 2: Pilot Study with Questionnaire

In the pilot study, the findings from the responses were analyzed to address changes that needed to be made to the questionnaire that would be used in the full study. The pilot study consisted of a small sample size that was not the intended sample population, so no research questions were addressed. However, the pilot study provided important feedback for the improvement of the questionnaire.

Participants

The sample for the pilot study consisted of University of Northern Colorado (UNC) Chemistry Graduate Teaching Assistants (GTAs), who taught laboratories in chemistry at UNC, and UNC pre-service chemistry teachers. This sampling frame was chosen based on convenience and is similar to the target population of high school science teachers due to their experience in science education. Questionnaire requests were sent by email to the GTAs and UNC pre-service chemistry teachers. Email lists were obtained from the Department of Chemistry and Biochemistry at UNC. The sample consisted of those who were willing and able to participate in the survey. The initial email included a link to the Qualtrics questionnaire and was sent to 33 potential participants. A follow-up reminder email was also sent a week later to those who had not yet completed the survey. Overall, 14 people opened the survey but it was completed by only 12 participants, which means 36% of those who were emailed completed the survey. Of the 12 who completed the survey, 11 were UNC GTAs and one was a pre-service teacher; five were male, six were female, and one was gender fluid using the write-in option; seven were not familiar with NGSS, two were slightly familiar, and three were moderately familiar; seven had 0-4 years teaching experience and five had 5-9 years teaching experience. Institutional Review Board (IRB) approval was obtained from Susan Hutchinson as a part of the SRM 700 Advanced Research Methods course during the Fall 2017 semester.

Survey Instrument

The pilot questionnaire (Appendix B) contained several parts, which include demographic questions, questions using the theory of planned behavior, and questions assessing the quality of the survey. A total of 65 items were included in the questionnaire and took participants approximately 10-15 minutes to complete. First, four demographic questions were asked, which include participants' current role in education, years of teaching experience, gender, and familiarity with NGSS. Following this, the participants were provided with instructions to "respond to all of the survey questions as if you are going to be teaching chemistry at a high school and your school is in a state that has adopted NGSS as the science standards for K-12 students." The participants were also provided with a definition of NGSS in case they were unfamiliar with the standards. After the participants were provided with instructions and the NGSS definition, they proceeded to the remaining questionnaire items.

The questionnaire items using the theory of planned behavior were developed using recommendations by Ajzen (1985; 1991) and Francis (2004). The questionnaire contains both direct and indirect measures related to the theory of planned behavior. A standard 7-point scale was used to construct the measures. The participants rated their beliefs about NGSS on a scale of 1 to 7 (all direct measures, behavioral beliefs, motivation to comply, and control beliefs) or -3 to +3 (outcome evaluations, normative beliefs, and control power) with varying scale descriptors, such as extremely unlikely to extremely likely and not at all to very much. The questionnaire is composed of four sets of questions using the theory of planned behavior as follows (see Appendix B).

Behavioral intentions to teach using Next Generation Science Standards. The first set of questions related to the participants' intentions to teach NGSS. There were three items to measure behavioral intention (BI), which is a direct variable. An example is "I expect to implement NGSS in my classroom" rated on a scale of strongly agree to strongly disagree. In order to calculate the score for BI, the mean of these three items was determined, and thus will have a possible score range of 1 to 7. A low score means respondents do not intend to implement NGSS and a high score means they have strong intentions to implement NGSS. A demonstration of internal consistency greater than 0.6 is important for all of the direct variables, which would mean that 40% or less of the variance in responses to the items would represent random measurement error (Francis et al., 2004). Therefore, internal consistency closer to one is ideal. The reliability estimate based on Cronbach's alpha for BI was 0.849 in the pilot study.

Attitude toward implementation of Next Generation Science Standards. The second set of questions related to attitudes about implementing NGSS (attitude toward the behavior). There were four items to measure the direct variable for attitude toward the behavior (ABd) and there were 22 items to measure the indirect variable (ABi). The following two items representing the salient belief of NGSS helping students to think critically were used as a part of the attitude toward behavior indirect variable:

1) My implementation of the NGSS would help students to think critically.
(extremely unlikely 1 2 3 4 5 6 7 extremely likely)

2) Helping my students to critically think is...
(extremely undesirable -3 -2 -1 0 1 2 3 extremely desirable)

Item 1 addressed the behavioral belief, while item 2 addressed the outcome evaluation.

A score for ABd was calculated by taking the mean of the responses on the 1 to 7 scale. A score for ABi was calculated using the scales 1 to 7 and -3 to +3. For every question with a 1 to 7 scale, there is a corresponding question with a -3 to +3 scale as shown in the two example questions above. The 1 to 7 scales are multipliers to amplify the -3 to +3 score by that amount. For example, a participant might answer 5 on the 1-7 scale and -2 on the -3 to +3 scale so that his or her score will be 5 x -2 = -10 for that item. For each salient belief, the response of the behavior belief is multiplied by the response of the outcome evaluation; then each of these products is summed and analyzed. There were 11 salient beliefs for ABi. For the ABd and ABi scores, a positive score means that the participant felt positively about implementation of NGSS whereas a negative score means that the participant felt negatively about implementation of NGSS. The possible score range for ABd was 1 to 7 and ABi was -231 to 231. The score range for ABi comes from Equation 1 described in Chapter II, in which the participant’s score on the unipolar scale (1 to 7) is multiplied by the bipolar scale (-3 to +3) for a possible range of -21 to 21 for each individual salient belief. This possible range is then multiplied by the 11 salient beliefs to obtain the possible score range for ABi (-231 to 231). The reliability estimate based on Cronbach’s alpha for ABd was 0.957, for ABi was 0.300, and for combined ABd and ABi was 0.705 in the pilot study.

Subjective norm. The third set of questions related to determining the social pressures perceived by the participant to implement NGSS or not to implement NGSS (subjective norm). There were three items to measure the direct variable for subjective norm (SNd) and there were 10 items to measure the indirect variable (SNi). Similar to attitude toward the behavior, two items were used for the indirect variable of subjective norm for the salient belief that other science teachers implement NGSS:

3) Other science teachers (do/do not) implement NGSS
(do not 1 2 3 4 5 6 7 do)

4) Doing what other science teachers do is important to me.
(not at all -3 -2 -1 0 1 2 3 very much)

Item 3 assesses the strength of the normative beliefs, while item 4 assesses the participant's motivation to comply.

A score for SNd was calculated by taking the mean of the responses on the 1 to 7 scale. A score for SNi was calculated by multiplying the response for the normative belief by the response for the motivation to comply and then each of these products is summed. There were five salient beliefs for SNi. A positive score means that the participant experienced social pressure to implement NGSS whereas a negative score means that the participant experienced social pressure not to implement NGSS. The possible score range for SNd was 1 to 7 and SNi was -105 to 105, which was obtained from Equation 2 in Chapter II. The sample reliability based on Cronbach's alpha for SNd was 0.181, for SNi was 0.542, and for combined SNd and SNi was 0.598 in the present pilot study.

Perceived behavioral control. The fourth set of questions related to the perceived barriers or aiding factors which could make it easier or harder to implement NGSS (perceived behavioral control). There were four items to measure the direct variable for perceived behavioral control (PBCd) and there were 12 items to measure the indirect variable (PBCi). For the independent variable of perceived behavioral control, these two items cover the salient belief that teachers are limited by their resources:

> 5) When I am implementing NGSS, I feel that I do not have enough resources (funding, curriculum materials, training, equipment, etc.)
> (extremely unlikely 1 2 3 4 5 6 7 extremely likely)
>
> 6) Having available resources (funding, curriculum materials, training, equipment, etc.) would make it (extremely difficult/extremely easy) to implement NGSS.
> (extremely difficult -3 -2 -1 0 1 2 3 extremely easy)

Item 5 assesses the control belief, while item 6 assesses the control power.

A score for PBCd was calculated by taking the mean of the responses on the 1 to 7 scale. A score for PBCi was calculated by multiplying the response for the control belief by the response for the control power and then each of these products is summed. There were six salient beliefs for SNi. For perceived behavioral control, a positive score means that the participant felt in control of implementing NGSS in his or her classroom, while a negative score means that the participant did not feel in control of implementing NGSS. The possible score range for PBCd was 1 to 7 and PBCi was -126 to 126, which was obtained from Equation 3 in Chapter II. Reliability estimates based on Cronbach's alpha for PBCd was 0.435, for PBCi was 0.570, and for combined PBCd and PBCi was 0.686 in the pilot study.

Survey feedback. Following the completion of the questionnaire, the participants were asked several questions about the quality of the survey: 1) Are there any questions that were confusing or difficult to answer? 2) At what point in the survey did you lose interest? 3) How might the format of this survey be improved? Responses to these questions helped with improving the questionnaire before conducting the full study.

Procedure

Pilot study participants were asked to complete the Qualtrics survey online. Based on the survey feedback about the quality of the survey and the results from the pilot study, the instrument was revised with several changes to the scale endpoints and addition of an SNd item. These changes were made before conducting the full study with high school science teachers. The changes are further discussed in Chapter IV Results and Discussion.

Data Analysis

Reliability of scores on each variable in the questionnaire was calculated using Cronbach alpha procedures. Direct variable score constructs that do not provide acceptable internal consistency, based on guidelines provided by Francis et al. (2004), may be revised or specific items in the construct may be omitted. They stated that an acceptable internal consistency is alpha ≥ 0.6, which means that all direct variable items can be included in the overall score for the construct (BI, ABd, SNd, and PBCd). It is important to note that Cronbach's alpha is not very reliable at this small sample size ($N=12$), therefore, omission of items was not done during the pilot study. SPSS (Version: IBM SPSS Statistics 24) was used to compute all statistical analyses.

For the pilot study, there was not enough statistical power to perform multiple regression analysis, confirmatory factor analysis, or independent samples *t*-tests. However, these statistical analyses were performed with the full study.

Part 3: Full Study with Questionnaire

Through the full study, the second and third research questions were addressed. Based on pilot study results, the questionnaire used was improved upon for use in the full study (see Appendix E). The improvements are discussed in Chapter IV Results and Discussion.

Participants

The participants in the full study consisted of high school science teachers in a state that has adopted NGSS. The sampling frame that was used is based on a list of high school science teachers in Iowa, a state that has adopted NGSS. State support and resources for education varies with each state and states adopted NGSS at different times. By surveying one state, these differences can be controlled. Institutional Review Board (IRB) approval was obtained from the University of Northern Colorado (Appendix D)--IRBNet ID: 1159749-1.

A list of Iowa high schools found at educationbug.org was used and each school website was viewed to compile science teacher staff email addresses. These email addresses were used to recruit participation in the full study. Alternative schools, which provide a different educational approach for students who may be considered at-risk, were not included in the full study. Twenty-eight schools were excluded due to a lack of teacher contact information on the school website. In Iowa, the survey was sent to 1,023 high school science teachers at 321 different high schools. The response rate was 25.2% for those who started the survey and the completion rate was 86.8%. Additionally, the National Science Teacher Association (NSTA) had a list server titled “NGSS,” that was utilized to obtain participants from areas other than Iowa. Unfortunately, a response rate cannot be calculated for the list server, because the survey request was sent to an unknown number of people. An initial email with a link to the questionnaire and a follow-up reminder email were sent to the Iowa high school science teachers and the five

NSTA list servers. The response types (completed, partial, and screened out) were recorded in Qualtrics and are presented in Table 3.2. Screened out participants consisted of those who answered no to the question "Are you currently a high school (9th-12th grade) science teacher?" The demographics of participants are shown in Table 3.3.

Table 3.2. Response Types

Response Type	**N (%)**
Completed	238 (87.18%)
Partial	19 (6.96%)
Screened Out	16 (5.86%)

Table 3.3. Demographics and Other Characteristics of Teachers (*N=257 *Completed and Partial Response*)

Characteristics	**N (%)**
Gender	249
Female	149 (59.84%)
Male	100 (40.16%)
Teaching experience (years)	253
0-4	51 (20.16%)
5-9	40 (15.81%)
10-14	43 (17.00%)
15-19	35 (13.83%)
>20	84 (33.20%)
Location	253
Rural	148 (58.50%)
Suburban	77 (30.43%)
Urban	28 (11.07%)
State	249
Iowa	213 (85.54%)
Other State*	36 (14.46%)
Familiarity with NGSS	252
Extremely Familiar	61 (24.21%)
Very Familiar	129 (51.19%)
Moderately Familiar	55 (21.83%)
Slightly Familiar	7 (2.78%)
Not Familiar At All	0 (0.00%)
Grade Level (Select all that apply)	
9^{th}	133 (18.63%)
10^{th}	181 (25.35%)
11^{th}	203 (28.43%)
12^{th}	197 (27.59%)
Content Area (Select all that apply)	
Biology	133 (19.62%)
Chemistry	121 (17.85%)
Physical Science	93 (13.72%)
Physics	82 (12.09%)
Earth Science	69 (10.18%)
Anatomy and Physiology	62 (9.14%)
Environmental Science	52 (7.67%)
Other	45 (6.64%)
Engineering	21 (3.10%)

*Other state (N): Arizona (1), California (7), Colorado (1), Idaho (1), Illinois (3), Kansas (1), Louisiana (1), Michigan (2), Minnesota (1), New Jersey (5), New York (1), North Carolina (1), Pennsylvania (1), Rhode Island (1), South Carolina (2), Washington (1), Wisconsin (5), Wyoming (1).

Survey Instrument

Demographic questions were asked of participants, but questions regarding the quality of the survey were not asked for the full study. The demographic questions that were asked include gender, grade level taught, subject(s) taught, geographic location (rural, suburban, and urban), years of teaching experience, and familiarity with NGSS (Table 3.3). The survey was programmed to screen out participants who were not high school teachers and who stated that they were not at all familiar with NGSS. A total of 66 items were in the questionnaire. One question for the SNd variable was added in order to improve internal consistency reliability. The SNd item was, "People who are important to me want me to implement NGSS." The scales on some questions were reversed so that all positive responses were on the left and all negative responses were on the right. One instructed response item was added to prevent response set (Meade & Craig, 2012). This item stated, "To ensure the quality of this survey, please click on 'strongly agree' for this item." The order of the direct variable questions in the survey was mixed up so that participants did not read all of those items at the same time since they have similar content. Otherwise, all questionnaire items remained the same from the pilot study to the full study (see Appendix E).

Validity

According to the theory of planned behavior (Ajzen, 1985; Haney et al., 1996), instrument validity is established in two ways: content validity and construct validity. Content validity is when we can "logically conclude whether or not the test content comprises an adequate definition of what it claims to measure" (Isaac & Michael, 1997, p. 125). To ensure content validity, the elicitation study was conducted and the results were used to develop measures for the questionnaire. Furthermore, since aggregation represents a more valid measure than any single belief, including at least three behavioral beliefs, normative beliefs, and control beliefs is recommended (Francis et al., 2004; Ajzen, 1991). By including more beliefs as a part of the indirect measures, this "almost certainly improve[s] the validity of the study" (Francis et al., p. 26). For all three indirect constructs in the questionnaire, more than three salient beliefs are covered, which supports the validity of the full study.

Construct validity answers the question, "To what extent do certain explanatory concepts or qualities account for performance on the test?" (Isaac & Michael, 1997, p. 125). Construct validity is evident by the significant correlations between the direct and indirect measures of the three constructs (AB, SN, and PBC). For the direct and indirect measures, the simple bivariate (Pearson's) correlations were: ABd and ABi=0.532, $p<0.01$; SNd and SNi=0.655, $p<0.01$; PBCd and PBCi=0.293, $p<0.01$. Construct validity was established since all of the direct and indirect measures for each of the constructs were correlated.

Reliability

Internal consistency reliability for the direct measures was tested. Reliability estimates based on Cronbach's alpha for BI, ABd, SNd, and PBCd were 0.855, 0.938, 0.768, and 0.593, respectively. This was used to help determine whether the items in the scale are measuring the same construct (Francis et al., 2004). When acceptable internal consistency reliability was not met, the item was deleted from the overall variable score and any analyses. The items that were removed were SNd3, PBCd3, and PBCd4.

This form of reliability is not considered to be ideal for indirect measures because someone may have positive or negative views of different salient beliefs within the same construct. Francis et al. (2004) recommended a test-retest for indirect measures. However, due to the anonymity of the study, this did not allow for completion of a test-retest with the indirect measures, since the same participants cannot be contacted again. As an alternative, reliability analysis was conducted with the indirect variables using Cronbach's alpha. Reliability estimates based on Cronbach's alpha for ABi, SNi, and PBCi were 0.812, 0.751, and 0.781. For all three indirect measures, satisfactory Cronbach's alpha values were obtained. This alternative method was used successfully by Lee, Cerreto, and Lee (2010). Unfortunately, this reliability measure for the indirect measures only provides weak evidence for reliability, which may limit the study's conclusions.

Prior test-retest reliability by Haney, Czerniak, and Lumpe (1996), which is the most similar research to the present study, indicated strong correlations between the two testings, thus providing evidence for stability reliability. They similarly tested internal consistency using Cronbach's alpha analysis and found the three direct constructs to range from 0.64 to 0.88.

Procedure

Questionnaires were emailed to 1023 Iowa science teachers and an unknown number of NSTA list server members. Participants in this study were asked to complete the Qualtrics survey online. Following the data collection, responses were analyzed.

Data Analysis

Prior to statistical analyses, the construct scores were calculated. The construct scores were used to determine if the participant held positive, negative, or neutral beliefs about implementing NGSS. Each individual salient belief score (behavioral belief X outcome evaluation, normative belief X motivation to comply, and control belief X control power) was also calculated. Frequencies and descriptive statistics were run and analyzed for distributional characteristics of each individual item, each salient belief, and each construct score.

Simple bivariate (Pearson's) correlations were run between each of the direct constructs and their corresponding indirect construct. Direct measures and indirect measures are expected to be positively correlated (Francis et al., 2004). Performing these correlations confirmed the validity of the indirect measures and were reported in the validity section in this chapter. Correlations were also performed between BI and each of the direct constructs as well as BI and each of the indirect constructs (BI-ABd; BI-SNd; BI-PBCd; BI-ABi; BI-SNi; BI-PBCi). This provided the relative importance of each of the direct and indirect constructs in relation to behavioral intention as well as the predictive validity of theory of planned behavior (Ajzen, 1985; Ajzen, 1991).

Estimation of Cronbach's alpha was performed on each of the direct and indirect constructs with a goal of alpha ≥ 0.6 for each construct (Francis et al., 2004). Items from the direct variables were removed if, when deleted, the Cronbach's alpha increased. The items that were deleted were SNd3, PBCd3 and PBCd4. All other items remained in the direct constructs for all further statistical analyses. Results from this are reported under the reliability section in this chapter.

A confirmatory factor analysis was conducted to ensure that the items appropriately matched with each of the constructs of the theory of planned behavior. With this method, it is specified how many factors there are and which variables load onto each factor in order to confirm the measurement model (Remler & Van Ryzin, 2015). In order to perform the confirmatory factor analysis, SAS (version 9.4) was used.

Multiple regression analysis was used in this study. The statistical assumptions for multiple linear regression are 1) there is a linear relationship between the dependent variable and the independent variables collectively and individually, 2) the distribution of the dependent variable is normal, 3) the distribution of the dependent variable has constant standard deviation throughout the range of values of the independent variables (homoscedasticity), and 4) the sample is randomly selected (Agresti & Finlay, 2009). The diagnostics examined to assess the extent to which the assumptions appear to have been met are 1) visualizing scatter plots and partial regression plots to check for linearity, 2) check a histogram of the studentized residuals, a Normal P-P Plot, and a Normal Q-Q Plot, 3) plot the studentized residuals against the unstandardized predicted values, and 4) the sample was randomly selected. Each of the assumptions were met and the plots can be seen in Appendix F. The criterion for significance was set at alpha=0.05.

In order to answer research question 3, backward elimination multiple linear regression was used with BI as the dependent variable and ABd, SNd, PBCd, and demographics (gender, years of experience, familiarity with NGSS, location, and grading system) were entered as the predictor variables. Individual predictor variables were deleted from the model if they did not contribute significantly ($p<0.1$). A final model containing only variables that make a significant contribution was constructed. The regression coefficients produced through this analysis serve as estimates of the weights of attitude toward the behavior, subjective norm, and perceived behavioral control (Ajzen, 1985). Also using multiple linear simultaneous entry regression, each direct construct was entered as the dependent variable and its corresponding indirect construct was entered as the predictor variable to determine an association between the paired measures.

In order to answer research question 2, which is to determine the specific beliefs that were of greatest influence on high school science teachers, the responses were classified on a low intender versus high intender basis using a BI score of less than 6 on the scale of 1 to 7 as the cutoff for low and high intenders. Those who received a score of 6 or greater were considered high intenders. Typically a median split would be used, but since the median is 6.667, which according to the scale would be someone who strongly intends to implement NGSS, it was not logical to use a median split. Nor was it logical to use intenders versus nonintenders using the middle response, 4, as the cutoff because only 5.3% of participants received a BI score of 4 or less. A series of t-tests was used to identify the specific beliefs that discriminate between the two groups (low intenders and high intenders). By examining differences in the salient beliefs, a more detailed explanation of the behavioral intention was provided, beyond just a prediction (Ajzen, 1985). The assumptions for t-tests are 1) the dependent variable is continuous, 2) the data must follow a normal distribution, 3) the sample must be a random sample from its population, 4) the two samples are independent, and 5) the variances of the two populations are equal (if not, the Levene's test was used and the t-test results for "equal variances were not assumed" was reported). All of the assumptions were met. The criterion for significance was set at alpha=0.05. SPSS (Version IBM SPSS Statistics 24) was used to compute all statistical analyses.

In this chapter, the methodology for each of the three parts of this study was described. The data analyses will be further discussed in the next chapter along with the results and discussion.

CHAPTER IV

RESULTS AND DISCUSSION

The results and discussion of the semi-structured interviews, the pilot study, and the full study will be discussed in this chapter. The three research questions will be answered in this chapter.

Part 1: Semi-structured Interviews (Elicitation Study)

The nine participants interviewed all provided insights on NGSS in order to answer the first research question: What are experts' opinions regarding Next Generation Science Standards in high school and their implementation? Generally, the participants were positive about NGSS, but one participant in particular had a relatively negative opinion of NGSS. Comparisons of NGSS to past standards were commonly discussed. The emerging themes that arose fall under the categories of past, present, and future. The past was discussed in the context of what changes needed to be made in the classrooms and comparisons with previously used science standards. The present was discussed in terms of how well the science standards are working for students. The future was discussed in terms of concerns for support to implement the standards.

Past: Changes for Teachers and Comparisons to Previous Standards

Topics discussed by participants related to the past are changes that needed to be made in lesson planning and assessments, comparisons to previous science standards, and advantages and disadvantages of using NGSS in the classroom. By highlighting comparisons of NGSS to previous standards, participants were able to identify several important aspects of the standards.

Advantages and disadvantages. There were many advantages of using NGSS discussed by the participants. One of the most commonly discussed advantages was the relevancy and real life aspect of the standards, which increase engagement in the classroom compared to past standards. Participant 2, a university staff member who works in an organization attempting to increase NGSS implementation, commented on this by saying:

> I feel that the [NGSS] are more relevant to what we do today in our society. I think it gives our students the opportunity to see the connections among the different science disciplines and really [gets] students to look more carefully at the practices. It's more explicit so I feel that the [NGSS] provide a more helpful way for teachers and students to really think about what are we doing with science in real life.

In addition to making science more realistic, NGSS connect to other disciplines such as engineering, math, and language arts as well as use a three-dimensional approach consisting of crosscutting concepts (CC), disciplinary core ideas (DCI), and science and engineering practices (SEP). Participant 3, a science representative for a state's Department of Education, discussed NGSS in comparison to previously used standards:

> In my opinion the NGSS are better because of the three-dimensional aspect also because they clearly start with that verb of what scientists do. Our old standards started with understand and apply knowledge of. So that was really hard, what does that understand and apply knowledge of mean versus construct a model to do this or support a claim that does this. It is a much clearer target for teachers and for students, so I definitely think that they are better.

Participants generally believed that NGSS are an improvement over previous science standards. Participant 5, who works as a high school science teacher, summarized the advantages of using NGSS:

> The advantages I see using NGSS in a classroom is that the students get into the topic, they guide the lessons and discussions, they are able to create solutions and relate activities to the questions on assessments. The students enjoy the lessons more and they see how the notes and articles have more of a purpose in the classroom and the real world.

Several disadvantages to using NGSS were discussed. One disadvantage was that getting teachers to want to implement NGSS was difficult and that teachers were not being given enough time and resources to learn how to implement NGSS. Another issue that arose was that teachers might focus on only one of the science and engineering practices and not provide a well-rounded science background to the students. Participant 3 summarized this:

> I think the biggest disadvantage for us adopting the performance expectations, and particularly aligned with this idea of standards-based grading is that it sort of artificially puts the three dimensions together. It doesn't mean the only way you can look and learn about Coulomb's Law is to use mathematical modeling. You can certainly learn it in a different practice. So part of the challenge again, especially when we have districts that are going standards-based is that they say "well, this is the standard and it puts this practice with this crosscutting concept with this DCI, so we have to create a body of evidence that will support that specific three-pronged [approach]." That worries me because that artificially says well this is the only way you can learn this content and that was never really the intent. The intent was always to be this was an example if you were asked to have an assessment to do this, would you be able to? The other thing I worry a little bit about, especially with standards-based is that it tends to lead us all to prioritizing standards. If you happen to prioritize standards that all have a particular practice associated with them, you could have your sixth graders working on nothing but modeling all year. . . So that I think is a place where we are really trying to have some conversations with folks where we say if you are going this route, you really need to think about how you have to use all of the practices in order to get students to understand the concepts.

The major differences, specifically positive differences, between NGSS and their previously used science standards are the use of the three dimensions (SEPs, CCs, and DCIs) and storylining in lesson creation. In storylining, students start with a central phenomenon and the unit is continually connected back to that phenomenon. By the end of the unit, students should be able to fully explain the phenomenon.

Few similarities with prior science standards were mentioned during the interviews. Participants mentioned that the science practices and the level of rigor were similar. The content of the science standards is also generally the same, yet Participant 4 commented, “The overpowering thing about [NGSS] is it just doesn’t have the content there, that’s the single biggest issue as [a] chemist.” The lack of similarities to other science standards shows how unique NGSS are and how groundbreaking the implementation of these standards was and will be in upcoming years.

Changes to lessons and assessments. Several major changes come with the adoption of NGSS. One change is integration within the science standards due to the crosscutting concepts, which is the integration of engineering, math, and language arts into the standards. There was generally positive feedback related to these subjects being integrated into the science curriculum. However, there was concern expressed whether or not this integration is actually happening in the classroom. Participant 9, a middle school science teacher, expressed the desire to collaborate with other departments in the school, but due to the school’s transition from traditional grading to standards based grading, they are finding it difficult to convince other teachers to work on integration with the science class due to overworked teachers. This teacher noted that if they were to collaborate with another teacher, it would most likely be the art teacher.

Another major change to science curriculum is that multiple choice tests will become obsolete. This type of test will be unable to gauge student understanding of the standard. Instead, short answer and essay questions will dominate assessments. NGSS are written as performance expectations that are intended to be three-dimensional. Participant 3 summarized the difficulty of creating assessments that work with NGSS:

> That is the big question and definitely one of the questions we are struggling with three-dimensional standards, how do you truly create a three dimensional assessment. The days of really being able to do summative assessments that are multiple-choice I think are going to be gone. We will have to move more into the realm of performance assessment and really well designed anchor tasks. And that doesn't mean that you can't have some multiple-choice, but multiple-choice will definitely have to change and will have to be just a portion of how we assess. It is going to be rare that we will be able to have a single task that would do much of anything. It will be that building and the body of evidence that students will show in order to show their competency or their proficiency and that will build over the course of the unit instead of just thinking of it as an exam at the end.

Not only will assessments change, but lesson planning and units will change with the implementation of NGSS. Storylining as described by Participant 6, a high school science teacher, is when the teacher "starts with an event phenomenon and has students questioning why things happen the way they do. Throughout the unit the students remain focused on the initial phenomenon and build the knowledge necessary to explain the phenomenon." Participants discussed how this type of classroom will take years to fully implement. However, Participant 6 believed that once they fully implement the storylining, their "classroom instruction will encourage independent scientific thinking and problem solving in my students more than my previous curriculum did."

Overall, teachers have had to make changes to their curriculum and assessments due to the implementation of NGSS. With these changes are advantages such as a more engaging and relevant curriculum, while disadvantages such as large amounts of time being spent on creating the new curriculum are worrisome to educators.

Present: Efficacy of Next Generation Science Standards for Students

Topics discussed by participants related to the present are concerns of efficacy of NGSS for students. This includes the ability of students to think critically, the concerns about incorporating appropriate content, and the implementation at all grade levels in order to best prepare students for college.

Critical thinking. Critical thinking and terminology related to it were a commonly discussed topic in the nine interviews. Although critical thinking is very difficult to define and is different in every discipline, terms used during interviews that relate to critical thinking are: “doing science,” engaged, rigor, deeper learning, relevant, problem-based learning, authentic learning, hands-on learning, and inquiry learning. Each of these different terms is related to the increase in use of higher order thinking skills.

When participants were asked if NGSS will increase the use of critical thinking skills in the classroom, the following are several of the responses. Participant 1 stated:

> Well, I don’t know if the students are actually…they’re kind of the receivers of what is being planned for them. It is the teachers who are using the NGSS to do it. And I don’t know if the students are interacting with the NGSS. So I think of it as kind of a couple steps removed.

Therefore, if lessons are done well, then theoretically, the students will be doing more critical thinking. Likewise, Participant 2 noted that “If we truly give the students the opportunity to use the practices to learn, those practices will support and use critical thinking and give them opportunities for critical thinking.” Comments like this were the general consensus of the participants interviewed.

However, Participant 4 was more reserved in his response regarding critical thinking stating that students in general have less ability to critically think as compared to when he first started teaching 30 years ago. He discussed the possible reasons as follows:

> I think it's because we now have a generation of students that are told that they are all above average, which is statistically impossible, who haven't been asked to [critically think] in the past. There are too many social passes now and students are told that they can do whatever they want. There is too much technology in the form of other things to keep them occupied. I don't think kids get out and play anymore and build things in the sand or with Legos, or pipes, or whatever. All they do is sit in front of a screen now and so I think that's more of the issue.

With this concern brings the question: Will NGSS be able to turn around the trend toward the lack of critical thinking seen by this participant? In time we will be able to measure the increase or decrease of critical thinking due to NGSS implementation.

Concerns over content of Next Generation Science Standards. There are several concerns related to the content of NGSS. Some believed the content is more broad while some believe it goes more in depth. Participant 4 believed NGSS are the bare minimum of what needs to be taught and that teachers need to go above and beyond what the standards include. Conversely, Participant 1 stated a barrier to teaching more than what is included in the standards. "I've had high school administrators come to my teachers and say if it's not in the standards, I don't want them teaching it." This puts teachers in a difficult situation when administrators do not believe that they should teach additional content, but the teachers believe additional content needs to be taught.

Another present concern of educators is related to political aspects of NGSS. Pruitt (2014) acknowledged this challenge and stated that the political climate is one of the major determining factors of whether a state will adopt NGSS or not. One concern from the participants is that NGSS is closer to a "national agenda" or "national curriculum" similar to the controversy over the Common Core math and language arts standards. Participant 3 recognized this concern:

> We as a state adopted just the performance expectations. We did not adopt the full page and we didn't adopt the clarification statements and the assessment boundaries. Not because as a group we didn't like them but just because Iowa is a very local control state and we want to have our local control.

Perhaps other states will follow Iowa's lead in adopting only the performance expectations to allow for more local control.

One surprising concern for use of NGSS was that elementary teachers seem to be resisting the science standards implementation. For example, two professors of elementary science education were asked to be interviewed. Both of them replied by stating that they were not familiar with NGSS and would not be able to participate due to a lack of knowledge. Participant 9, who is a middle school science teacher, was most familiar with the resistance from elementary teachers.

> Researcher: Do you know if the elementary schools are using NGSS very much?
> Participant 9: There are a couple teachers that do, and then most of them don't.
> Researcher: Do they even have a science time, like an hour every day or something like that?
> Participant 9: No not really. This is kind of what the curriculum director and I are trying to start pushing, because by the time they get to me…I mean this is kind of going across the board in a lot of subjects, they don't know the basics hardly in middle school, so you have to reteach them everything from scratch. They don't really have a whole lot. They are told they have to have this much amount of reading, this much amount of math, and they aren't doing any cross curricular stuff. Rather than reading the story about little Johnny and how he can't get this apple off the top of the tree, they are not doing any of that cross curriculum stuff. So they are either reading, or they are in math, or they are in science. They really don't have a lot of time, so it's kind of frustrating. I feel like the biggest resistance is from elementary, a lot of them aren't…I don't want to wrap them up in their huge category, but I remember even going through school a lot of the elementary teachers, because I was an elementary [education] teacher, all of them hated science.

When this participant was told that an attempt by the researcher was made to interview elementary educators, but the educators did not have knowledge of NGSS, he stated, “Yeah, that doesn’t surprise me at all.” Isabelle (2017) posed the question: “How is the vision of the NGSS ever going to be achieved when many elementary schools across the United States allot a very small amount of time to the teaching of science?” (p. 84). If the content is not being taught at the elementary level, this puts a large amount of pressure on middle and high school teachers to introduce science concepts to students. Isabelle (2017) argued that science education must be valued by schools and administrators; when teachers have adequate classroom time, science materials, and professional development at the elementary level, this enables quality science instruction.

Participants mentioned concerns of students being college ready with these NGSS since it is seen as having less content than previous standards, even though the content is supposed to be more in depth. Participant 4 discussed this:

> So my opinion in that and what I read from advanced placement teachers is that [NGSS] are a minimal set of standards, they do not reach the level of previous high school chemistry classes which means that kids aren’t coming out ready for college chemistry. They are being forced to teach all these weird topics in there that don’t fit. They are trying to force connections across disciplines that are weak and perhaps beyond student comprehension in terms of the connectedness.

With a lack of chemistry content in the standards, it is possible that students will be unprepared for college level chemistry. This participant also noted that “We need to aim higher.” He views the standards as limiting science content instead of enabling science learning. Talanquer and Sevian (2013) agreed with this by discussing their belief in the *Journal of Chemical Education* that NGSS fell “short of fully representing the nature and power of chemical knowledge” (p. 28). They believe that in order for students to become scientifically literate in chemistry, educational resources will need to be created that give students the opportunity to integrate chemistry practices with core chemistry ideas.

However, regarding earth science, there is an increase in content, especially compared to the previous Iowa science standards. Participant 3 was very aware of the issues regarding the implementation of earth science standards. I told this participant that I had not had any earth science since 7th grade. She acknowledged this is a major issue, specifically in Iowa.

> I graduated from high school probably 25 years before you did and I also did not have earth science at the high school level. It has been a long time problem, in Iowa in particular, but I think nationwide, when we think of science we think biology, chemistry, physics. We particularly think biology, chemistry, physics for anyone who is college bound. The earth science or environmental science has traditionally been only for those students who are non-college bound students. That is a huge problem. We have a tremendous number of issues in our world that require knowledge of earth science concepts. So we are working very hard to help districts to hear that message that you are going to leave kids and citizens behind if we don't figure out a way to have earth science. Now I do also understand districts are saying we don't have the money or the staff to hire somebody else to teach a full earth science course, so there are a couple of ways people are addressing it. They are taking a solid look at environmental science. They are trying hard to make it more earth science based environmental science. But we also have several districts that are looking at the NGSS appendices which have potential high school course sequences and one of them is integrating earth science into a traditional biology, chemistry, and physics.

She further discussed several ways that Iowa is working to give professional development to teachers who are teaching earth science in order to help them feel more comfortable teaching the content. Overall, there are a number of concerns that the participants have regarding implementation of NGSS, yet attitudes still remained generally positive regarding the standards.

Future: Support for Implementation

Themes discussed by participants related to the future are support for implementation, which includes resources and trainings for teachers, incentives for implementation, and teachers' ability to implement the standards.

Sources of support. Teachers need administrative support in order to implement NGSS. They also need support from other science teachers. One participant noted that his curriculum director is his only resource since the other science teacher is choosing not to implement NGSS. Generally, participants said there is not much if any discussion among professors of science education and there is little discussion among secondary teachers. This lack of discussion leaves teachers on their own to decide how to implement NGSS. This is one area of improvement for the future that could be supported by several statewide or regional workshops.

Teachers need support in the form of incentives and time. Incentives can come in the form of money or resources for the classroom. Teachers need to be paid for time spent on the work and not be expected to do it on their own personal time. Curriculum resources are not readily available for teachers. One participant discussed how states are only given the resources when they officially adopt NGSS. Thus, districts that are in states that have not adopted NGSS are not given access to certain curriculum resources. These resources are especially necessary since textbooks are less commonly used in the classroom. Another participant discussed how resources such as demonstrations and models are very expensive to purchase for the classroom, which also limits teachers. Furthermore, professional development for teachers and training for pre-service teachers is another form of support that teachers will continue to need in order to implement NGSS in a timely and effective manner.

Teacher ability to implement standards. One question for the participants was if experienced teachers versus first-year teachers would be better able to implement NGSS. There was a mix of responses. Experienced teachers were believed to have better classroom management, which is necessary for NGSS since students are taking more control in the classroom. However, new teachers are seen as more innovative with lesson planning and are more willing to adapt to new challenges. Conversely, Participant 5 believed both groups of teachers are in similar situations. She stated:

> In the program I am in over the summer, there is a mix between beginning and experienced teachers. Both are in the same boat when they came into the program and are leaving with the same information and experience. The experienced teachers have mentioned it is hard for them to let go of the way they have always taught and to get rid of units that do not meet the standards any longer.

The belief that new teachers are more adaptive is backed by Hanuscin and Zangori (2016) who stated that pre-service teachers tend to view new standards more positively as compared to experienced teachers who have expressed "frustration, loss of power, increased paperwork, elimination of cherished activities, peer pressure, and loss of personal freedom associated with standards" (p. 800). Ultimately, collaboration between experienced and new teachers would yield optimal results when implementing NGSS.

Part 2: Pilot Study with Questionnaire

Descriptive Statistics

The variable scores were calculated for each direct measure (BI, ABd, SNd, and PBCd) and each indirect measure (ABi, SNi, and PBCi). The mean of participant responses was calculated for each score. The mean scores with standard deviations for direct variables are displayed in Table 4.1. The mean scores with standard deviations for indirect variables are displayed in Table 4.2.

Table 4.1. Direct Construct Mean Score with Standard Deviation

Direct Variable	**Mean Score**	**SD**
BI*	5.53	0.948
ABd*	5.31	1.202
SNd*	4.36	0.688
PBCd*	4.44	0.70

*Possible range for mean score was 1 to 7

Table 4.2. Indirect Construct Mean Score with Standard Deviation

Indirect Variable	**Mean Score**	**SD**
ABi*	51.83	16.05
SNi**	16.42	13.846
PBCi***	21.33	23.754

*Possible range for mean score was -231 to 231
**Possible range for mean score was -105 to 105
***Possible range for mean score was -126 to 126

The indirect construct scores showed weak attitude, social pressure, and level of control toward implementing NGSS, which may be due to the sample not being the intended audience of the survey. This was also apparent in the open-ended questions where participants believed that they did not know enough about NGSS in order to answer the questions. In order to prevent this, for the full study, a screening question needed to be added to remove participants who are not at all familiar with NGSS. Participants had some difficulty answering the questions because they were not the intended audience and were not very familiar with NGSS. The familiarity mean was 4.30, where 4 means slightly familiar and 5 means not familiar at all.

Reliability

Cronbach's alpha is also not reliable at this small sample size; therefore, no items were removed from the full study questionnaire based on these values. Furthermore, Francis et al. (2004) stated that because people can logically have both positive and negative beliefs about the same behavior, the reliability of indirect measures using internal consistency is not recommended. This may have contributed to why all of the indirect variable Cronbach alpha estimates were below 0.60. No items were removed from the indirect constructs due to the small sample size.

One item was added to the subjective norm direct measures for the full study because of such a low Cronbach's alpha (0.181) in the pilot study. Although when one item was deleted, the alpha became 0.549, this is likely because the two items left were very similar in wording. So by adding the item "People who are important to me want me to implement NGSS (strongly agree→ strongly disagree)," this will allow for potentially better internal consistency reliability for the subjective norm direct variable in the full study questionnaire.

Simple Bivariate Correlations

Simple bivariate correlations between direct and indirect measures of the same construct were performed in order to confirm the validity of scores for the indirect measures (Francis et al., 2004). If there are low correlations, it is likely a result from indirect measures that are poorly constructed or did not cover the major salient beliefs of that measured construct (Francis et al., 2004). The results of this analysis are presented in Table 4.3. The scatter plots from the moderate correlations between ABd and ABi and between PBCd and PBCi, which were both found to be statistically significant, are shown in Figure 4.1.

Table 4.3 Simple Bivariate Correlations for Direct and Indirect Scores (*N=12*)

Variables	**Pearson Correlation**	**Sig. (2-tailed)**
ABd with ABi	0.593*	0.042
SNd with SNi	0.425	0.169
PBCd with PBCi	0.685*	0.014

*Correlation is significant at the 0.05 level (2-tailed).

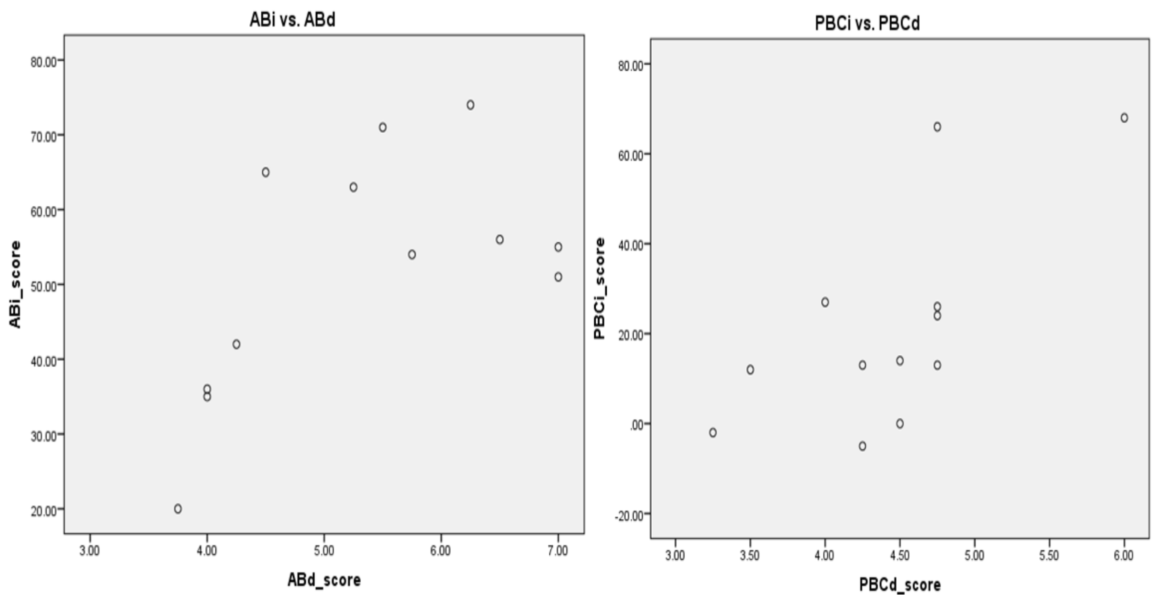

Figure 4.1. Scatter plot of bivariate correlations of ABi with ABd (left) and PBCi with PBCd (right)

Due to the small sample size (*N=12*), multiple linear regression and further analysis was not run. The bivariate correlations were statistically significant for the direct and indirect variables of attitude toward the behavior and perceived behavioral control. This is most likely inflated due to the small sample size, but this was encouraging for when the full study was conducted.

Survey Feedback

The open-ended responses about the experience of taking the survey were analyzed and summarized. Participants believed several aspects of the survey were confusing or difficult to answer including item scales that were reversed and questions that were repetitive. Participants commented that the length of the survey is appropriate and ended before interest was lost. They also noted that because they were not the intended audience of the survey, it did cause some distraction because they did not know how to answer the questions. Participants' suggestions on how to improve the format of the survey include preventing wordiness of questions or leading questions, improving the definition of NGSS, and screening out people from the survey if they are not familiar with NGSS. One participant suggested implementing an instructed response item where all participants are instructed to answer "Strongly agree," for example, if they are reading the questions thoroughly. This practice is strongly endorsed by Meade and Craig (2012) to prevent careless responders.

The open-ended responses from participants were helpful in determining what changes to make to the survey before implementation of the full study. Some participants stated that the scales should be made consistent instead of reversing them periodically. Originally, this was done in order to prevent survey fatigue, but instead may have introduced survey fatigue if the survey was more difficult to answer. Francis et al. (2004) acknowledged that mixing of positive and negative endpoints can be counterproductive, but is a common practice to minimize response set. Instead, an instructed response item can be used so that all participants must click on a specific response to answer the question (Meade & Craig, 2012).

A few participants thought some questions were repetitive, which is most likely due to the direct variable items being similarly worded. Unfortunately, these items cannot change, but the order of the items can be rearranged so that they are not grouped together.

Francis et al. (2004) stated, “Ajzen recommends that items be mixed up throughout the document” (p. 26). For the full study, rearranging all question items can help prevent participants from seeing similarly worded questions one after another.

Most participants thought that the survey length was appropriate. It took all of the participants between 10-15 minutes to complete instead of the expected 15-20 minutes. With a shorter time frame on the consent form and email to the full study participants, this might mean more participants would be willing to take part in the survey.

Part 3: Full Study with Questionnaire

Descriptive Statistics

The construct scores were determined and indicated whether the participants held positive, negative or neutral beliefs about implementing NGSS. For the direct constructs, as seen in Table 4.4, a mean score of greater than 4 indicated that participants are more likely to implement NGSS either due to being in favor of implementing NGSS (ABd), experiencing social pressure to implement NGSS (SNd), or feeling in control of implementing NGSS (PBCd). Since all of the mean scores are greater than 4, participants generally are more likely to implement NGSS in their classroom.

Table 4.4. Direct Construct Mean Score with Standard Deviation (Range 1 to 7; *N*=246)

	# of items	**Mean**	**SD**
BI	3	6.19	0.99
ABd	4	5.55	1.304
SNd	3	5.89	0.982
PBCd	2	5.27	1.169

For the indirect constructs, as seen in Table 4.5, a positive score indicated that participants are more likely to implement NGSS, while a negative score indicated they are less likely to implement NGSS. The attitude mean score reflected a fairly weak positive attitude toward implementing NGSS. The range present in the data for attitude mean score was -22 to 145, indicating that even participants with negative views do not have strongly negative views. The subjective norm score reflected that participants on average experience weak to moderate social pressure to implement NGSS. The range present in the data for subjective norm mean score was -27 to 105, indicating that some participants feel an enormous amount of social pressure from students' parents, administrators, students, the department of education, and other science teachers to implement NGSS. The perceived behavioral control mean score also reflected a fairly weak level of positive control, meaning the participants believe implementing NGSS is fairly manageable. The range present in the data for perceived behavioral control mean score was -40 to 114, indicating that teachers tend to feel like they have more control over NGSS implementation.

Table 4.5. Indirect Construct Mean Score with Standard Deviation

	# of items	**Mean**	**SD**	**N**
ABi[a]	22	49.04	28.013	245
SNi[b]	10	35.92	24.205	238
PBCi[c]	12	30.85	23.802	238

[a]Possible range of -231 to 231
[b]Possible range of -105 to 105
[c]Possible range of -126 to 126

Salient belief scores (behavioral belief X outcome evaluation, normative belief X motivation to comply, and control belief X control power) were also calculated in order to observe the beliefs at an individual level rather than in the calculated scores as shown in Table 4.4 and 4.5. The salient beliefs measuring attitude toward the implementation of NGSS are shown in Table 4.6. It is important to note that the possible range for each of the salient beliefs was -21 to 21. Some beliefs had responses within that range, while some had responses within a smaller range as indicated in Table 4.6. There are four salient beliefs where only positive responses were observed: implementing NGSS would help students to think critically, increase student engagement in learning chemistry, allow for increased integration of the science disciplines, and make chemistry more relevant to the students' everyday lives. This is likely in part due to the wording of the outcome evaluation, which was on a scale of extremely desirable to extremely undesirable. The most surprising of these four is that none of the participants stated that increased integration of the science disciplines is undesirable. It is possible that the participants recognize the potential benefits of integration: "NGSS may encourage interdisciplinary cooperation within schools, and more focused use of community resources to enhance the integration of science with other disciplines, drawing STEM professionals into the schools, and drawing students out [of] their schools to engage in science in their communities" (Lynch & Bryan, 2014, p. 1).

Table 4.6. Means and Standard Deviations for Indirect Salient Beliefs Measuring Attitude toward the Behavior (Possible Range: -21 to 21)

Salient Belief	**Mean**	**SD**	**Low**	**High**	***N***
Implementing NGSS would…					
1. Help students to think critically.	17.29	4.233	0	21	245
2. Increase student engagement in learning chemistry.	13.82	6.027	0	21	240
3. Allow for increased integration of the science disciplines.	14.02	6.204	0	21	244
4. Decrease the amount of content covered in the course.	-2.74	6.253	-21	21	243
5. Make chemistry more relevant to the students' everyday lives.	13.11	6.168	0	21	240
6. Take more resources (funding, curriculum materials, training, equipment, etc.)	-2.45	3.754	-21	8	244
7. Take more time to plan lessons.	-1.66	3.314	-21	18	244
8. Work well with my grading system (standards-based, traditional, etc.)	9.35	7.819	-14	21	244
9. Change my previously used lessons.	-0.20	3.187	-10	21	244
10. Change my previously used assessments.	-0.16	3.055	-12	21	244
11. Result in classroom management difficulties	-10.78	7.669	-21	18	244

Mean responses to salient beliefs 4, 6, 7, 9, and 10 in Table 4.6 were relatively close to neutral, meaning the participants did not feel strongly one way or the other. Therefore, on average, participants do not believe that the amount of content covered will change, that more resources will be necessary, that it will take more time to plan lessons, or that it will change their previously used lessons or assessments. The neutral response to the latter is somewhat worrisome. Sondergeld, Peters-Burton, and Johnson (2016) believe "there is an urgent need for significant change in the mind-set of educators regarding assessment techniques, particularly with integrated dimensions of NGSS" (p. 67). If teachers do not believe that implementing NGSS will change their previously used lessons or assessments, are they actually changing them to accommodate the new standards? Or, perhaps they believe they have already been implementing NGSS.

Even though the mean was neutral for the salient belief that implementing NGSS takes more resources, many teachers selected that they would need at least one resource. From the "select all that apply" question, "Which of the following resources would you require more of if implementing NGSS?" the results were as follows: funding (116, 22.01%), curriculum materials (128, 24.29%), training/professional development (118, 22.39%), supplies/equipment (144, 27.32%), and other (21, 3.98%). Responses for "other" included: time to plan curriculum, units, and lessons and time to collaborate with other teachers. One person stated that additional time for teaching is needed because "NGSS is asking that a similar amount of material be covered in an unrealistically detailed way. The time required to cover the NGSS in the manner that is expected would require a 1-year biology class to be 2 years." Overall, many teachers need various resources in order to implement NGSS.

The salient beliefs measuring social pressures to implement NGSS are shown in Table 4.7. The two salient beliefs with the highest means are that high school science teachers experience social pressure from their administration and from the state Department of Education. The social pressures from other science teachers, students' parents, and students are on average present, but perhaps not as noticeable as those from the administrators or the Department of Education. It is also important to recognize there is a range from -21 to 21 on three of the salient beliefs, meaning that participants' beliefs vary from one extreme to the other.

Table 4.7. Means and Standard Deviations for Indirect Salient Beliefs Measuring Subjective Norm (Possible Range: -21 to 21)

Salient Belief	**Mean**	**SD**	**Low**	**High**	***N***
1. Other science teachers	2.70	6.474	-21	21	238
2. Administration	12.17	7.479	-7	21	238
3. Students	4.61	7.917	-21	21	237
4. Students' parents	3.92	7.074	-21	21	237
5. State Department of Education	12.55	6.415	-5	21	238

The salient beliefs measuring perceived behavioral control to implement NGSS are shown in Table 4.8. The means for the salient beliefs about not enough time to plan lessons or to teach using NGSS lessons and not enough resources were all close to neutral, which indicated that on average teachers do not feel these barriers greatly affect their abilities to implement NGSS. The remaining three salient beliefs were moderately positive meaning that the teachers perceive these beliefs as making them more likely to implement NGSS. From this, we can infer that professional development, collaboration with colleagues, and observing classes using NGSS would be beneficial ways for teachers to feel that they have more control in the process of implementing NGSS.

Table 4.8. Means and Standard Deviations for Indirect Salient Beliefs Measuring Perceived Behavioral Control (Range: -21 to 21)

Salient Belief	**Mean**	**SD**	**Low**	**High**	***N***
1. Not enough time to plan lessons	-1.71	4.197	-21	18	238
2. Not enough time during the class period for lessons using NGSS	-1.58	4.603	-21	18	238
3. I do not have enough resources (funding, curriculum materials, equipment, etc.)	1.37	5.042	-15	21	238
4. Attending professional development and training opportunities about NGSS empowers me to use NGSS in my classroom.	10.50	7.902	-12	21	238
5. Collaboration with colleagues about implementation of NGSS is encouraging.	11.89	7.755	-4	21	237
6. Observation of other classrooms using NGSS is helpful.	10.55	8.429	-21	21	235

Simple Bivariate (Pearson's) Correlations

Correlations between BI and each of the direct constructs as well as the indirect constructs were performed. These provided the relative importance of each of the direct and indirect constructs in relation to the behavioral intention as well as the predictive validity of theory of planned behavior (Ajzen, 1985; Ajzen 1991). These correlations are reported in Table 4.9. All of the correlations were significant at the 0.01 level and were moderate or strong correlations.

Table 4.9. Simple Bivariate (Pearson's) Correlations for BI with Direct and Indirect Constructs

Variables	**Correlation**	**N**
BI-ABd	0.760*	246
BI-SNd	0.722*	246
BI-PBCd	0.578*	246
BI-ABi	0.497*	245
BI-SNi	0.554*	238
BI-PBCi	0.565*	238

*Correlation is significant at the 0.01 level (2-tailed).

Table 4.10. Simple Bivariate (Pearson's) Correlations with Direct and Indirect Constructs

Variables	**Correlation**	**N**
ABd-ABi	0.532*	245
SNd-SNi	0.655*	238
PBCd-PBCi	0.293*	238

*Correlation is significant at the 0.01 level (2-tailed).

The correlations in Table 4.9 were used in conjunction with the correlations in Table 4.10 in order to establish a direct pathway between the indirect construct to the direct construct to the behavioral intention. For example, since the relationship between BI and ABd was significant and the relationship between ABd and ABi was also significant, a direct pathway exists between ABi, ABd, and BI. A similar pathway was established between SNi, SNd, and BI as well as PBCi, PBCd, and BI. Therefore, the salient beliefs found in the indirect constructs are valid predictors of behavioral intention.

Confirmatory Factor Analysis

A confirmatory factor analysis was conducted in which there were four factors specified (BI, AB, SN, PBC) and the direct and indirect construct scores were specified to load onto their corresponding factor. This was done in order to confirm the goodness-of-fit of the theory of planned behavior for the indirect and direct constructs. Several tests for model fit are displayed in Table 4.11.

Table 4.11. Confirmatory Factor Analysis Theory of Planned Behavior Model Fit Results (*N*=238)

Test	**Result**	**Recommended Value***	**Accepted model?**
Chi-squared test (*df*=8)	19.3300	Ratio of Chi-squared to *df* ≤ 2 or 3	Yes (2.42 < 3)
Root mean square error of approximation (RMSEA)	0.0773	<0.06 to 0.08 with confidence interval	Yes
RMSEA 90% Confidence Interval	0.0332 to 0.1220	--	--
Comparative fit index (CFI)	0.9865	≥0.95 for acceptance	Yes
Standardized root mean square residual (SRMR)	0.0351	≤0.08 for acceptance	Yes
Non-Normed Fit Index (NNFI)	0.9645	≥0.95 for acceptance	Yes
Normed Fit Index (NFI)	0.9775	≥0.95 for acceptance	Yes
Root mean square residual (RMR)	0.0351	Smaller is better; 0 indicates perfect fit	Yes

* Schreiber, Nora, Stage, Barlow, & King, 2006, p. 330

The chi-squared test reports the difference between observed and expected covariance matrices. The null hypothesis states that the predicted covariance matrix is equivalent to the observed covariance matrix (Albright & Park, 2009). The χ^2=19.33 (*df*=8, *p*=0.0132). Therefore, the null hypothesis is not rejected so the model estimates sufficiently reproduce sample covariance and the model fits the data well. However, this test is sensitive to sample size and may be invalid when distributional assumptions are violated, thus it has been recognized as problematic (Albright & Park, 2009). Consequently, it is important to use additional tests when assessing the model.

The root mean square error of approximation (RMSEA) test is sensitive to the number of parameters estimated, but is much less sensitive to sample size (Albright & Park, 2009). RMSEA ranges from 0 to 1, where smaller values indicate a better model fit.

A value of 0.06 to 0.08 or less indicates an acceptable model fit, although this is a subjective cutoff (Albright & Park, 2009; Schreiber, Nora, Stage, Barlow, & King, 2006). This test indicated an acceptable fit for the model, since RMSEA=0.0773 is smaller than the 0.08 value for a good model fit. However, it must be noted that if the cutoff were at 0.06, the model would not be accepted.

As shown in Table 4.11, a good model fit was indicated by the following indices: the Comparative Fit Index (CFI), the standardized root mean square residual (SRMR), the Non-Normed Fit Index (NNFI), the Normed Fit Index (NFI), and the root mean square residual (RMR). Overall, the model seems to be a good fit for the data. NNFI, CFI, and RMSEA are preferred for one time analysis (Schreiber et al., 2006). In general, if the majority of the indices indicate a good fit, then there is likely a good fit with the model (Schreiber et al., 2006).

Since the model fit is acceptable, the parameter estimates were examined. In order to do this, "the ratio of each parameter estimate to its standard error is distributed as a z statistic and is significant at the 0.05 level if its value exceeds 1.96 and at the 0.01 level if its value exceeds 2.256" (Suhr, 2006, p. 2). The standardized results for variances are shown in Table 4.12. All of the ratios (t values) are significant at the 0.01 level.

Table 4.12. Standardized Results for Variances from Confirmatory Factor Analysis

Variable	**Estimate**	**Standard Error**	**t Value**
BI	-0.10673	0.02747	-3.88563
ABd	0.15579	0.05815	2.67880
SNd	0.16255	0.05327	3.05137
PBCd	0.69589	0.06572	10.58909
ABi	0.66099	0.05468	12.08918
SNi	0.48730	0.05457	8.92898
PBCi	0.71777	0.06351	11.30233

The squared multiple correlations represent "the reliability of the observed variables in relationship to the latent constructs;" they indicate the amount of variance explained by each factor (Schreiber et al., 2006, p. 327). ABd (0.8442) and PBCi (0.2822) have the highest and lowest squared multiple correlation values, respectively. The squared multiple correlations are displayed in Table 4.13. The construct attitude toward the behavior (AB) accounts for 84.42% of the variance in ABd and 33.90% of the variance in ABi. The construct subjective norm (SN) accounts for 83.75% of the variance in SNd and 51.27% of the variance in SNi. The construct perceived behavioral control (PBC) accounts for 30.41% of the variance in PBCd and 28.22% of the variance in PBCi. In summary, the theory of planned behavior model was a good fit for the direct and indirect construct scores.

Table 4.13. Squared Multiple Correlations from Confirmatory Factor Analysis

Variable	**R^2**
ABd	0.8442
SNd	0.8375
PBCd	0.3041
ABi	0.3390
SNi	0.5127
PBCi	0.2822
BI	N/A

Multiple Regression Analysis
(Research Question 3)

Multiple regression analysis can be used in two ways: to determine the degree of relationship between the dependent variable (BI) and the independent variables and to predict the behavioral intention of an individual based on the weighted scores (Isaac & Michael, 1997). The independent variables entered into the backward elimination were ABd, SNd, PBCd, gender, location, grading system, years of experience, and familiarity with NGSS. Location and grading system were eliminated from the model, while all others remained in the final model. In multiple regression, a slope describes the effect of an independent variable while controlling the effects of the other independent variables in the model (Agresti & Finlay, 2009). Table 4.14 summarizes the final model.

Table 4.14. Final Regression Model for BI as Dependent Variable as Predicted by the ABd, SNd, PBCd, Gender, Years of Experience, and Familiarity with NGSS (*N*= 232)

Model	**Unstandardized Coefficients B**	**Lower 95% CI for B**	**Upper 95% CI for B**	**t**	**Sig.**
Intercept	1.250	0.711	1.789	4.701	<0.001*
ABd	0.308	0.234	0.382	8.196	<0.001*
SNd	0.424	0.341	0.507	10.040	<0.001*
PBCd	0.068	-0.010	0.145	1.716	0.088
Gender	-0.132	-0.272	0.008	-1.853	0.065
Years of Experience	-0.040	-0.086	0.005	-1.755	0.081
Familiarity	0.143	0.045	0.240	2.872	0.004*

*Significant at p<0.01

For the final model, 73.2% of the variance in behavioral intent is explained by the remaining six independent variables, $F(6)=102.85$, $p<0.001$. ABd, SNd, and familiarity were found to be significant at a level of 0.01. PBCd, gender, and years of experience were found to be significant at the 0.1 level, which may reflect "chance, sampling error, or statistical noise" (Remler & Van Ryzin, 2015, p. 294). However, due to the exploratory nature of the study, it is reasonable to report this. Of the three direct constructs, subjective norm had the most substantial impact (β=0.424) on teachers' intentions to implement NGSS; for every one unit increase of the subjective norm score, BI increased on average by 0.424 units, after adjusting for the other independent variables. This contradicts the conclusion by Haney, Czerniak, and Lumpe (1996) in which subjective norm made very little contribution toward behavioral intention. It also contradicts the findings of Crawley (1988) and Crawley and Koballa (1991) in which subjective norm was not a major predictor of behavioral intention. Each of these studies is over two decades old, so it is plausible that social pressures have become more apparent in modern science education. It appears from the teachers surveyed in this study, those who value the social supports provided to them are more likely to implement NGSS.

Additionally, for every increase of attitude toward behavior by one unit, BI increased on average by 0.308 units. This influence on intention is more than four times that of perceived behavioral control ($\beta=0.068$). This finding suggests that teachers' intentions to implement NGSS are mainly influenced by social pressures and their views of NGSS, and very weakly influenced by their perceived ability to implement the standards.

Furthermore, it was surprising to find that familiarity played an even more significant role than that of perceived behavioral control. For every increase in familiarity by one unit, BI increased on average by 0.143 units, when holding the other independent variables constant. It is reasonable that as a person's familiarity increases, their intention of implementing NGSS increases. This finding is supported by the study by Haney, Czerniak, and Lumpe (1996) in which those who were most familiar with the standards held the most favorable beliefs, specifically the beliefs for perceived behavioral control. Smith and Southerland (2007) discussed that familiarity with the science education concept inquiry "was most often tied to experiences in university courses and, occasionally, connected to attendance at conferences sponsored by the National Science Teachers Association" (p. 406). Therefore, an appropriate intervention would be to increase familiarity with NGSS through trainings and professional development for current as well as pre-service teachers.

Gender remained in the final model at a 10% significance level. A male's BI score was, on average, lower by 0.132 when compared to females. This needs to be observed with caution because zero is within the confidence interval, which means there is a chance that the null hypothesis of no difference between men and women could be true. This result is similar to Haney, Czerniak, and Lumpe's (1996) research, in which gender differences were found in the teachers' intentions to implement the science standards, specifically female teachers reported higher intent to implement.

A teacher's years of experience also remained in the final model at a 10% significance. After adjusting for the other variables, the BI score decreases on average by 0.040 units per unit increase of a teacher's years of experience. Again, zero is within the confidence interval, which means that there is a chance that the null hypothesis of no difference between years of experience could be true. Research by Hanuscin and Zangori (2016) supported this with their finding that experienced teachers tended to view new standards negatively as compared to pre-service teachers.

Using multiple linear simultaneous entry regression, each direct construct was entered as the dependent variable and its corresponding indirect construct was entered as the predictor variable to determine an association between the paired measures. The results are presented in Table 4.15. Since the relationships between ABd and ABi, SNd and SNi, and PBCd and PBCi are all significant, a direct pathway exists between the direct and indirect constructs. Therefore, the salient beliefs found in the indirect constructs are valid predictors of attitude toward the behavior, subjective norm, and perceived behavioral control.

Table 4.15. Regression Analysis for the Direct Construct as Dependent Variable as Predicted by the Indirect Construct

Analysis	**R^2**	**F**	**Sig. F**	**Unstandardized Coefficients B**	
				Intercept	**Indirect Score**
ABi and ABd	0.284	96.151	<0.001*	4.335*	0.025*
SNi and SNd	0.429	117.576	<0.001*	4.919*	0.026*
PBCi and PBCd	0.086	22.157	<0.001*	4.796*	0.014*

*Significant at p< 0.001

T-tests with Low Intenders and High Intenders (Research Question 2)

The low intenders group (*N*=67) had a BI score *M*=4.89 (*SD*=0.93). By comparison, the high intenders group (*N*=179) had a higher BI score *M*=6.67 (*SD*=0.39). To test the hypothesis that the low intenders and the high intenders were associated with statistically significantly different responses to each individual salient belief, a series of independent samples *t*-test was performed. A significant value for the *t*-test is p<0.05, which indicates we can then reject the null hypothesis that the means are equal. Thus, the difference in low and high intenders is statistically significant for that salient belief. Levene's test for equality of variances was used to test the homogeneity of variances assumption. This test assumes that the standard deviations are the same in both samples. A significant p value of 0.05 or less means that the standard deviations are not the same, so the homogeneity of variances assumption does not hold. The equal variances not assumed *t*-value was reported if the assumption did not hold, as indicated by ** in Tables 4.16, 4.17, and 4.18. A summary of the *t*-tests for the attitude toward behavior salient beliefs is presented in Table 4.16.

Table 4.16. Attitude toward Behavior Salient Beliefs Independent Samples *t*-test Comparing Low Intenders and High Intenders BI Score

Salient Belief	**Levene's Test for Equality of Variances**		***t*-test for Equality of Means**		
	F	**Sig**	**t**	**df**	**Sig. (2-tailed)**
AB1**	11.14	0.001	7.50	91.30	<0.001***
AB2**	6.55	0.011	6.17	138.46	<0.001***
AB3*	0.86	0.356	8.07	242	<0.001***
AB4**	10.35	0.001	-0.26	164.78	0.799
AB5*	2.52	0.114	5.63	238	<0.001***
AB6*	3.70	0.056	0.12	242	0.907
AB7*	1.49	0.224	-0.084	242	0.933
AB8**	7.32	0.007	7.39	150.67	<0.001***
AB9*	3.08	0.081	2.59	242	0.010***
AB10*	3.69	0.056	3.11	242	0.002***
AB11*	0.856	0.356	-2.816	242	0.005***

*Equal variances assumed
**Equal variances not assumed
***Significant at p< 0.01

As seen in Table 4.16, eight out of the eleven salient beliefs had a difference of means that were statistically significant. Those who are seeking to increase the implementation of NGSS, such as administrators or the state Department of Education, could promote the following salient beliefs: implementing NGSS would help students to think critically (AB1), *t*(91.30)=7.50, *p*<0.001*, Cohen's d*=1.15; implementing NGSS would increase student engagement in learning chemistry (AB2), *t*(138.46)=6.17, *p*<0.001*, Cohen's d*=0.85; and implementing NGSS would make chemistry more relevant to the students' everyday lives (AB5), *t*(238)=5.63, *p*<0.001*, Cohen's d*=0.84. High intenders (*M*=18.56, *SD*=3.26) believed critical thinking among students was more desirable and more likely when implementing NGSS than the low intenders (*M*=13.91, *SD*=4.67). The high intenders (*M*=15.08, *SD*=5.94) also believed increased student engagement in learning chemistry was more desirable and more likely when implementing NGSS than the low intenders (*M*=10.43, *SD*=4.88). Likewise, the high intenders (*M*=14.39, *SD*=5.96) believed making chemistry more relevant to students' everyday lives was more desirable and more likely when implementing NGSS than the low intenders (*M*=9.65, *SD*=5.36).

Those who desire to increase NGSS implementation might also provide teachers with examples of how implementing NGSS would allow for increased integration of the science disciplines (AB3), *t*(242)=8.07, *p*<0.001, *Cohen's d*=1.17 and how implementing NGSS would work well with the participant's grading system (AB8), *t*(150.67)=7.39, *p*<0.001, *Cohen's d*=1.00. High intenders (*M*=15.77, *SD*=5.59) believed increased integration of the science disciplines was more desirable and more likely when implementing NGSS than the low intenders (*M*=9.39, *SD*=5.31). Similarly, the high intenders (*M*=11.23, *SD*=7.62) believed NGSS working well with their grading system was more desirable and more likely when implementing NGSS than the low intenders (*M*=4.37, *SD*=5.98).

The salient belief that implementing NGSS would change the participant's previously used lesson plans (AB9) was statistically significant, *t*(242)=2.59, *p*<0.01, *Cohen's d*=0.40. The results indicate that high intenders (*M*=0.12, *SD*=3.39) reported changing their previously used lesson plans to be more desirable and more likely when implementing NGSS as compared to the low intenders (*M*=-1.04, *SD*=2.41). It is important to note that the mean for the high intenders is almost neutral (close to zero), where a neutral response indicates changing lesson plans is neither desirable nor undesirable. The negative mean for low intenders indicates that they think changing their lesson plans is undesirable. This is similar for the salient belief that implementing NGSS would change the participant's previously used assessments (AB10), which was statistically significant, $t(242)=3.11$, $p<0.002$, *Cohen's d*=0.49. Again, high intenders ($M=0.2034$, $SD=3.28$) reported changing their previously used assessments to be more desirable and more likely when implementing NGSS as compared to the low intenders ($M=-1.13$, $SD=2.10$).

The salient belief that implementing NGSS would result in classroom management difficulties (AB11) was statistically significant, $t(242)=-2.816$, $p<0.005$, *Cohen's d*=0.41. High intenders ($M=-11.62$, $SD=7.74$) believed classroom management difficulties were less desirable and less likely when implementing NGSS than low intenders ($M=-8.57$, $SD=7.07$).

A summary of the *t*-tests for the subjective norm salient beliefs is presented in Table 4.17. As seen in Table 4.17, all five subjective norm salient beliefs had a difference of means that were statistically significant. The social pressures that are statistically important for high intender implementation of NGSS include those from other science teachers (SN1), $t(161.55)=3.80$, $p<0.001$, *Cohen's d*=0.51; administrators (SN2), $t(103.63)=5.56$, $p<0.001$, *Cohen's d*=0.83; students (SN3), $t(204.74)=9.02$, $p<0.001$, *Cohen's d*=1.15; students' parents (SN4), $t(215.49)=8.16$, $p<0.001$, *Cohen's d*=1.02; and the state Department of Education (SN5), $t(236)=4.21$, $p<0.001$, *Cohen's d*=0.60. For each of these salient beliefs, the high intenders reported higher on the scale that other science teachers, administrators, students, parents, and the state Department of Education think that they should implement NGSS and that their approval is important to them as compared to low intenders. The means and standard deviations for the high intenders and low intenders are reported for each specific salient belief in the following paragraph.

Table 4.17. Subjective Norm Salient Beliefs Independent Samples *t*-test Comparing Low Intenders and High Intenders BI Score

Salient Belief	**Levene's Test for Equality of Variances**		***t*-test for Equality of Means**		
	F	**Sig**	**t**	**Df**	**Sig. (2-tailed)**
SN1**	15.17	<0.001	3.80	161.55	<0.001***
SN2**	6.09	0.014	5.56	103.63	<0.001***
SN3**	74.43	<0.001	9.02	204.74	<0.001***
SN4**	71.59	<0.001	8.16	215.49	<0.001***
SN5*	2.38	0.124	4.21	236	<0.001***

*Equal variances assumed
**Equal variances not assumed
***Significant at p< 0.001

High intenders (*M*=3.56, *SD*=6.78) reported higher on the scale that other science teachers do implement NGSS and that doing what other science teachers do is important to them as compared to the low intenders (*M*=0.51, *SD*=5.03). High intenders (*M*=13.88, *SD*=6.58) reported higher on the scale that administrators think they should implement NGSS and that administration approval is important to them as compared to low intenders (*M*=7.82, *SD*=7.91). High intenders (*M*=6.72, *SD*=7.97) reported higher on the scale that students would approve of their implementation and that student approval is important to them as compared to low intenders (*M*=-0.75, *SD*=4.56). It is important to note that the negative mean for low intenders indicates that they believe, on average, students would somewhat disapprove of their implementation of NGSS. High intenders (*M*=5.62, *SD*=7.33) reported higher on the scale that parents would approve of their implementation and that parent approval is important to them as compared to low intenders (*M*=-0.39, *SD*=3.88). Again, it is important to note that the negative mean for low intenders indicates that they believe, on average, parents would somewhat disapprove of their implementation of NGSS. High intenders (*M*=13.61, *SD*=6.05) reported higher on the scale that state Department of Education thinks they should implement NGSS and that what the state Department of Education thinks is important to them as compared to low intenders (*M*=9.85, *SD*=6.56).

A summary of the *t*-tests for the perceived behavioral control salient beliefs is presented in Table 4.18. As seen in Table 4.18, three out of the six perceived behavioral control salient beliefs had a difference of means that were statistically significant. These three perceived behavioral control beliefs could be utilized by administrators and the state Department of Education in order to promote the implementation of NGSS.

Table 4.18. Perceived Behavioral Control Salient Beliefs Independent Samples *t*-test Comparing Low Intenders and High Intenders BI Score

Salient Belief	**Levene's Test for Equality of Variances**		***t*-test for Equality of Means**		
	F	**Sig**	**t**	**Df**	**Sig. (2-tailed)**
PBC1*	0.149	0.700	0.74	236	0.436
PBC2*	0.952	0.330	0.82	236	0.414
PBC3**	5.22	0.023	1.61	172.54	0.110
PBC4**	17.39	<0.001	9.09	150.55	<0.001***
PBC5**	6.34	0.012	8.93	139.88	<0.001***
PBC6*	0.575	0.449	5.61	233	<0.001***

*Equal variances assumed
**Equal variances not assumed
***Significant at p< 0.001

The salient belief that attending professional development and training opportunities about NGSS empowers the respondent to utilize NGSS (PBC4) was statistically significant, *t*(150.55)=9.09, *p*<0.001, *Cohen's d*=1.24. The results indicate that high intenders (*M*=12.84, *SD*=7.37) were more likely to believe attending professional development empowers them and makes them more likely to use NGSS as compared to low intenders (*M*=4.55, *SD*=5.86).

The salient belief that collaborating with colleagues about NGSS is encouraging (PBC5) was statistically significant, *t*(139.88)=8.93, *p*<0.001, *Cohen's d*=1.24. The results indicate high intenders (*M*=14.18, *SD*=7.14) were more likely to believe collaboration with colleagues is encouraging and makes them more likely to implement NGSS as compared to low intenders (*M*=5.98, *SD*=5.99). These findings are similar to those by Hanuscin and Zangori (2016), in which elementary pre-service teachers initially felt overwhelmed by the NGSS, but through collaboration with their peers, they were successfully able to design instruction using NGSS.

The salient belief that observing other classrooms using NGSS is helpful was statistically significant, $t(233)=5.61$, $p<0.001$, *Cohen's d*=0.81. The results indicate high intenders (*M*=12.37, *SD*=7.86) were more likely to believe observing other classrooms using NGSS is helpful and that doing so makes them more likely to implement NGSS as compared to low intenders (*M*=5.91, *SD*=8.10).

Survey Feedback

During the data collection process, I received five emails from Iowa high school science teachers and two emails from the NSTA NGSS list server recipients. Each of them responded to my survey request with either feedback, complaints, or opinions related to NGSS or the survey. I value their opinions and am therefore choosing to display their comments, anonymously, in this section. By examining these comments, I am able to get a deeper understanding of reasons why participants may have chosen not to take the survey or may have not completed the survey. In this section, I have quoted the comments followed by my commentary as to how they might affect the results of this study.

This first email is from an Iowa high school science teacher:

> I will not submit your survey because it does not give me an opportunity to explain myself. I am a professional and hardworking science teacher and your multiple choice questions would cut my insight. Your NGSS standards are not supported with any training or curriculum materials. You miss major important

> content and repeat biased content. You cannot decipher or figure out ways of teaching the standards easily and it causes me to lose the art of teaching and new teachers to be utterly bewildered. All of us want to quit because of them. I luckily can decipher the ones in my strongest content area but in the content areas that I am least strong it is difficult to plan and assess. Where are projectiles and kinematics in the new Physics standards? You have the middle school spiraling and repeating the same content over and over again, say evolution, but missing all of the other content. It is an insult that these "standards" are not properly written and content oriented. Yes, it is good to integrate all sciences and I can do that and standards can promote that so that all teachers, even the lazy ones do that, but that is not what the NGSS is doing. It is like playing darts at your content blindfolded and throwing in as much jargon as possible, but no way of helping teachers actually figure out how to teach in that style. Even in the high school there is way too much overlap in photosynthesis and food chain. Is that really going to help students become better nurses and doctors? What about the 9 standards all on climate change. Is that pushing political views on students? Teaching and assessing this content has made my classes less hands on. I like a list of content/concepts to teach and a list of ways of teaching that to integrate and make it higher order and authentic problem solving. Increasing in rigor and higher order thinking. The NGSS is nothing more than a maze of words and of little help. I do believe in standards and aligning our instruction and assessments accordingly but the previous standards were so much better, but again could be improved upon.

I believe this teacher’s response is an excellent summary of how some science teachers feel about implementing NGSS. At the beginning, her recommendation of adding an item for free-response opinions is something that I would also recommend if this survey were to be used again. By adding a free-response writing section, I would have been able to obtain more insight as to why teachers have the beliefs they do because I would have been able to compare each person’s BI score to their comments. However, some people did leave opinions in the write-in “other” options for the questions about type of grading system used in the classroom and resources that would be beneficial. Her comment that they “all want to quit” because of the standards is similar to a comment that was recorded as a write-in response to the question about the type of grading system used, that man wrote, “Spoiler alert - NGSS is a big reason I'm retiring after 43 years of experience." Overall, her email touches on many frustrations held by her and others about NGSS.

This second comment is from an Iowa high school science teacher: "I started your survey but never finished; we have already implemented NGSS, 3rd year now." Similarly, this third comment is from an Iowa high school science teacher: "I just wanted to add some quick feedback to your survey: This was a little bit difficult for me to answer because NGSS is already implemented in my classroom. Some of my answers may not make sense because of this." These comments provide possible insight as to why some people did not complete the survey. The survey was intended for those who have or have not started implementing NGSS, but it would be helpful to know what part of the survey caused confusion about this. This fourth email was received from an Iowa high school science teacher and her recommendations might help clarify the confusion experienced by the aforementioned teachers:

> I think this is an amazing survey to collect data on. One thing that I think should have been part of the questionnaire is whether or not the teacher has already begun to implement NGSS into their curriculum, or if their education to becoming a science teacher included training on NGSS. That information could impact the way a subject answers the questions you asked, at least I know it did for me. I apologize if this skews your data collection, it was just something I thought of as I was taking the survey. For me it is not as rough of transition because I have already learned about NGSS through my methods courses at the University of Northern Iowa, and as a third year teacher, I have already worked with a team of fellow science teachers to implement them into the new curriculum for several subject areas within the field of science. In fact I am in my second position as a science teacher in a new school this year, and they had not yet implemented them, but I came in with a curriculum in which they are already integrated into the lessons. As you can see that is something that would adjust how I answered your questions, since I have already been using the NGSS as my template for all three years I have been teaching now.

Adding questions about whether participants have already begun implementing NGSS and whether they have received training on NGSS is an excellent suggestion. These questions could be used to collect additional demographic information and to clarify that this survey is for those who have or have not started to implement NGSS. From her response, it is evident that schools in Iowa vary greatly in how far along they are in the implementation process.

The fifth email is from an Iowa high school science teacher: “I would like to qualify one of my statements in your survey. Iowa did not adopt all of the NGSS, only the Performance Expectations. We don't have the framework or any of the supplemental information in the state standards, just the PE's. So no we did not adopt the NGSS, but in a way we sort of did.” On the NSTA website (http://ngss.nsta.org/About.aspx), Iowa is considered to be a state that adopted NGSS, which is why it was used as the sampling frame in this study. However, this confusion might have caused Iowans to mark “no” on the question about if the state has adopted NGSS. This is why it was important to include a demographic question about which state the participant is from, so that I could verify if they accurately marked the state adoption question. A recommendation for improving the survey would be to include a more specific question such as, “Has your school adopted NGSS?” would likely provide more accurate responses, since some school districts have adopted NGSS rather than the whole state.

This sixth email is from an NSTA NGSS list server participant:

> Though I did complete your survey, I feel that my responses are meaningless in the context of my classroom and teaching practice. I have used problem based tasks and proficiency based grading for years. The only change to my teaching is remapping my lessons to NGSS standards and practices for administration and my teacher evaluation purposes. It is demeaning to me to be asked questions implying that no one [has] ever taught using NGSS methods. It has been implemented because there were teachers following these practices. So, planning lessons and changing assessments will take no time at all. Resources are and have always been a problem in urban districts. I believe that $250 was allotted to a science department of 9 teachers (not each- in aggregate).

This email brings up one major question that I have had throughout this research process: How can you differentiate between people who believe they are implementing NGSS and those who truly are implementing NGSS? This teacher states that her lessons have already been using NGSS before they existed. There is a rubric available called the Educator Evaluating the Quality of Instructional Products (EQuIP) Rubric, which is tool that science educators can use "to examine the alignment and overall quality of lessons and units with respect to NGSS" (Ewing, 2015, p. 13). The EQuIP rubric could be utilized in conjunction with the theory of planned behavior questionnaire in order to further provide evidence to answer the question of how do we differentiate between people who truly do implement NGSS and those who say they do.

This same question is brought up in the seventh email I received from an NSTA NGSS list server participant:

> I did the survey. Just as an observation, I feel like the questions won't get good data...here's the thing: I was sent by my district to participate in the state's committee to adopt/not adopt the NGSS. NJ did. My district has moved (since then) from 180 science classes to 90 science classes in alternating days to semester science courses. It has spent a total of 100 hours planning curriculum, which involved classroom teacher[s] who are minimally educated in NGSS, looking online and pirating activities from other curricula that honestly aren't aligned. If you asked the teachers I work with, they would all tell you they ARE teaching NGSS (because there is a huge lack of gnosis) but, really we only partly do NGSS. We write them on the lesson plans but if you walked into any of the classes, mostly it's lecture, worksheets and activities. The same activities as pre-NGSS. Additionally, we have the supplies we go out and buy or borrow. Our district planned to use lab-aids, net with vendors etc. To then be told by the superintendent's office that there are $0.00 allotted for Science. No joke ZERO. The supplies I do have from the school is mostly from 5th grade science kits from 2009.

The last two emails shown above both end with the lack of funding for resources and supplies. Funding is a concern for many in education, including the 116 participants who selected that as a resource that they need more of in order to implement NGSS. The primary sources of K-12 education funding come from the state and local governments, with supplemental funding from the federal government (U.S. Department of Education, 2005). Unfortunately, it will likely take political action for local school districts to increase their funding and help science educators receive the resources they need.

In this chapter, the results and discussion for the semi-structured interviews, the pilot study, and the full study were considered. Quantitative data analysis for the full study included the use of descriptive statistics, correlations, confirmatory factor analysis, independent samples *t*-tests, and backward elimination multiple regression. A summary of this will be provided in the next chapter, along with the limitations, implications, and future research.

CHAPTER V

CONCLUSION AND IMPLICATIONS

In the first part of the study, nine science education experts were interviewed and the transcripts were analyzed for common themes, in order to answer the first research question. The themes that arose during this study include changes to lessons and assessments that would need to be made with NGSS, concerns over the content of NGSS, and resources and time support for implementation of NGSS. During the interviews most of the participants had a generally positive outlook on NGSS, but they did mention several concerns or disadvantages. From the themes discovered in this exploratory study, a quantitative survey was developed using the theory of planned behavior and was ultimately distributed to examine the attitudes and behavioral intentions of high school science teachers.

In the second part of the study, the survey was piloted with a small sample (N=12) from the University of Northern Colorado Chemistry Department. From this pilot study, important information about survey format and difficulties was obtained and utilized in the editing of the survey before the full study was performed. The bivariate correlations were statistically significant for two of the three indirect and direct constructs, which were likely inflated due to the small sample, but remained promising.

Using the final version of the questionnaire, the full study was conducted with high school science teachers, in order to answer the second and third research questions.

This study supports prior research that a teacher's attitude can affect his or her intent to implement science education reform (Bybee, 1993; Crawley & Koballa, 1991; Cuban, 1990; Fullan & Miles,1992; Gess-Newsome et al., 2003; Haney, Czerniak, & Lumpe, 1996; Smith & Southerland, 2007; Thompson, 1992). Additionally, the constructs of the theory of planned behavior (attitude toward behavior, subjective norm, and perceived behavioral control) were all found to significantly contribute to a teacher's intent to implement NGSS. The results from the backward elimination multiple regression indicate that social pressures (SN) experienced by teachers are most important in predicting behavioral intent, followed by their attitude toward the behavior (AB). The perceived behavioral control (PBC) made less of a contribution to the prediction of behavioral intent, which indicates that the barrier (lack of time and resources) and enabler (professional development, collaboration, observation) salient beliefs did not matter as much to teachers as compared to the other two constructs. Therefore, professional development and trainings must take into account teacher attitudes about the implementation of NGSS and social pressures.

Limitations

Limitations to the elicitation study were based on willingness to participate. I reached out to many people who would have had much insight on the topic of NGSS, but did not receive a response. The generalizability of the full study findings is limited to Iowa, since this was the state used as the sampling frame. To increase generalizability, this survey should be used in other states as well. Self-reporting is susceptible to personal biases where teachers may believe they are implementing NGSS, but in reality they are not or they are implementing NGSS incorrectly (Remler & Van Ryzin, 2015).

Future Research

Before using this questionnaire again, I would recommend several changes. First, an addition of a free-response writing section would allow the researcher to be able to gain insight into why teachers have the beliefs they do. Second, adding a question about whether the participant has already begun implementing NGSS would clarify that this survey is for those who have or have not started to implement NGSS. Third, adding questions about what type of trainings the teacher has received could help assess which types of trainings are most beneficial in fostering high intentions to implement NGSS. Finally, a survey question stating “Has your school adopted NGSS?” would be better than “Has your state adopted NGSS?” because even though a state has adopted NGSS, that doesn’t mean the school has.

Furthermore, there are many opportunities for future study using this questionnaire or an adapted version of it for all states’ science standards as long as enough participant responses are able to be obtained in each state. This survey would also be appropriate to use in states that have very recently adopted NGSS, such as New Mexico which adopted NGSS in November 2017. In addition to the questionnaire, a future study could analyze teachers’ implementation approach in which teachers could include a lesson or student work that used NGSS and the same lesson that was used under the prior science standards in that state. The lessons or student work could be compared for content and alignment with NGSS.

Further research is needed to clarify the difference between those who believe they are implementing NGSS and those who truly are implementing NGSS. This can help ensure that the curriculum in schools is aligned with NGSS as opposed to those who are still using old lessons that are not correctly aligned with the standards. Harris, Sithole, and Kibirige (2017) conducted a needs and preparedness assessment with 214 K-12 teachers from 16 different states before the implementation of NGSS. They reported that the teachers were not prepared with the knowledge needed to successfully implement NGSS. It is critical that teachers understand "piecemeal changes and learning new isolated techniques will not be enough" (Reiser, 2013, p. 11). In future research, collecting artifacts such as lesson plans and units using NGSS would provide evidence for changes teachers have made in order to implement NGSS. The EQuIP Rubric can be a tool used to differentiate between those who have aligned their curriculum with NGSS and those who have not (Ewing, 2015). Researchers using this rubric may also prevent personal biases that teachers have when self-reporting as in the present study.

Implications

The study results offer valuable information about the implementation of NGSS in high school science classrooms. Since the subjective norm made the largest contribution to a teacher's intent to implement NGSS, administrators and the state Department of Education should make an increased effort to let teachers know that they want them to implement NGSS. This may increase positive social pressures and, therefore, increase the likelihood of NGSS implementation.

The regression model showed that familiarity has a significant role in a teacher's intent to implement NGSS. Because of this, the survey could be improved to assess a teacher's familiarity based on knowledge of specific areas of NGSS rather than the one self-report question that was used in this survey. Also, assessing a teacher's familiarity with NGSS before and after professional development meetings would be ideal. By increasing teachers' familiarity with NGSS, they are more likely to implement the standards; therefore, an effort should be made to increase familiarity for all science teachers.

Using independent samples *t*-tests, the differences between low intenders and high intenders to implement NGSS were significant on a number of salient beliefs. The attitude toward behavior salient beliefs that had a difference of means that were statistically significant were about critical thinking, student engagement, integration of science disciplines, relevance to students' lives, grading system, changing lessons and assessments, and classroom management. Teachers need to be shown the potential benefits of NGSS such as increased critical thinking, engagement, and relevance. They also need to be supported and provided examples of how to integrate the science disciplines, how to use NGSS with their grading system, and how to change their lessons, assessments, and classroom management practices. High intenders held more positive views in these areas, so these salient beliefs should be emphasized during professional development in order to promote the correct use of NGSS.

Furthermore, high intenders, on average, found professional development, collaboration, and observations of other classrooms to be more empowering and helpful than low intenders. Some research provides evidence for positive teacher and student outcomes from professional development that includes "coaching and mentoring, collaboration among colleagues, observing and discussing classroom practice, and having professional development of sufficient duration that teachers actually have the time to learn and improve" (Demonte, 2013, p.20). In addition, Next Generation Science Standards and Achieve (2017) expressed that two essential indicators for districts implementing NGSS were professional learning for teachers and educator collaboration within the district. However, further research on best practices in the areas of professional development, collaboration, and observations, specifically for science teachers, would be beneficial.

The questionnaire developed in this study is of value because it can be utilized by a state Department of Education or administrators, especially those in large school districts where a large sample size is available. The questionnaire could be used periodically throughout the state or district in order to observe shifts in teacher attitudes, social pressures, or perceived areas of control. The results can then be used to customize professional development so it is better suited for the teachers in that region.

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APPENDIX A

SEMI-STRUCTURED INTERVIEW QUESTIONS

1. What science standards did you use (or were familiar with) prior to NGSS?
2. What similarities do you see between the previous standards and NGSS?
3. What differences do you see between the previous standards and NGSS?
4. In your opinion, which do you believe is better? Why?
5. (If interviewee is from Colorado) Do you believe the current Colorado science standards should be replaced with NGSS? Why?
6. Have you taught or created a unit or lesson using a standard from NGSS?
    a. If so, how has your lesson/unit planning changed since implementation of NGSS?
    b. How have your daily objectives changed?
7. Have you taught or created an assessment using a standard from NGSS? If so, how has your assessment planning changed since implementation of NGSS?
8. What advantages do you see from using NGSS in the classroom?
9. What disadvantages do you see from using NGSS in the classroom?
10. In your opinion, how are NGSS standards changing students' ability to critically think?
11. Do you and your colleagues talk about NGSS in faculty meetings? What is discussed?
12. Have you attended NGSS trainings? Were they helpful to you?
13. Do you believe teachers are adopting NGSS fast enough?
14. Do you believe beginning teachers are following NGSS better or worse than experienced teachers?
15. In your opinion, has NGSS improved the science classroom in general or made it worse?

APPENDIX B

PILOT STUDY QUESTIONNAIRE

Consent Form

CONSENT FORM FOR HUMAN PARTICIPANTS IN RESEARCH
UNIVERSITY OF NORTHERN COLORADO

Project Title: Theory of Planned Behavior Applied to High School Chemistry Teachers Implementing Next Generation Science Standards

Researcher: Anna Pierce, Graduate Student, Department of Chemistry and Biochemistry
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Purpose and Description: The primary purpose of this study is to pilot a survey examining teachers' intentions to implement Next Generation Science Standards (NGSS) in high school chemistry courses. Next Generation Science Standards are followed by K-12 teachers in many parts of the United States. The collected data from this pilot study will be used to revise the survey before expanding data collection to chemistry high school teachers. In this study, UNC Chemistry Graduate Teaching Assistants and UNC pre-service chemistry teachers will be surveyed and will be asked to take the questionnaire as if they will be teaching high school chemistry and are in a school where NGSS is used in the classroom.

In the survey, a series of questions will be asked regarding the participant's attitude and intentions toward implementing NGSS. You will also be asked to provide some basic demographic information. The online survey should take 15-20 minutes of your time. You can choose to skip questions you do not wish to answer. Although your name and email address will be known by the primary researcher, your identity will not be linked to your survey responses. We cannot guarantee confidentiality due to the electronic nature of these surveys, but all efforts will be made to ensure confidentiality. There are no foreseen potential risks in this study. In no way will your employment or status as a student be affected by participation in this study.

The goal of this study is to benefit the field of chemistry education, but there may be no direct benefit to you. The possible benefit of your participation is through examining your own beliefs about implementation of NGSS.

Participation is voluntary. You may decide not to participate in this study and if you begin participation you may still decide to stop and withdraw at any time. Your decision will be respected and will not result in loss of benefits to which you are otherwise entitled. Having read the above and having had an opportunity to ask any questions, please complete the questionnaire if you would like to participate in this research. By completing the questionnaire, you will give us permission for your participation. You may print this page for future reference. If you have any concerns about your selection or treatment as a research participant, please contact Sherry May, IRB Administrator, Office of Sponsored Programs, 25 Kepner Hall, University of Northern Colorado Greeley, CO 80639; 970-351-1910.

Thank you for your willingness and consideration to participate in this research study. Please click the next button to begin the survey and to agree to participation in this questionnaire.

Demographic Questions

1. What is your current role in education
    a. UNC Graduate Teaching Assistant
    b. UNC Pre-service Science Teacher
    c. Other
2. How many years of teaching experience do you have?
    a. 0-4 years
    b. 5-9 years
    c. 10-14 years
    d. 15-19 years
    e. 20+ years
3. What is your gender?
    a. Female
    b. Male
    c. Write in: _______
4. How familiar are you with Next Generation Science Standards (NGSS)?
    a. Extremely familiar
    b. Very familiar
    c. Moderately familiar
    d. Slightly familiar
    e. Not familiar at all

Instructions and Definition

Instructions: This is a pilot survey that will eventually be given to high school chemistry teachers. Please respond to all of the survey questions as if you are going to be teaching chemistry at a high school and your school is in a state that has adopted Next Generation Science standards (NGSS) as the science standards for K-12 students.

Definition of Next Generation Science Standards (NGSS): The NGSS are new education standards adopted by multiple states in order to give all students a globally competitive science education. "By the end of the 12th grade, students should have gained sufficient knowledge of the practices, crosscutting concepts, and core ideas of science and engineering to engage in public discussions on science-related issues, to be critical consumers of scientific information related to their everyday lives, and to continue to learn about science throughout their lives" (Bodner, 2011).

5. Click here to indicate you understand the instructions. (Please contact the primary researcher if you have any further questions.)

Generalized Behavioral Intention Measurement

6. I expect to implement NGSS in my classroom.
    a. Strongly agree→ strongly disagree (7→ 1)
7. I want to implement NGSS in my classroom.
    a. Strongly agree→ strongly disagree (7→ 1)

8. I intend to implement NGSS in my classroom.
    a. Strongly agree→ strongly disagree (7→ 1)

Direct Measurement of Attitude

9. Implementing NGSS in my classroom is:
    a. harmful→ beneficial (1→ 7)
    b. bad→ good (1→ 7)
    c. unpleasant (for me)→ pleasant (for me) (1→ 7)
    d. worthless→ useful (1→ 7)

Indirect Measurement of Attitude:
Behavioral Beliefs Paired with
Outcome Evaluations

10. My implementing the NGSS would help students to think critically. *[behavioral belief]*
    a. Extremely likely→ extremely unlikely (7→ 1)
11. Helping my students to think critically is: *[outcome evaluation]*
    a. Extremely desirable→ extremely undesirable (+3→ -3)
12. My implementing the NGSS would increase student engagement in learning chemistry. *[behavioral belief]*
    a. Extremely likely→ extremely unlikely (7→ 1)
13. Increasing student engagement in learning chemistry is: *[outcome evaluation]*
    a. Extremely desirable→ extremely undesirable (+3→ -3)
14. My implementing the NGSS would allow for increased integration of the science disciplines. *[behavioral belief]*
    a. Extremely likely→ extremely unlikely (7→ 1)
15. Increasing integration of the science disciplines is: *[outcome evaluation]*
    a. Extremely desirable→ extremely undesirable (+3→ -3)
16. My implementing the NGSS would decrease the amount of content covered in the course *[behavioral belief]*
    a. Extremely likely→ extremely unlikely (1→ 7)
17. Decreasing the amount of content covered in the course is: *[outcome evaluation]*
    a. Extremely desirable→ extremely undesirable (+3→ -3)
18. My implementing the NGSS would make chemistry more relevant to the students' everyday lives. *[behavioral belief]*
    a. Extremely likely→ extremely unlikely (7→ 1)
19. Making chemistry more relevant to the students' everyday lives is: *[outcome evaluation]*
    a. Extremely desirable→ extremely undesirable (+3→ -3)
20. My implementing the NGSS would take more resources (funding, curriculum materials, training, equipment, etc.) *[behavioral belief]*
    a. Extremely likely→ extremely unlikely (1→ 7)
    b. IF EXTREMELY LIKELY→ SLIGHTLY LIKELY IS SELECTED, THE FOLLOWING QUESTION WILL BE ASKED:
        i. Which of the following resources would you require more of if implementing NGSS? (Select all that apply)
            1. Funding
            2. Curriculum materials

3. Training/professional development
4. Supplies/equipment
5. Other ______________

21. Requiring more resources (funding, curriculum materials, training, equipment, etc.) is: *[outcome evaluation]*
    a. Extremely desirable→ extremely undesirable (+3→ -3)
22. My implementing the NGSS would take more time to plan lessons. *[behavioral belief]*
    a. Extremely likely→ extremely unlikely (1→ 7)
23. Taking more time to plan lessons is: *[outcome evaluation]*
    a. Extremely desirable→ extremely undesirable (+3→ -3)
24. My implementing the NGSS would work well with my grading system (standards-based grading, traditional grading, etc.) *[behavioral belief]*
    a. Extremely likely→ extremely unlikely (7→ 1)
        i. IF EXTREMELY LIKELY→ EXTREMELY UNLIKELY IS SELECTED, THE FOLLOWING QUESTION WILL BE ASKED:
            1. What grading system do you primarily use in your classroom?
                a. Standards-based grading
                b. Traditional grading
                c. Other _________________
25. NGSS working well with my grading system (standards-based, traditional, etc.) is: *[outcome evaluation]*
    a. Extremely desirable→ extremely undesirable (+3→ -3)
26. My implementing the NGSS would change my previously used lessons. *[behavioral belief]*
    a. Extremely likely→ extremely unlikely (1→ 7)
27. Changing my previously used lessons is:
    a. Extremely desirable→ extremely undesirable (+3→ -3)
28. My implementing the NGSS would change my previously used assessments. *[behavioral belief]*
    a. Extremely likely→ extremely unlikely (1→ 7)
29. Changing my previously used assessments is: *[outcome evaluation]*
    a. Extremely desirable→ extremely undesirable (+3→ -3)
30. My implementing the NGSS would result in classroom management difficulties. *[behavioral belief]*
    a. Extremely likely→ extremely unlikely (1→ 7)
31. Having classroom management difficulties is: *[outcome evaluation]*
    a. Extremely desirable→ extremely undesirable (+3→ -3)

Direct Measurement of Subjective Norm

32. Most people who are important to me think that I (<u>should/should not)</u> implement NGSS.
    a. Should→ should not (7→ 1)
33. It is expected of me that I implement NGSS.
    a. Strongly disagree→ strongly agree (1→ 7)

34. I feel under social pressure to implement NGSS.
    a. Strongly disagree→ strongly agree (1→ 7)

Indirect Measurement of Subjective Norm:
Normative Beliefs Paired with
Motivation to Comply

35. Other science teachers (DO/DO NOT) implement NGSS. *[normative belief]*
    a. Do→ do not (+3→ -3)
36. Doing what other science teachers do is important to me. *[motivation to comply]*
    a. Very much→ not at all (7→ 1)
37. The administration thinks I <u>(should/should not)</u> implement NGSS. *[normative belief]*
    a. Should→ should not (+3→ -3)
38. Administration approval of my teaching is important to me. *[motivation to comply]*
    a. Very much→ not at all (7→ 1)
39. Students would <u>(approve/disapprove)</u> of my implementation of NGSS. *[normative belief]*
    a. Approve→ disapprove (+3→ -3)
40. Student approval of my teaching is important to me. *[motivation to comply]*
    a. Very much→ not at all (7→ 1)
41. Parents would <u>(approve/disapprove)</u> of my implementation of NGSS. *[normative belief]*
    a. Approve→ disapprove (+3→ -3)
42. Parent approval of my teaching is important to me. *[motivation to comply]*
    a. Very much→ not at all (7→ 1)
43. The state Department of Education thinks I <u>(should/should not)</u> implement NGSS. *[normative belief]*
    a. Should→ should not (+3→ -3)
44. What the state Department of Education thinks I should do is important to me. *[motivation to comply]*
    a. Very much→ not at all (7→ 1)

Direct Measurement of Perceived
Behavioral Control

45. I am confident that I could implement NGSS if I wanted to.
    a. Strongly agree→ strongly disagree (7→ 1)
46. For me to teach using NGSS is
    a. Extremely easy→ Extremely difficult (7→ 1)
47. The decision to implement NGSS is beyond my control.
    a. Strongly agree→ strongly disagree (1→ 7)
48. Whether I implement NGSS or not is entirely up to me
    a. Strongly agree→ strongly disagree (7→ 1)

Indirect Measurement of Perceived Behavioral Control: Control Beliefs Paired with Control Power

49. When I am implementing the NGSS, I feel like there is not enough time to lesson plan. *[control belief]*
    a. Extremely likely→ extremely unlikely (1→ 7)
50. Feeling like there is not enough time to lesson plan makes it <u>(more likely/less likely)</u> to implement NGSS. *[control power]*
    a. More likely→ less likely (+3→ -3)
51. When I am implementing the NGSS, I feel like there is not enough time during the class period for lessons using NGSS. *[control belief]*
    a. Extremely likely→ extremely unlikely (1→ 7)
52. Feeling like there is not enough time during the class period for the lesson using NGSS makes it <u>(more likely/less likely)</u> to implement NGSS. *[control power]*
    a. More likely→ less likely (+3→ -3)
53. When I am implementing NGSS, I feel that I do not have enough resources (funding, curriculum materials, equipment, etc.). *[control belief]*
    a. Extremely likely→ extremely unlikely (1→ 7)
54. Having available resources (funding, curriculum materials, equipment, etc.) would make it <u>(easy/difficult)</u> to implement NGSS. *[control power]*
    a. Much easier→ much more difficult (+3→ -3) to implement NGSS
55. When I attend professional development and training opportunities about NGSS, I feel empowered to utilize NGSS in my classroom. *[control belief]*
    a. Extremely likely→ extremely unlikely (7→ 1)
56. Feeling empowered during professional development and training opportunities about NGSS make me <u>(less likely/more likely)</u> to implement NGSS. *[control power]*
    a. less likely → more likely (-3→ +3)
57. Collaboration with colleagues about implementation of NGSS is encouraging. *[control belief]*
    a. Extremely likely→ extremely unlikely (7→ 1)
58. When I collaborate with colleagues, I am <u>(less likely/more likely)</u> to implement NGSS. *[control power]*
    a. less likely → more likely (-3→ +3)
59. Observation of other classrooms using NGSS is helpful. *[control belief]*
    a. Extremely likely→ extremely unlikely (7→ 1)
60. When I observe other classrooms using NGSS, I am <u>(less likely/more likely)</u> to implement NGSS. *[control power]*
    a. less likely → more likely (-3-+3)

Post-Questionnaire Questions to Help Improve Survey

Please answer the following questions about the survey you just completed.

61. Are there any questions that were confusing or difficult to answer? If so, please indicate which questions and what aspects you found confusing or difficult to answer.

62. At what point in the survey did you lose interest? Why?
63. How might the format of this survey be improved?

APPENDIX C

INSTITUTIONAL REVIEW BOARD APPROVAL FOR QUALITATIVE RESEARCH

UNIVERSITY OF
NORTHERN COLORADO

Institutional Review Board

DATE:	October 21, 2016
TO:	Anna Pierce
FROM:	University of Northern Colorado (UNCO) IRB
PROJECT TITLE:	[957989-1] Implementation of Next Generation Science Standards in High Schools (Expert Interviews)
SUBMISSION TYPE:	New Project
ACTION:	APPROVAL/VERIFICATION OF EXEMPT STATUS
DECISION DATE:	October 21, 2016
EXPIRATION DATE:	October 21, 2020

Thank you for your submission of New Project materials for this project. The University of Northern Colorado (UNCO) IRB approves this project and verifies its status as EXEMPT according to federal IRB regulations.

Anna -

Thank you for your patience with the UNC IRB process. Your application is verified/approved exempt and you may begin participant recruitment and data collection.

Please note that all identifiable data (signed consent forms, audio recordings) must be destroyed 3 years following the end of data collection.

Best wishes with your research.

Sincerely,

Dr. Megan Stellino, UNC IRB Co-Chair

We will retain a copy of this correspondence within our records for a duration of 4 years.

If you have any questions, please contact Sherry May at 970-351-1910 or Sherry.May@unco.edu. Please include your project title and reference number in all correspondence with this committee.

APPENDIX D

INSTITUTIONAL REVIEW BOARD APPROVAL FOR QUANTITATIVE RESEARCH

UNIVERSITY OF
NORTHERN COLORADO

Institutional Review Board

DATE:	November 30, 2017
TO:	Anna Pierce
FROM:	University of Northern Colorado (UNCO) IRB
PROJECT TITLE:	[1159749-1] Theory of Planned Behavior Applied to High School Science Teachers Implementing Next Generation Science Standards
SUBMISSION TYPE:	New Project
ACTION:	APPROVAL/VERIFICATION OF EXEMPT STATUS
DECISION DATE:	November 29, 2017
EXPIRATION DATE:	November 29, 2021

Thank you for your submission of New Project materials for this project. The University of Northern Colorado (UNCO) IRB approves this project and verifies its status as EXEMPT according to federal IRB regulations.

Anna -

Thank you for a very clear and thorough IRB application. Your materials and protocols are verified/approved exempt and you may begin participant recruitment and data collection.

Best wishes with this research.

Sincerely,

Dr. Megan Stellino, UNC IRB Co-Chair

We will retain a copy of this correspondence within our records for a duration of 4 years.

If you have any questions, please contact Sherry May at 970-351-1910 or Sherry.May@unco.edu. Please include your project title and reference number in all correspondence with this committee.

APPENDIX E

FULL STUDY QUESTIONNAIRE

Consent Form

CONSENT FORM FOR HUMAN PARTICIPANTS IN RESEARCH
UNIVERSITY OF NORTHERN COLORADO

Project Title: Theory of Planned Behavior Applied to High School Science Teachers Implementing Next Generation Science Standards
Researcher: Anna Pierce, Graduate Student, Department of Chemistry and Biochemistry
Research advisor: Corina Brown, Ph.D., Department of Chemistry and Biochemistry
Phone: 515-537-6988 Email: anna.pierce@unco.edu
970-351-1285 corina.brown@unco.edu

Purpose and Description: The primary purpose of this study is to examine teachers' intentions to implement Next Generation Science Standards (NGSS) in high school science courses. Next Generation Science Standards are followed by K-12 teachers in many parts of the United States. The collected data from this study will be used to examine the implementation of NGSS in high school science classrooms.

In the survey, a series of questions will be asked regarding your attitude and intentions toward implementing NGSS. You will also be asked to provide some basic demographic information. The online survey should take 10-15 minutes of your time. You can choose to skip questions you do not wish to answer. Although your email address is known by the primary researcher, your identity cannot be linked to your survey responses. We cannot guarantee confidentiality due to the electronic nature of these surveys, but all efforts will be made to ensure confidentiality. There are no foreseen potential risks in this study. In no way will your employment be affected by participation in this study.

The goal of this study is to benefit the field of science education, but there may be no direct benefit to you. The possible benefit of your participation is through examining your own beliefs about implementation of NGSS.

Participation is voluntary. You may decide not to participate in this study and if you begin participation you may still decide to stop and withdraw at any time. Your decision will be respected and will not result in loss of benefits to which you are otherwise entitled. Having read the above and having had an opportunity to ask any questions, please complete the questionnaire if you would like to participate in this research. By completing the questionnaire, you will give us permission for your participation. You may print this page for future reference. If you have any concerns about your selection or treatment as a research participant, please contact Sherry May, IRB Administrator, Office of Sponsored Programs, 25 Kepner Hall, University of Northern Colorado Greeley, CO 80639; 970-351-1910.

Thank you for your willingness and consideration to participate in this research study.

Please click the next button to begin the survey and to agree to participation in this questionnaire.

Demographic Questions

1. Are you currently a high school (9th-12th grade) science teacher?
    a. Yes
    b. No *If “No” is selected, skip to end of survey.
2. How familiar are you with Next Generation Science Standards (NGSS)?
    a. Extremely familiar
    b. Very familiar
    c. Moderately familiar
    d. Slightly familiar
    e. Not familiar at all *If “Not familiar at all is selected,” skip to end of survey.
3. In which state do you currently teach?
    a. *All states plus Puerto Rico and Washington D.C. are provided
4. Do you teach in a state that has adopted NGSS?
    a. Yes
    b. No
    c. I don’t know
5. How would you describe the location where you currently teach?
    a. Rural
    b. Suburban
    c. Urban
6. What content area(s) do you teach? (Select all that apply.)
    a. Biology
    b. Chemistry
    c. Physics
    d. Physical Science
    e. Earth Science
    f. Engineering
    g. Anatomy and Physiology
    h. Environmental Science
    i. Other *Write-in option
7. What grade level(s) do you currently teach? (Select all that apply)
    a. 9th grade
    b. 10th grade
    c. 11th grade
    d. 12th grade
8. How many years of teaching experience do you have?
    a. 0-4 years
    b. 5-9 years
    c. 10-14 years
    d. 15-19 years
    e. 20+ years
9. What is your gender?
    a. Female
    b. Male
    c. Write in: _______

Instructions

Instructions: Please respond to the following prompts to the best of your ability.

Generalized Behavioral Intention Measurement

NOTE: These direct measures are mixed throughout the survey.

10. BI1. I expect to implement NGSS in my classroom.
    a. Strongly agree→ strongly disagree (7→ 1)
11. BI2. I want to implement NGSS in my classroom.
    a. Strongly agree→ strongly disagree (7→ 1)
12. BI3. I intend to implement NGSS in my classroom.
    a. Strongly agree→ strongly disagree (7→ 1)

Instructed Response Question

13. To ensure the quality of this survey, please click on "strongly agree" for this item. *[instructed response item]*
    a. Strongly agree→ strongly disagree *Strongly agree=0, all other options=1

Direct Measurement of Attitude

14. Implementing NGSS in my classroom is:
    a. ABd1 beneficial→ harmful (7→ 1)
    b. ABd2 good→ bad (7→ 1)
    c. ABd3 pleasant (for me)→ unpleasant (for me) (7→ 1)
    d. ABd4 useful→ worthless (7→ 1)

Indirect Measurement of Attitude: Behavioral Beliefs Paired with Outcome Evaluations

15. ABi1bb My implementing the NGSS would help students to think critically. *[behavioral belief]*
    a. Extremely likely→ extremely unlikely (7→ 1)
16. ABi1oe Helping my students to think critically is: *[outcome evaluation]*
    a. Extremely desirable→ extremely undesirable (+3→ -3)
17. ABi2bb My implementing the NGSS would increase student engagement in learning chemistry. *[behavioral belief]*
    a. Extremely likely→ extremely unlikely (7→ 1)
18. ABi2oe Increasing student engagement in learning chemistry is: *[outcome evaluation]*
    a. Extremely desirable→ extremely undesirable (+3→ -3)
19. ABi3bb My implementing the NGSS would allow for increased integration of the science disciplines. *[behavioral belief]*
    a. Extremely likely→ extremely unlikely (7→ 1)
20. ABi3oe Increasing integration of the science disciplines is: *[outcome evaluation]*
    a. Extremely desirable→ extremely undesirable (+3→ -3)
21. ABi4bb My implementing the NGSS would decrease the amount of content covered in the course *[behavioral belief]*
    a. Extremely likely→ extremely unlikely (1→ 7)
22. ABi4oe Decreasing the amount of content covered in the course is: *[outcome evaluation]*
    a. Extremely desirable→ extremely undesirable (+3→ -3)

23. ABi5bb My implementing the NGSS would make chemistry more relevant to the students' everyday lives. *[behavioral belief]*
    a. Extremely likely→ extremely unlikely (7→ 1)
24. ABi5oe Making chemistry more relevant to the students' everyday lives is: *[outcome evaluation]*
    a. Extremely desirable→ extremely undesirable (+3→ -3)
25. ABi6bb My implementing the NGSS would take more resources (funding, curriculum materials, training, equipment, etc.) *[behavioral belief]*
    a. Extremely likely→ extremely unlikely (1→ 7)
    b. IF EXTREMELY LIKELY→ SLIGHTLY LIKELY IS SELECTED, THE FOLLOWING QUESTION WILL BE ASKED:
        i. ABi6.1Which of the following resources would you require more of if implementing NGSS? (Select all that apply)
            1. Funding
            2. Curriculum materials
            3. Training/professional development
            4. Supplies/equipment
            5. Other ______________
26. ABi6oe Requiring more resources (funding, curriculum materials, training, equipment, etc.) is: *[outcome evaluation]*
    a. Extremely desirable→ extremely undesirable (+3→ -3)
27. ABi7bb My implementing the NGSS would take more time to plan lessons. *[behavioral belief]*
    a. Extremely likely→ extremely unlikely (1→ 7)
28. ABi7oe Taking more time to plan lessons is: *[outcome evaluation]*
    a. Extremely desirable→ extremely undesirable (+3→ -3)
29. ABi8bb My implementing the NGSS would work well with my grading system (standards-based grading, traditional grading, etc.) *[behavioral belief]*
    a. Extremely likely→ extremely unlikely (7→ 1)
        i. IF EXTREMELY LIKELY→ EXTREMELY UNLIKELY IS SELECTED, THE FOLLOWING QUESTION WILL BE ASKED:
            1. ABi8.1 What grading system do you primarily use in your classroom?
                a. Standards-based grading
                b. Traditional grading
                c. Other _________________
30. ABi8oe NGSS working well with my grading system (standards-based, traditional, etc.) is: *[outcome evaluation]*
    a. Extremely desirable→ extremely undesirable (+3→ -3)
31. ABi9bb My implementing the NGSS would change my previously used lessons. *[behavioral belief]*
    a. Extremely likely→ extremely unlikely (1→ 7)
32. ABi9oe Changing my previously used lessons is:
    a. Extremely desirable→ extremely undesirable (+3→ -3)

33. ABi10bb My implementing the NGSS would change my previously used assessments. *[behavioral belief]*
    a. Extremely likely→ extremely unlikely (1→ 7)
34. ABi10oe Changing my previously used assessments is: *[outcome evaluation]*
    a. Extremely desirable→ extremely undesirable (+3→ -3)
35. ABi11bb My implementing the NGSS would result in classroom management difficulties. *[behavioral belief]*
    a. Extremely likely→ extremely unlikely (1→ 7)
36. ABi11oe Having classroom management difficulties is: *[outcome evaluation]*
    a. Extremely desirable→ extremely undesirable (+3→ -3)

Direct Measurement of Subjective Norm

NOTE: These direct measures are mixed throughout the survey.

37. SNd1 Most people who are important to me think that I (should/should not) implement NGSS.
    a. Should→ should not (7→ 1)
38. SNd2 It is expected of me that I implement NGSS.
    a. Strongly agree→ strongly disagree (7→ 1)
39. SNd3 I feel under social pressure to implement NGSS.
    a. Strongly agree→ strongly disagree (7→ 1)
40. SNd4 People who are important to me want me to implement NGSS.
    a. Strongly agree→ strongly disagree (7→ 1)

Indirect Measurement of Subjective Norm:
Normative Beliefs Paired with
Motivation to Comply

41. SNi1nb Other science teachers (DO/DO NOT) implement NGSS. *[normative belief]*
    a. Do→ do not (+3→ -3)
42. SNi1mc Doing what other science teachers do is important to me. *[motivation to comply]*
    a. Very much→ not at all (7→ 1)
43. SNi2nb The administration thinks I (should/should not) implement NGSS. *[normative belief]*
    a. Should→ should not (+3→ -3)
44. SNi2mc Administration approval of my teaching is important to me. *[motivation to comply]*
    a. Very much→ not at all (7→ 1)
45. SNi3nb Students would (approve/disapprove) of my implementation of NGSS. *[normative belief]*
    a. Approve→ disapprove (+3→ -3)
46. SNi3mc Student approval of my teaching is important to me. *[motivation to comply]*
    a. Very much→ not at all (7→ 1)
47. SNi4nb Parents would (approve/disapprove) of my implementation of NGSS. *[normative belief]*
    a. Approve→ disapprove (+3→ -3)

48. SNi4mc Parent approval of my teaching is important to me. *[motivation to comply]*
    a. Very much→ not at all (7→ 1)
49. SNi5nb The state Department of Education thinks I (should/should not) implement NGSS. *[normative belief]*
    a. Should→ should not (+3→ -3)
50. SNi5mc What the state Department of Education thinks I should do is important to me. *[motivation to comply]*
    a. Very much→ not at all (7→ 1)

Direct Measurement of Perceived Behavioral Control

NOTE: These direct measures are mixed throughout the survey.

51. PBCd1 I am confident that I could implement NGSS if I wanted to.
    a. Strongly agree→ strongly disagree (7→ 1)
52. PBCd2 For me to teach using NGSS is
    a. Extremely easy→ Extremely difficult (7→ 1)
53. PBCd3 The decision to implement NGSS is beyond my control.
    a. Strongly agree→ strongly disagree (1→ 7)
54. PBCd4 Whether I implement NGSS or not is entirely up to me.
    a. Strongly agree→ strongly disagree (7→ 1)

Indirect Measurement of Perceived Behavioral Control: Control Beliefs Paired with Control Power

55. PBCi1cb When I implement the NGSS, I feel that there is not enough time to plan lessons. *[control belief]*
    a. Extremely likely→ extremely unlikely (1→ 7)
56. PBCi1pp Feeling like there is not enough time to plan lessons makes it (more likely/less likely) to implement NGSS. *[control power]*
    a. More likely→ less likely (+3→ -3)
57. PBCi2cb When I implement the NGSS, I feel that there is not enough time during the class period for lessons using NGSS. *[control belief]*
    a. Extremely likely→ extremely unlikely (1→ 7)
58. PBCi2pp Feeling like there is not enough time during the class period for the lesson using NGSS makes it (more likely/less likely) to implement NGSS. *[control power]*
    a. More likely→ less likely (+3→ -3)
59. PBCi3cb When I implement the NGSS, I feel that I do not have enough resources (funding, curriculum materials, equipment, etc.). *[control belief]*
    a. Extremely likely→ extremely unlikely (1→ 7)
60. PBCi3pp Having available resources (funding, curriculum materials, equipment, etc.) would make it (easy/difficult) to implement NGSS. *[control power]*
    a. Much easier→ much more difficult (+3→ -3) to implement NGSS
61. PBCi4cb When I attend professional development and training opportunities about NGSS, I feel empowered to utilize NGSS in my classroom. *[control belief]*
    a. Extremely likely→ extremely unlikely (7→ 1)

62. PBCi4pp Feeling empowered during professional development and training opportunities about NGSS make me (more likely/less likely) to implement NGSS. *[control power]*
    a. More likely → less likely (+3→ -3)
63. PBCi5cb Collaboration with colleagues about implementation of NGSS is encouraging. *[control belief]*
    a. Extremely likely→ extremely unlikely (7→ 1)
64. PBCi5pp When I collaborate with colleagues, I am (more likely/less likely) to implement NGSS. *[control power]*
    a. More likely → less likely (+3→ -3)
65. PBCi6cb Observation of other classrooms using NGSS is helpful. *[control belief]*
    a. Extremely likely→ extremely unlikely (7→ 1)
66. PBCi6pp When I observe other classrooms using NGSS, I am (more likely/less likely) to implement NGSS. *[control power]*
    a. More likely → less likely (+3→-3)

APPENDIX F

ASSUMPTIONS FOR MULTIPLE

LINEAR REGRESSION

1) Assumption: there is a linear relationship between the dependent variable and the independent variables collectively and individually. Diagnostic: visualizing scatter plots and partial regression plots to check for linearity.

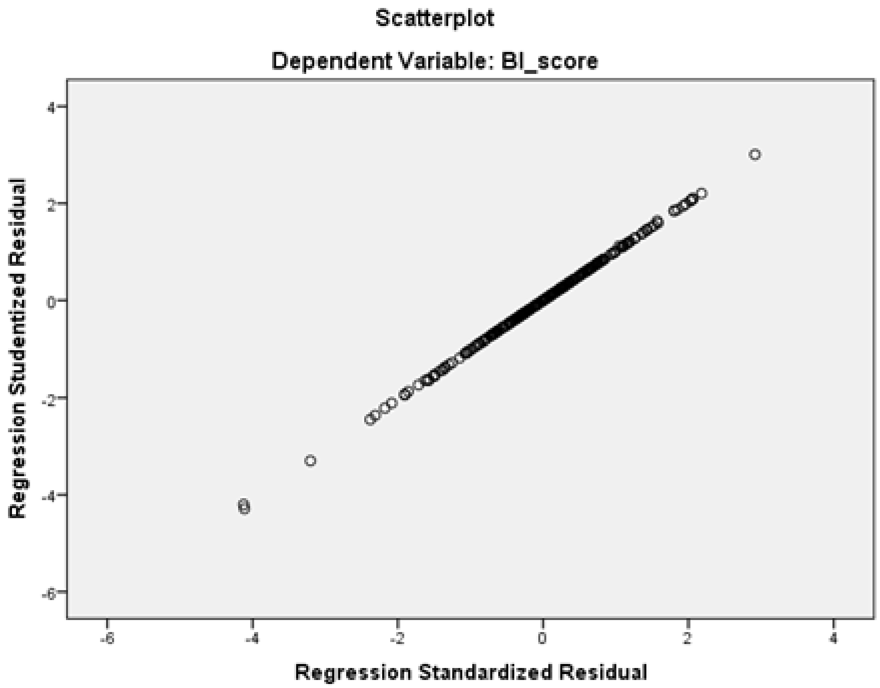

Figure F.1. Scatter plot between studentized residual and standardized residual

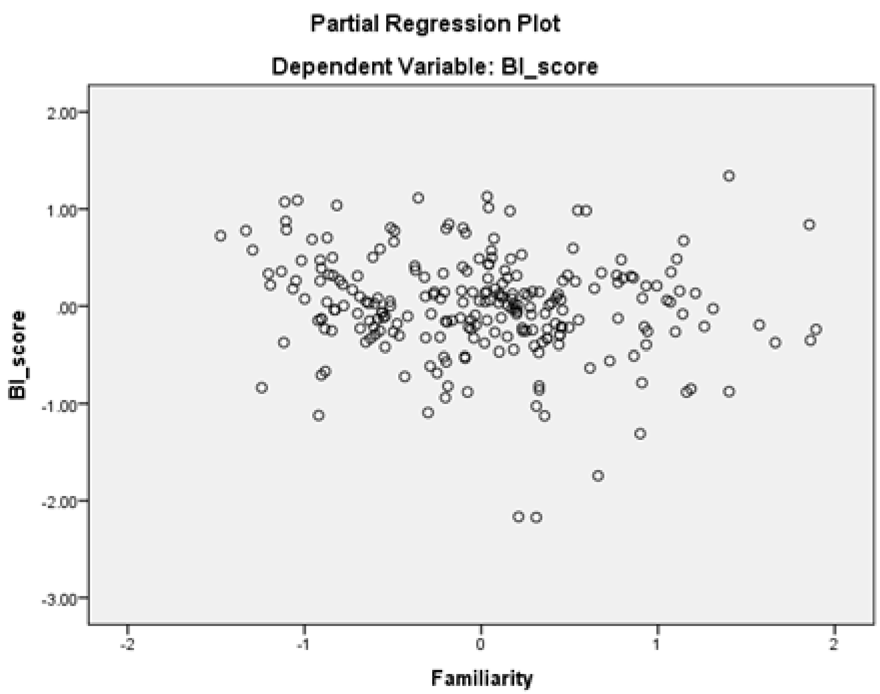

Figure F.2. Partial regression plot between BI and familiarity

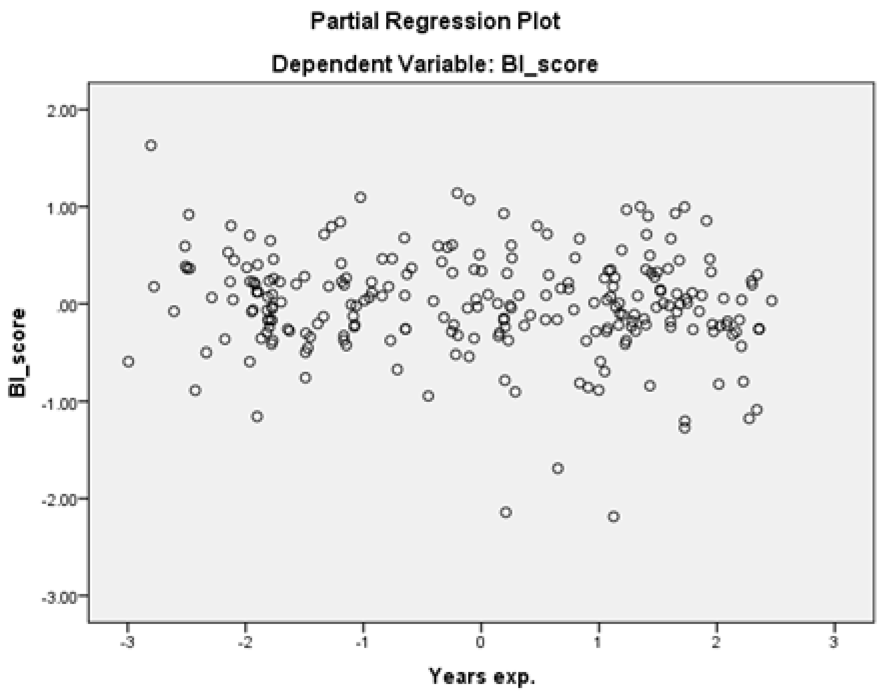

Figure F.3. Partial regression plot between BI and years of experience

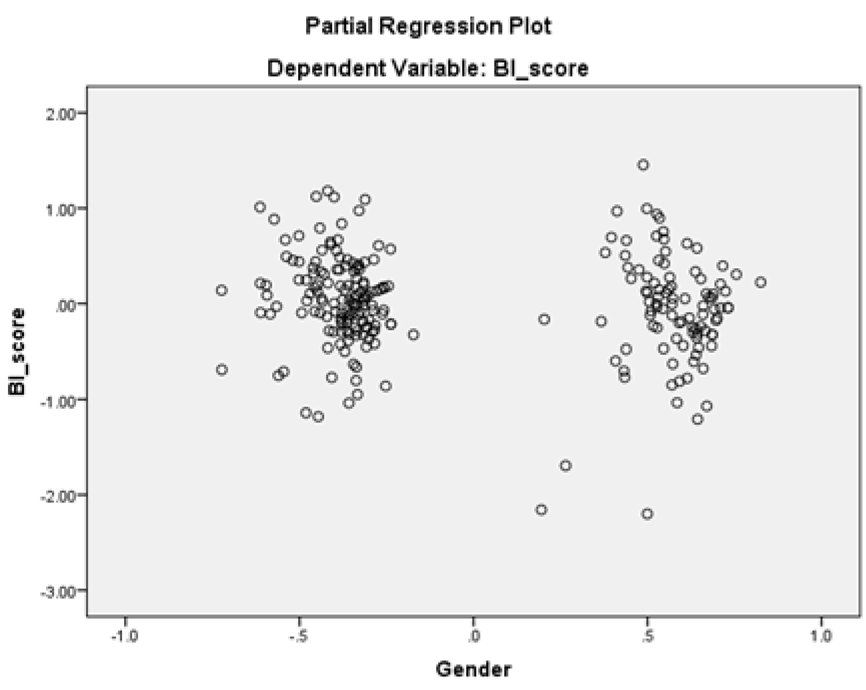

Figure F.4. Partial regression plot between BI and gender

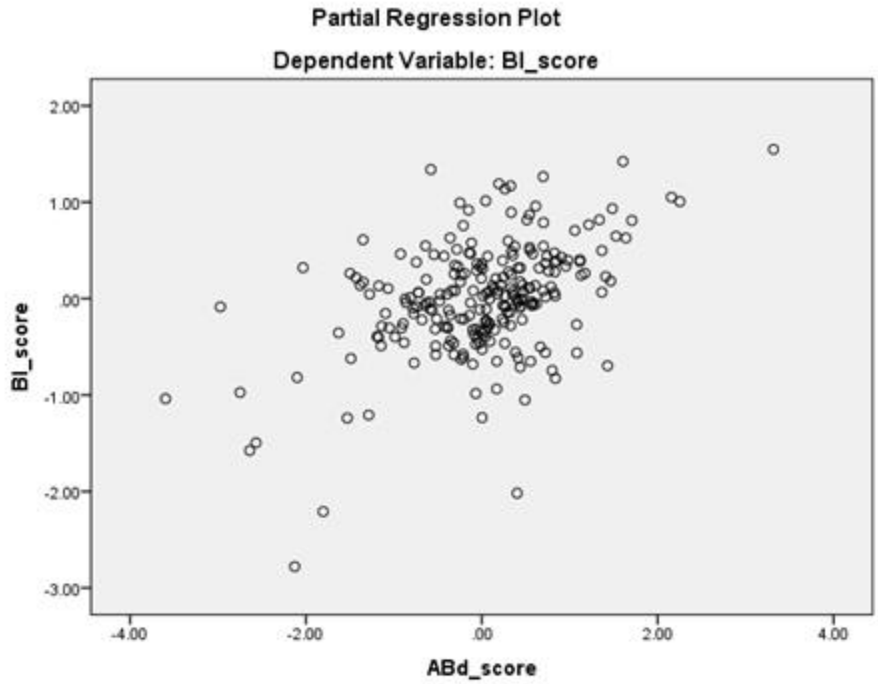

Figure F.5. Partial regression plot between BI and ABd

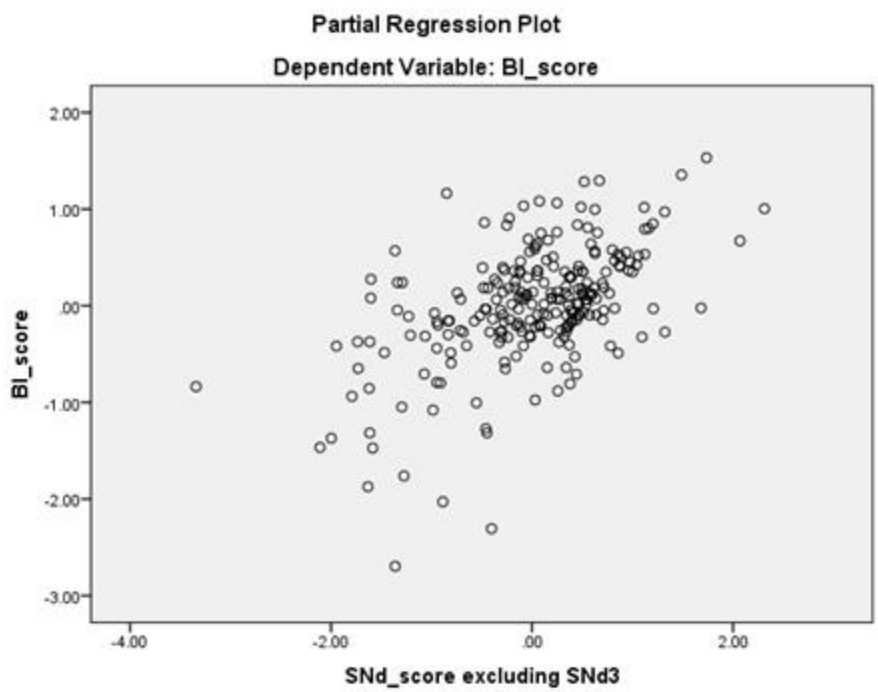

Figure F.6. Partial regression plot between BI and SNd

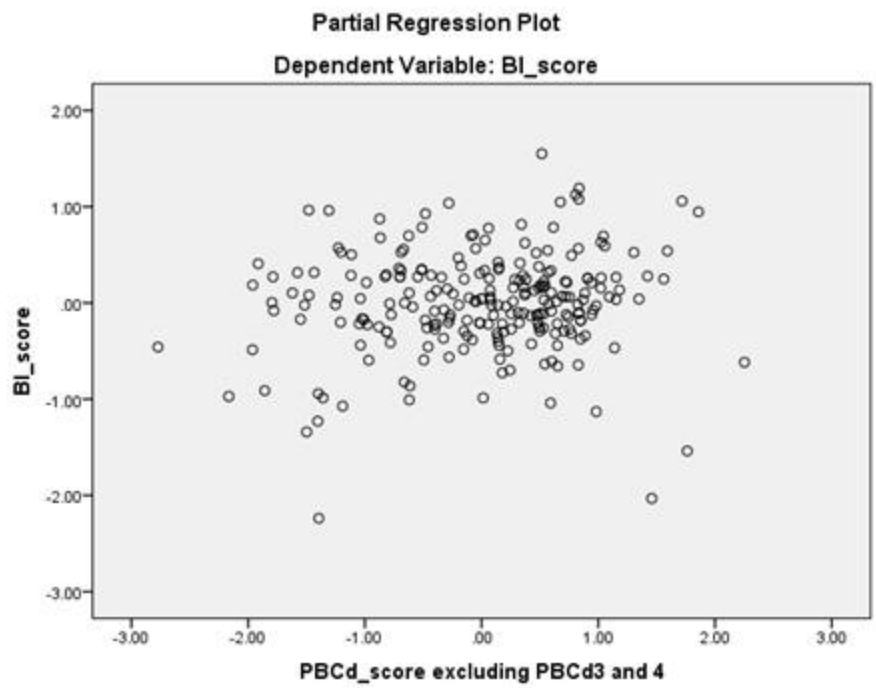

Figure F.7. Partial regression plot between BI and PBCd

2) Assumption: the distribution of the dependent variable is normal. Diagnostics: check a histogram of the studentized residuals, a Normal P-P Plot, and a Normal Q-Q Plot.

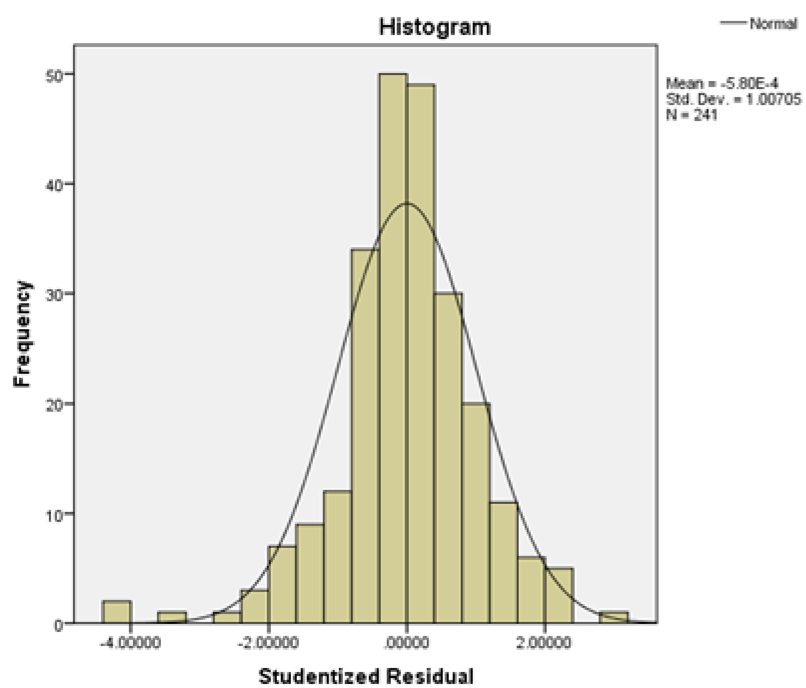

Figure F.8. Histogram of studentized residuals

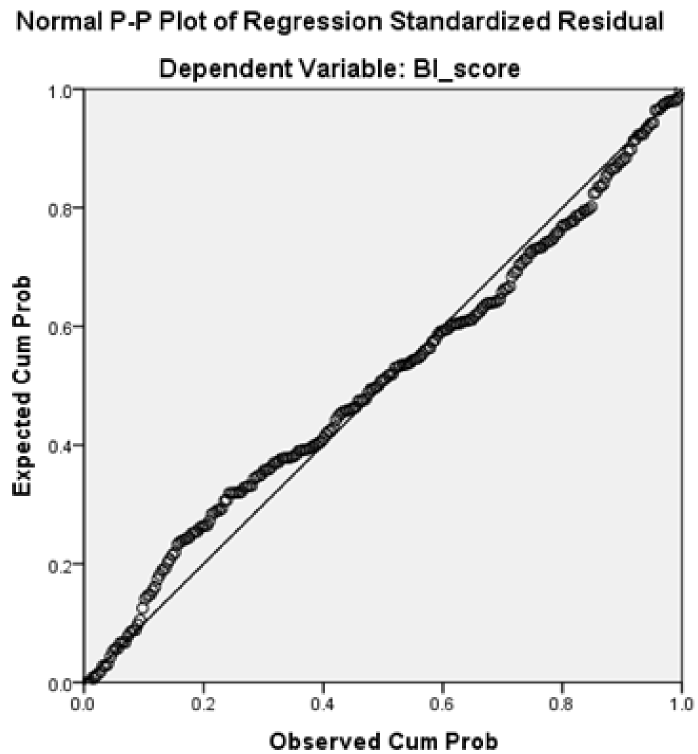

Figure F.9. Normal P-P plot of regression standardized residuals

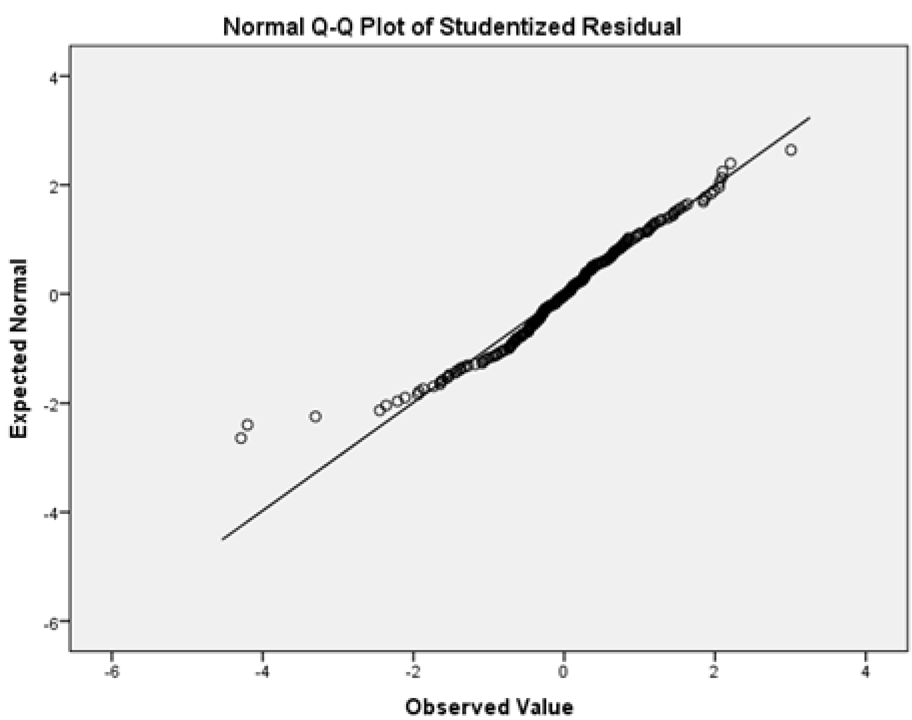

Figure F.10. Normal Q-Q plot of studentized residuals

3) Assumption: the distribution of the dependent variable has constant standard deviation throughout the range of values of the independent variables (homoscedasticity). Diagnostics: plot the studentized residuals against the unstandardized predicted values.

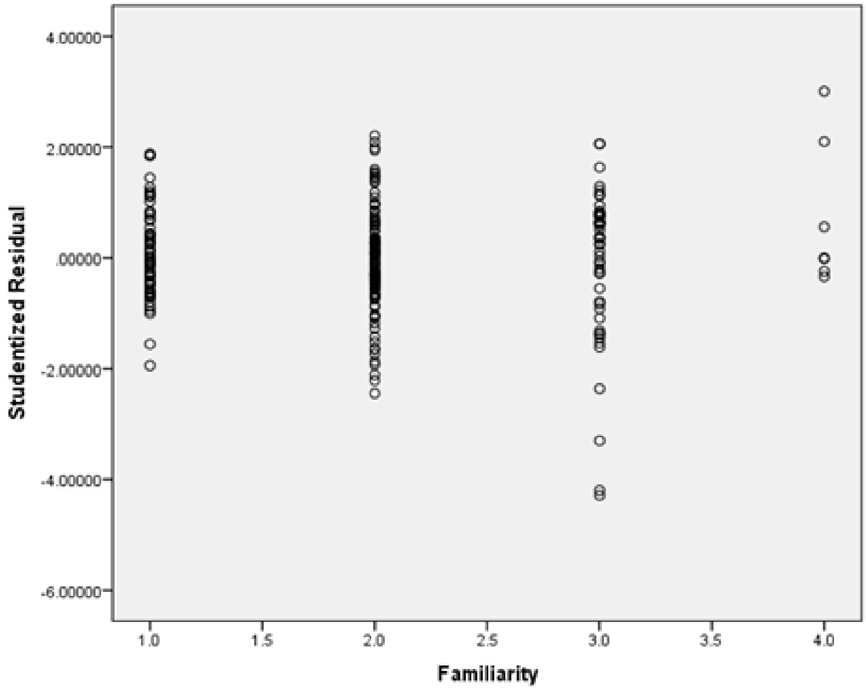

Figure 6.11. Studentized residuals with the unstandardized predicted values for familiarity

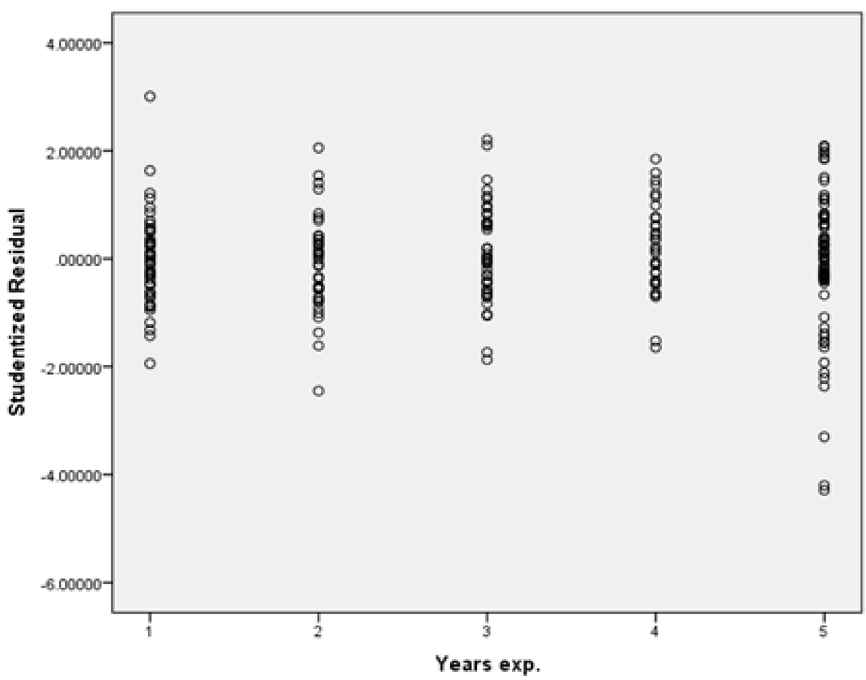

Figure F.12. Studentized residuals with the unstandardized predicted values for years of experience

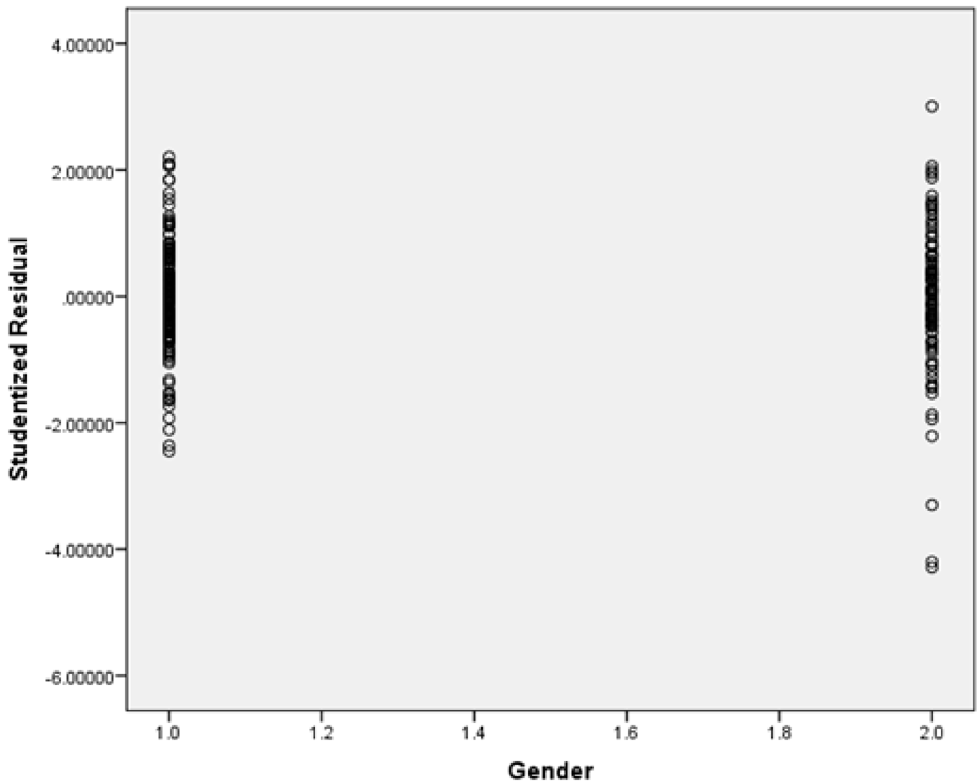

Figure F.13. Studentized residuals with the unstandardized predicted values for gender

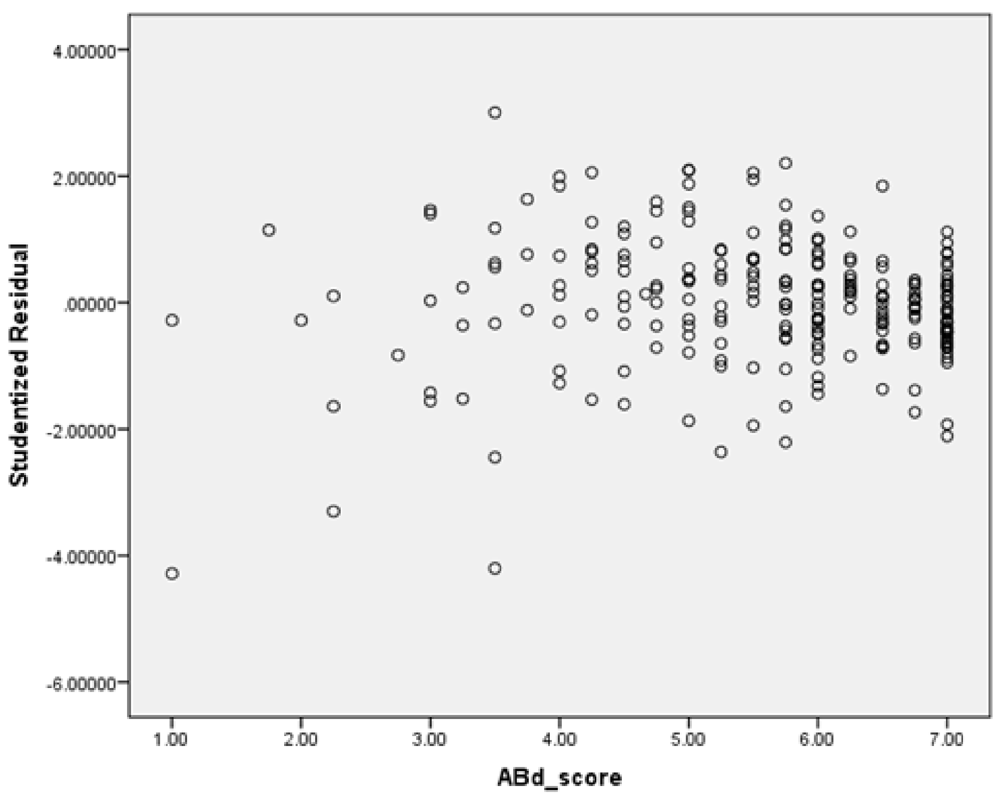

Figure F.14. Studentized residuals with the unstandardized predicted values for ABd

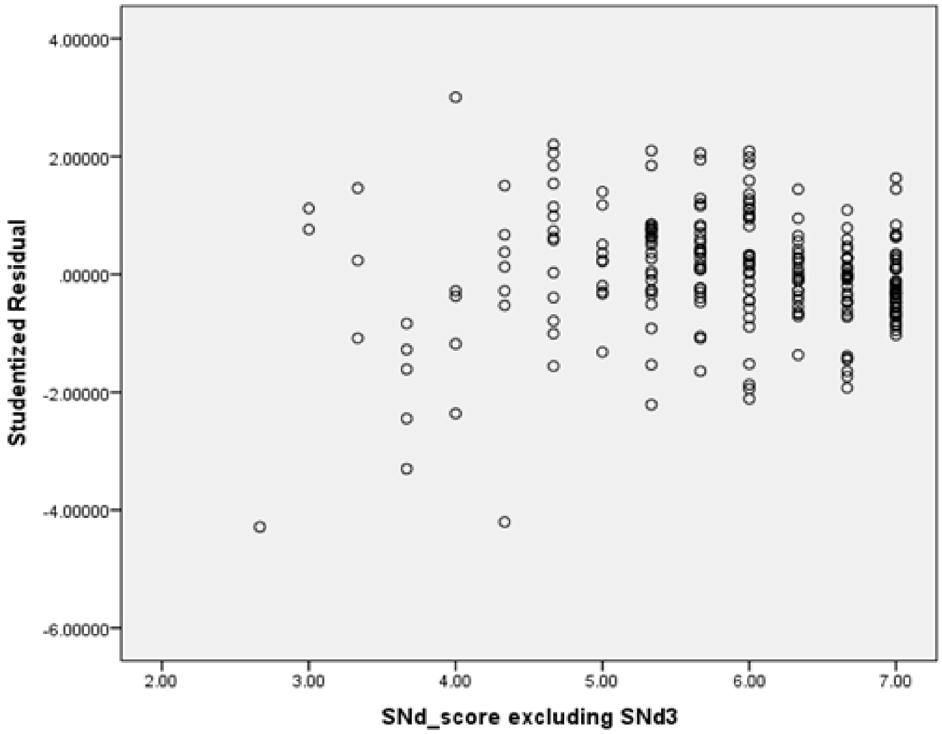

Figure F.15. Studentized residuals with the unstandardized predicted values for SNd

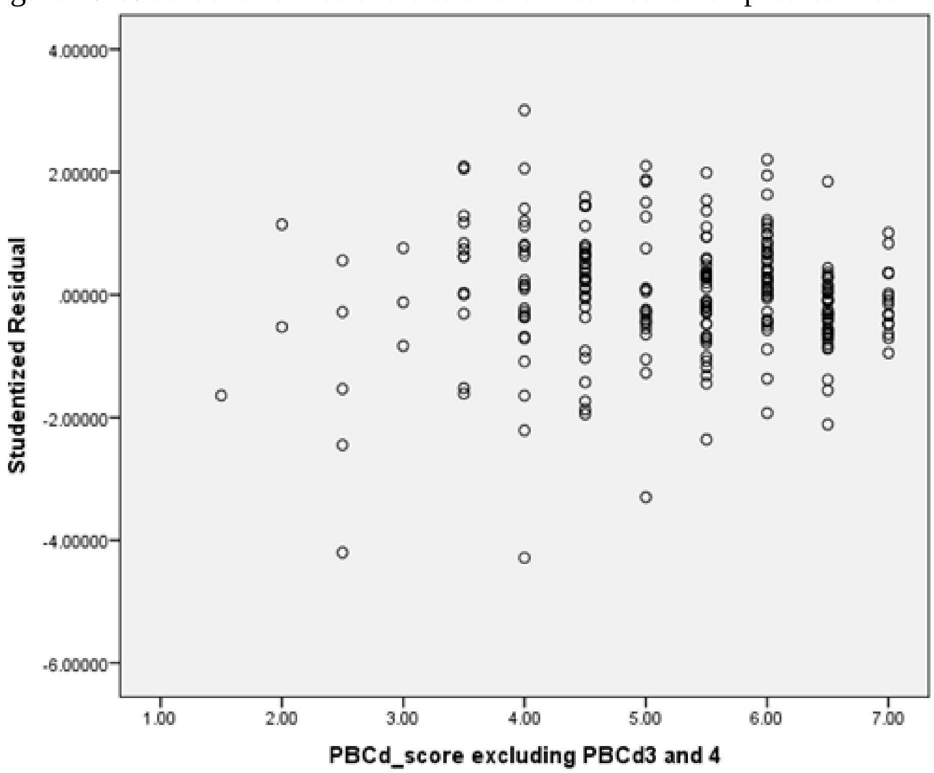

Figure F.16. Studentized residuals with the unstandardized predicted values for PBCd