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# Exploring Freshmen College Students' Self-Efficacy, Attitudes, and Intentions Toward Chemistry

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# EXPLORING FRESHMEN COLLEGE STUDENTS' SELF-EFFICACY, ATTITUDES, AND INTENTIONS TOWARD CHEMISTRY

A Capstone Experience/ Thesis Project

Presented in Partial Fulfillment of the Requirements for

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Honors College Graduate Distinction at Western Kentucky University

By

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ABSTRACT

This study examined the self-efficacy beliefs, attitudes towards general chemistry, and intentions to take future chemistry courses in a sample of ($n$ = 1,126) first-time, first-year freshmen from a large comprehensive university in the Mid-South. The main purpose of the study was to determine the amount of variance in students' intentions which could be predicted by self-efficacy, attitudes, and other known influences (past performance, past experience and choice of major). Findings from a standard multiple regression indicate that self-efficacy ($\beta = 0.07$, $p < .05$) and attitude ($\beta = 0.50$, $p < .001$) are both significant and predict 29.3% of the variance in intentions, with attitudes making a larger unique contribution. Using a hierarchical regression to control for other known factors, self-efficacy and attitudes were still able to predict 23.5% of the variance in intentions. Overall, the five independent variables were able to predict 31.7% of the variance in intentions. Implications for secondary and postsecondary science educators and STEM administrators are discussed.

Keywords: Chemistry education, Self-efficacy, Attitudes, Intentions, STEM retention, Motivation

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VITA

FIELDS OF STUDY

Chemistry; Science and Math Education

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Cook, A.F. (2012, October). *Exploring college freshmen students' self-efficacy, attitudes, and intentions toward chemistry*. Presented at the Kentucky Honors Roundtable, Murray, KY.

Cook, A. F., Day, M. M., & Pesterfield, L. L. (2012, August). *Inquiry-based 5E lesson on VSEPR Theory: Effective modeling in a high school classroom*. Presented at the American Chemical Society National Meeting, Philadelphia, PA.

Overstreet, S. N., Cook, A. F., & Duffin, L. C. (2012, March). *STEM switchers: Why education?.* Presented at the Western Kentucky University Student Research Conference, Bowling Green, KY.

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## AWARDS

April 2013............AERA Undergraduate Student Education Research Training Workshop Fellow, San Francisco, CA

March 2013..........Session Winner, Undergraduate Paper Session 13: Social Sciences/Services, WKU Research Conference

August 2012.........Invited to participate in Sci-Mix at the American Chemical Society National Meeting, Philadelphia, PA

April 2012............Awarded Outstanding Senior in Chemical Education at WKU

March 2012..........Session Winner, Undergraduate Paper Session 13: Social Sciences/Services (Co-presenter), WKU Research Conference

July 2011..............Inducted as a Kentucky Colonel

2011-2013............Awarded the Robert Noyce Teacher Scholarship, $10,000-$14,000

2009-2013............Awarded the Award of Excellence Scholarship by Western Kentucky University, $11,500

2009......................Valedictorian, Owen County High School, Owenton, Kentucky

2008......................Kentucky Governor's Scholar Induction

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# CHAPTER 1

# INTRODUCTION

One of the largest questions in education over the past twenty years has been "How do we increase the number of students enrolling in STEM disciplines?" (e.g., Business-Higher Education Forum, 2010; Dalgety & Coll, 2006; Luzzo, Hasper Albert, Bibby, & Martinelli, 1999; Powell, 1989). Although postsecondary enrollment has been increasing, the number of students enrolling in STEM (Science, Technology, Engineering, and Mathematics) disciplines has been steadily declining (United States Government Accountability Office, 2006). The National Center for Education Statistics (2009) reported that in 2001, about 2.7 million students graduated from high school and in the same year almost 1.7 million students enrolled in either a two- or four-year college. According to the National Science Board (2010), of these 1.7 million students, only 233,000 students graduated with a bachelor's degree in a STEM discipline after six years.

Over the past five years only 15.6 percent of awarded bachelor's degrees in the United States were in the STEM disciplines. This statistic is a serious concern when we compare it to the fact that China awarded 46.7 percent of their bachelor degrees to STEM disciplines; South Korea awarded 37.8 percent and Germany awarded 28.1 percent (Business-Higher Education Forum, 2010). These statistics are no surprise when you consider that K-12 students in the United States perform poorly on international math and science tests causing the U.S. to be classified as "statistically below average" compared to students in 57 countries (Wood & Associates, 2008-09).

So why are students unmotivated to choose a STEM discipline? Many researchers in the field of motivation have been seeking this answer and more. Two constructs that appear to impact students' intended career choices are attitude (Ajzen, 1991; Mahoney, 2010; Maltese & Tai, 2011; Ware & Lee, 1988) and self-efficacy (Andrew, 1998; Bandura, 1997; Lent, Brown & Hackett, 1994; Mau, 2003). When people are not interested in a domain, they typically do not continue to pursue that specific domain (Ajzen, 1991). Likewise, when a person perceives that they are not adequate in a particular skill set, they typically do not continue to do activities that require that skill set (Bandura, 1997; Zimmerman, 1995). These two principles can be applied to choosing to pursue a degree in a STEM discipline; if a student is not interested in a STEM profession and/or the student perceives him or herself as lacking the skills necessary to perform well in a STEM profession, then the student is likely to abstain from pursuing a STEM degree.

Students who wish to pursue STEM careers in physics, biology, environmental science, medicine, engineering, pharmacy, etc. must have a working knowledge of college-level general chemistry. The term "chemistry" can encompass all types of chemistry at all levels, whereas "general chemistry" is often used to describe the introductory level chemistry course either in a secondary or postsecondary environment. General chemistry is a complex and challenging course, but the skills and knowledge learned in that course are essential and mandatory for almost every STEM discipline (Luzzo et al., 1999). At the college level, a general chemistry course often consists of freshmen and sophomores who are completing the course as a pre-requisite for some further study of science, technology or engineering.

First-time, first-year college freshmen are an ideal population to study because of their situation. They have previous experiences in science or math, they are roughly similar in their chemistry background (i.e., taking courses offered at the high school and AP levels), they are beginning their college career which in turn reflects their final career choice, and they are early enough in their academic pursuits where they can change majors easily with little consequence. In fact, in the Cooperative Institutional Research Program's (CIRP) Freshman Survey of 203,967 first-time, full-time students across the United States, 13.6% reported that there was a "very good chance" that they would change majors, while 14.2% were still undecided in their choice of major (Pryor, DeAngelo, Blake, Hurtado, & Tran, 2011). In fact, Daempfle (2002) suggests that the first year of college is particularly important because 35 percent of STEM majors switch after their first year (as cited in Business-Higher Education Forum, 2010). Therefore, the purpose of this study is to examine how first-time, first-year college freshmen students' perceived skills (self-efficacy) in chemistry and liking of chemistry (attitudes) affects their willingness to enroll in future chemistry courses (intentions). These motivational factors are important to study in order to help repair the STEM shortage.

# CHAPTER 2

# LITERATURE REVIEW

## Self-Efficacy

Self-efficacy refers to a person's belief about his or her capabilities on a specific task (Bandura, 1997). Research has shown that students with a higher self-efficacy typically choose more challenging tasks and persist longer on challenging tasks than students with lower self-efficacy (Bandura, 1997; Bandura & Schunk, 1981; Dalgety, Coll, & Jones, 2003; Lent, Brown & Larkin, 1984). Likewise, students with a high self-efficacy will show more effort when pursuing a challenging task and will generally perform higher on that given task than students with low self-efficacy (Bandura, 1997; Crippen & Earl, 2007).

In the current context, *general chemistry self-efficacy* refers to a student's belief that he or she is capable of successfully performing tasks affiliated with general chemistry content (e.g. using Hess' Law or correctly applying chemical nomenclature). The operational definition of general chemistry self-efficacy in this study, however, does not include a person's belief in his or her capability to be successful in a chemistry laboratory which has been included in prior conceptions of chemistry self-efficacy (Aydin & Uzuntiryaki, 2009; Dalgety et al., 2003; Kurbanoğlu & Akin, 2010;

Uzuntiryaki & Aydin, 2009). The laboratory component was omitted in this study to maintain parsimony. Laboratory experiences at the secondary and postsecondary levels tend to vary in terms of quantity and quality and we wanted an operational definition that would be applicable to both levels of study regardless of the varying laboratory experiences. Unfortunately, research on self-efficacy for general chemistry is sparse due to measurement limitations; however there is some research that suggests that self-efficacy for chemistry (content plus lab) is positively related to students' chemistry grades (Zusho, Pintrinch, & Coppolla, 2003) and attitudes towards chemistry, and is negatively related to chemistry laboratory anxiety (Kurbanoğlu & Akin, 2010). Therefore, self-efficacy is an important motivational variable that has been shown to influence cognitive and behavioral choices.

Self-efficacy is influenced by four factors: past experiences, vicarious experiences, verbal persuasion, and psychological state (Bandura, 1997). Past experiences are considered the greatest factor impacting self-efficacy beliefs because individuals gain important competence-related feedback from direct participation in a specific task. This feedback influences one's belief in his/her capabilities and expectations for future success or failure (Bandura, 1997). Vicarious experiences occur when a person compares themselves to others and observes others' successes or failures on a particular task. If a person sees someone who they deem to be similar in ability and intelligence fail at a task, then his/her self-efficacy will likely decrease. Another way self-efficacy can increase is if a person performs above his/her peers on a task. Verbal persuasion, such as a teacher providing encouragement to a student, can have a positive or negative effect on self-efficacy; however, it is limited in its effectiveness. Finally, psychological states such as anxiety, stress, mood or emotional level can affect self-efficacy (Bandura, 1997; Bayraktar, 2011). Consistent with the theory, Dalgety and Coll (2006) found that past experiences contributed to students' self-efficacy for chemistry tasks; therefore, students' postsecondary experience was greatly impacted by their secondary chemistry experiences. In addition, chemistry self-efficacy increased as students had success early in their postsecondary chemistry course. Since past experiences are the greatest contributing factor to self-efficacy (Bandura, 1997), it is important to measure first-time, first-year freshmen's past experiences related to chemistry (i.e., ACT science sub-score, choice of major, and number of prior chemistry classes completed).

Many researchers have studied and measured self-efficacy in a variety of contexts and for a variety of purposes. As mentioned previously, self-efficacy is task-specific and therefore, loses its predictive validity if it is treated as a general measure (Bandura, 1997; Bandura, 2006). Although there have been scales made to test science self-efficacy which were found to be reliable and delivered effective results (Andrew, 1998; Karaarslan & Sungur, 2011; Kiran & Sungur, 2012), many researchers are now developing scales with a deeper level of specificity based on Bandura's (2006) recommendations. Chemistry self-efficacy measures have previously been developed for use at either the secondary (Aydin & Uzuntiryaki, 2009) or postsecondary levels specifically (Dalgety et al., 2003; Uzuntiryaki & Aydin, 2009), but no scales were found that have been used and validated at both levels. In addition, the chemistry self-efficacy scales found in the literature typically include a laboratory component and/or were designed to be used for their intended audience only (e.g., nursing majors or science pre-service or in-service teachers) (Andrew, 1998; van Aalderen-Smeets, Walma van der Molen & Asma, 2012).

This study sought to use an instrument that measured the self-efficacy of general chemistry that could be used for all students at either the secondary or postsecondary level. In order to be used for general chemistry, the content of the scale must be that of general chemistry at both the secondary and postsecondary levels. Therefore, laboratory questions were not appropriate for use due to the lack of laboratory experience given in some secondary institutions. To test the self-efficacy of general chemistry, the scale must inquire about student's beliefs to perform specific tasks encountered in general chemistry curriculum only (e.g. converting grams to moles, correctly using chemical nomenclature etc.). No scale was found which specifically measured self-efficacy for general chemistry *content* sans laboratory experiences which could generalize to both academic levels. Therefore the Self-Efficacy for General Chemistry (SEGC) scale was developed and tested in a pilot study with students at the postsecondary level based on the recommendations of Bandura (2006). A follow-up study testing the SEGC scale with students at the secondary level was beyond the scope of the current study, but will be forth-coming. The SEGC scale consists of 14 items that specifically focus on concepts taught in a general chemistry course and does not include items that assess beliefs about laboratory skills. The SEGC scale was shown to have good internal consistency ($\alpha$ = 0.97) and accounted for 71.9% of the variance in scores of the latent variable in the pilot study.

Chemistry is challenging and takes persistence at the secondary level, and even more so at the postsecondary level. Students with a high self-efficacy toward chemistry will be more likely to take on the challenge of chemistry and persist through the courses. In addition, research suggests that self-efficacy accounts for “a little over 25% of the variance in vocational and academic interests” (Brown & Lent, 2006, p. 213) and that academic interests influence our subsequent career decisions or intentions (Dalgety & Coll, 2006). Ajzen (1991) defines intentions as indications of people’s willingness to try and/or amount of effort they will exert in order to perform the behavior. Therefore, since there is a positive correlation between self-efficacy and intentions (Bandura, 2006), it would be presumed that general chemistry self-efficacy would be a predictor of intentions toward chemistry. This study will seek to determine how much predictive power self-efficacy for general chemistry has for intentions to take future chemistry courses using the SEGC scale.

**Attitudes**

It is agreed that one of the purposes of introductory science courses, whether at the secondary or postsecondary level, should be to ignite positive student attitudes toward that specific science subject (Cheung, 2009a; Dalgety et al., 2003). Based on the Theory of Planned Behavior, derived from the Theory of Reasoned Action, attitude towards a behavior combined with normative beliefs (beliefs about the normative expectations of others) and control beliefs (beliefs about the factors which control the performance of the behavior) produce an intention which is the antecedent of behavior (Ajzen, 1991). Intentions include the motivational factors that influence a behavior similar to self-efficacy yet not made explicit in the theory (Dalgety et al., 2003). The stronger the person's attitude, the greater their perceived control, the stronger the intention, and the more likely the person is to carry out the behavior (Ajzen, 1991).

In science, a person's thoughts, feelings, and behaviors towards the discipline are important to consider because attitudes have been shown to influence academic performance (Bennett, Rollnick, Green, & White, 2001; Cheung, 2009b; Cukrowska, Staskun & Schoeman, 1999; Green, Liem, Martin, Colmar, Marsh, & McInerney, 2012; Salta & Tzougraki, 2004; Xu & Lewis, 2011), self-efficacy (Bandura, 2006; Dalgety & Coll, 2006; Dalgety et al., 2003; van Aalderen-Smeets, Walma van der Molen, & Asma, 2011), as well as intentions (Ajzen, 1991; Cheung, 2009a; France, France, & Himawan, 2006; Glasman & Albarracín, 2006; Kurbanoğlu & Akin, 2010; MacIntyre, & Blackie, 2012). Similar to self-efficacy, attitudes are task-specific; therefore, there is a difference between attitude toward science and attitude towards chemistry. Many researchers agree that research on attitudes must be broken down into subjects such as chemistry, physics, and biology instead of a general science attitude measure (Cheung, 2009a; Zacharia & Barton, 2004). The research specifically examining attitude toward chemistry is sparse; however, the research found echoes previous findings about attitudes towards science in general. Chemistry attitude is positively related to chemistry achievement (Salta & Tzougraki, 2004; Xu & Lewis, 2011), self-efficacy (Dalgety & Coll, 2006; Dalgety et al., 2003) and intentions to take future chemistry (Crawley & Koballa, 1992; Dalgety & Coll, 2006; Kurbanoğlu & Akin, 2010).

The Attitude Toward Chemistry Lessons Scale (ATCLS; Cheung, 2009b) was developed to measure a person's attitude (i.e., predisposition to respond to something in a favorable or unfavorable manner) toward chemistry lessons (i.e., theory plus laboratory) and is an instrument that most closely aligns with this study's operational definition of chemistry attitude. The ATCLS is a 12-item scale where the total score represents overall attitude toward chemistry with four subscales (3 items each) representing the following dimensions: 1) liking of chemistry lessons, 2) liking of chemistry laboratory work, 3) evaluative beliefs for school chemistry (i.e., usefulness of chemistry), and 4) behavioral tendencies to learn chemistry (i.e., what people say they would do if given opportunities) (Cheung, 2009b). Even though the ATCLS contains three items related to chemistry laboratory, the items are very general. In addition, the ATCLS has been shown to have good psychometric properties (i.e., strong factorial validity and internal consistency) and has been used to examine students' attitudes towards chemistry in secondary institutions (Cheung, 2009a; Khan & Ali, 2012). Thus, we elected to extend the use of the ATCLS to a postsecondary sample. In addition, we wanted to add to the existent body of literature using the ATCLS to examine the predictive power of first-time, first-year college freshmen's attitudes towards general chemistry on their intentions to take future chemistry courses.

## General Chemistry

Ebbing and Gammon (2010) define chemistry as "the science of the composition and structure of materials and of the changes that materials undergo" (p. 2). Chemistry is a complex science that helps not only explain the world around us, but also helps to explain processes in many other STEM fields such as biology, physics, environmental science, and medical sciences. There are many different types of chemistry; there is organic chemistry, biochemistry, thermochemistry, physical chemistry, theoretical chemistry, experimental chemistry, chemical engineering, etc. The term "general chemistry" is used to describe an introductory course (either at the secondary or postsecondary level) that seeks to introduce critical chemistry concepts that are important to *all* types of chemistry and related subjects; basically to give an overview or introduction to chemistry.

General chemistry curriculum consists of concrete and abstract concepts, which force students to think analytically, spatially, and mathematically. Students in a general chemistry course must have a basic understanding of mathematical procedures, especially manipulation of algebraic expressions. This knowledge is the most important pre-requisite to general chemistry. According to the American Chemical Society's (ACS) Guidelines and Evaluation Procedures (2008), an introductory general chemistry course should provide students with the knowledge of "basic chemical concepts such as stoichiometry, states of matter, atomic structure, molecular structure and bonding, thermodynamics, equilibria, and kinetics" (p.9). Every concept listed as "basic chemistry knowledge" is used in many other STEM fields to help prepare STEM professionals. To fully understand this basic knowledge, students must be able to think abstractly about an atomic structure they cannot see, they must be able to think spatially in order to understand molecular structure and bonding, and they must be able to think concretely to convert units using stoichiometry. These are only the *ways* in which students must think. This list does not include the memorization of elements, ions, and basic equations and constants. It does not include the interpretation of graphs and data. It does not include the structure of the periodic table, predicting products of reactions, or determining the heats of formation and reaction. In addition, the ACS Guidelines and Evaluation Procedures

(2008) also include a list of skills that students should gain from a general chemistry course: problem-solving skills, chemical literature skills, communication skills, team skills and ethics. The general chemistry course is a complex and challenging course that is essential for training STEM professionals; therefore, the present study will address the following research questions:

1. How well do self-efficacy beliefs for general chemistry and attitudes toward chemistry predict intentions to take future chemistry courses?
2. Which is the better predictor of intentions; self efficacy for general chemistry or attitude toward chemistry?
3. If other known factors that influence intentions (i.e., past experiences, past performances, and choice of major) were controlled, is self-efficacy for general chemistry and attitude toward chemistry still able to predict a large amount of the variance in intentions to take future chemistry courses?

# CHAPTER 3

# METHODS

## Pilot Study

Prior to the present study, a pilot study was carried out using 106 students enrolled at Western Kentucky University. Participants were primarily female (73.8%), came from a variety of majors (56.3% STEM), and reported a mean number of 2.17 chemistry classes taken prior to the study. For the pilot and present study, measures of self-efficacy for general chemistry, attitude towards chemistry, and intentions toward chemistry were needed. These scales needed to have good internal consistency, contain only general chemistry content, and be useable by both secondary and postsecondary general chemistry courses. The Attitude Toward Chemistry Lessons Scale (ATCLS; Cheung, 2009b) fit the parameters of this study showcasing good internal consistency in the validation studies ($\alpha = 0.76$ to 0.86) and our pilot study ($\alpha = 0.95$) and explaining 66.8% of the variance in scores of the latent variable, attitudes. However, a scale measuring self-efficacy for general chemistry or intentions to enroll in chemistry which fit the purposes of this study was not found.

Therefore, a team consisting of two undergraduate chemistry majors, an educational psychologist, a professor of chemistry education, and a professor of chemistry worked together to develop a scale to measure self-efficacy for general chemistry. For the Self-Efficacy for General Chemistry (SEGC) scale, we started by examining content from textbooks used in both secondary and postsecondary general chemistry courses to identify specific subject matter typically covered (e.g. significant figures, VSEPR Theory, nomenclature, etc.) in general chemistry courses. Our goal was to identify specific content-based tasks students are asked to complete in a general chemistry course because Bandura (2006) recommended that scales measuring self-efficacy should be task-oriented. After much discussion and debate, the final scale resulted in 14 items representing specific tasks required in general chemistry (see Appendix A). Participants were asked to rate their level of confidence in their capabilities to complete the tasks on a 7-point Likert scale with anchors at 1 (*not at all confident*) and 7 (*extremely confident*). The scale showed strong internal consistency ($\alpha = 0.97$) and explained 72.2% of the variance in scores for the latent variable, self-efficacy.

A scale to measure students' intentions to take future chemistry courses was also necessary, therefore the General Chemistry Intentions (GCI) scale was created by a team consisting of two undergraduate chemistry majors and an educational psychologist. The scale was constructed based on the recommendations of Fishbein & Ajzen (2010) who state that the items must be self-directed and compatible with the behavioral criterion. The behavioral criterion in this study was a student's choice (intention) to take chemistry courses during his/her college career; therefore the scale was created to accommodate this behavioral criterion and took into account the temporal variation (i.e., taking a chemistry course next semester, within the next year, or prior to graduation) that was possible for college students. This scale contains 6 items which collectively measures students' intentions to take future chemistry courses (e.g., “I intend to enroll in a chemistry course next semester.”) and again is evaluated using a 7-point Likert scale with anchors at 1 (*not at all true for me*) and 7 (*completely true for me*). To avoid response bias, both positive and negatively worded items were included. For analysis, the negatively worded items were reversed. This scale showed strong internal consistency ($\alpha = 0.88$) in the pilot study.

**Participants**

Participants were 1,126 first-time, first-year freshmen at Western Kentucky University (WKU). In the fall of 2012, there were 3,375 first-time, first-year freshmen (WKU Office of Institutional Research, 2012). Based on these data, we obtained 33% of the total population of first-time, first-year freshmen. Of the 1,126 participants, 64.3% were female, which accurately reflects the 61% of females who make up the total enrollment at WKU (WKU Office of Institutional Research, 2012). Of the participants, 75.7% self-identified as White, 16.8% as African American, 2.5% as Hispanic, and 1.8% as Asian. The mean age of the sample was 19 years old. Students’ intended majors were 43.8% non-STEM, 40.5% STEM, and 15.6% were either undecided or exploratory; the most frequent majors indicated were nursing (7.2%), elementary education (5.4%) and biology (5.3%). During the fall of 2012 when these data were collected, elementary education, nursing, and biology were the three majors with the highest enrollment as identified by WKU (WKU Office of Institutional Research, 2012). Based on the aforementioned data, the sample can be considered representative of the population of first-time, first-year freshmen at WKU.

**Instruments**

Self-efficacy for general chemistry was measured with the Self-Efficacy for General Chemistry (SEGC) scale created specifically for this study and piloted in a separate study. The SEGC scale contains 14 items which together, measure students' perceived abilities to be successful in performing specific general chemistry content-related tasks. Participants are asked to rate their level of confidence in their capabilities to complete the tasks using a 7-point Likert scale with anchors at 1 (*not at all confident*) and 7 (*extremely confident*). The total mean score from the SEGC scale represents an overall self-efficacy towards general chemistry. The full scale can be found in Appendix A. As expected based on the pilot study, the scale showed good internal consistency in the present study ($\alpha = 0.94$) and explained 57.2% of the variance in scores for the latent variable, self-efficacy.

Attitude towards general chemistry was measured using the 12-item Attitude Toward Chemistry Lessons Scale (ATCLS; Cheung, 2009b) where participants were asked to rate their level of agreement for each item using a 7-point Likert scale with anchors at 1 (*strongly disagree*) and 7 (*strongly agree*). The total mean score from the ATCLS represents an overall attitude towards general chemistry. The full scale can be found in Appendix B. In the present study, the scale showed good internal consistency ($\alpha = 0.94$) and explained 60.9% of the variance in scores for the latent variable, attitude.

Intentions to take future chemistry courses were examined using the newly created General Chemistry Intentions (GCI) scale. The GCI scale contains 6 items which asks students to pinpoint when/if they plan to take a chemistry course in the future. Three of the items are positively worded (e.g., "I intend to enroll in a chemistry course next semester”) and three items are negatively worded (e.g., “I do not intend to enroll a chemistry course unless I have to”). The full scale can be found in Appendix C. Participants are asked to rate how true each statement is to them using a 7-point Likert scale with anchors at 1 (*definitely not true for me*) and 7 (*completely true for me*). Responses on the negatively worded items are reversed before computing a total mean score representing the student’s intentions to take future chemistry courses. Like the pilot study, the scale showed good internal consistency in the present study ($\alpha = 0.88$) and explained 61.7% of the variance in scores for the latent variable, intentions.

Background information was obtained from the participants. Basic demographics such as gender, socio-economic status, race/ethnicity, and intended major were collected. In addition, ACT score on the science subtest was used to represent past performance in general science while quantity of high school chemistry courses taken was used to represent “chemistry experience.”

**Procedures**

Prior to beginning the study, permission was sought and granted by the Institutional Review Board at Western Kentucky University to carry out the study (see Appendix D). The goal of participant recruitment was to gather a representative sample of the first-time, first-year freshmen enrolled in the fall 2012 semester at WKU; therefore, we used both face-to-face and online methods for soliciting participants and collecting data. For face-to-face recruitment and data collection, the first author targeted the M.A.S.T.E.R. Plan program which is designed to orient new students to campus during the week prior to the first day of fall semester classes. She also targeted a freshmen-level course designed to introduce new students to college life entitled, the University Experience (UE), which had multiple sections and different instructors. For both the M.A.S.T.E.R Plan and the UE course, she sought permission prior to recruitment and data collection. She then trained a group of undergraduate upperclassmen to assist in recruitment and data collection and organized the materials (i.e., paper surveys, schedules, procedures) to ensure a systematic (i.e., reliable and valid) data collection process.

For online recruitment and data collection, we created an online version of the survey using Qualtrics and advertised the study on the Department of Psychology's Study Board. Study Board is an electronic warehouse of current psychological research taking place at WKU and is a forum for students to use when selecting studies in which they would like to participate. Depending on the psychology course in which they are registered, students can also earn course credit. As an incentive for participation, students in both recruitment methods (i.e., face-to-face and online) received entry into a raffle upon completion of the survey which entered them into a drawing for many prizes such as a Kindle Fire and various gift cards. The money used to purchase the prizes came from an internal institutional grant award (i.e., FUSE) given to the project.

Data collection occurred during the first three weeks of the fall 2012 semester in an effort to prevent *current* chemistry experience from impacting the data (i.e., participant's views about chemistry). Once data collection was complete, all participants were given identification numbers and data were entered into the IBM SPSS 20.0 software program. Raffle entries with participant names were collected and kept separate from the data collected in the surveys to ensure anonymity of the participants.

**Analyses**

In order to answer research questions one and two, a standard multiple regression was conducted using the IBM SPSS 20.0 program. A multiple regression is appropriate to measure the variance of a model and the relative contributions of each of the variables to the model for a large data set (Tabachnick & Fidell, 2007). The $R^2$ value from performing the regression will indicate the amount of variance the model predicts on the dependent variable which is intentions toward chemistry; a subsequent analysis of variance (ANOVA) will determine the significance level of the $R^2$ value, answering research question one. The beta value from the multiple regression calculation will answer research question two by indicating which variables made a statistically significant unique contribution to the model.

To answer research question three, a hierarchical multiple regression must be performed. After controlling for ACT scores, choice of a STEM major, and quantity of high school chemistry classes taken (i.e., prior mastery experience), the change in $R^2$ value will indicate how much additional variance is explained by students' self-efficacy for general chemistry and their attitude towards chemistry. The change in the significant $F$ statistic will indicate the significance level of the contribution, answering research question three.

# CHAPTER 4

## RESULTS

Before performing either a standard or a hierarchical multiple regression, there are a number of assumptions that must be tested. Multiple regressions require a large sample size, but what is considered “large”? Based on Tabachnick and Fidell’s (2007) formula: $N > 50 + 8m$ (where m = the number of independent variables), we would need a sample size of 90 participants since we are testing five independent variables (i.e., ACT-Science score, STEM or non-STEM major, number of prior chemistry classes, self-efficacy for general chemistry, and attitude toward chemistry). With a sample of 1,126, we have generously met this assumption.

A second and extremely important assumption to be tested is that of multicollinearity -- or ensuring that independent variables are not too highly correlated with one another. Although it is expected that there will be correlations between independent variables, a high correlation creates difficulties in interpreting the individual contributions of each independent variable (Tabachnick & Fidell, 2007). Based on the Pearson correlation results seen in Table 4.1, all variables show a significant correlation ($p < .01$) with the dependent variable -- intentions toward general chemistry. Also, there are no correlations between independent variables that are too high (above .7), indicating that the assumptions for multicollinearity have been met. The Normal Probability Plot, Scatterplot and Mahalanobis distances were inspected to check for violations of outliers, normality, linearity, homoscedasticity, and independence of residuals; all assumptions were satisfied. Table 4.2 displays the descriptive statistics (i.e., means and standard deviations) for the continuous variables (i.e., intentions, self-efficacy, attitudes, ACT, and quantity of prior chemistry classes).

**Table 4.1**

*Pearson Correlation for All Variables*

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1. Intentions | 1.00 | | | | | |
| 2. Quantity of H.S. Chemistry | 0.17*** | 1.00 | | | | |
| 3. ACT Science Score | 0.12** | 0.15*** | 1.00 | | | |
| 4. Intended major | 0.24*** | 0.02 | 0.11** | 1.00 | | |
| 5. Self-Efficacy | 0.34*** | 0.33*** | 0.26*** | 0.05* | 1.00 | |
| 6. Attitude | 0.54*** | 0.20*** | 0.21*** | 0.16*** | 0.54*** | 1.00 |

*Note*. $p < .05$, $^{**}p < .01$, $^{***}p < .001$.

**Table 4.2**

*Descriptive Statistics for All Continuous Variables*

| | *N* | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Intentions | 1101 | 1.00 | 7.00 | 3.86 | 1.73 |
| Self-efficacy | 1120 | 1.00 | 7.00 | 2.80 | 1.31 |
| Attitude | 1118 | 1.00 | 7.00 | 3.21 | 1.39 |
| Quantity of H.S. Chemistry | 1122 | 0 | 4 | 1.22 | 0.70 |
| ACT Science score | 837 | 0 | 36 | 21.9 | 4.96 |

*Note.* Intended major is a categorical variable. Proportions are reported in the Participants section.

In order to assess our first two research questions, a standard multiple regression was performed to determine if general chemistry self-efficacy and attitudes toward chemistry significantly predict intentions toward chemistry, and if so which is the stronger predictor. The regression variables are reported in Table 4.3.

**Table 4.3**

*Summary of Standard Regression Analysis*

| | B | *R* | $R^2$ | Partial *r* |
|---|---|---|---|---|
| Model | | 0.54 | 0.29 | |
| Self-efficacy | 0.07* | | | 0.06 |
| Attitude | 0.50*** | | | 0.45 |

*Note.* $p < .05$, $***p < .001$.

Self-efficacy and attitudes were shown to contribute significantly to the regression model, $F$ (2, 1093) = 227.45, $p < .001$ and accounted for 29.3% of the variance in the dependent variable -- intentions. Although both self-efficacy ($\beta = 0.07$, $p < .05$) and attitude ($\beta = 0.50$, $p < .001$) make significant contributions to the model, attitude was found to make the largest unique contribution. The partial correlation coefficient for attitude is 0.45 indicating that attitude uniquely explains 20.3% of the variance in intentions. For self-efficacy, the partial correlation coefficient value is 0.06 indicating a unique contribution of 3.6% to the explanation of variance in intentions.

To evaluate research question three, a hierarchical multiple regression was used to assess the ability of self-efficacy for general chemistry and attitude for general chemistry to predict intentions toward chemistry, after controlling for known influential factors (i.e., quantity of high school chemistry courses taken, ACT science score, and choice of STEM or non-STEM major). For the hierarchical multiple regression, quantity of high school chemistry courses, ACT science scores, and choice of major were entered at stage one to control for previous experiences which are known to influence intentions. At stage two, self-efficacy for general chemistry and attitude toward general chemistry were entered. The multiple regression variables are reported in Table 4.4.

**Table 4.4**

*Summary of Hierarchical Regression Analysis*

| Variable | B | *R* | $R^2$ | $\Delta R^2$ | $\Delta F$ | *df* | Partial *r* |
|---|---|---|---|---|---|---|---|
| Step 1 | | 0.29 | 0.08 | 0.09 | 25.67*** | 3, 821 | |
| H.S Quantity | 0.16*** | | | | | | 0.16 |
| ACT Science | $0.06^{+}$ | | | | | | 0.06 |
| Choice of Major | 0.23*** | | | | | | 0.23 |
| Step 2 | | 0.57 | 0.32 | 0.24 | 142.07*** | 2, 819 | |
| H.S Quantity | $0.06^{+}$ | | | | | | 0.06 |
| ACT Science | -0.04 | | | | | | -0.05 |
| Choice of Major | 0.16*** | | | | | | 0.19 |
| Self-efficacy | $0.06^{+}$ | | | | | | 0.06 |
| Attitude | 0.48*** | | | | | | 0.43 |

*Note.* $^{+}$ $p < .10$, ***$p < .001$; Values were rounded to the hundredths place in the table.

The hierarchical multiple regression was evaluated and at stage one, the regression model was significant, $F$ (3, 821) = 25.67, $p < .001$ and the three control variables (i.e., quantity of high school chemistry courses, ACT science scores and choice of major) accounted for 8.2% of the variance in the dependent variable -- intentions. When self-efficacy and attitude for general chemistry were added at stage two an additional 23.5% of the variance in intentions was explained and was also significant, $F$ (5, 819) = 77.52, $p < .001$. Together all five independent variables accounted for 31.7% of the variance in intentions. Of the three control variables, only choice of major was a significant predictor in the final model (β = .16, $p < .001$) with a partial correlation of 0.19 indicating that choice of major uniquely explains 3.6% of the variance in intentions. Quantity of high school chemistry courses was only marginally significant (β = .06, $p < .07$). Furthermore, attitude was the strongest and only significant predictor in the final model (β = .48, $p < .001$) with a partial correlation of 0.43 indicating that attitude uniquely explains 18.5% of the variance in intentions. Self-efficacy was only marginally significant (β = .06, $p = .08$).

# CHAPTER 5

# DISCUSSION

In this study, we sought to examine the effect of self-efficacy and attitudes towards general chemistry on first-time, first-year freshmen students' intentions to take future chemistry courses. Our findings suggest that in general, the freshmen population at Western Kentucky University does not feel confident in their ability to perform in general chemistry (*M* = 2.80, *SD* = 1.31), has a relatively poor attitude towards chemistry (*M* = 3.21, *SD* = 1.39), and expresses moderate intentions toward enrolling in future chemistry courses (*M* = 3.86, *SD* = 1.73). These findings are corroborated by other studies (Cheung, 2009a) and indicate that somewhere in the pipeline students have failed to discover "the importance of school chemistry and behavioral tendencies to learn chemistry in any positive ways" (Cheung, 2009a, p. 84).

Our results are even more important when we consider the amount of predictive power that self-efficacy and attitudes have on intentions to enroll in chemistry, a common prerequisite of many STEM majors. In the present study, self-efficacy and attitude alone were found to predict 29.3% of the variance of intentions. Of the two, attitude ($\beta = .504$, $p < .001$) made the larger significant contribution. Once prior experiences (ACT science score, intended major, and quantity of high school chemistry courses) were added to the model, the five independent variables were able to predict 31.7% of the variance in intentions. Together these results suggest that self-efficacy and attitude are important motivational variables that should be considered when trying to determine students' intentions to engage and persist in chemistry and thus, STEM-related fields. Students with low self-efficacy and unfavorable attitudes towards chemistry can negatively affect the efforts of postsecondary institutions to recruit, retain, and graduate STEM majors. Therefore, educators at both the secondary and postsecondary levels should seek to improve students' self-efficacy and attitudes toward chemistry.

ACT data reveals that less than one in five $12^{th}$ graders are interested in a STEM major or career (Business-Higher Education Forum, 2010). Sadly, less than 40 percent of students intending to major in a STEM discipline upon entering college actually complete a degree in STEM (Wood & Associates, 2008-09). However, jobs requiring STEM degrees are projected to increase four times as fast as the overall job growth (Business-Higher Education Forum, 2010). Therefore, for institutions to compete in the national and international market, they must recruit and retain STEM majors by increasing students' self-efficacy and attitudes toward general chemistry. Since experiences occur at both the secondary and postsecondary level, educators must find ways to increase self-efficacy and attitudes at both levels.

**Secondary Level**

STEM recruitment and retention at the secondary level should focus on pedagogical techniques that will give students the experiences they need to improve their self-efficacy and attitude towards chemistry (Cheung, 2009a; Dalgety & Coll, 2006; Kurbanoğlu & Akin, 2010), thereby increasing their intentions to enroll and engage in majors involving chemistry at the postsecondary level. Suggestions to improve chemistry self-efficacy and attitude differ from author to author, but typically seek to give students meaningful tasks connected to the content at which they can succeed. Meaningful tasks refer to learning tasks that are designed to be relevant for the students and provide opportunities for students to connect new content with information they already know (i.e., stored in long-term memory). Learning through meaningful tasks has been shown to be more effective than learning information in isolated pieces (Lin, 2007; Mayer, 2002). When students learn through meaningful tasks, they accomplish greater depth of understanding, therefore adding to their mastery experiences and increasing their self-efficacy (Uzuntiryaki & Aydin, 2009). Meaningful tasks come in a variety of forms: student-performed inquiry-based experiments, real-life applications, inquiry-based instruction, and cooperative learning.

One type of task that should be used more often in secondary chemistry courses is that of inquiry-based experiments or labs (Kurbanoğlu & Akin, 2010). Essential to providing the students direct mastery experiences that are optimally challenging as Bandura's (1996) theory suggests is that of student-driven experiments or labs. In these experiments or labs, the students themselves are designing and/or performing the activities with appropriate guidance from the teacher – not the teacher performing the activities while the students observe. In addition, these experiments or labs should be connected to the real-world to mimic students' natural experiences (as closely as possible) to help make the content more meaningful to the students (Bransford, Brown, & Cocking, 2000).

Due to the microscopic scale of chemistry and its reliance on teaching abstract concepts (e.g., the mole, the structure of the atom, chemical bonding), students often struggle with the everyday applications of chemistry. To alleviate this problem, educators should incorporate real-life applications into their chemistry instruction (Cheung, 2009a; Kurbanoğlu & Akin, 2010). Since “much of what is learned is specific to the situation in which it is learned” (Anderson, Reder, & Simon, 1996, p. 5), real-world tasks would be more meaningful to students than relying on abstract instruction to describe microscopic processes. One example of a real-life application in chemistry might include having the students examine disulfide bonds in hair-care products designed to produce permanent waves or curls. They could also explore the chemistry behind household cleaners and identify the dangers involved when the cleaners are mixed. Other real-world tasks could involve the exploration of drug interactions, the dangers of heavy metals in paint, or classes of fire extinguishers to name a few. The defining component of a real-world or authentic task is that the students practice thinking similar to that required in the real world (van Merriënboer, Kirschner, & Kester, 2003). Real-life applications require students to use higher order thinking processes; “authentic activities foster the kinds of thinking and problem-solving skills that are important in out-of-school settings…” (Putnam & Borko, 2000, pp. 4-5). These higher order thinking skills are necessary for success in a STEM major, and allowing students to see that the content is used outside of school fosters stronger attitudes toward chemistry because of an increase in the perceived value of the discipline (Anderman & Wolters, 2006).

Another pedagogical technique that has been offered to provide meaningful learning is the use of inquiry-based instruction, which can be defined as “an active learning process in which students answer research questions through data analysis” (Bell, Smetana, & Binns, 2005, p 31). Inquiry-based instruction helps “students attain a deeper understanding of scientific ideas and more sophisticated forms of scientific thinking" (Criswell, 2012, p. 199). There are many different levels of inquiry (i.e. confirmatory, structured, guided and open) and models of inquiry-based instruction (e.g., project-based instruction, using the 5E-model where the lesson guides students through an Engagement, Exploration, Explanation, and Elaboration with constant Evaluation), but in general, instruction that requires students to actively discover content through analysis of research is inquiry (Criswell, 2012; Wheeler & Bell, 2012). This content could have already been revealed and the instruction is confirming it, or the content could be unknown to the student and the activity allows students to discover it. For example, in chemistry, a teacher could give students a sample set of compounds with the correct IUPAC name and then have the students determine the rules for nomenclature.

During the inquiry-based learning process, students are asked to think critically not only about the content, but about themselves as learners which help students to build their arsenal of learning strategies (i.e., metacognitive skills) and thus, achievement (Anderson & Nashon, 2007; Kurbanoğlu & Akin, 2010; Uzuntiryaki & Aydin, 2009). Because inquiry-based techniques provide meaningful instruction within chemistry courses, students tend to have a deeper understanding of the chemistry content and as a result, an increased self-efficacy and attitude toward chemistry. In fact, it is clear that secondary science education administrators and educators have recognized the need to use inquiry-based instruction and real-life applications to promote deeper levels of learning. This transition can be seen from the Next Generation Science Standards which emphasize inquiry techniques integrated with engineering design challenges. This is a positive step in the direction of improved secondary science pedagogy.

Cooperative learning, also typically used in inquiry-based classrooms, is another pedagogical technique that has been identified to improve students' attitudes. Cooperative learning tasks are specifically designed for completion by a group of students who must work with one another to reach a common goal or learning objective. Social interaction is a key component in cooperative learning because it allows students to test their schemas (i.e., ideas) and evaluate their own understanding with that of their peers (Wadsworth, 2004). Cooperative learning can provide "a sense of social support for students which can decrease feelings of isolation and the belief that everyone understands this but me," (Kurbanoğlu & Akin, 2012, p. 353) which can be a common feeling in STEM courses. In addition, collaborative learning helps to foster self-regulation (Feldmann, Martinez-Pons, & Shaham, 1995). Self-regulation encompasses setting goals, and also having the motivation, thought processes, strategies and behaviors to accomplish the goals set (Zimmerman & Schunk, 2001). Self-regulation is an important set of skills to learn in the secondary level because successful completion of a STEM major at the postsecondary level will require students to be self-motivated, select and use adaptive study and test-taking strategies, and persevere through the many difficult courses.

Since students become more independent as they progress to the postsecondary level, they must also become more metacognitive, or aware of and in control over their cognitive processes. Secondary teachers must teach students *how* to be self-regulated and metacognitive in order to be successful at the postsecondary level as individual learners. Emotional awareness is one component of metacognition and self-regulation that students must understand in order to evaluate their learning and progression towards their goal. As

Pajares (2005) has pointed out, students can get a fairly good sense of their confidence by the emotional feelings they experience as they contemplate an action. Negative feelings provide cues about a negative self-efficacy or attitude toward the behavior, even when one is unaware of these negative tendencies. Students who approach a general chemistry lesson with apprehension likely lack confidence in their science skills (Kurbanoğlu & Akin, 2010). Moreover, those negative feelings can themselves trigger additional stress and agitation that help ensure the inadequate performance feared (Kurbanoğlu & Akin, 2010). A chemistry teacher can help students read their emotional feelings and understand that these feelings should not be ignored (Britner & Pajares, 2006). Since a person's thoughts and feelings contribute to their attitude, this intervention technique can be especially useful for encouraging positive chemistry attitudes in order to increase retention.

**Postsecondary Level**

In order to increase STEM retention, some researchers have suggested creating an introductory course which would provide a "bridge" from secondary STEM experiences to the larger, more impersonal, rigorous postsecondary STEM courses – those courses that do not implement the previously described student-centered pedagogy (e.g., Business-Higher Education Forum, 2010; Koenig, Schen, Edwards, & Bao, 2012; Springer, Stanne & Donovan, 1999; Tinto, 1993; Urban Institute, 2005). Although some of these bridge courses have been shown to have a "positive impact on first-to-second year retention" (Koenig et al., 2012, p.27), the present research suggests that bridge courses are simply treating the symptoms of a larger and much more deeply rooted problem.

The National Science Foundation (1996) discovered that one of students' barriers to completing a STEM degree was the difficulty, competitiveness, and impersonal large-lecture format of introductory STEM courses. Within these introductory courses, it has previously been reported that students' low grades have reduced their self-efficacy in their STEM abilities (Seymour & Hewitt, 1997). Although, the pedagogical techniques in the previous section were recommended for secondary education, they would be as useful, if not more useful, at the postsecondary level. Typically, large introductory STEM courses are taught using direct instruction and are very teacher-centered (e.g., the teacher lectures at the students or performs a demonstration while the students passively observe). Postsecondary institutions should consider implementing more meaningful, student-centered instruction such as inquiry-based techniques in an effort to increase student understanding, metacognition, and self-regulation (Cheung, 2009a; Criswell, 2012; Dalgety & Coll, 2006; Kurbanoglu & Akin, 2010; Wheeler & Bell, 2012).

Postsecondary institutions should restructure these STEM classes by reducing their size to less than fifty students so that strategies such as inquiry-based instruction and cooperative learning could be effectively used. The ACS and the National Science Teachers Association (NSTA) recommend that only 24 students be in a laboratory area (ACS, 2012). Shouldn't lecture classes foster the same physical engagement that laboratories do? Postsecondary instructors should be trained in the aforementioned pedagogical techniques so that they may appropriately guide students through group-oriented, inquiry-based instruction. Improving the pedagogy at the postsecondary level is the most effective way to foster high student engagement, understanding, self-efficacy, and attitudes, and thus, recruitment and retention in STEM disciplines. Therefore, in order for this pedagogical shift to be accomplished, post-secondary administrators will have to allocate more resources to facilitate such an initiative. In addition, STEM instructors will need to be willing to learn how to make a positive difference for postsecondary STEM education by moving away from the “factory-model” that is currently accepted as the status quo. The skills and knowledge gained from the student-centered instruction will be important to STEM majors as they continue their studies and will help to increase their attitudes and self-efficacy for chemistry. In addition, these techniques are likely to attract more non-STEM majors into the field.

In addition to improved pedagogy, providing mentoring and research opportunities for majors and non-majors has also been shown to increase student retention, especially with minorities (Kim, Fann & Misa-Escalante, 2011; Wilson et al., 2012). One particular program is called the LSU-HHMI Professors Program, which includes mentoring, undergraduate research, and focused education (Wilson et al., 2012). Mentoring has been shown to produce higher GPAs, higher retention rates, and more classes completed per semester for undergraduate students in comparison to their un-mentored peers (Campbell & Campbell, 1997). Undergraduate research has also been shown to be correlated with reduced attrition rates (Nagda, Gregerman, Jonides, von Hippel & Lerner., 1998) and increased enrollment in graduate education programs (Hathaway, Nagda, & Gregerman, 2002), especially for underrepresented students. Focused education (e.g. learning strategies, successful completion of gateway courses, navigating competitive and collaborative academic settings, GRE preparation, etc.) has also been identified as necessary for student success (Wilson et al., 2012). Unlike other studies seeking to improve retention, participants in this study were identified as “underperformers” academically. Graduation rates for participants in the LSU-HHMI Professors Program were 20% higher than the graduation rates for the comparable group of students (Wilson et al., 2012). This difference was even larger for African Americans, the identified minority group in the study. The success from this program adds important empirical evidence to support the need for postsecondary STEM programs to create opportunities for *all* students – declared and undeclared STEM majors – where students can gain important mastery experiences and skills. Mentoring, undergraduate research, and focused education within the various STEM program-areas would help students achieve academic success and thus, bolster self-efficacy beliefs and attitudes toward STEM thereby improving retention in the STEM disciplines.

Although the LSU-HHMI Professors Program includes research, mentoring, and focused education, it is not a unique idea at postsecondary institutions. Research Experience for Undergraduates (REU) Programs are common around the country and have been shown to recruit undergraduates into STEM disciplines and retain them (Gibson & Bruno, 2012; Kim, Fann & Misa-Escalante, 2011). It is important to note that these programs have been shown to *recruit* students, meaning that mentoring and research should be an experience that is encouraged for non-STEM majors as well, in hopes that it will attract them to the field. These programs provide students with meaningful learning experiences which increase their self-efficacy and attitude, and therefore their intentions to persist in STEM disciplines.

## Limitations and Future Research

Within this research study, we must acknowledge a limitation and provide our suggestions for future research. The SEGC scale asks participants to rate their confidence (i.e., self-efficacy beliefs) on very specific tasks while the ATCLS (Cheung, 2009b) surveys participants' attitudes about chemistry at a more general level. Although the SEGC scale was aligned with the suggestions from Bandura (2006), we believe that the level of specificity and the use of chemistry vocabulary (e.g. Hess' Law, stoichiometric conversions, VSEPR theory) within the SEGC scale might have intimidated participants which negatively affected their perceived abilities resulting in lower self-efficacy scores and ultimately, less predictive power of the construct on intentions to take future chemistry courses. Perhaps the SEGC scale was "too specific" when trying to capture students' beliefs about their capabilities in general chemistry. Future research should focus on scale modifications with a similar population to test the various levels of specificity on intentions to take future chemistry courses. Would self-efficacy become the stronger predictor of intentions over attitudes if the level of specificity matched the other scales used? Would self-efficacy and attitudes result in stronger prediction and explain more of the variance in intentions? We would want to know.

We believe, however, that the SEGC scale in its current form would still be a useful tool for chemistry educators. They could use the SEGC scale to gauge their students' self-efficacy beliefs for the general chemistry content prior to beginning a general chemistry course. The information gathered from the SEGC scale could allow chemistry educators to then design instructional interventions to help increase student success, interest, and performance, which could help to increase self-efficacy, attitudes, and students' intentions to pursue STEM careers. Our intention during the scale's development was for the SEGC scale to be used at both the secondary and postsecondary levels; therefore, future research would first need to validate this scale at the secondary level. In addition, future research should be conducted within these classrooms to test the effectiveness of these interventions on important motivational variables such as self-efficacy and attitudes, as well as college and career-readiness variables such as GPA, ACT, and career intentions.

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APPENDIX A

SELF-EFFICACY FOR GENERAL CHEMISTRY (SEGC) SCALE

INSTRUCTIONS: Please indicate your opinion about each of the questions below by marking with a CIRCLE any one of the seven responses in the columns on the right side, ranging from (1) “Not at all Confident” to (7) “Very Confident” as each represents a degree on the continuum.

1. How confident are you in your ability to perform measurement conversions?
2. How confident are you in your ability to perform stoichiometric conversions?
3. How confident are you in your ability to assign the correct number of significant figures to a calculation?
4. How confident are you in your ability to write a balanced chemical equation for a given reaction?
5. How confident are you in your ability to categorize a reaction (single-displacement, combination, etc.) based on the reaction’s chemical equation?
6. How confident are you in your ability to apply Hess’ Law of Formation?
7. How confident are you in your ability to classify a reaction as endothermic or exothermic?
8. How confident are you in your ability to write a correct electron configuration for any given element
9. How confident are you in your ability to differentiate between ionic and covalent bonds?

10. How confident are you in your ability to categorize a molecule’s structure based on VSEPR theory?
11. How confident are you in your ability to differentiate between different models of atomic structure?
12. How confident are you in your ability to apply the Ideal Gas Law?
13. How confident are you in your ability to properly assign nomenclature to ionic, covalent, and acidic compounds?
14. How confident are you in your ability to explain periodic trends?

## APPENDIX B

## ATTITUDE TOWARD CHEMISTRY LESSONS SCALE (ATCLS) (Cheung, 2009b)

INSTRUCTIONS**:** Please indicate your opinion about each of the questions below by marking with a CIRCLE any one of the seven responses in the columns on the right side, ranging from (1) “Strongly Disagree” to (7) “Strongly Agree” as each represents a degree on the continuum.

1. I like chemistry more than any other school subjects.
2. Chemistry lessons are interesting.
3. Chemistry is useful for solving everyday problems.
4. Chemistry is one of my favorite subjects.
5. I am willing to spend more time on reading chemistry books.
6. I like to do chemistry experiments.
7. When I am working in the chemistry lab, I feel I am doing something important.
8. People must understand chemistry because it affects their lives.
9. I like trying to solve new problems in chemistry.
10. Doing chemistry experiments in school is fun.
11. Chemistry is one of the most important subjects for people to study.
12. If I had a chance, I would do a project in chemistry.

# APPENDIX C

## GENERAL CHEMISTRY INTENTIONS (GCI) SCALE

INSTRUCTIONS: Please indicate your opinion about each of the questions below by marking with a CIRCLE any one of the seven responses in the columns on the right side, ranging from (1) “Not true at all for me” to (7) “Completely true for me” as each represents a degree on the continuum.

1. I intend to enroll in a chemistry course next semester
2. I do not intend to enroll in a chemistry class within the next year
3. I intend to enroll in a chemistry course before the end of my college career
4. I intend to NEVER enroll in a chemistry course in the future
5. I do not intend to enroll a chemistry course unless I have to
6. I intend to enroll in a chemistry course within the next year

APPENDIX D

RESEARCH PARTICIPANT CONSENT FORM

RESEARCH PARTICIPANT CONSENT FORM

Exploring freshmen college students' self-efficacy, attitudes, and intentions toward chemistry.

Lisa C. Duffin, Ph.D. (270) 745-6324
Department of Psychology
Western Kentucky University

**Purpose of Research**
We are interested in your chemistry attitudes, self-efficacy beliefs, and intentions to take future chemistry courses.

**Specific Procedures to be Used**
To participate in the study, we will ask you to complete a short survey. No names will be collected in this study, so your responses will be completely anonymous.

**Benefits to the Individual or Others**
This research activity will not directly benefit you at this time. However, your participation will provide information that will advance the field of chemistry education research and may benefit educators, their future students, and policymakers at the local, state, and federal levels.

**Risks to the Individual**
There is very little risk associated with your participation in this study. The risk is no greater than what you would encounter in a regular day.

**Confidentiality**
All information collected for this study will be completely anonymous. No names or identifiable information will be collected. Data obtained in this study will be securely stored in Dr. Lisa Duffin's password-protected computer. Only members of the research team have access to this data; however, the research records may be inspected by the Western Kentucky University Institutional Review Board or its designees, and (as allowable by law) state and federal agencies.

**Voluntary Nature of Participation**
I do not have to participate in this research project. Refusal to participate in this study will have no effect on any future services I may be entitled to from the University. If I agree to participate I can withdraw my participation at any time without penalty.

**Contact Information:**
If I have any questions about this research project, I can contact Dr. Lisa Duffin at (270) 745-6324 or via email at lisa.duffin@wku.edu. If I have concerns about the treatment of research participants, I can contact the Institutional Review Board at WKU at (270) 745-2129.

***Your continued cooperation with the following research implies your consent.***

THIS PROJECT HAS BEEN REVIEWED AND APPROVED BY
THE WESTERN KENTUCKY UNIVERSITY INSTITUTIONAL REVIEW BOARD
Paul Mooney, Human Protections Administrator
TELEPHONE: (270) 745-2129

INSTITUTIONAL REVIEW BOARD WKU APPROVED