6-2016

Understanding College Students' Exam Process in a General Chemistry Course

Angela Willson
Western Michigan University

UNDERSTANDING COLLEGE STUDENTS' EXAM PROCESS IN A GENERAL CHEMISTRY COURSE

by

Angela Willson

A thesis submitted to the Graduate College
in partial fulfillment of the requirements
for the degree of Master of Science
Chemistry
Western Michigan University
June 2016

Thesis committee:

Megan Grunert Kowalske, Ph.D., Chair
James Kiddle, Ph.D.
Elke Schoffers, Ph.D.

UNDERSTANDING COLLEGE STUDENTS' EXAM PROCESS IN A GENERAL CHEMISTRY COURSE

Angela Willson, M.S.

Western Michigan University, 2016

The main way most college chemistry courses assess what a student has learned is through a summative exam. After introductory science courses, such as general chemistry, many students cite poor teaching and disappointing grades in these courses as a reason for dropping out of STEM programs. There has been a lack of qualitative research on students' experiences of the complete process of taking an exam from start to finish, or the exam process, which includes preparing for an exam, taking an exam, receiving feedback, and responding to feedback after the exam has been graded.

My goal in this exploratory study was to understand the phenomenon of students' exam process using phenomenographic methods to answer the research questions: How do students think about and approach (1) Exam preparation? (2) Taking an exam? (3) Results and feedback after an exam? Data was collected through interviews with two groups. One group was interviewed using a semi-structured interview protocol both before and after an exam and the other was interviewed only after the exam using the combined protocol. Qualitative interviews were analyzed using emergent coding to describe students' experiences of the exam process in their general chemistry course. Interesting themes from this research include students' perceptions of their confidence, how self-efficacy is a part of students' exam process, and how students seek out and use feedback from exams during the exam process.

ACKNOWLEDGEMENTS

I would like to begin by acknowledging my advisor, Dr. Megan Grunert Kowalske; she has been patient as I began my first experience with education research. Thank you also to the other members of my graduate committee, Dr. James Kiddle and Dr. Elke Schoffers, for taking time to review my work. Additionally, I would like to thank the faculty and graduate students in the Mallinson Institute for Science Education who listened patiently as I sorted through the details of my project and made sense of the phenomenon of exam process.

Lastly, I would like to thank my family. My grandparents, James and Joanne, have supported me from the sidelines for the last 26 years and counting. They inspire me with their example of what hard work and dedication can accomplish. My soon-to-be husband, James, also has had patience with me every step of the way and I would not be here without his constant words of encouragement.

Angela Willson

TABLE OF CONTENTS

Table of Contents - Continued

CHAPTER

Table of Contents – Continued

CHAPTER

Table of Contents – Continued

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Motivation

The main way most college chemistry courses assess what a student has learned is through a summative exam. After introductory science courses, such as general chemistry, many students cite poor teaching and disappointing grades in these courses as a reason for dropping out of STEM programs (Seymour & Hewitt, 1997). The overall goal of this study was to develop an in-depth understanding of college students' exam processes in a general chemistry course, including how the students prepare for an exam, take an exam, and respond to feedback from an exam. The objective of this exploratory study was to characterize how students experience the phenomenon of the entire exam process to add to the current body of literature on what shapes students' experiences in college courses.

Overview of the Chapters

The following five chapters presented in this thesis cover the background for the study, the methods used, results from student interviews, and an analysis of the results. This introduction, Chapter 1, will provide an overview of the purpose of this study. Chapter 2 presents a review of the current literature on students' motivations and beliefs when they enter a college course as well as literature on the exam process as I have defined it. Chapter 3 discusses the methodologies and methods used in this study, including guiding theoretical frameworks, methodological frameworks, data collection methods, and data analysis procedures. In Chapter 4

the results are presented that were obtained through this study. Lastly, Chapter 5 concludes the thesis by discussing results, implications of the study, and plans for future work.

Contributions of the Study

By understanding this exam process in a general chemistry course, we may be able to better understand what problems students are experiencing related to exam-taking in general chemistry courses that are causing them to drop out of programs. This could lead to methods of improving students' experiences in chemistry courses, which could in turn lead to lower rates of attrition from chemistry courses. In addition to these broader implications, this study could more specifically help individual professors currently teaching introductory chemistry courses better understand the types of students in their class as it relates to the exam process. This could help improve the students' experience with exams in other science classes they take as well as their experience in other general education university courses.

Overview

There has been a lack of research on students' experiences of the complete process of taking an exam from start to finish. This includes preparing for an exam, taking an exam, receiving feedback, and responding to feedback after the exam has been graded. For this study, I will refer to this entire experience as the exam process. I propose to study students' exam process through phenomenographic research methods. Previous studies that focused primarily on performance on exams focus on performance and not experience (i.e. Galyon et al., 2012; Mathabathe & Potgieter, 2014; Pazicini and Bauer, 2014). Using phenomenography will reveal

categories of how different student experience preparing for an exam, taking an exam, and responding to feedback from an exam.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction of Literature Review

A student's view of and reflection on his or her own experience is directly related to their metacognition and self-efficacy beliefs. This chapter provides a broad view on metacognition and self-efficacy literature and their impacts on the overall student experience. Metacognition will serve as a guiding theoretical framework for this study, which has been applied in education research as a predictor of student performance. This literature review will also act as a general overview for those unfamiliar with the topics of metacognition and self-efficacy. Then, I will discuss more specifically the existing literature on college students' exam processes and their relation to performance predictors like metacognition, self-regulation, self-efficacy, and GPA. The articles in this review were limited by focusing primarily on studies that occurred in post-secondary settings. Articles using formative assessment and interventions were eliminated because the focus of this study was to categorize the current state of the exam process in a traditional chemistry course that uses primarily summative assessment.

Metacognition as Theoretical Framework

Flavell (1976) defined metacognition as "knowledge concerning one's own cognitive processes and products" (p. 232). This means that during learning students must regulate their performance by deciding when they know information or when they do not know information. Additionally, they then must decide how much additional studying is required for the desired performance outcome. Metacognition also encompasses the ability to accurately predict

"correctness or outcome of one's performance" (Gagné, 1987, p. 75). Baird (1990) defines metacognition using three similar components as Flavell's (1976) definition, which includes a student's knowledge, a student's awareness, and a student's control of their learning. Case and Gunstone (2006) used these definitions of metacognition and used it as a theoretical framework in a metacognitive focused study. Their four aspects of metacognition include: (1) knowledge and awareness of learning (conception of learning), (2a) organizing one's learning, (2b) monitoring of learning, and (3) purpose for learning beyond the subject itself (2006). Literature shows that metacognition is a major component of the student learning process, and therefore, of the exam process. In addition, Hattie's (2009) meta-analysis showed that metacognition has an effect size of 0.69, or a large significant effect on student performance. Therefore, I will use the four aspects of metacognition from Case and Gunstone (2006) as a theoretical framework for this exploratory study on the exam process.

Definition of Self-Efficacy Beliefs

Self-efficacy beliefs are an individual's expectation of his or her ability to succeed at a given task (Bandura, 1997). Therefore, often without realizing it, students will evaluate their ability and determine how likely they feel they will be successful. Bandura first introduced the idea of self-efficacy in 1977, and he has published on it many times since (Bandura, 1977, 1993, 1997; Bandura & Schunk, 1981). Numerous studies from the literature have demonstrated self-efficacy's impact on student performance and experience, which will be discussed in the section entitled Self Efficacy and the Exam Process.

College Students' Experience and Adjustment

When studying the experience of students in an introductory chemistry course it is important to remember that many of these students are in their first semester of university. This transition from high school to university places new stresses on a student like experiencing more independence and more intense demands on their time. Meyer et al. (2009) studied first-year students' perceptions of college academics and how perceptions changed by interviewing 52 college freshmen at a small liberal arts university. All of the interviewed students indicated that they thought college was going to be academically demanding, which they had heard from instructors, media, and other close personal relations. These students also voiced concerns about their perception of the difficulty of college courses before they attended college. Once students had begun college and were interviewed later in the semester some of their perceptions changed. Overall there were three groups of students based on how their perceptions matched their experience (i.e. whether their perception matched their experience or whether their perception was that college would be more or less difficult than they experienced). This study shows that although some students find college more difficult or as difficult as they expected (40%), a majority of students actually viewed college as less difficult than expected (60%). This qualitative study gives a general view of students' perceptions and how it matches the reality of their lived experiences.

Other studies approach the idea of first-year college student performance and adjustment using quantitative measures of self-efficacy (i.e. Chemers et al., 2001). This study looked at three mediating processes of self-efficacy effects: cognitive processes, motivational processes, and affective processes, by measuring academic self-efficacy, optimism, and challenge-threat evaluation after the first-quarter of studies. This quantitative study demonstrated a strong

relationships between self-efficacy and both academic performance and personal adjustment. This study showed that students who entered college confident in their ability to be successful academically performed significantly better than less confident students. Self-efficacy was found to be a significant measure and have predictive power above other objective measures such as high school GPA or past performance on similar academic tasks. Self-efficacy beliefs also had an indirect effect on performance. According to Chemers et al. (2001), students with high self-efficacy saw the college experience as an exciting challenge rather than as a threat. Therefore, students with higher self-efficacy will work harder and persist longer in their studies than students with lower self-efficacy. Overall, this was a strong study that showed the effect self-efficacy can have on academic performance. One issue with the data collection for this study was the 23% response from the 1,600 first-year students surveyed. This low response rate is in part because the survey was administered by mail.

Other studies like Dalgety and Coll (2006) have looked more specifically at this factor of self-efficacy with regards to first-year science students in chemistry. This study differed from Chemers et al. (2001) because it was not looking at general academic self-efficacy, but at students' self-efficacy about the subject of chemistry. Dalgety and Coll (2006) acknowledged that chemistry courses have both majors and non-majors enrolled. Students typically have lower self-efficacy for subjects outside of their major (Bodner et al., 2001). This study employed a mixed-methods design to collected data. Quantitative data was collected using a previously validated instrument called the *Chemistry Attitudes and Experience Questionnaire* (CAEQ). In addition to the survey, which was administered to two sections of a general chemistry course three times, including at the beginning of the first semester, the end of the semester and the end of the second semester, the authors also collected demographic data like gender, ethnicity, and

reasons for taking general chemistry. The authors also used qualitative interviews with a subset of 19 students at the beginning of the course students to ask about their self-efficacy beliefs about studying chemistry. Of these 19 students, 14 students were interviewed at the completion of the course. These transcripts were returned to participants for member checking, a common way to improve reliability in qualitative studies. The interview transcripts were coded using an emergent coding scheme.

Dalgety and Coll (2006) found that students were in general confident about the tasks that are required in a first-year chemistry course. They saw an increase in confidence from the first semester to the second semester. The authors attributed this to the fact that those who drop out are less confident than those who continue to study chemistry for a second semester and not an overall increase in confidence. In the interviews, students' self-efficacy beliefs were related to prior learning experiences; for example, high school experiences contributed to their perception of their chemistry ability. This study provides insights into students who were highly motivated to take chemistry as science majors. One area of concern for students was having the necessary study skills for chemistry rather than being able to complete specific chemistry tasks. Students were concerned with the amount of memorization they saw as necessary to be successful on an assessment. Overall, students in this study had chosen to study chemistry, which explains the high chemistry self-efficacy exhibited on the CAEQ survey. The authors found this high self-efficacy could be attributed mainly to prior achievement. For example, students who received high grades at the beginning of the semester were more likely to be more engaged with their chemistry studies. This study presented the quantitative and qualitative results in series and not in tandem. The results would be stronger if the two sources of data were integrated to make claims using both sources.

Self-efficacy and Exam Process

Self-efficacy beliefs are one component that has an affect on students' experience in a college course, which means they affect a students' experience of the exam process. Most studies that look at self-efficacy and its relation to students' experiences of the exam process use quantitative methods to measure self-efficacy against performance outcomes. For example, Galyon et al. (2012) explores the relationship between self-efficacy and variables like exam score, course grades and GPA. This study used quantitative measures to cluster 165 participating college students into levels of self-efficacy (e.g. low, medium and high). These clusters were used to determine high or low participation and/or exam scores in relation to self-efficacy. According to the authors, the purpose of this study was to determine how self-efficacy beliefs affect product variables, like exam scores versus process variables, like class participation. The authors found that students with low and medium self-efficacy were significantly more likely to be in the low participant group than in the high participant group. Students with high self-efficacy beliefs were more likely to be in the high participation group. A similar trend was seen between self-efficacy clusters and exam performance, meaning that only students in the high self-efficacy group were more likely to be in the high, rather than low, exam performance group. The correlation between GPA and self-efficacy beliefs was found to be significant. However, the study showed no significant difference between levels of self-efficacy beliefs and GPA levels or between levels of self-efficacy beliefs and participation. However, exam scores did differ significantly across GPA levels. The authors showed that there may be a weak correlation between self-efficacy and product variables (i.e. exam scores). Only when self-efficacy is high is it likely to impact academic performance. This implies that interventions to improve self-efficacy beliefs may be most effective for the low and medium self-efficacy groups.

In addition to self-efficacy beliefs as a variable in relation to exam performance, other authors chose to look at competence as a measure of one's ability to do something successfully. A student is said to be experiencing the Dunning-Kruger effect when he or she fails to accurately assess their competence and therefore believes they are more confident than they actually are. The Dunning-Kruger effect is well documented in clinical psychology, but Pazicini and Bauer (2014) recognized that the Dunning-Kruger effect had not been as well documented in authentic classroom settings. The authors hypothesized that this effect is evident in students in an introductory chemistry course who begin with a poor sense of their abilities, underestimate the time necessary to study for an exam, and in turn get a poor result on their first exam. Then, these students do not understand how to respond to the feedback of their exams to reach future success in the course. This study is a large study documenting the Dunning-Kruger effect in a classroom setting using three separate measurements with a sample of 1500 students. The authors collected data during each of the course exams where they asked each student to rate their estimated ability using a percentile ranking. These perceived ability scores were correlated with a percentile rating from their exam scores. The study found the Dunning-Kruger effect in all nine sections of the general chemistry course. Students with low exam scores overestimated their performance and students who earned high exam scores underestimated their performance, but to a lesser degree of inaccuracy than students with low exam scores. Female students' perceptions were less inflated than those of male students. Students' perceptions did not change over time. This study indicates that possible differences could exist between students' ability to estimate performance. The ability to estimate one's performance and adjust accordingly is directly related to metacognitive skills and would affect a student's exam process.

Metacognition and Exam Process

As stated earlier, metacognition consists of two main parts, knowledge of cognition and regulation of cognition. This means that a learner must have the ability to accurately assess what he or she has learned and then use that assessment to make decisions on the next course of action. For example, in a general chemistry course students will use metacognitive skills to decide how to study, what to study, and what to give the most attention to. Therefore, metacognition is directly related to the choices a student makes during the exam process.

Mathabathe and Potgieter (2014) studied metacognitive skills and learning gains in chemistry using a mixed-methods design. Quantitative data were used to measure performance and learning gains and qualitative data were used to further the researchers' understanding of how metacognition impacts judgments of performance. The focus of the course that acted as the research setting did not seek to improve metacognitive skills and therefore did not act as an intervention. The researchers collected pretest and posttest data using a 20-item test instrument that was piloted and validated. The purpose of this instrument was to collect both qualitative and quantitative data simultaneously and measured procedural knowledge, formal reasoning, and numeric problem-solving with stoichiometry questions. Both test scores were used to represent actual performance and the students' confidence scores were used to measure perceived performance. Similar to the Dunning-Kruger effect study from Pazicini and Bauer (2014), this study found that a majority of students were overconfident when evaluating their performance. Although the students' score improved on the post-test, their ability to evaluate their performance accurately did not. This shows that accuracy of judgment remained low for students even as their level of content knowledge increased. The authors of this study do not make a clear

tie between performance evaluations back to additional metacognitive skills. Additionally, there was no measure of metacognitive skills beyond if students were overconfident, realistic, or under-confident when predicting performance.

Most metacognition studies do not measure metacognitive skills directly, but instead use study habits or test performance as a proxy. For example, Jensen and Barron (2014) used quantitative methods to track grades throughout a college introductory biology course. This study found that on average individual scores decreased 0.09 grade points from midterm grades. This is obviously a very small gain in scores. These results may indicate that early grades are a good predictor of final grades; almost half of the students in this study received identical grades on the first exam as they did in the course at large. This study demonstrates that metacognitive skills did not develop over the course of the semester, which was probably why grades did not change drastically.

This results from these studies may make it seem like students are unable to develop metacognitive skills. However, in addition to research on relationships between variables like metacognition and exam performance, another body of research focuses on interventions to improve metacognition. There are many documented intervention studies that have had some success in improving students' metacognitive skills. For example, Bercher (2012) used a self-monitoring intervention and measured the affect this had on exam performance. This study asked students to reflect on their mastery and how they expected to do on an exam compared to how they actually did on an exam. This study supported the idea that students can improve their performance if they are asked to reflect on their mastery of the content and their performance. However, the study did not focus on how students changed their exam preparation as a result of the reflection inventories. Overall, this was a weak study because it is a small quantitative

sample size that did not use a specific instrument. More research would have to be done in this area with qualitative interviews to ascertain how students changed their studying.

Other Aspects of the Exam Process

There are many pieces in the exam process that contribute to the complexity of studying this phenomenon. The literature in this section deals with factors that affect students' studying experience. When preparing for an exam and taking an exam, a student must decide which material to study and how to study it (i.e. strategy, amount of time, frequency, etc.), which is directly related to a student's metacognition. Metacognitive skills can be used to decide how to approach preparing for an exam. To do this, a student needs to decide what content is important to learn and how difficult that material will be to learn. Both of these processes are within the student's control. The difficulty of exam questions is not within the student's control, but instead is determined by the instructor. This means students may view the difficulty and types of questions asked on the exam as out of their control instead of preparing for more difficult questions when studying.

Gulacar and Bowman (2014) studied the students' and teachers' perceptions of the difficulty of exams. It was important to see who was more accurate and how metacognition affected students' ability to assess difficulty of problems because it was an integral part of student performance in a general chemistry course. They used a survey taken by both students and the instructors as the primary source of data. From this survey, a significant correlation was seen between students' difficulty ratings and their success on a problem. For example, as students rated a problem as more difficult they were less likely to answer the question correctly. This shows that students had at least a somewhat accurate view of question difficulty and their

ability to correctly answer a question. Additionally, students' familiarity with a problem was related to their success on a problem. As students felt more comfortable or familiar with a question, they were more likely to answer a question correctly. Overall, faculty and student perceptions of difficulty were similar. However, who was more accurate in their perception when there are differences? Students in the two cohorts had a significant correlation between their performance and difficulty rating. This correlation was not seen with faculty, which led the authors to conclude that students are more accurate at measuring the difficulty of problems. This study demonstrates that students do have an ability to judge whether they have answered a question correctly or not. This study does not suggest that the answer to this disagreement in difficulty ratings is to reduce the difficulty of exam questions. Instead, the author suggested that faculty consider improving students' confidence with difficult problems by helping students become familiar with these problems before the exam.

Other aspects of the exam process like study habits of students and how feedback improves exam performance were explored through intervention studies (i.e. Deslauriers et al. 2012; Milner et al. 2015). Intervention studies are tricky because it is very difficult to change beliefs and habits that are deeply engrained in a student. In the study by, Deslauriers et al. (2012) the unit of analysis was low performing students, who have shown to be (e.g. Pazicini and Bauer (2014) a group of students that would gain the most from interventions. In their intervention, students met individually with instructors or received a personalized email from their instructor. Students who met with an instructor to discuss specific study strategies improved their exam score approximately 32% from one exam to the next. Other intervention strategies were not as successful. For example, Milner et al. (2015) used an online quiz game to provide feedback to students in a biochemistry course. In this study, two groups of students received similar practice

questions in two different formats. One group of students received a PDF copy of practice questions that were with a separate document that included correct answers for each question. The other group of students used a game, which was comprised of the same questions as the PDF, as the mode of taking the practice test. Students using the game to practice for the test were given immediate correct/incorrect feedback and could check on their progress using reports the system created. The authors hypothesized that students using the game to practice would have a higher engagement with the material. However, there was no difference in exam scores between the two groups. These two studies illustrated that feedback may be most effective when it is individualized for each student and may not be dependent on how feedback is given to the student.

Gap in the Literature

The literature on the exam process in most education research focused on how student variables affected the outcome of exam performance using quantitative research methods. A review of the literature revealed that exam performance has been studied in relation to variables like self-efficacy, motivation, and score prediction. Only one study (Scheja, 2006) could be found that studied the exam process qualitatively. Scheja (2006) used a phenomenographic method to study students' perceptions of studying in relation to their engineering course. There was no specific interview protocol given in the article and only sample questions, like asking students to describe studying for a college exam to someone who hasn't had the experience, were given. Although it appeared Scheja (2006) had the goal of documenting the exam process for students, the data analysis focused primarily on students who were falling out of phase with their studies. In Chapter 3, I will describe the methodological design of a study examining the holistic

view of exam process beyond students' perceptions of their shortcomings during their preparation for exams. There is currently a lack of qualitative literature that views the entire exam process in this way, including preparing for an exam, taking an exam, and responding to feedback from an exam.

CHAPTER III

METHODOLOGIES AND METHODS

Overview

This chapter outlines the methodological framework used in this study. It includes a discussion of this framework, the rationale behind its use, the methods and procedures for data collection, and the methods and procedures for data analysis. In addition, a section on the role of the researcher and the limitations inherent with the study design is included.

Research Questions

The overarching question that will guide this study was: How do college students think about and approach the exam process in a chemistry course?

Sub questions:

(1) How do students think about and approach preparing for an exam?

(2) How do students think about and approach taking an exam?

(3) How do students think about and approach responding to feedback from an exam?

Rationale for Methodologies and Methods

This study was designed to understand the process by which students prepare for, take, and then reflect on exams in a general chemistry course. For the purposes of this thesis, this will be called the exam process. Different students experience exam preparation differently and therefore will have individual lived experiences relating to the process of exam preparation. Concurrently, there will be some similarities in how students experience aspects of the exam

process. This study looks to identify both similarities and differences in how students experience the exam process so that instructors can be better equipped to help all students be successful and maximize their learning in general chemistry.

Exam preparation has typically been studied by looking at exam results in a quantitative way, which does not allow individual voices to be heard from different types of students. For this reason, this study was designed using qualitative methods. Data from qualitative interviews was collected as the primary source of data for this study. This allowed the researcher to capture the experiences of each student with regards to about their exam preparation in their own words by using phenomenography.

Methodological Framework

Methodology

To gain a deeper understanding of undergraduate students' exam preparation in a general chemistry course, this study was based in qualitative methodology (Creswell 2013). The data for this study was gathered through semi-structured interviews. This data was analyzed using a thematic analysis with a semi-structured coding scheme to understand how each individual student experiences the phenomenon of exam preparation and reflection differently.

Phenomenography

The purpose of phenomenographic research is to identify "the different ways in which people experience, interpret, understand, perceive or conceptualize a certain phenomenon or aspect of reality" (Orgill, 2007, p. 133). This means that the primary aims of a

phenomenographic study are description, analysis, and understanding of experiences. Whereas in a phenomenology the goal is to find the thread of similar experience between all participants, in a phenomenography, the goal is instead to find different categories of experiences. This is the difference between studying a first-order perspective with a focus on the phenomenon (phenomenology) and studying a second-order perspective, or how people experience the phenomenon in various ways (phenomenography). Because of this the main goal of a phenomenography is to understand the relationship between the participant and their experiences with a given phenomenon. In this research, my goal was to understand how students experience the exam process in a variety of ways. There are four underlying assumptions of a phenomenographic study that were established by Marton and Booth (1997). This provides a research framework for this phenomenographic study:

a) Individuals conceptualize in a limited number of different ways when they reflect upon a given phenomenon
b) Conceptions may reflect differences between individuals or differences within the same individual
c) This variation in students' conceptions can be described using a limited number of categories
d) Categories of students' conceptions form a complex system or outcome space.

Based on the four assumptions addressed above and the idea that there are limited perspectives of any phenomenon, including the exam process, the participants in this study were chosen to cover as many different view points as possible. By choosing a variety of students, the goal was to characterize these categories of experience. These students were chosen using the

demographic survey data, described below in the participant section, to give the largest variety of perspectives.

Participants

The participants in this study were all enrolled in a General Chemistry I course at a Midwestern university during this study. These participants were recruited by a short in-class explanation of the study, followed by the opportunity to volunteer for the study. First, I asked faculty teaching General Chemistry I if I could recruit students for my study who were enrolled in their section. Then I went to these general chemistry courses and introduced the study to potential participants briefly. Then, I gave each student a small slip of paper and asked him or her to write one of two items. If the student was interested in participating, I asked them to write the easiest way to contact them (i.e. email or phone number). If the student was not interested in participating, I asked the student to write their favorite movie. This way, the confidentiality of potential participants was not compromised during the recruitment process. I also did not have to rely on accessing faculty class lists to recruit students by using this strategy.

Purposeful sampling was used from here to determine the best candidates for my study by asking the student to fill out a brief questionnaire about them, including demographic information. The demographic survey, which can be seen in the appendices, began with a consent question to ensure the privacy and protection of participants. Using the data from the survey, I narrowed the participants to 10 students to interview. Then, I arranged the participants into two interview groups while trying to balance the demographics in each group for age, race and major. I also considered each student's self-reported grade and the section of the course they were enrolled in (regular or honors). Each participant sat for either one or two individual

interviews with me to collect data. Ultimately, I interviewed eight students. Three students were in Group A and five students were in Group B. Group A had two white students and one African American student. Group B had four white students and one African American student. The breakdown of the demographics of participants in each group is shown in the Table 3.1.

Table 3.1: Demographics of the two interview groups

Group A	Group B
Female, first-year Biochemistry major (A1) Male, first-year Engineering major (A2) Female, first-year Chemistry major (A3)	Male, first-year Physics major (B1) Female, first-year Chemistry major (B2) Male, first-year Engineering major (B3) Male, first-year Engineering major (B4) Male, third year Biology major (B5)

The two groups only differed in the number of interviews that they were asked to participate in. The set of groups were arranged to have a pair of similar students with one in each group. For example, I interviewed one female first-year chemistry major who had self-reported an expected grade of a C in her chemistry class in Group A and likewise a female first-year chemistry major with an expected grade of a C in Group B. Group A was interviewed twice, once before an exam to ask about preparation before the exam and once after an exam to ask about reflecting on taking the exam and receiving feedback. The second group was interviewed once after the exam to ask about the entire exam preparation process from start to finish. Students were given a $20 gift card in exchange for participating in the interviews. The interview schedule is shown in Table 3.2.

Table 3.2: Interview schedule for the two interview groups

	Before Exam (Mid October)	After Exam (Late Oct-Early Nov)
Group A	Pre-exam interview about exam preparation	Post-exam interview about reflecting on exam feedback
Group B		Post-exam interview about the entire process of exam preparation and feedback

The reason to separate participants into two groups was to make sure that there was minimal researcher impact on the group that was interviewed before and after. As a qualitative researcher, I acknowledge that the researcher plays a role in constructing an interview and therefore the data with the participant (Creswell, 2013). This means that it is possible that by asking a student to reflect on their thinking in a pre-exam interview could act as an intervention. Therefore, through the interview I could impact their reflection on their exam preparation process before the second interview and get biased results. This was the rationale behind constructing two interview groups, to see how students' answers differed for the group who only had one interview after the exam.

Data Collection Methods

A single researcher conducted all interviews to maintain consistency throughout data collection. The average length of a single interview for Group A was 20 minutes, and because two interviews were essentially conducted, the average length of a single interview for Group B was 30-40 minutes. An interview protocol that was created using the research questions was used as a guide in every student interview. Using a semi-structured interview protocol allowed me to remain consistent across each interview while also remaining open to emerging ideas throughout

the course of the interview process. I was able to ask probing questions or follow-up on participant statements instead of being restricted to following the protocol. There were three interview protocols for this research because of the two unique groups. One interview protocol focused on the pre-exam questions, a second interview protocol focused on the post-exam questions, and the third interview protocol was a combination of these two protocols designed for a single interview. The interview protocols for the interviews conducted before and after the exam can be seen in Tables 3.3-3.5.

Table 3.3: Interview protocol for group A (before exam)

<table>
<tr><td colspan="2">Guiding question:
How do students think about and approach taking an exam?</td></tr>
<tr><td>Possible questions:</td><td rowspan="8">In a student's answers, I will be looking for the following topics in responses:
Amount of time preparing for exam
Recurrence of exam preparation (i.e. how often)
Types of materials reviewed to prepare
Use of materials to prepare
Solution when a question or problem arises during preparation
Environment where preparation occurs</td></tr>
<tr><td>What thoughts come to mind when you think about taking an exam?</td></tr>
<tr><td>How do you prepare for taking an exam in general?</td></tr>
<tr><td>How have you prepared for taking this exam in your general chemistry course?</td></tr>
<tr><td>How often have you studied?</td></tr>
<tr><td>How long did you study?</td></tr>
<tr><td>Who have you prepared for this exam with?</td></tr>
<tr><td>How successful do you think you are going to be on this exam?</td></tr>
</table>

Table 3.4: Interview protocol for group A (after exam)

<table>
<tr><td colspan="2">Guiding question:
How do students think about and respond to the results of their exam?</td></tr>
<tr><td>Possible questions:</td><td rowspan="8">In a student's answers, I will look for the following topics in responses:
• Reflecting on instructor feedback and self-feedback
• Reflecting on connection to preparation
• Understanding individual feedback from instructor
• Applying individual feedback from instructor</td></tr>
<tr><td>Think back to the day of the exam, what did you do before the exam?</td></tr>
<tr><td>What thoughts/emotions/feelings did you have as you were taking this exam?
(i.e. What were your thoughts as you read the first question on the exam?)</td></tr>
<tr><td>What are your thoughts on the results of your exam?</td></tr>
<tr><td>What does your score mean to you?
What feedback did you receive? If you didn't receive feedback, will you seek it out?</td></tr>
<tr><td>How do you determine how well you did on the exam?</td></tr>
<tr><td>Do you compare your performance to the performance of your peers?</td></tr>
<tr><td>How did you respond to the results of your exam?</td></tr>
</table>

Table 3.5: Interview protocol for group B (only after exam)

<table>
<tr><td colspan="2">Guiding questions:
How do students think about and approach taking an exam?
How do students think about and respond to the results of their exam?</td></tr>
<tr><td>Possible questions:
What thoughts come to mind when you think about taking an exam?</td><td rowspan="14">In a student's answers, I will look for the following topics in responses:
Amount of time preparing for exam
Recurrence of exam preparation (i.e. how often)
Types of materials reviewed to prepare
Use of materials to prepare
Solution when a question or problem arises during preparation
Environment where preparation occurs
Reflecting on instructor feedback and self-feedback
Reflecting on connection to preparation
Understanding individual feedback from instructor
Applying individual feedback from instructor</td></tr>
<tr><td>How do you prepare for taking an exam in general?</td></tr>
<tr><td>How have you prepared for taking this exam in your General Chemistry course?</td></tr>
<tr><td>How often did you study?</td></tr>
<tr><td>How long did you study?</td></tr>
<tr><td>Who did you prepared for this exam with?</td></tr>
<tr><td>How successful did you think you were going to be on this exam?</td></tr>
<tr><td>Think back to the day of the exam, what did you do before the exam?</td></tr>
<tr><td>What thoughts/emotions/feelings did you have as you were taking this exam?
(i.e. What were your thoughts as you read the first question on the exam?)</td></tr>
<tr><td>What are your thoughts on the results of your exam?</td></tr>
<tr><td>What does your score mean to you?
What feedback did you receive? If you didn't receive feedback, will you seek it out?</td></tr>
<tr><td>How do you determine how well you did on the exam?</td></tr>
<tr><td>Do you compare your performance to the performance of your peers?</td></tr>
<tr><td>How will you respond to the results of your exam?</td></tr>
</table>

Data Analysis

The purpose of phenomenographic research is to organize participants' experiences into distinct categories of description. This process of searching for themes was a critical piece for me to keep in mind throughout the interview process. After collecting interview data, each interview was transcribed and the original recordings were deleted.

To analyze the data from the semi-structured interviews, I read through the transcripts several times to remember the context of each interview. Then, I began to make notes about the different ways the students viewed exam preparation and feedback from the exam. These differing views became codes that were applied to all of the interview transcripts. For example, students discussed a variety of materials they used during the interviews. Each of these materials was labeled with a code (i.e. textbook, lecture notes, note cards, YouTube, websites). I repeated this coding process for all of the interview transcripts.

Then, I reviewed each emergent code to make sure they sufficiently described the students' views presented in the interviews. Then I reviewed the data an additional time to modify, add to, or delete codes from the different categories. Eventually, I reached a point where the codes were no longer changing after many reviews of the data. Then, I looked at how any codes related to or were different from each other to group codes into categories. For example, the material codes described above were divided into two separate categories, internal materials and external materials. The categories and corresponding codes will be described further in Chapter 4.Creswell (2013) describes this method of data analysis as a spiral analysis.

Finally, once the coding scheme was finalized, I developed a codebook that included all of the emergent codes, like the codes under the categories of internal materials and external materials. Then, all of the interview transcripts were uploaded into a qualitative analysis software

that was used to sort the highlighted data using the established codebook. Two external auditors repeated the coding process using the same codebook. Each auditor coded one of the eight transcripts and this was used to calculate a percent agreement as described by Campbell et al (2013). They describe calculating percent agreement by "dividing the total number of agreements for all codes by the total number of agreements and disagreements for all codes combined" (Campbell et al. 2013, p. 309). Using this method, percent agreement between the researcher and the two external auditors was found to be 82%.

Self-Efficacy as Emergent Codes

While using an emergent coding scheme to categorize themes, Bandura's (1997) four theoretical sources that contribute to the development of self-efficacy beliefs became evident in the data. The specific quotations to support these themes will be discussed further in the results with the other emergent themes. For example, I had coded "previous experience with chemistry" in my interview data sets. This code would become Mastery Experience, one of the theoretical sources, in my final codebook. The four theoretical sources are Mastery Experience, Vicarious Experience, Social Persuasion, and Physiological and Affective States (Bandura 1997).

The first theoretical source, Mastery Experience, deals with the previous experiences that the student has that make them feel more or less successful as a chemistry student. For example, if a student had a number of advanced chemistry courses in high school they may have more confidence that they can be successful in a college chemistry course. Vicarious Experience, the second theoretical source, is related to students' views of those around them. For example, a student may judge their ability by judging a peer they view as having a similar ability. If they see a peer with similar ability as successful they may believe they can be as successful. Physiological

and Affective States is the idea that people use information from their body to judge their capability. For example, someone with test anxiety might feel that they cannot be as successful on an exam because their body is telling them to be nervous about the exam. Finally, Social Persuasion is the factor that states that self-efficacy can be affected by the outside influence of significant people to the student. For example, if a professor meets with a student in office hours and tells them that it seems like the student is prepared for the exam, the student may feel more able to perform well on the exam as a result.

Applicable existing codes from the emergent study were reassigned as the four factors that contribute to self-efficacy beliefs: Mastery Experience, Physiological and Affective States, Social Persuasion, and Vicarious Experience.

Role of the Researcher

In qualitative research, the researcher must be engaged in the research process from conceptualizing the study to data collection and analysis. The data collected through this study will come from participants through the interview process, meaning it will be co-constructed. Because I am currently a chemistry instructor with a background in the sciences, I am qualified to carry out this chemistry education research. From my own lived experiences as a chemistry student who took similar classes that the participants in this study are currently taking, a chemistry instructor who has worked with undergraduate students, and a researcher who prepared the literature review for this research, I had preconceived notions of what participants were going to say about the exam process before the interviews. However, phenomenography is similar to anthropologic research. This means that as the researcher I did not have to remove all of my own experiences of the phenomenon from the research process. This is because the

assumption of phenomenography is that there are multiple different perspectives to uncover about a given phenomenon. It should be noted that I do have experience of my own with this phenomenon of the exam process because I have been both a chemistry student and a chemistry instructor. This means I have established my own methods of studying in chemistry, which means that I had pre-conceived notions of how others study. As an instructor, I have also seen a variety of students in my own classrooms. I had to consider myself as a student and the students I have had in my own classroom when analyzing data to avoid as much bias as possible. I did this by including others in my research process. I consulted my committee chair throughout the process and used this as a sounding board for my ideas. In addition, I used outside auditors to code my interviews, as reported in the data analysis section of this chapter.

Limitations

It is important to recognize that phenomenological traditions make no claim to uncovering truth. Rather, the primary assumption is that how the phenomenon is experienced is due to an interaction between people and individual experiences with the external world. Therefore, phenomenography can have the "tendency to equate participants' experiences with their *accounts* of those experiences" (Orgill, 2007, p.136). This criticism suggests a disconnect between what a researcher observes of the participants' experience and how a participant describes their experiences. Therefore, it is important to make the distinction between students' experiences and the unique account each provides of their individual experiences.

The students interviewed in this study discussed their own experiences, but this does not mean that we can know for sure how they experienced the exam process. Instead, I relied on what each student told me about their individual experiences. I am limited to these students'

accounts of their experiences when I discuss the phenomenon of the exam process. Therefore, one limitation is the sample size of eight participants. These participants were recruited from the entire class, but participation was based on volunteers. Therefore, these participants may not be representative of the entire population.

Interviews were done late in the semester (November) close to finals time. This means that the results are not representative of first-year student's views early in the semester. If the interviews had been taken earlier in the semester, students may have commented on their experience differently.

In addition, it is possible that two researchers interpreting the data will come up with different categories. Although phenomenography does not call for a neutral researcher, because of the discreet number of ways to experience a phenomenon, some researchers criticize the claim that a researcher will not affect the data collection and analysis in some way. I kept a reflexive journal throughout data collection and data analysis to show my thought process on developing categories, which improves reliability and validity.

CHAPTER IV

RESULTS AND DISCUSSION

Introduction

This chapter presents the themes that emerged from the analysis of the semi-structured interview data collected from students in both Group A (before and after exam) and Group B (after exam only) about their experiences of the exam process. The categories of description presented do not represent a concrete classification of the individuals, but my own interpretation of their experiences, as they were uncovered from the interview data.

Overview of Themes

When describing the themes that emerged from the data, I think of each category like a gear. One theme does not simply occur in isolation but each theme is part of the larger picture of how a student experiences the exam process. Figure 4.1 shows this image with each theme depicted.

Figure 4.1. Themes from emergent coding of semi-structured interviews

Each of these themes, represented by gears in Figure 4.1, will be further explicated in the following sections. First, a description of the theme will be presented followed by supporting quotations from the data. Then, in each section a connection will be made back to the guiding theories of metacognition and self-efficacy beliefs.

Description of Themes

Materials and Strategies

When discussing the exam process in their General Chemistry I course, students discussed the variety of materials they used when they were preparing for an exam. These materials were broken into two major categories: internal and external.

Internal Materials

I found from my data analysis that students primarily used materials that were from within the course. For example, these materials were given by the instructor directly (i.e. textbook, study guide) or were created by the students from these instructor materials (i.e. outlines from textbook, lecture notes). Although students depended on these materials in different ways for preparation, each student primarily used these internal materials as described here.

Textbook

There were multiple ways students used their textbook during the exam process with varying levels of depth. Students who used the most surface level approach to using the textbook only skimmed through the book to get a general idea of what topics were

covered in lecture. For example, Participant A1 said, “I just read the whole chapter, like sometimes skim through it and everything.” This skimming approach did not involve synthesis of the material. Participant B1 described a higher order approach to using the textbook that required taking notes and connecting back to the lecture. Participant B1 said,

> Generally, the easiest way to figure out … especially for math and chemistry classes it is based off of a textbook, so it means reading through that and taking a bunch of notes and paying attention in class on what is emphasized and what’s not.

Of the students who were interviewed, two discussed using the textbook to create additional study materials. This went beyond simply reading or skimming the textbook to trying to come to a deeper understanding of the material. For example, Participant A3 commented, “I went through all of the chapters and took notes, especially anything bolded or anything in concept maps or diagrams in our book, made note of those”. This quotation showed a deeper approach to using the textbook than simply reading a chapter. Participant A3 showed a high level of metacognitive skills by creating her own materials because she showed an understanding of the best strategies to learn the material.

In addition to outlines, another strategy used by students who participated in interviews was making note cards to prepare for an exam. Students who made note cards typically commented on how time intensive making the note cards was. Also, students typically viewed the material on the card as disconnected, must-know pieces of information to be memorized. For example, Participant B4 said,

> Usually, I make little flash cards with questions and answers of what's on the review sheet … our instructor will say you need to know dimensional analysis or something and then I'll put dimensional analysis or whatever on the note card and then on the back I'll put what it is when I go through and figure that out.

Additionally, Participant B1 commented that sometimes there were so many note cards that it was nearly impossible to memorize each card, even when the content was a weakness for this student. Participant B1 said,

> Even though I make note cards on the people, it is a lot of people (scientists) to memorize especially when it is about a subject (like chemistry) that has been building up for hundreds of years. So, the questions like that I tend to get wrong unfortunately because it isn't something that I know how to emphasize.

This quotation shows that this student feels like he knows what to study. This means he has used some metacognitive skills in his exam preparation to uncover the content he needs to emphasize to be successful in his chemistry class. The instructor asks questions about chemists relevant to what they are studying. However, this student believes that he has not uncovered the best strategy to learn about these scientists in his exam preparation.

Practice Questions

A subset of students interviewed mentioned using the textbook to specifically look at practice questions at the back of the chapter for extra practice or practice exams that the professor makes available. These students primarily commented on using practice questions in the back of the book, which they found helpful, especially when they were learning mathematical problem solving. Participants discussed using these practice

questions in their preparation in addition to required assignments. For example, participant B5 said,

> For chemistry, the second test and the third test I prepared a lot more by doing a lot more of the equations because when I actually have to do math in a course, I do best by doing many, many, many problems.

Participant B3 added that these problems could help because then he knew he understood the material. For example, Participant B3 said, “I like to look at those problems in the book first because the answers are right there, so then I know I understand it before I do the homework”. By doing the problems in the book first, Participant B3 felt higher confidence in his ability to do the online homework. This shows that doing the practice problems and accumulating mastery experiences contributed to higher self-efficacy beliefs for this student.

Online Homework

Students in these chemistry courses were assigned online homework assignments that were due on the day of the exams. Students viewed this online homework as a good starting point when preparing for an exam. For example, Participant B5 said,

> Before the exam, I’ll make sure to do all of the online homework, which is the only homework that is available in the course and I’ll run through all of those problems and I’ll see what kinds of concepts they are asking on there. I’ll see what I have a hard time with there.

Similarly, Participant A2 said, “The online problems helped a lot to pinpoint what you didn’t know and then I would go through each section and anything I didn’t understand”.

Study Guide

Students described using online homework assigned by the instructor to determine what was important to focus on during the exam process. In addition, students paid close attention to what the instructor viewed as important to determine what they would focus on while studying. When using the study guide that the instructor provided, students were more confident that this information would be relevant to the exam than their own judgments. For example, Participant A2 said,

> Our instructor gives us a review packet, which is very, very nice. So when we do our homework it covers every single thing in the chapter. We use a system online that covers every little small detail from the chapter. Then he gives us the review packet and we can be like "Oh, this is the stuff we actually need to focus on", so that is the most beneficial thing because if it's on the review packet it is for sure going to be on the test. If it's not on the review packet, chances are its not going to be on the test, so it's the best tool.

This participant viewed the study guide as more helpful in assisting with exam preparation than the online homework.

However, other participants who focused on the study guide were not always better judges of what would be on the exam. Participant A1 discussed her experience with the study guide and how it related to what would be on the test when she said,

> Before when our instructor gave a review sheet of what to study and everything … it was chapter 7 and chapter 9 and a little bit of chapter 8, but our instructor said not to focus on chapter 8. So, I didn't really review chapter 8 that much but

> then on the exam there was a whole page on chapter 8 and I wasn't ready for it, so it made it really hard to understand.

This quotation indicated that Participant A1 was relying on what the instructor said and not her own metacognitive skills when preparing for the exam. Other students were using information from the instructor and their own self-regulatory skills to assess what information was important for the exam.

Laboratory

In general, the interviews did not show that students used laboratory materials during their exam process. The only crossover between laboratory and the lecture, or exam, seemed to have when the focus was specifically on learning math processes in the lab. For example, Participant B3 said,

> I don't consider the laboratory a huge factor. It helped with the stoichiometry because we did a lot of the problems in lab made it a little bit easier when it came to doing the exam ... I think doing math in the lab has been the most helpful thing we've done.

This quotation indicated that students may not have seen the connection between their laboratory assignments and their in-class work. It was also probable that students weren't concerned with laboratory material because it wasn't tested in the lecture directly.

External Materials

Students used primarily internal materials, but when they were struggling to come up with an answer to a difficult question, they would occasionally look to external

materials to find an answer. Students discussed using videos and websites when they were struggling to overcome obstacles during their exam preparation.

Video

Students used video in two primary ways, one was to look up an answer to a specific question and the other was to see the topic taught in a different way. For example, Participant A2 used Khan Academy, an online educational video-based website, to look up an answer for a specific question. Participant A2 said, "I used Khan Academy … I thought I understood it but I wasn't sure. I'm glad I went back through it and could break it down from the very beginning to understand it".

Participant A1 discussed using YouTube to see a topic in a new way that was different from how the material was presented in class. Participant A1 said,

> On YouTube one topic can be explained in many different ways. Like if I don't understand it the way the instructor explained it that one time in class then I can find another way from another person who might have a different way of teaching. There are many different types of way to explain the same thing, which is what YouTube is good for.

Although students were using primarily internal materials, they used external materials, like videos, to support their learning. Students who used external materials were self-aware enough to realize that the instructor was not always conveying information in the a way that the student could learn. Therefore, these students sought out other resources available to them to learn the content.

Website

Students also used websites and general searches to find information online to help with their exam preparation. Occasionally students used this ability to search anything as a crutch that actually inhibited their studying. For example, Participant B1 said,

> While you are doing the homework online you don't need to have any of the equations memorized because Google is just a tab away… But you need to have things memorized for the exams.

This quotation showed that students sometimes rely on online resources instead of memorizing information that they only saw as useful for a single exam. Participant B4 echoed this when he said, "I normally just copy and paste the questions into Google, get the answers and move on".

Additionally, students used websites like Wikipedia to look up a second source of information beyond the textbook because it might have been worded slightly differently. This is similar to using YouTube to see material presented in a different way. Participant B5 said,

> Normally if the wording is poor in there (the textbook), which normally it is pretty good, then I use Wikipedia as my next place to search. That first intro paragraph on the Wikipedia page will usually give me a pretty good idea of what that concept is referring to.

There were not very many students that discussed looking up information on the Internet. I do not have the data to further understand how self-efficacy beliefs and/or metacognition influenced how students use online materials.

Environment

In addition to the types of materials students used when preparing for an exam, students also discussed the environment in which they prepared for the exam. Students, in general, discussed the space they put themselves in to study (i.e. location, background noise), the number of breaks they took, the focus they put on the material, and distractions that impeded their preparation.

Students typically discussed studying in their room or another study space, alone, with no outside distractions. For example, Participant A3 described the space she studied in when she said,

> I either study in our study room in our dorm or usually the tutor lounge in our dorm, which is open from 8pm to midnight. There aren't that many people in there and I can always get help when I need it.

Students also recognized that they needed to focus on the material and take breaks to avoid cognitive overload. Participant A1 said, "I need to take breaks so I don't get overloaded with material. So I read one section and then go eat or listen to music or watch a movie, then read another section". In addition, some students used technology to keep background music playing to avoid additional outside distractions. Participant A2 said,

> I'll have music playing and it gives me something like if there's a couple problems like … well if there wasn't something to keep me drawn in then I would probably leave to do something else… My blinders are on and I am focused on chemistry. My mind has to focus on one thing at a time. If I am focused, then I'm focused and if I'm not, then I'm not.

Students typically had a set environment they put themselves in when they studied and used similar strategies in all of the courses, including general chemistry. I did not have enough data to discuss how the environment a student prepares for an exam in is related to metacognitive skills or self-efficacy beliefs.

Strategies

From the data analysis, it appears that students used a variety of strategies to make sense of the content for an exam. Some students focused more on memorizing key information for an exam and did not appear to move to a level of conceptual understanding. Students also had two different approaches to adapting their strategies between exams. Some students discussed changing their strategies between exams to be more successful on later exams. Other students discussed simply needing more time with their same study strategies and saw this as the way to be successful on future exams. Student B1 described his group's study strategy,

> We went through all of the Chapter 10 problems and figured out what we understood and which things we need to remember and worked on the equations we needed to have memorized.

Student B1 did not discuss any additional measures that were taken to integrate the concepts together to come to a deeper understanding of the chemistry content. It is possible that these types of questions were not on the exam, which was why students did not concern themselves with understanding the material at a deeper level.

Other students, however, were more concerned with a deeper conceptual understanding and saw this as necessary to be successful in their General Chemistry I

course. In the interview before the exam, Participant A3 said, “I think it’s important, especially for retention, to make sure that you understand the view and the overall concepts and how they all inter-link because they do”. In addition to discussing connections between content, Participant A3 discussed conceptual understanding of the material as critical when preparing for an exam. She also discussed adapting her study strategies during the semester. Participant A3 said,

> Now that I had gotten over that [initial nervous feeling when taking exams] and knew what to expect from the instructor, like if there is an exception to a rule it is probably going to be on there, that’s the first thing I look for now so that it won’t trip me up.

This quotation demonstrates that Participant A3 was looking at what she did know, but also what she didn’t know to make decisions about how to adapt her strategies. These strategies she was using related directly to high metacognitive skills.

In contrast, students who discussed memorizing content as their way of learning tended to be the students who wanted to spend more time using the same study strategies to be successful on future exams. Participant A1 discussed memorizing information as how she learned to prepare for exams. Participant A1 said, “I feel like the way that I studied for my second exam that I can just do more of it and be more ready for the third exam”. This quotation demonstrates that she was not using metacognitive skills to adapt her strategies throughout the semester. Even though she had not been performing as well as she would have liked on exams, she still saw no reason to change her system.

Assistance

The data revealed the different sources students used to look for assistance beyond the materials they used. This included the people they sought out, or did not seek out, during the exam process.

Personal

Some students approached difficulties in the course by themselves. These students did not look to outside sources for extra help with problems. This might have been because they preferred to study alone, saw others as distractions, or simply did not see the value in consulting peers. For example, Participant B4 said, “Usually I study by myself. I work better by myself because I get distracted around other people.”

Participant B5 also discussed working through difficulties by himself when he said, “There’s nothing I can’t figure out on my own. I don’t feel like I need someone there who is double checking me”.

Peer

Students also discussed reaching out to peers for assistance with the content before the exam. For some students, this meant continuously working with peers from other classes or from their laboratory section. Participant A3 said,

> I study by myself first and then maybe two days before the test I like to talk it over with other people because generally I have looked at it before they have and the process of me trying to teach it and explain it to them makes me more confident that I understand that topic

This quotation was demonstrative of students who met with peers once they felt confident with their knowledge of the material. Other students worked together more consistently. Participant B1 said,

> I have one (study group) for chemistry of like three people and we go through all the problems and try to figure out what we don't understand when doing certain problems on the homework and a lot of the times it feels like there is no right answer until you realize that you read something wrong or something like that. That's why it is a lot more helpful to have more people focusing on something then you just making the same mistake over and over again.

Students who incorporated some element of studying with their peers, like Participant B1, seemed to have higher self-efficacy beliefs, which meant they were more confident in their ability to succeed on the exams. This was because students had a point of reference to judge their own ability against. This phenomenon will be discussed further in the Vicarious Experience section of the Self-Efficacy theme.

Tutor

Some students whom I interviewed were more comfortable meeting with a tutor who was designated to the course than with the instructor of the course because they saw the tutor as having a more open schedule than their instructor. Participant A1 said,

> There are SI sessions that they do and I just sometimes if there is a problem in the homework that I really don't understand then I'll print it out and give it to the girl in the SI session and she will explain it to me by going through the problems with me and then I understand it.

Participant A3 agreed that sometimes it was easier to understand the material when talking to a tutor. Participant A3 said,

> I actually started going to the tutors and since they approach it a little differently, um, it might be the smaller age gap or just differences in teaching, but it was easier for them to see that I wasn't making sense of what they were telling me.

Students like Participant A3 saw the tutor as an expert in the content. This added to these students' self-efficacy beliefs because they could construct their knowledge with the tutor. These students knew they were understanding the material correctly and felt more confident going into the exam.

Instructor

Some students showed hesitancy to approach their instructor to get additional help. For example, Participant B2 said,

> I feel like with the university, some of the professors seem less approachable or it is more difficult to see them. You have to go out of your way and fit it into your schedule. It is a lot harder to get one on one time even with office hours.

Participant B1 said,

> As well as our instructor has office hours, but I wouldn't know where to go for them. That's the thing with having your teacher's office hours. A lot of times people just don't know where teacher's offices would be. That is something I have run into in multiple classes.

Both of these quotations show that students didn't necessarily know how to ask instructors for help even if they wanted more help. Other students went to instructors for quick questions. Participant B3 said

> If it's a quick question I'll just go to the instructor right after class and we can just look at the problem and be able to tell me if I did it right or if I did it wrong, but I haven't had to do that much, so I haven't gone to office hours.

Only a minority of students interviewed in this study went to their instructor more regularly with deeper questions and problems. Participant A3 said, "I would go into office hours with the instructor and ask for clarification or for the instructor to present it in a different way that could make more sense to me". Participant A3 said she went to office hours often because sometimes she was not able to understand all of the material the first time and needed further clarification. She said,

> Often times, if our instructor says something to me and explains a process to me, I don't usually absorb most of it. I have to ask for an example or to work through a problem with me or if it is an equation then show an example in the book so that I have something concrete to reference. I am not an auditory learner, so that was key to me absorbing information when asking for help.

Students who worked with their instructors, like Participant A3, went through a process of learning how to work with their instructor to get the most out of office hours. For Participant A3 this meant asking for specific examples when working with her instructor instead of discussing information in general. This student knew her learning style and used that to her advantage to gain the most out of working with her instructor.

Challenges

Many students in this General Chemistry I course were first time college students. The transition to college can be difficult and students are working to balance each part of their life with being a student. For some students who were interviewed, this meant balancing multiple classes. For other students, it meant difficulties balancing their social or work life with their studies.

Balancing Multiple Classes

The most common challenge students cited during their first semester of college was balancing the workload of four or five college courses for the first time. Participant A1 said,

> I was having trouble with my English class. I was consumed with essays that I had due and everything for that English class and a lot of reading to do. There was a lot going on in that class. I didn't have that much time to commit to chemistry.

Participant A1 further described this when she said,

> I felt like chemistry was not that hard. I was trying to finish the hard stuff first at the end of the semester. I just told myself that I would just … that when I was done with the hard stuff that I would move to the chemistry.

These two quotations show that students were constantly evaluating their courses to decide what was the highest priority and that was where they put their focus. This changed week-by-week or moment-by-moment. Students usually could not put all of their attention on a single course like they wanted to. Participant B1 demonstrated this similar demand of multiple classes. Participant B1 said,

> It also depends on when I have exams for my other classes because if I have an exam three days after my chemistry exam then I am going to be studying for that and not thinking about chemistry for a little bit and then it gets closer and closer to the exam where it is more important to understand the concept.

Balancing multiple classes was the most common challenge in their chemistry course for all first-year students, including Participant A1 and Participant B1. These students simply did not have the experience taking that many college courses at a time. This balance was a skill that students learned with time. For example, Participant B5, who was an upperclassman, did not feel these same constraints from taking multiple classes at once.

Balancing Work and Study

In addition to citing balancing multiple classes, a subset of students in General Chemistry I courses were also working full or part-time jobs along with taking a full load of courses. These students had unique challenges when learning how to balance school and work. Participant A2 said, "I am also working 20 hours a week in addition to 14 credit hours as an engineering student. It's been a lot… The biggest transition is just the time".

In addition to preparing for an exam, balancing work hours with being a student also impacted Participant B5's ability to get additional feedback after the exam. Participant B5 said,

> When the feedback is offered I have to go to work. The instructor offers sessions right after class and I always have to leave to go to work. The office hours and

> study sessions on the weekend and times that the instructor can talk have all fallen while I'm working.

This quotation demonstrated that students, like Participant B5, recognized that these sessions could be valuable to their success, but have to make the decision to go to work instead.

Balancing Social Life and Study

Students in a new college environment were often making friends for the first time away from home. This required balancing students' social lives with their school lives. Participant A1 said, "It was my first college semester, so I felt like I wasn't socializing enough and I was trying to make friends and dealing with school. I didn't feel like I had any extra time to commit to chemistry". Additionally, students were dealing with school breaks mid-semester, but the schoolwork didn't necessarily stop. Participant B1 said,

> This time [before the exam] it was about break and having something going on every single day plus traveling more than 5 hours. There was a lot going on. I wish I had more normal academic things to say, but social things get in the way too.

These quotations demonstrated the various ways students balanced their social lives and their school lives when they were away for their first semester of college. Students were highly aware that their social lives affected their exam preparation. Students discussed doing in their best in their first-semester to balance their social lives with studying, but it was still a challenge they faced.

Perceptions

The interview data revealed students' perceptions of how they experienced the exam process. This included outcomes that participants viewed as within their control (internal locus of control) and outcomes that the participants viewed as outside of their control (external locus of control). The main focus of interview data that was coded as a perception dealt with attributes of exam performance.

Internal Locus of Control

Confidence

To discuss this part of students' experiences with the exam process, I divided confidence is into multiple levels (i.e. high confidence and low confidence). I also discuss confidence in terms of the part of the exam process (i.e. before an exam versus after an exam). This means that a student could have had high confidence before the exam and continued to have high confidence after the exam had been taken. Another student may have been highly confident in their ability before an exam, but the exam itself caused them to question their ability and they had low confidence after the exam. There are other possible variations, but these were the two that were most commonly seen in the students interviewed.

Some students who were confident before the exam continued to have this high level of confidence after they took the exam. These were the students who typically performed well on the exam and saw themselves as successful. Participant A2 said,

> I thought that I should do okay. I thought I'd probably get like a B or a low A. And I was like, okay I guess I'll do pretty good. Then I started going through the exam and as I went along I got more and more confident as I saw the problems… Generally how I feel going in, is how I feel going out (of the exam).

This student went on to receive the grade they expected on this exam. This showed that some students can accurately judge their abilities. Participant A2 showed high self-efficacy beliefs and metacognitive skills. He accurately judged his performance and received the grade he expected based on his judgments during the exam.

Other students had weaker metacognitive skills and did not feel confident in judging their own performance. Participant A1 said,

> At first, I felt like I was going to do good on that first exam, then I started reading the questions and I didn't feel like I was ready enough. When I actually started the test and before that I felt like I was going to do good.

This quotation is very similar to Participant A2's confidence description with one major difference. Participant A1 was not as successful at judging her ability, which caused her level of confidence to change after taking the exam.

Interview data also suggested, like the literature, that students could improve these abilities over time. Participant A3 discussed this change over the course of the semester.

> The first exam, I had no clue what to expect and I wasn't really sure how well it would correlate to the teaching or to the homework or to the lectures and so I made a lot of very, very simple mistakes. So, recognizing that and getting frustrated with myself over it as I went along I did (made) fewer and fewer

> (mistakes) as I went. Then by the time I did the cumulative makeup and the final, I had very little worry or doubt going in that I would not know what was going on.

Expectation of Performance and Views of Success

Students viewed their expectations for their performance and their views of success as within their control. Their expectations were directly tied to how they viewed the results of their exam. Therefore, how they viewed their performance in relation to their actual performance could have an impact on self-efficacy beliefs. The students interviewed had differing views about how they expected to do on the exam in relation to the grade they received on the exam. Some students, like Participant A2, knew exactly what to expect and found that their expectations matched the reality of taking the exam. Participant A2 said, "I felt like I knew exactly what to expect on the exam and there weren't any surprises." However, other students felt that they worked hard and didn't get the grade they worked for. For example, Participant A1 said,

> I was expecting a B because I felt like I had prepared and worked hard, but then I didn't get a B… if I had gotten a B, I would have … I feel like I would have gotten what I worked for. I felt like I studied too hard for this failing grade.

Some students' expectations also shifted over the course of the semester. Participant A1 was unhappy with the results of her grade. She felt like she had worked hard and should have received a higher grade that matched the level of work she put in to her exam preparation. She later went on to say that she planned to spend more time with the same study strategies to get a better grade on the final. This showed a lack of

metacognitive skills. She did not have the ability to reflect on this grade and realize that a different strategy might have helped her be more successful.

Participant B1 discussed her high confidence at the beginning of the semester that did not reflect the grade she received on the first exam. After that, she had to change her expectations to match the reality of the situation. Participant B1 said, "I don't have the grade I wanted in the end, but I know the concepts and I am confident about doing well on the final. The exams didn't go as wonderfully as I'd hoped." This shows that students who come in highly confident in their ability without the skills to be successful are often surprised with their first grades when they enter college. This first grade may have a large impact on their self-efficacy beliefs for the rest of the semester. For example, Participant B1 discussed constantly keeping a realistic view of the grade she could expect while preparing. She was trying to avoid being over-confident because she did not want to get another low grade.

Participant B2 also experienced a similar shift in expectation over the course of the semester. Participant B2 said, "Well, it was like obviously I didn't know as much as I thought I did, so I need to work harder and be more realistic about how I can expect to perform on exams."

Students also had differing views of success that were revealed through their interviews. Students typically looked to the score they received on an exam to judge their own success. For example, Participant A2 said,

> I know when I walk out that I am expecting this score. So, when I get my results and if I don't get that score or higher I feel like I haven't been successful that I

didn't successfully study. I wasn't ready for the exam. But if I score as I expected, then I feel good about it.

According to the interview data, there were also some students that viewed success as simply passing the course with the minimum grade necessary. For example, Participant B4 said, "I've done well. I haven't gotten A's, but I've gotten like BAs and a couple Cs…. Cs get degrees, I guess".

Other students seemed to view themselves as successful as long as the grade they received was in line with what they felt they deserved based on how much work they put in. For example, Participant B5 said, "I was successful. That score reflects what I earned. I got what I expected. I could have prepared more, but I didn't, so I got what I deserved". This quotation represents an internal locus of control because the student felt the grade he earned was the grade he expected. He recognized that he could have done more, but because he didn't, he had realistic expectations of his performance.

External Locus of Control

How Teacher Teaches

The teacher, who the students view as the one in control of the content of the course, had an obvious impact on students' perceptions of the exam process. This emerged from the data with phrases like "our instructor likes", which indicates that the instructor is controlling 1) how he/she teaches and 2) how the content will be assessed on the exam. For example, participants discussed their views of what their instructors said or focused on and the impact on their exam process. Students generally seem to all have views on what their instructor

was doing and appeared to consider that heavily when preparing for an exam. For example, Participant A3 said,

> So, I know a lot of teachers come in on the first day of class and say "I will never try to trick you with an exam". Well our instructor didn't say that and it's kind of what our instructor ends up doing. It's not in a bad way to trick you and give you a bad grade, but our instructor wants to make sure you recognize all of the little details that could trip you up.

This quotation demonstrated that the student had a good understanding of what the instructor was looking for on the exam, however, this ability took time for students to develop over the course of the semester. Participant B3 said,

> Honestly, going into the first exam I had no idea what to expect. I studied the book heavily and the concepts, but I also practiced some problems. I did this just to make sure I had an even focus of both the concepts and the math, but now I see that our instructor likes to ask a lot more math problem related questions rather than concepts. I mean … there are some concept questions, but I feel like its much more heavily focused on the problems.

This quotation represents how this student viewed the types of questions his instructor asked on exams. Some students viewed the exam as more concept heavy and others viewed the same exam as more focused on mathematical concepts.

In addition, students attempted to understand what the instructor wanted, and for students like Participant B4, this seemed to impact how they viewed chemistry. Participant B4 said,

> For the first test, you never know what a teacher is going to be looking for on that first test, so early on in the semester yeah it was a lot about what the teacher would be looking for. So, it was like oh our chemistry instructor won't be focusing on this type of problems. So it helped me figure out what exactly chemistry is.

This quotation also demonstrates how some students changed their own perceptions based on what the instructor, this external source, looked for out of the students.

Difficulty

Participants viewed the difficulty of the material and questions on the exam as outside of their control. For example, Participant A1 said, "So the way that the instructor writes down questions is completely different than how the book and the homework words it. That's why the exam questions are hard for me to understand". For this student, the questions were difficult to understand because of how the instructor worded the questions. In a similar vein, Participant A2 said,

> Some of the conceptual stuff I don't like as much because everyone words it in a weird way, so if you take one word and you take it as looking at this, but someone really meant look at it like this, then words are kind of limited.

> Although this student was not directly placing blame on the instructor, he was still not taking the sole responsibility for his difficulty with these types of questions.

Using Feedback

One question I had when I began this study was, how do students think about feedback from an exam during the exam process? Students said that they often did not receive much feedback beyond a score, and in some cases, which question or questions they specifically got right or wrong. Participant A3, from the honors section of general chemistry, described the form of feedback from their instructor. Participant A3 said,

> Our instructor gives us … we get an email with all of the answers and we have our tests, so I can go back through and see exactly which ones I got wrong, so I'll always go into office hours the next day and go through all of the ones I got wrong.

The regular section of general chemistry did not receive their exams back. This group of students received only their score; they did not get to keep a copy of the questions or receive an answer sheet after the exam. Participant B3 said, "Well, we obviously get the score back and our instructor is willing to go over the exam". This student did not seek out this additional feedback, but knew that it was available to him if he wanted to go over his exam.

A few students from the regular section that did not receive their exam back discussed going back over their notes trying to uncover which questions they got right or wrong. Participant B1 said,

> I basically go back to the chapter notes and figure out … thinking back to the problems, but you can't remember a lot of those problems by the time you are trying to figure out

> the grade that you got, unfortunately, but trying to look back and figure out what concepts or what problems I probably messed up on because you don't get your test back.

It was difficult for this student to understand his shortcomings on the exam because he did not have the exam to refer back to. This was common practice for students in the regular section of the General Chemistry I course. Finally, students discussed seeking out more feedback and how it differed from their high school experience. Participant B2 said,

> It probably would have helped to reach out for more feedback because when I get feedback in other courses, or at least some feedback, it helps. We just don't get as much feedback in my college courses as we did in high school. High school is much more upfront because you are face to face with your teachers all the time.

This quotation from Participant B2 demonstrates that students did not always know how seek out additional feedback even when the instructor makes it available to them. They did not understand how to get additional assistance when they need it.

Self-efficacy

Self-efficacy beliefs were defined in Chapter 2 as an individual's expectation of his or her ability to succeed at a given task (Bandura, 1997). How the four sources of self-efficacy beliefs, mastery experience, vicarious experience, social persuasion, and psychological and affective states, were seen in the results of this study is described further in this section.

Mastery Experience

As described in Chapter 3, Bandura (1997) describes mastery experience as previous experiences a student has that contributes to their perception of their ability.

Analysis of the student interviews revealed that there were multiple sources that potentially contribute to their mastery experience. These included experiences as a student in high school, experiences as a student in college, and experiences with chemistry content.

One type of mastery experience was experience in high school. Participant B2 said,

> I was an honors student in high school and it was always really easy and I never had to study and here at the university, it's like … well, it's my first year, I might have to study a little bit, but it shouldn't be too big of a deal and then I was completely wrong.

This student thought that because of her previous experience as a successful high school student that this should automatically translate to being a successful college student. In reality, she found that this experience should not necessarily have contributed as strongly to her college chemistry self-efficacy beliefs. In contrast, Participant A2 had low self-efficacy beliefs coming into this general chemistry course because of a lack of experience in high school with chemistry. Participant A2 said, "I was nervous going into it because I didn't have any chemistry in high school, so at the beginning I was really worried because I felt like I was just memorizing stuff". Participant A2 had to use metacognitive skills to overcome his low self-efficacy beliefs. He realized that he couldn't be successful in his chemistry course by simply memorizing information, but instead had to use different strategies to become successful.

A second group of students discussed their previous experiences with college courses before their first semester at this Midwestern university. These students were

first-semester students who had taken a college course in high school or in the summer before this general chemistry course. Participant A2 said,

> So, I had a really hard class that forced me to re-prioritize. I'm sure if I hadn't had that course and this was me being in college for the first time, then my experience would have been totally different. It would have been so much worse because I would have been trying to figure out how to shift everything during this semester.

Students with this previous college experience, like Participant A2, seemed to know what to expect out of a college course. They had realistic expectations of how difficult the course would be and knew how much time to dedicate to their studies in part due to this previous college experience. Having a previous college course contributed to students' self-efficacy in a positive way and these students typically had high beliefs in their ability to be successful. Participant B5 said,

> I think you get very good at picking up … and maybe that just comes with going to school as long as I have and having lots of experience in the classroom. You can tell when an instructor is trying to emphasize something and when they are not.

Participant B5, who had a lot of college experience, had high self-efficacy beliefs due to this experience. He felt confident that he had the ability to determine what content was important due to his experience in other courses.

There was also a third group of students whose mastery experiences were related to previous experiences in chemistry courses. Not only did Participant B5 have experience in college courses, he also had experience with chemistry because he had

taken general chemistry before. He didn't fail the course, but was re-taking it for admittance into another program. Participant B5 said,

> I'm very familiar with the material, which helps. After having gone through so much chemistry, I feel really confident with it. I feel like a lot of the course has been 'oh yeah, yeah I remember that, oh okay that's right'.

Participant B5 showed high self-efficacy with chemistry content, which also helped him feel that he could be successful in this chemistry course.

Students discussed a variety of experiences that contributed to their high self-efficacy beliefs in this first-year general chemistry course. Some of their self-efficacy beliefs were found to be too high, meaning that students were over-confident in their abilities going in and found that their expectations did not match reality. Other students, specifically those with experience in college or more specifically with college chemistry, had high-self efficacy beliefs that were validated during their experience in their general chemistry course.

Vicarious Experience

Bandura (1997) described vicarious experience as peer interactions that contribute to a student's perception of their ability. In college chemistry, this means that students are judging their peers' ability to perform well on an exam to judge their own perceived ability. From the data, this appears to have an effect on students' exam processes. Some students may not want to work with other students because they don't want to be seen as weak by their peers. Participant A1 said,

> I don't like studying with other people because if I am studying with other people and they are understanding it more than I am or I understand it more than they do, it's not really helping me … if they understand it more than I do, then I don't feel comfortable. In that situation I'd rather ask the teacher to help me.

It is inevitable that students will compare themselves to others. The question is, will this have a positive or negative impact on their self-efficacy? For Participant A1, it appeared that comparing herself with peers negatively impacted her belief in herself if she felt her peers understood more or were better prepared than she was. However, other students saw this process of peer comparisons as having a positive impact on their own self-beliefs. For example, Participant A2 said,

> Well if someone does a lot better than you than it gives you … it makes you think about 'where did I go wrong?' there's also that fallback to 'I didn't do so well and can I double check what happened?'. Generally, if I know that I did really well … then I can say 'hey, I did really good, is it just me or did you do well too?'

In this example, Participant A2 compared his score with his engineering peers' scores. He saw these peers as his equals, i.e. that they have similar ability to him, which meant that he used his peers' scores as a way to judge his own performance and success. Participant B2 had a similar experience with her peers.

> Sometimes we talk in this group about how we did on the exams. For all of us, our grades kept going up through the course of the semester as we learned how to study. We were all first-year students, so it helped all of us see everyone else in our group getting better together, which helped our morale.

Social Persuasion

The qualitative data demonstrated that mastery and vicarious experiences were the most common factors that contributed to students' experiences with the exam process. However, there were a few instances of social persuasion, which Bandura (1997) described as how outside parties can influence a student's perceived ability using words of affirmation. Conversely, negative words can have a negative impact on students' self-efficacy beliefs.

Participant A1 discussed an email exchange with the course professor after receiving a poor grade on an exam. She said,

> When I got that score I emailed my instructor and asked, "how bad does the score affect my overall grade in the class?" and so far I am not failing, I still have a passing grade for the class and if I do really good on my final I can get an even better grade, so our instructor said that when I am going to take my finals, don't go in saying that "I can't do it", go in thinking that I can do it.

These positive words added to the student's self-efficacy beliefs as she prepared to take the final. She had obviously not lost hope that she could receive a good grade on the final that would give her a better grade in the course overall.

In addition to direct words of affirmation, students could be affected by social persuasion if they saw that the instructor saw them as excellent students. Participant A3 said,

> No, but my instructor laughs a lot when I come in because my instructor always says that there are students that care and students that this is their only science

> with lab that they have to take to get their degree and it is very easy to tell who is in there to actually learn it and who is in there just to get a C or better in the class.

Through this quotation, we see that the instructor was confirming Participant A3's high self-efficacy beliefs. She could see that her instructor recognized her hard work. She did not directly discuss how this impacted her self-efficacy, but it was evident that she was confident going into the final that she knew the information she needed to be successful. She was also considering changing her major to chemistry in part because of her experience with her instructor.

Psychological and Affective States

According to Bandura (1997), students also judge their ability based on what their bodies and emotions tell them. Students described trying to stay calm during exams and that they tried not to be thrown by a single item on an exam. Participant B3 said,

> It's kind of like … personally I try not to freak out when I don't know what something means, but sometimes I can't help but think "geez, if this is what this problem looks like what is the rest of the exam going to look like?" Most of the time, if I come across a problem like that [that I'm struggling with], I'll just skip that problem and I'll do the ones that I'm really sure about instead and then I can think more clearly and focus on the ones I'm not sure about.

Some students mitigated this worry by keeping a set routine on exams. Participant B5 said,

> I have a very, very set routine with every single exam that I take. The first thing I do is … well at first the instructor doesn't want you to look at it, then when I

finally can, I flip it over and put my name and form letter at the top and then I stop and close my eyes and take about three deep breaths and I read the first page.

I believe that psychological and affective states may have the largest affect on taking an exam, which was in general the hardest topic to gather data about during the interviews. Overall, it seems that some students tried to have a very set routine when it came to taking exams.

Chapter Conclusions

The exam process was affected in part by a student's self-efficacy beliefs and metacognitive skills. Some categories that affected the process of preparing for an exam for these students was the materials they used, the strategies they used to translate this content into knowledge, and how they sought out assistance. There was not enough data about the types of materials student used to discuss further the connections this had to self-efficacy beliefs or metacognitive skills. In general, the students interviewed in this study relied primarily on internal materials during the exam process. Internal materials included those materials generated by the course. For example, students relied heavily on lecture material and textbooks to decide what content was important to focus on. Additionally, students used these materials to generate their own study materials, like outlines or note cards.

The strategies used and how students sought out assistance was more closely related to student's self-efficacy beliefs and metacognitive skills. Students who were more able to adapt their strategies and had realistic views on how they expected to do on an exam reported higher grades. Table 4.1 gives a summary of how participants reported that they performed on the exam.

Table 4.1: Participants self-reported grades on exam

Level of Performance on Exam	Participant	Grade Reported
High Performance (A)	A2	A
	A3	A
	B5	A
Middle Performance (B or C)	B1	C
	B2	B
	B3	C
	B4	C
Low Performance (D or E)	A1	E

The grades earned on the exam (i.e. low, middle, or high) did not appear to have any direct connection to gender or major. For example, one female chemistry first-year major (A3) received an A on the exam during the interviews, another female first-year chemistry major (B2) received a C on the exam and the third female first-year chemistry major received a failing grade on the exam (A1).

The lowest performing student had a different view of what learning meant than the higher performing students. Participant A1 said, “I’m not a person that likes memorizing stuff. I like doing stuff based on logic and I feel like chemistry is getting to be about memorizing a lot”. She saw learning in chemistry as having to memorize large amounts of information. In contrast, participant A3 viewed learning as seeing how all of the concepts tied together. Participant A3 said, “I think it’s important, especially for retention, to make sure that you understand the view and the overall concepts and how they all inter-link because they do”.

There were some differences in seeking out feedback after an exam between the students interviewed based on the grade they received on the exam. The lowest performing student sought out feedback to try to figure out which questions she did not understand on the exam. She discussed this process as a way to be ready for the final. The lowest performing student

attributed her lower performance to mainly external factors such as the questions were difficult to understand.

Only a few high performing students sought out additional feedback, which they saw as a way to improve on future exams, and not only on the final. These students seemed to be seeking out feedback in a way that reflected high metacognitive skills to improve future performance through self-regulation. These students mentioned connecting content to other topics and adapting study strategies over the course of the semester. High performing students, like Participant A3, also discussed meeting with peers to teach each other the content. Participant A3 said,

> I feel like I'm a teacher to a point. I'm usually with a couple to four friends who all do fairly well in the class, so it is really a give and take with that because anything I don't understand I know that one of the boys in our little study group is really, really good with the theoretical parts of things and I'm better with the math, so we work really well together when we are trying to figure out what the other one doesn't know. So I can bring my own strengths to the group and use other members strengths when I have a weakness.

The students in the highest performing group were also most likely to discuss the use of problem solving to get through a problem they didn't understand on the exam. This was in contrast to low performing and middle performing students who said they would take their best guess. Participant A2 said,

> There was one question that was talking about … I figured it out. We hadn't done an example like that in class, but it took one of our equations that we did know and mixed it up. So, I looked at it and was like wait … it has this, this and this, which I learned from physics, that if it has those different things think of which formula has those same

variables and use that formula. I think it was something about you are given so much of something in moles and I was like “hey this looks like this other formula that we know”, so I figured it out.

None of the students that self-reported as middle performing students (receiving a B or C) sought out instructor feedback after an exam. These students typically also had the lowest self-efficacy beliefs. They started the semester with very high confidence, in part due to a mastery experience or vicarious experience. Then, when the middle performing students received a lower grade than expected on the first exam, they re-evaluated their performance ability and expected to do worse on subsequent exams. These students saw any grade above a failing grade as being successful. They knew they could have worked harder for a better grade, but were overall satisfied. The students in this middle group seemed to not know how to access instructor’s office hours or other relevant help for the course and did not seek out this information.

Overall, the data showed that students could be divided into groups based on exam performance (i.e. low, medium, high). Students from these performance level groups approached the exam process in similar ways.

CHAPTER V

CONCLUSIONS AND IMPLICATIONS

Chapter Summary

This final chapter reviews the experiences each student had with the exam process, as well as general assertions from the data in this study. This will show the results in the context of each student and attempt to characterize types of students and how they experienced the exam process. Then a review of the research questions and answers to these questions are presented. Finally, implications for educators based on this study's findings are presented and a conclusion to provide an overview of potential future work is given.

General Assertions

Some general differences could be seen between the students interviewed that were correlated to their performance. The only themes that did not correlate to level of performance were the types of materials used and the environment in which a student studied. Other themes, like strategies used, how students dealt with challenges of life balance, assistance, and seeking out feedback, did correlate to performance. Students in the highest performing group demonstrated characteristics that suggested high self-efficacy beliefs and high metacognitive skills. These high performing students' beliefs in their abilities most closely matched with reality when they received their exam grades. High performing students were also most likely to adapt their study strategies based on learning more about what types of questions or what type of content the instructor focused on. These students occasionally sought out additional feedback from their instructor. The lowest performing student that was interviewed in this study also

sought out additional feedback. The middle performing students were least likely to seek out feedback. A summary of characteristics observed for each group of student performance is given below.

Lowest Performing Student

According to the self-reported data of participants in this study, the student with the lowest grade was characterized by the following approaches to the exam process:

- Focused on memorizing content
- Did not adapt study strategies throughout the semester, which implied low metacognitive skills (i.e. I only need to spend more time doing the same things I did on the last exam)
- Generally had high self-efficacy beliefs going into an exam, possibly in part because she had met with instructors or tutors before the exam
- Felt the work she put in did not match her earned grade
- Discussed struggling to balance other classes and her social life during her first semester of college
- Had minimal contact with her peers about any aspect of the course
- Thought exam questions were difficult due to their wording

Middle Performing Students

According to the self-reported data of participants in this study, students with average grades were characterized by the following approaches to the exam process:

- Focused on a mix of memorization, but had started moving towards conceptual understanding
- Careful to not feel over-confident going into later exams, possibly due to being over-confident on the first exam
- Often relied on technology during their studying to look up key information that they couldn't memorize
- Felt satisfied with their grade even if it was lower than their ideal grade. (i.e. "Cs get degrees")
- Interacted with peers of similar skill level about the course material, but there was no clear indication of group roles
- Relied heavily on vicarious experiences to feel successful in the course
- Used the best guess method to answer questions they did not know the answer to on an exam
- Least likely to seek outside help of instructor or tutor

Highest Performing Students

According to the self-reported data of participants in this study, students with the highest grades were characterized by the following approaches to the exam process:

- Focused on conceptual understanding, how chemistry concepts connected to other courses, and how each topic connected to others presented in the course
- Adapted study strategies based on the types of questions asked on an exam
- Generally had high confidence before and after an exam
- Felt they were successful based on their grade

- Discussed mastering the balance between their chemistry class and other aspects of their lives (i.e. social, work, other classes), in part due to previous mastery experiences (i.e. rigorous high school or college course before General Chemistry I)
- Met with peers to "teach" each other material and used each person's skills to benefit the larger group
- Used problem solving to come to an educated answer on questions to which they did not know the answer

Addressing the Research Questions

(1) How do students think about and approach preparing for an exam?

Not surprisingly, when you sit down and interview a student about the exam process, their primary focus was on preparing for the exam. The students placed their attention on what materials to use out of the large amount of information that has been presented and how to learn the material. Lower performing students seemed to think of learning as memorizing. Higher performing students saw learning as making meaningful connections between the topics presented. Therefore, students who received high grades on exams tended to use higher metacognitive skills and have high self-efficacy during their exam preparation. Also, these higher performing students typically met with peer groups and sought to teach each other the material. Overall, students with similar exam performance used similar techniques to prepare for exams. There were no distinct differences seen in exam preparation between students based on major, gender, or race. Performance was most strongly related to exam preparation.

(2) How do students think about and approach taking an exam?

Students who performed well on exams were most likely to have a routine way of taking the exam. These students were confident in their preparation before the exam and were able to use problem-solving skills to eliminate possible multiple-choice selections when they were not confident of an answer. Lower performing students did not show these high level metacognitive skills during their interviews before or after the exam. They were more likely to minimize their confidence going into an exam because they may have been over-confident on the first exam. Students did not specifically discuss affective states during the exam that could have affected taking the exam. Overall, ascertaining how students approach taking an exam was the most difficult research question to answer because students had the least to say about it in the post-exam interviews.

(3) How do students think about and approach to responding to feedback from an exam?

Students received different feedback depending on who was teaching the course. The honors students received an answer key and were allowed to keep the questions that were on the exam. Therefore, these students were more able to get feedback without seeking out additional information from the instructor. Students in the regular course did not receive an answer key and were not allowed to keep the questions that were on the exam. The students in this course, especially the middle performing students, were the most likely to use their memory as their source of feedback. For example, a student reported sitting down with his textbook and trying to remember what was on the exam. Students who received middle or average grades on the exam were also least likely to seek out additional feedback on an exam. These students described trying to simply remember what was on the exam and looking through their notes to find what

the right answer was. They often cited not knowing where their instructor's office was or when office hours were as reasons to not seek out additional feedback. The lowest performing student and the highest performing students were equally likely to seek out feedback, but for different reasons. Low performing students were typically looking forward to the final, yet did not adapt their study strategies during the semester. They instead cited simply needing "more time" to study the same way before the next exam. Higher performing students sought out feedback to learn how to better prepare for the next exam and were not looking only towards the final. They were more able to adjust and understand what types of questions an instructor would ask and use that knowledge to their advantage when preparing for future exams.

Implications

This study is potentially valuable for current college chemistry instructors. These instructors have a unique opportunity when working with first-year college students who are potential science majors. By further understanding these students and their views of the exam process (i.e. preparing for an exam, taking an exam, and responding to feedback from an exam), we may be better able to assist low and middle performing students in our general chemistry courses. The data from this study shows that students are listening to our lectures to guide their exam preparation. This means we should think carefully about what information we are presenting to students and showing students clearly what information is relevant. One way to show relevant information is to make it clear how the topic being presented connects in a storyline to other topics before it and after it. Also, students are using the textbook provided for the course to also make decisions about preparing for an exam. A clear tutorial of how to use the textbook for a given course may be invaluable for helping students succeed during their first

semester of college. It is also important to make ourselves available to all students. This may mean using the syllabus review at the beginning of the semester with clear goals in mind. If students do not know where our office is, how can we help them? We could possibly send students on an office scavenger hunt for a few extra points or clearly make ourselves available for appointments outside of regular office hours.

Recommendations for Future Work

There are several ways this work could be continued in the future. This exploratory study was designed to characterize the current state of how students view the exam process. This study looked specifically at a General Chemistry I course. This study could be repeated in a longitudinal fashion in a similar chemistry course to look more authentically at how students change their exam process in real-time over the course of a semester. This would potentially mitigate one weakness of this study, which is that a student was asked to talk about their exam process after they had experienced the phenomena. Additionally, data could be collected using open-ended surveys to capture a larger range of experiences by sampling more students. This sample could potentially be more representative of the class as a whole. Future research could also focus on looking at the exam process in other introductory or higher-level science courses. Is the exam process the same in an introductory biology course as it is in a general chemistry course? Do students who are chemistry majors and are enrolled in an organic chemistry course view the exam process differently than these general chemistry students? In summary, this exploratory study attempted to characterize the current state of the exam process in a course that relies heavily on summative exams. The exam process has typically not been viewed through a

qualitative research lens. However, value can be added to current existing quantitative literature with qualitative data.

REFERENCES

Baird, J. R. (1990). Metacognition, purposeful enquiry and conceptual change. In E. Hegarty- Hazel (Ed.), The student laboratory and the science curriculum (pp. 183–200). London: Routledge.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavior change. *Psychological Review, 84,* 191-215

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist, 28*(2), 117-148.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: W.H. Freeman.

Bandura, A., & Schunk, D.H. (1981). Cultivating competence, self-efficacy, and intrinsic interest through proximal self-motivation. *Journal of Personality and Social Psychology, 41*(3), 586-598.

Bercher, D. A. (2012). "Self-Monitoring tools and Student Academic Success: When Perception Matches Reality." Journal of College Science Teaching 41(4): 26-32.

Bodner, G., Oakes, W., Lowery, K., Del Carlo, D., White, S. & Samarapungavan, A. (2001, March). A phenomenographic study of the lived experience of freshman engineering students and their instructors at Purdue University. Paper presented at the annual conference of the National Association for Research in Science Teaching. St Louis, MO.

Campbell, J. L. et al. (2013). "Coding in-depth semistructured interviews: problems of unitization and intercoder reliability and agreement." Sociological Methods & Research 42(3): 294-320.

Case, J. and R. Gunstone (2006). "Metacognitive development: A view beyond cognition." Research in Science Education 36(1-2): 51-67.

Chemers, M.M., Hu, L.-t, & Garcia, B.F. (2001). Academic self-efficacy and first-year college student performance and adjustment. *Journal of Educational Psychology 93*(1), 55-64.

Creswell, J. (2013). Qualitative inquiry and research design: choosing among five approaches. Los Angeles: SAGE Publications.

Dalgety, J., & Coll, R. K. (2006). Exploring first-year students' chemistry self-efficacy. *International Journal of Science and Mathematics Education, 4,* 97-116.

Deslauriers, L., Harris, S., Lane, E., and Wieman, C.E. (2012). "Transforming the lowest-performing students: An intervention that worked." Journal of College Science Teaching. 41(6)L 80-88.

Flavell, J. H. (1976). Metacognitive aspects of problem solving. In L. B. Resnick (Ed.), The nature of intelligence (pp. 231–235). Hillsdale, NJ: Lawrence Erlbaum.

Gagné, R. (1987). Instructional technology: Foundations. Hillsdale, N.J: L. Erlbaum Associates.

Gulacar, O. and C. R. Bowman (2014). "Determining what our students need most: exploring student perceptions and comparing difficulty ratings of students and faculty." Chem. Educ. Res. Pract. **15**(4): 587-593.

Hattie, J. (2009). Visible learning: a synthesis of over 800 meta-analyses relating to achievement. London New York: Routledge.

Jensen, P. A. and J. N. Barron (2014). "Midterm and First-Exam Grades Predict Final Grades in Biology Courses." Journal of College Science Teaching 44(2): 82-89.

Lord, T. (2008). ""Darn it, Professor. Just Tell Us What We Need to Know to Pass Your Course"." Journal of College Science Teaching 37(3): 71-73.

Marton, F. (1986). Phenomenography – A research approach to investigating different understandings of reality. Journal of Thought, 21(3), 28-49.

Marton, F. & Booth, S. (1997). *Learning and Awareness* (Mahwah, NJ: Lawrence Erlbaum).

Mathabethe, K. C. and M. Potgieter (2014). "Metacognitive monitoring and learning gain in foundation chemistry." Chemistry Education Research and Practice 15: 94-104.

Meyer, M. D. E. et al. (2009). "The identity of a "college student": Perceptions of college academics and academic rigor among first-year students." College Student Journal 43(4): 1070-1079.

Milner, R. et al. (2015). "Exploring the use of an online quiz game to provide formative feedback in a large-enrollment, introductory biochemistry course." Journal of College Science Teaching 45(2): 86-97.

Orgill, M. (2007). Phenomenography. In G. Bodner & M. Orgill. *Theoretical frameworks for research in chemistry and science education.* (pp. 132-151). Upper Saddle, NJ: Pearson Prentice Hall.

Pazicni, S. and C. F. Bauer (2014). "Characterizing illusions of competence in introductory chemistry students." Chemistry Education Research and Practice 15(1): 24-34.

Pyett, P. M. (2003). "Validation of Qualitative Research in the “Real World”." Qualitative Health Research 13(8): 1170-1179.

Sandberg, J. (1997). Are Phenomenographic Results Reliable?, Higher Education Research & Development, 16:2, 203-212, DOI: 10.1080/0729436970160207

Scheja, M. (2006). "Delayed understanding and staying in phase: Students' perceptions of their study situation." Higher Education 52(3): 421-445.

Seymour, E. and N. Hewitt (1997). Talking about leaving: Why undergraduates leave the sciences, Westview Press.

Svensson, L. (1997). Theoretical Foundations of Phenomenography, Higher Education Research & Development, 16:2, 159-171, DOI: 10.1080/0729436970160204

APPENDIX: HSIRB Approval

Date: October 6, 2015

To: Megan Grunert Kowalske, Principal Investigator
Angela Willson, Student Investigator for thesis

From: Amy Naugle, Ph.D., Chair

Re: HSIRB Project Number 15-09-24

This letter will serve as confirmation that your research project titled "Understanding College Students' Exam Preparation in a General Chemistry Course" has been **approved** under the **expedited** category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note: This research may **only** be conducted exactly in the form it was approved.
You must seek specific board approval for any changes in this project (e.g., ***you must request a post approval change to enroll subjects beyond the number stated in your application under "Number of subjects you want to complete the study***)." Failure to obtain approval for changes will result in a protocol deviation. In addition, if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

Reapproval of the project is required if it extends beyond the termination date stated below.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: October 5, 2016