RELATIONSHIPS OF APPROACHES TO STUDYING, METACOGNITION, AND INTELLECTUAL DEVELOPMENT OF GENERAL CHEMISTRY STUDENTS

Henrietta N. Egenti, B.S, M.S.

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APPROVED:

Marc Cutright, Major Professor
Diana Mason, Minor Professor
Ron W. Newsom, Committee Member
Janice Holden, Chair of the Department of Counseling and Higher Education
Jerry Thomas, Dean of the College of Education
James D. Meernik, Acting Dean of the Toulouse Graduate School
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This study investigated approaches to studying, intellectual developments, and metacognitive skills of general chemistry students enrolled for the spring 2011 semester at a single campus of a multi-campus community college. The three instruments used were the Approaches and Study Skills Inventory for Students (ASSIST), the Learning Environment Preferences (LEP), and the Executive Process Questionnaire (EPQ). The subjects were 138 students enrolled in either general chemistry 1 or 2. The results revealed that the preferred approach to study was the strategic approach. The intellectual development of the students was predominantly Perry’s position 2 (dualist) in transition to position 3 (multiplicity). Correlation statistics revealed that deep approach to studying is related to effective employment of metacognitive skills. Students with a deep approach to studying were likely to utilize effective metacognitive skills. Students with a surface approach to studying used no metacognitive skills or ineffective metacognitive skills. Multiple logistic regression analysis was conducted to ascertain which of the three variables, namely approaches to studying, ability to metacognate, or level of intellectual development, was the most salient in predicting the success of general chemistry students. No single variable was found to predict students’ success in general chemistry classes; however, a surface approach to studying predisposes general chemistry students to fail. The implication of this study is that students’ study approaches, intellectual developments, and metacognitive skills are requisite information to enable instructional remediation early in the semester.
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CHAPTER I
INTRODUCTION

The equal access nature of the community college has conferred on it a uniqueness that may not be present in other types of institutions of higher learning. Its primary mission is to educate the masses. Regardless of race, gender, ethnicity, socioeconomic status, and the plethora of other differences that students present, a community college education should enable the acquisition of higher order thinking skills. Community colleges are important aspects of higher education, since many students who present themselves at universities and colleges commenced their higher educational career at a community college.

It is important that educational practices at community colleges are rigorous and aligned with the goals of the rest of higher education. The best method for achieving this rigor has been debated by stakeholders in the educational enterprise, and its attainment is intimately related to the aims of a higher education. Should intellectual development be for utilitarian purposes or achieved by exposure to the Great Books? Despite philosophical orientations and what is purported to be the aims of a college education, providing a college education demands that instructors are fully cognizant of the distinctive nature of the student and educate from a view grounded in acknowledgment of individual differences and a phenomenological perspective. To enable students to attain their maximum potential through the development of intellectual abilities, instructors must evaluate their present intellectual abilities. Also, to assist students, instructors must have in addition to knowledge of their epistemological development, pertinent information about their ability to metacognate and how they navigate and orchestrate their studying. This is prerequisite information for any instructor in a college classroom because this information influences every facet of the learning environment, including instructional and
assessment techniques. If instructors do not know where the students are, how are they going to help them reach their destination?

Statement of Problem

Chemistry is a rigorous subject, and success in the subject requires certain skills that students employ while studying. Many students find the subject difficult and fail because of a lack of these skills. These skills enable effective learning that augments instructor behavior in the classroom. Student success in the subject and beyond may be achieved if they employ certain skills during their personal studying. The problem is that students’ intellectual development, their ability to metacognate, and how they approach studying is not known. Knowledge of this will inform instruction.

Purpose of the Study

The purpose of the study is to determine the relationships among the approaches to studying that students employ while studying, the metacognitive skills that students use in their studying, and their level of intellectual development. The focus of the present study was general chemistry students at a community college. Ascertaining these pieces of information will enable the enhancement of instruction to address the areas of student needs. A paucity of research on how students enrolled in general chemistry study and whether these students employ aspects of metacognition during their studying was the motivation for this present study. Of additional interest is the investigation of whether students’ level of intellectual development is related to their approaches to studying and their metacognitive abilities.

Significance of the Study

The availability of incentives to procure a tertiary education has granted opportunities to an unprecedented number of students otherwise unable to attend college. One such incentive is
tuition reimbursement paid by local independent school districts for their recent graduates to attend the local community college. Students should be educated in an environment that nurtures their innate abilities and enhances their ability to function effectively. Effective and efficient functioning in a society that is in flux depends less on rote memorization of facts from the content area but more on the acquired ability to rationalize and deal with complexity. The significance of this study is that it attempts to find the interrelationship among approaches to studying, intellectual development, and metacognition. It is unique in that it is the first study to use the three instruments to investigate the interrelationship among three constructs in the chemistry context. One study that tested the interrelationship of approaches to studying, metacognition, and Perry’s intellectual development that utilized different instruments from those used in the present study was Lonka and Lindblom-Ylanne (1996), who investigated medical and psychological students’ approaches. They found the results inconclusive and proposed that “this study should be considered exploratory” (p. 21).

Other studies have investigated the relationship between approaches to studying and metacognition (Case & Gunstone, 2002; Davidowitz & Rollnick, 2003; Hall, 2001; Pettersen, 2010; Ross, Green, Salisbury-Glennon, & Tollefson, 2006; Spada, Nikcevic, Moneta, & Ireson, 2006; Vermunt, 1996). Some studies investigated the relationship between epistemological or intellectual development and metacognition (Hansen, 1998; Janassen, 2000; Paulsen & Feldman, 2007; Pulmones, 2010). Additional studies focused on the relationship between Perry’s level of intellectual development and approaches to studying (Entwistle & Peterson, 2004; Fang-Zhang & Watkins, 2001; Marton, Hounsell, & Entwistle, 1997).
Research Questions

1. What approaches to studying as measured by the Approaches and Study Skills Inventory for Students (ASSIST) do students enrolled in general chemistry employ?

2. What is the level of intellectual development as measured by the Learning Environment Preferences (LEP) of a sample of students enrolled in general chemistry?

3. Is there a correlation between approaches to studying and metacognition as measured by the Executive Process Questionnaire (EPQ)?

4. Which of the three variables, namely approaches to studying, ability to metacognate, and level of intellectual or epistemological development, is more salient in predicting chemistry success?

The first question was answered by the ASSIST. The third question was answered by the EPQ, and the second was be answered by the LEP, an instrument that measures the Perry’s form of intellectual and ethical schemata. A multiple logistic regression analysis was applied to answer the fourth question.

Research Hypotheses

1. There is a positive relationship between general chemistry students who engage in metacognition during studying and high intellectual development.

2. Deep approach to studying is related to employment of metacognition and intellectual development.
Operational Definitions

Approaches to studying: The strategies and tactics that students employ in their study behavior.

ASSIST: Approaches and Study Skills Inventory for Students. Instrument used to measure student approaches to studying.

Chemistry success: End of course grade of A or B.

Deep approach: Approach to studying that involves seeking meaning, relating ideas, use of evidence, and interest in ideas.

EPQ: Executive Process Questionnaire. Instrument used to measure metacognition

General Chemistry 1: General inorganic chemistry for students majoring in science or science-related fields.

General Chemistry 2: A continuation of general inorganic chemistry 1 for students majoring in science or science-related fields.

Intellectual or epistemological development: The nature of knowledge and how knowledge changes over time.

LEP: Learning Environment Preferences. An instrument that measures the cognitive aspect of Perry’s schemes of intellectual and ethical development.

Metacognition: Knowledge of one’s cognitive processes and ability to monitor, modify, and interpret thinking during learning a task (Flavell, 1976).

Strategic approach: Approach to studying that involves organized studying, time management, monitoring effectiveness, and achievement motivation.

Surface approach: Approach to studying that involves lack of understanding, lack of purpose, syllabus-boundness, and fear of failure.
Limitations

There are several limitations associated with the present study. The first is that the sample is one of convenience: a sample of students enrolled for the semester investigated in a general chemistry class. The second limitation is related to the use of Perry’s form of intellectual and ethical scheme as a determinant of intellectual development in the present sample of students at a community college. The scheme is problematic because it was validated with a Harvard University sample, among mostly male white students from the 1950s. The relevance to present day students and the present sample of a mixed demography is questionable. However, the instrument has been validated in several contexts and has both high reliability and validity. Further limitation to the present study is the impact of demographic and other data. The assumption in the present study is that these do not affect approaches to studying, metacognition, and intellectual or epistemological development. Another limitation is that the course is a required course for a majority of the students and not an elective; hence attitude towards chemistry may not be favorable. This may impact students’ responses to the questionnaire.

Delimitations

The present study is limited to students enrolled in a general chemistry class (general chemistry 1 or 2) at a single community college campus.
CHAPTER II

LITERATURE REVIEW

Effective learning is facilitated when the learner is fully engaged and participating responsibly in the learning process. Irrespective of the instructor’s behavior or role in the learning environment, students must assume responsibility and ownership of their learning. Active learning is not limited to how the instructor structures the learning environment to facilitate active participation but involves active participation outside the classroom. Rogers (1969) asserted that:

Learning is facilitated when the student participates responsibly in the learning process. When he chooses his own directions, helps to discover his own learning resources, formulates own problems, decides his own course of action, lives with the consequences of these choices, then significant learning is maximized. Independence, creativity, and self-reliance are all facilitated when self-criticism and self-evaluation are basic. (p. 162–3)

Metacognitive skills enable the self-criticism and self-evaluation required by students to excel in chemistry courses. Succinctly, metacognition is regarded as knowledge about ones learning and how to monitor it. Flavell (1976) defined metacognition as:

One’s knowledge concerning one’s own cognitive processes and products or anything related to them…to the monitoring and consequent regulation and orchestration of these processes in relationship to the cognitive objects of data on which they bear, usually in the service of some concrete goals or objective. (p. 232)

Also referred to as metamemory, metalearning, and metaattention, metacognition is “cognition about cognition.” Sternberg, Kaufman, and Grigorenko (2008) discussed an aspect of
metacognition referred to as metacomponents. “Metacomponents are the metacognitive or executive processes used in planning, monitoring, evaluating, problem-solving, and performance” (p. 49). A component is a mental process (Sternberg et al., 2008). Of the three types of components, namely metacomponent, performance component, and knowledge acquisition component, metacomponent is the most important. Metacomponent is the most important because it involves higher order processes used in planning, monitoring, and evaluating performance of a task. Performance components are processes used in actually doing the task. Knowledge acquisition components are processes used in learning new things (Sternberg et al., 2008).

Comparatively, Schraw (2001) explicated three types of metacognitive awareness: declarative, procedural, and conditional knowledge. Declarative knowledge is knowledge about the individual as a learner and “what factors influence one’s performance” (p. 4). Procedural knowledge involves knowledge about how to do things, thus it is about “heuristics and strategies” (p. 4). Conditional knowledge is “knowing when and why to use declarative and procedural knowledge. Summarily, metacognition as opposed to cognition, which involves ‘thinking activities that students use to process subject matter’” (Vermunt & Vermetten, 2004, p. 361). Metacognition enables regulation, monitoring, planning, and assessment of ability to accomplish the desired learning outcomes.

Based on the theoretical premise that the methodology of instruction is not the most important aspect of the learning process, the present study asserts that whole and active learning are facilitated by exemplary classroom instruction in conjunction with the approaches to studying that students espouse. The approaches and orientation to studying that students espouse for studying outside the classroom determine how effective maximum acquisition and retention of
content material become. Originating from the memory research of Craik and Lockhart (1972), several approaches to studying have been identified. “They conceptualized memory as the result of successive series of analysis each at a deeper level than the previous one” (Surprenant & Neath, 2009, p. 20). The deeper the level of processing, the better the memory. “Rehearsal then will be beneficial only to the extent that it induces a deeper level of processing” (Surprenant & Neath, 2009, p. 20). Craik and Lockhart (1972) proposed that:

Preliminary stages are concerned with the analysis of such physical or sensory features as lines, angles, brightness, pitch, and loudness, while later stages are more concerned with matching the input against stored abstractions from past learning; that is, later stages are concerned pattern recognition and the extraction of meaning. This conception of a series or hierarchy of processing stages is often referred to as depth of processing where greater depth implies a greater degree of semantic or cognitive analysis. After the stimulus has been recognized, it may undergo further processing by enrichment or elaboration. (p. 675)

In the tradition of levels of processing, Morton and Säljo (1976) introduced the ideas of deep and surface levels of processing. At the surface level of processing, the student has the intent of memorizing the information. In contrast, the deep level involves the intention to understand the material. Morton and Säljo concluded that approaches to studying are a function of both the context and content of the educational process.

Though used interchangeably in numerous research studies, it is important to distinguish the two interrelated constructs-approaches and orientation to studying. From an experiential or phenomenological premise, approach refers to how an individual goes about the learning task. Regardless of which strategies and tactics are employed in study behavior (Schmeck, 1988), any
approach to learning involves a “motive and a strategy” (p.11). An approach is the totality of several factors that determine response to the present. These factors include learning styles, assessment and course demands, and “epistemological beliefs of students, goals, prior experiences, ability, and individual differences in their approaches to learning” (Watters & Watters, 2007, p. 23). Highly dependent on contextual and course demands, approach is a complex construct with elements of both consistency and variability (Entwistle, 2000). Albeit, approaches to studying may be low in consistency and amenable to change, some students are consistent in adaptation of certain approaches to their studying at the exclusion of other approaches.

Concomitantly, orientation to studying and approaches to studying are descriptive of how students tackle their studying, but in terms of stability, orientation is purported to be a more stable construct (Entwistle, Hanley, & Hounsell, 1979). Its stability is due to the fact that it is a more general descriptor of how students study; it encompasses approaches to studying, the type of motivation involved including learning styles and study skills. For instance, a meaning orientation would involve a deep approach, with an intrinsic type of motivation. These students thrive in learning and teaching environments that permit student exploration and use of any resources and strategies to gain a thorough understanding of the concepts. In personal studying, these students attempt to understand the concept by relating it to related ideas. A reproducing orientation involves a surface approach and extrinsic motivation with a preference for a highly structured learning and teaching environment. These students are anxious and syllabus-bound (Entwistle, Hanley, & Hounsell, 1979). They study facts in isolation without the explicit intention of understanding. They often resort to memorization as the strategy of choice. If it is not mentioned by the instructor, these students do not attend to it. An achieving orientation
involves a strategic approach motivated by the overwhelming need to gain the highest grade possible regardless of comprehension. These students are spuriously regarded as the model student. They are extrinsically motivated to achieve. Psychologically, these students are obsessive in their attempt to succeed. The problem is that these students are not focused on understanding the material. They are focused on externally defined criteria that are likely to preclude understanding. They are slick learners and highly in-tuned to assessment and instructor demands. Their intention is not to understand the material but to “impress staff” (Ramsden, 1997, p. 23). Ramsden (1997) identified a fourth orientation that he described as the non-academic orientation. Students under this orientation are plagued by ineffective study skills and lack of motivation. There is a disconnect between the course and student life. These students pose a challenge to the astute instructor who must determine how best to engage the student.

Any description of each of the approaches to studying must distinguish style from strategy. The strategy that a student employs to study implies a choice; to “tackle a specific learning task in the light of its perceived demands and style is a broad characterization of a student’s preferred way of tackling learning tasks generally” (Entwistle, Hanley, & Hounsell, 1979, p. 368). The implication of the distinction between strategy and style is that style is durable while strategy is more amenable to change, prone to variability, and dependent on the learning task. Pask (1976) developed two learning styles referred to as holist and serialist based on the strategies used during studying. Eventually, Entwistle and McCune (2004) developed Approaches and Study Skills Inventory for Students (ASSIST), the instrument that was used to ascertain the study approaches of the students in the present study.

The caveat with orientation or approaches to studying is the proclivity to regard the construct as stable in all individuals and in all contexts. Although stability and generalizability
have been authenticated and validated under varying conditions, students possess unique attributes that elicit differential contextual reactions. Laurillard (1979) is of the opinion that students should not be rigidly allotted to fixed categories or orientations but rather studied in terms of response to particular learning environment. She proposes that approaches or orientation are more dependent on course demands and student perception of what course demands are required. Similarly, Long (2003) in a cluster analysis of responses to the ASSIST found that students reported “using aspects of both study approaches together” (p. 24). He referred to it as study approach dissonance. The study was composed of 4,138 students from various disciplines including English, sociology, law, business studies, medicine, nursing, economics, biology, and teacher training. It was only in the highest and lowest academically accomplished students was there distinction between approaches. He found low academically performing students were disproportionally utilizing surface approaches to studying. Other students exhibited what he referred to as adaptive methods in studying. He asserted that aberrant study methods were not dependent on the discipline or year of study but on idiosyncratic response to the learning environment.

Approaches to studying have been the focus of many research studies, but those approaches have not been the subject of many studies in the sciences, especially chemistry. The paucity of studies of approaches to studying of science students is one of the impetuses for the present study. The findings from previous studies of approaches to studying of science students are discussed. Laurillard (1979) conducted her research with science students and posited that although there is a distinction in the approaches to studying, learning is a context-driven endeavor. Zeegers and Martin (2001) studying first-year chemistry students corroborated with Laurillard that perception of the task and assessment demands influence students’ approach to
studying. They theorized that approach to studying “is amenable to change and that students can be taught to adopt those approaches that are thought to lead to success, that is a deep approach” (p. 37). Similarly, Walker et al. (2010), who used the ASSIST with 705 first year health science students, examined the effect of curriculum change on adaptation of deep approach to studying.

Antithetically, Reid, Duval, and Evans (2005), in a study of Year 1 medical students at the University of Edinburgh found that, although students scored high on deep and strategic approaches and low on surface approach, there was no “increase in deep approach during Year 2, in fact there tended to be a slight falling off in both deep and strategic scores” (p. 404). In that study, effort was made to promote deep approach and discourage surface approach during Year 2, but it was found to be rather ineffective.

Chin and Brown (2000) conducted their qualitative research aimed at the characteristic of deep and surface approaches adopted by eighth-grade science students and found that students engaging in deep approach “gave more elaborate explanations which described mechanisms and cause-effect relationships or referred to personal experiences; asked questions which focused on explanations and causes, predictions, or resolving discrepancies in knowledge and engaged in on-line theorizing” (p. 109). Conversely, “students using a surface approach gave explanations that were reformulation of the questions, a black box variety, which did not refer to mechanism of macroscopic description which referred only to what was visible, basic factual or procedural information” (p. 109). Watters and Watters (2007) conducted research in a biological context and found that undergraduate biology students were surface learners motivated by desire to pass exams and acquire information by rote memorization. Zeegers (2001), in a longitudinal study of first-year chemistry students at an Australian University, found that they were predominately utilizing surface approach due to a perception that science learning involves the accumulation of
factual information. Kelly (2005) conducted a study of chemistry laboratory students and found predominant use of surface approach. Minasian-Batmanian, Lingard, and Prosser (2006) in a study of biochemistry students found that 83% of students were using the surface approach to studying. Kreber (2003), in a study of 1080 undergraduate science students, found that heavy workload and inappropriate assessment encouraged surface approach. Additionally, they corroborated Richardson (1994) that age is a predictor of deep approach. Mature students are more likely to utilize deep approach, while younger students are likely to espouse a surface approach.

Investigating the theory that students adjust their approach according to perceived nature of the subject matter, Laird and colleagues (2008) in a study of 80,000 seniors and 10,000 faculty members found that discipline does make a difference in approach. This is in contrast to Long (2003) above. They found that according to Biglan category of disciplinary areas, students majoring in the soft fields such as accounting, sociology, psychology, political science, etc., were predisposed to deep approach compared to those majoring in the hard fields such as chemistry, mathematics, physics, etc. Further results from this study indicated that faculty across disciplines promoted deep approaches, and it was found that the seniors who engaged in deep approach to learning reported more satisfaction with college life. The findings of this study contrast the findings of Byrne and colleagues (2010), who found that science students had higher scores on the deep approach compared to the accounting students. Additionally, they found that the science students had a higher score on the surface approach than the accounting students, corroborating Zeegers (2001).

Despite the dearth of science-related studies, the approaches to studying of college students have been the subject of a plethora of research studies in non-science fields. It is
customary to authenticate the reliability and validity of an instrument used in a study. The purpose of this part of the review of literature is to verify the validity and reliability of the instrument that will be used in the present study to measure the approaches of studying of college students. Numerous studies have validated the ASSIST in different contexts and countries (Entwistle, Tait, & McCune, 1998, 2000). The original validation study was conducted by the creators Entwistle and colleagues (2000) and used three samples of students from Scottish and English universities and from a historically disadvantaged South African university. No major differences were found between the African students and the Western European sample. The instrument possesses high cross-cultural consistency. Using maximum likelihood exploratory factor analysis, three approaches were determined with intention, motivation, and strategic dimensions to each approach. Table 1 illustrates the relationship between the approaches and their various dimensions.

Table 1

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<th>Approach</th>
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<th>Motivation</th>
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<td>Deep</td>
<td>Understanding</td>
<td>Interest</td>
<td>Operation/Comprehension</td>
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<td>Vocational relevance</td>
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<td>Surface</td>
<td>Reproduce</td>
<td>Fear of failure</td>
<td>Rote learning</td>
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<td>Completion of course</td>
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<td>Strategic</td>
<td>Academic success</td>
<td>Achievement</td>
<td>Operation/Comprehension/ Rote Learning</td>
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<td>Competition</td>
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Originating from the naturalistic experiments of Marton and Säljö (1976), the ASSIST, which is the last in a group of inventories, and its many related inventories such as Approaches
to Studying Inventory (ASI; Entwistle & Ramsden, 1983), Revised Approaches to Studying Inventory (RASI; Entwistle & Tait, 1995), Study Process Questionnaire (SPQ; Biggs, 1993), and its Revised Study Process Questionnaire (R-SPQ; Biggs, Kember, & Leung, 2001) have been formulated to measure student learning in higher education and how they orchestrate their studying. Speth, Namuth, and Lee (2007) noted that the 2000 version of the ASSIST differs from the ASI in that the Strategic Scale on the ASSIST includes an aspect of metacognition and self-regulation. In their study a sample size of 446 students (230 males, 216 females) enrolled in agricultural science courses using lessons from the Library on Crop Technology was used. Reliability coefficient measured by Cronbach’s $\alpha$ indicated a 0.65 for the deep approach, 0.70 for the strategic and 0.75 for the surface. The range for other studies from various countries and with different versions of the ASI was between $\alpha = 0.59$ and $\alpha = 0.83$. A unique feature of this study was that, whereas it is not the norm to include student commentary as part of data analysis in quantitative research, in this study, students were allowed to comment on their personal method of studying. This aspect of qualitative analysis added richness usually missing from most quantitative methodologies to the study. The results of the quantitative analysis and comments of students were indicative of the reliability and validity of the ASSIST. The researchers stated and provided a rationale for the selection of factor analysis and specifically the use of maximum likelihood factor analysis. However, the study had several limitations: First, there was the use of a convenience sample rather than a random sample and the problem of self-reporting of an instrument. These issues may pose some problem if generalizability of the study is a goal of the research. A concern of using this particular instrument is that it might be differentially interpreted since it was created in Britain using British English rather than American English. The researchers cognizant of this changed the word “tutor” to “instructor”
and “marks” to “grades.” This resolved an area of concern regarding the proposed use of the ASSIST for the present study of whether the instrument could be utilized as it is without modification to an American context without compromising validity or reliability.

Another validation study was conducted by Diseth (2001). The significance of this study is that it validated the ASSIST in a different context thereby authenticating it as a valid and reliable instrument because it was able to produce the same results in different contexts. A sample size of 573 (397 females and 169 males) was used in the study with data analyzed by confirmatory factor analysis in addition to exploratory factor analysis. The sample was divided into two; exploratory factor analysis done on the first sample, and Sample 2 was used to cross-validate the factor solution from Sample 1. The data were further subjected to structural equation modeling which confirmed the findings. Diseth (2001) is pertinent to the present study because the anticipated small sample size makes the possibility of an exploratory study infeasible or not practical. Informed of the construct validity of the ASSIST, confirmatory analysis of data collected from the students enrolled in the general chemistry class may suffice.

Further cross-cultural and cross-discipline validations were provided by Byrne, Flood, and Willis (2004). Data were collected from 298 U.S. accounting students and 437 Irish accounting students. Factor analysis with maximum likelihood extraction was used, and the Cronbach alpha ranged from 0.80 to 0.87 for the U.S. sample and 0.83 to 0.87 for the Irish sample, which indicated high internal consistency. One of the limitations of the ASSIST is that it “measures the broad learning approaches of a group of students, but it fails to fully capture the complexity of individualized ways of learning and studying” (p. 455). Byrne and colleagues recommended qualitative in addition to quantitative to thoroughly investigate the theoretical assumption. The authors did not provide the opportunity for a qualitative investigation. Another
limitation was that some of the subscales of the ASSIST did not load as expected; the problematic areas were alertness to assessment demands and monitoring effectiveness. Despite these shortcomings, the findings indicated that the ASSIST is a valid and reliable instrument for measuring student approaches to studying. Byrne, Flood, and Willis (2009) replicated their previous study of U.S. and Irish accounting students using the ASSIST. Rather than a validation of the ASSIST, the purpose of this study was to determine whether the culture of a particular institution influenced the study orientation or approach. The sample size was comprised of 204 U.S. and 309 Irish students. As previously asserted by Ramsden (2003), there are several factors that inform student approach to studying; these include academic ability, prior learning experiences, and cultural context. The culture of the Irish University is one of teacher-centered, large group lectures (with up to 2,000 students). Information transmission is the main mode of interaction. Students are passive, and, even when given opportunities for small group interactions during tutorials conducted by tutors/instructors, they are still in the mode of information recipients. This type of environment has been found to be associated with development of surface approach. In contrast, the U.S. university students were in smaller classes of no more than 40 students. These students were more engaged and more interactive during lectures. Another notable difference between the two samples was the assessment techniques that were prevalent at each institution. While the assessment technique of Irish students involved a single assignment and formal terminal examination, which was 80% of the course grade, the U.S. students were evaluated by continuous assessment of several tests and assignments. Using the Mann-Whitney U test, they found that both samples preferred the strategic approach over the deep or surface approach. They had posited that the more supportive U.S. environment would encourage deep approach. The significance of the study is that it
informed the present study in terms of the institutional culture. Would the teaching and learning, and student-centered environment of the community college impact the approach to study of students?

Further validation was conducted by Valadas, Gonçalves, and Faísca (2010) in a Portuguese context. This validation study is significant because it recognized the area of study as an influential factor in the type of approach a student espouses. A sample size of 566 students (218 males and 348 females) aged between 18 and 48 years, with a mean age of 22.29 years, from different areas: humanities and social sciences, natural, physical, and technological sciences. The division according to discipline was humanities and social sciences (45.76%) and natural, physical, and technological sciences (54.24%). Principal component axis factor analysis was used to analyze the data. The results indicate that the ASSIST is a reliable and valid instrument for measuring approaches to Portuguese student studying. However, there were several limitations of the study. They proposed that qualitative and quantitative research methodologies are necessitated for a thorough understanding of a construct, especially as it pertains to individual student studying, but no attempt was made to incorporate elements of qualitative research methodology. Albeit statistical significance was attained, it was noted that the sample was not representative of the population. The statistical significance was probably obtained as a result of the large sample size. This means that generalizability should be done with caution and alertness to individual differences inherent in students of higher education. Also, the study was inconclusive regarding the connection between approach to studying and the discipline or subject area.

Several research studies investigated the relationship between approaches to studying and metacognition. Vermunt (1996), using phenomenographic analysis, had proposed that students
differ in how they process information and study. Metacognition enables approaches that are active, self-directed, and constructive. The role of the instructor must be congruent with the transformational nature of metacognition. Spada and colleagues (2006) based their study on the theoretical premise that test-anxious individuals adopt a surface approach and that test anxiety is due to “general maladaptive metacognitive beliefs, in particular beliefs that anxiety and worrying are uncontrollable and dangerous as opposed to beliefs that concern the examination situation” (p. 616). Utilizing structural equation modeling, they concluded that the reduction of test anxiety prevents students from resorting to surface approach and depends on metacognitive intervention. The limitations of the study were that the use of the structural equation connotes causation, the sample size of 109 students (79 females and 30 males), and self-report of the instruments. These issues permit generalizability with caution.

Similarly, Ross and colleagues (2006) utilized an experimental design to investigate whether students adjusted their study approach to align with the cognitive demands of the exam. Item type and cognitive complexity were controlled since previous studies had found that students assumed that essay questions demanded deep-level processing and multiple choice demanded surface-level processing, despite the fact that well written multiple-choice items can demand higher order cognitive skills, and ill-written essay items can demand lower order cognitive skills. The limitations of the study were the disproportionate use of females (74% versus 26% male), students were told the type of cognitive processing the exam items demanded, and the experimental design introduced problems of ecological validity. Additionally, the use of MANOVA, ANOVA, and MANCOVA without the explicit statement of whether the assumptions of these tests were met means that generalizability was compromised. The conclusion from this study was that students adjusted their study approach to align with
examination demand. The implication is that it is imperative that exam and assignment demands are made explicit to students.

Another study that found that, despite claims to the contrary, study approaches are amenable to change, as in the investigation by Case and Gunstone (2002). Who found that metacognition and study approaches are related. The study was conducted with students enrolled in a chemical engineering course; the theoretical basis of the study was that orientations or approaches to study are changeable and contextual, and all aspects of the learning environment impact the approach selected, including teaching, assessment, and curriculum. The research methodology was qualitative in nature with purposeful sampling of 11 students. For a qualitative study, purposeful sampling and sample size are not problematic, but the generalizability is seriously jeopardized. However, qualitative studies can provide salient information on constructs if vast amounts of data from various sources are collected. This study involved interviews and student self-reflective journals. Self-selected groups were used, which in a country such as South Africa (where the study was conducted) is usually homogenous in terms of race, social background, quality of prior education. The researchers were of the opinion that these factors did not adversely affect the outcome of the study. Data analysis involved coding and use of the NUD*IST software package. Attempt at triangulation was made to validate the study. One of the findings from this study was that risk-taking (which is necessary for metacognition) is precluded in “time-pressed assessment” (p. 466). Conceptual shift is difficult, and students tend to resist change from surface to deep conceptual reasoning because it requires major cognitive shifts to metacognitive skills. It is necessary and the responsibility of the instructor to structure the learning environment to allow students to develop the metacognitive skills needed to succeed in tertiary science courses.
Studies that promote the development of metacognition in the college classroom regard it as a transforming agent. Several studies investigated development of metacognition to enhance student learning. Using a sample of 35 students and semi-structured interviews, Romainville (1994) concluded that metacognition promoted academic achievement. Also McAlpine, Weston, Beauchamp, Wiseman, and Beauchamp (1999) proposed that development of metacognition in students is intricately connected to instructor metacognition. The study was conducted with six professors as they planned instruction and evaluated students. Based on their model of reflection, they gleaned ideas about how experts metacognate, which is pertinent to models of reflection of students. Despite the sample size and the fact that the study was done with instructors rather than students, the study is salient in the development of metacognition. Along the lines of expert versus novice in terms of metacognitive reflection, Janssen (1996) used the term *studax* to describe the student who: (a) demonstrates a high degree of metacognition skills, (b) is a deep-level processor, (c) is intrinsically motivated, and (d) is able to adjust studying to align with course or examination demands. Succinctly, they are expert students. The article was a description of the theory of studaxology and was comprehensive in its theoretical grounding of the term and description of the concept in attainable terms. Grossman (2009) recognized that students must be availed of metacognitive skills that will enable them to function as expert learners rather than novice learners. Metacognitive reflection as a means of enhancing learning was the focus of Masui and De Corte’s 1999 study. With a sample of 141 freshmen business economic students, they concluded that it was possible and beneficial to overtly train students in the art of metacognition. They found enhanced academic performance. The limitation of the study is that ecological validity cannot be granted.
Coutinho (2008) found that metacognition development is crucial for academically weak students. It is imperative that metacognitive instruction is part of an active learning model. The goal of chemistry instruction is to use an active learning and a reflection model. Downing, Kwong, Chan, Lam, and Downing (2009) investigated the use of problem-based learning and the development of metacognition. Problem-based learning (PBL) requires student engagement in the learning environment, and the ability to solve problems requires development of metacognitive skills. To solve chemical problems without metacognition makes problem-based learning difficult. The study distinguished cognitive from metacognitive; cognitive involves content specific information, whereas metacognitive is procedural in nature. Metacognition was measured with the Learning and Study Strategies Inventory (LASSI), an instrument developed by Weinstein and Palmer (2002) at The University of Texas at Austin. The sample size of 66 was divided into two groups, A and B. There were 33 students in each group, and students were assigned either into the PBL group or the non-PBL group. The seven-jump approach (Vermunt, 2007) was used for the PBL group and the traditional approach for the non-PBL group. The test used for analysis was the Wilcoxon signed ranks; mean scores were collected and tabulated for the two groups. Findings demonstrated that the PBL group was more confident and less anxious about study at the university. The gains made by the PBL group could be as a result of the nature of the PBL, in which students are supported through the process. Some of the limitations of the study include the sample size, use of foreign students (Hong Kong), problems of experimental design (which, in this case, the longitudinal nature of study may have resolved), and lack of statement describing why the Wilcoxon test was used.

Vos and De Graaff (2004) also described the development of metacognition in the context of active learning in engineering (ALE). They distinguished between PBL and project-
organized learning (POL). The commonality between the two aspects of active learning is that reflection, which is part of metacognition, may involve cognitive dissonance and trepidation for students. Hmelo-Silver (2004) also focused on PBL, especially the relationship to metacognition and the ability of metacognition to facilitate the development of intrinsic motivation. While not a research study, this article provided a comprehensive description of all facets of PBL and proposed that research is needed to realize the potentials inherent in PBL. PBL necessitates use of metacognitive skills to develop self-directed and lifelong learning skills. This corroborates Cornford (2002), who had postulated that the development of life-long learning required the teaching of metacognition in conjunction with the subject matter rather than isolated from the content area.

Similarly, Elen and Lowyck (1998) had suggested further study to investigate instructional metacognition after they had used a sample of 488 to conduct a survey of university freshmen and their response to instructional metacognition. Awareness of metacognitive skills is not sufficient for the transformational change that metacognition has the capability to achieve. Practice and use in teaching will reinforce students’ efforts to metacognate. Hammouri (2003) investigated the role of cognitive/metacognitive processes in the use of holistic/analytic strategies in solving mathematic problems. The mixed method approach was used. The qualitative aspect of the study involved journals, audio-tapes, and interviews, whereas the quantitative method involved the use of regression analysis. Sample size for the study was 178 (89.9%) females. They concluded that the lack of ability to metacognate hinders effective problem-solving and the ability to apply holistic/analytic strategies to problem-solving. The limitations of the study were that the sample was predominately female and the country of origin
was Jordan. Cultural bias may compromise generalizability. Also, in an attempt validate the study, the mixed method approach was utilized without explanation of the rationale for its use. The relationship of metacognition and problem-solving was also investigated by Deed (2009) who proposed that metacognition can be developed by the use of a specific type of question, the strategic question. This is the type of question that enables students to metacognate effectively and efficiently. They “provide a basis for critical consideration of how students strategize their learning” (p. 482). A qualitative method of case study was used with a sample of 200 students. This posed a limitation on the study because of the possible introduction of elements of bias in the research design.

Are there subject-related benefits of metacognitive instruction? In chemistry, Rickey and Stacy (2000) used metacognition to develop the Model Observe Reflect Explain (MORE) thinking frame. Davidowitz and Rollnick (2003) developed the Competency Tripod based on metacognition and used it in conjunction with the flow diagram. Four students were used in the study, and they concluded that “metacognition is a prerequisite for deep approach” (p. 47). Novak (1990) found that the use of two metacognitive tools (e.g., concept maps and Vee diagrams) facilitated meaningful learning. Yet the ability to use these tools requires instruction on how to metacognitively draw concept maps and Vee diagrams. Ivanitskaya, Clark, Montgomery, and Primeau (2002) posited that interdisciplinary studies promote acquisition of metacognitive skills that may transfer to other situations. The above studies promoted the idea that effective teaching requires the incorporation of metacognition skills within the curriculum design. Instructors possess expert metacognitive skills, and they have a responsibility to model metacognition for their students, in addition to making a concerted effort to use metacognitive strategies in their instruction. However, because transformational change presents difficulties
and frustration for students who are entrenched in the traditional and possibly safer methods of studying, proceeding with caution is advisable until students are competent and able to self-direct their learning. Be prepared for resistance and even hostility as students adjust.

One of the purposes of higher education is the development of students as life-long learners who are able to function effectively in society as a result of their exposure to higher education. The college experience and its contribution to the development of the student should be significant. Perry’s *Forms of Intellectual and Ethical Development in the College Years: A Scheme* (1970) assumes that college freshmen have a dualistic view of science. All problems are solvable, and textbooks have all the rights answers. The student’s responsibility is to find the right answer and reproduce it. This is reminiscent of the surface approach to studying. The surface approach contradicts what higher education hopes to accomplish in its graduates.

Moving students through the positions of the scheme from basic duality to developing commitments is a daunting task. One that is arduous and replete of inconsistencies, uncertainties, frustration, and ambiguity. Perry (1970) used words such as *retreat, escape,* and *temporizing* to describe the frustration and dilemma experienced by students but which are necessary for growth. Unfortunately, for some students attrition becomes an option. To enable student progress and persistence, instructors must evaluate student approach to studying and implement changes in instructional and curriculum designs that will enable students to attain contextual relativism or beyond, the point at which metacognition begins (Marra, 2005).

Perry’s positions are grounded in epistemology, which is defined as the origins, foundations, limits, and validity of knowledge. Epistemological development or intellectual development describes one’s beliefs about knowledge and truth and how these beliefs change over time (Hofer & Pintrich, 1997). Perry’s (1999) nine positions are categorized into three broad areas of
sequential development – dualism, relativism, and commitment in relativism. Each of the broad areas is composed of three positions. Dualism is composed of Positions 1, 2, and 3. At Position 1, which is termed basic duality, students believe that there are absolutes and that those in authorities possess the correct answers to the absolutes. Knowledge structure is good or bad, right or wrong, us or them. Persons in authority such as instructors have the correct answers to the facts and are supposed to transmit these to students. Students resist any attempt to venture beyond the prescribed lesson or contemplate the possibility of multiple solutions to problems. At Position 2, which is termed multiplicity pre-legitimate, to the student, knowledge is still right or wrong and instructors are still the source of knowledge. Ideas about multiplicity are entertained but not as legitimate. Attempts at multiplicity by the instructor are viewed by the student as a stratagem to allow discovery of the right answer. At Position 3, which is termed multiplicity subordinate, knowledge is still right or wrong, but some knowledge is unknown transiently. The instructor is still the source of knowledge or how to find it. This position culminates the dualism category by students gaining awareness of diversity or uncertainty.

At Position 4, which is termed multiplicity correlate or relativism subordinate, students believe that some knowledge is right or wrong, and some are not known yet. Subjectivity is introduced because “any has a right to his own opinion.” Authorities may not have all the answers but they provide a way to think. At Position 5 (relativism correlate, competing, or diffuse), to the student, most knowledge is contextual and relativistic. This is the most dramatic shift from dualism. Marra (2005) asserts that “students learn methods and criteria of their discipline, metacognition begins” (p. 138). Students assume responsibility for their learning and understanding. At the final stage of this position-relativism diffuse, there are no absolutes and
authority depends on evidence. At Position 6 (commitment foreseen), knowledge is relative, “contingent on context,” and not absolute. Commitment to certain values is deemed necessary.

The third category, commitment in relativism, encompasses Positions 7 to 9. At these positions, knowledge is not absolute, and there are no authorities. In an environment of competing choices, one must function in such an environment cognizant of these multi-valid values, but commit to certain values. A sense of identity is developed. “The teacher is neither the authority on the subject nor personal friend during this process, but rather a more experienced fellow worker, or mentor” (Bizzell, 1984, p. 448). Implicit in Perry’s position is the fact that a college education should enable the epistemological development of individuals who can engage in higher order critical thinking skills and are able to reflectively arrive at valid conclusions.

Perry’s scheme has received criticisms from its inception to the present day, but regardless, it has been instrumental in the critical study of college students. The most deleterious criticisms have been that the scheme suffers from gender bias, lack of cross-cultural validation, and relevance to the present population of students. This is because the original sample used to develop the instrument, the Check-list of Educational Values (CLEV), that informed the scheme predominantly consisted of white males from an elite research institution. Additionally, the sample that was used to validate the scheme was of similar demography; the validating sample was randomly selected and comprised of 109 first-year Harvard students (85 men and 24 women) of the entering classes of 1958-1959 and 1959-1960. These students were followed during these 4 years of college. Of the 24 women, only 2 were used in the final study; the other 22 were not used. Belenky, Clinchy, Goldberger, and Tarule (1986), who used an all female sample, proposed that while Perry’s scheme could be adapted to females, it did not capture their true voice. Baxter-Magolda (1992), who used a sample of both male and female participants,
found that certain epistemological developmental traits were not gender-specific, but that there were gender-related reasoning patterns. The important caveat here is that rather than the simple dichotomy of gender differences, the focus should be on generalized individual differences.

While the significance of Perry is indisputable, studies that challenge its basic assumptions are to be evaluated with the view that they add to the conversation of intellectual development. In view of its limitations, especially as it applies to cross-cultural sample, it is imperative that it is validated in other contexts and with other student populations. This is the explicit rationale for the use of Perry’s scheme in the present study. It may be the assumption that community college students may be dualist; therefore, cognizance of this information could inform teaching and curriculum development at the community college level.

Additionally, chemistry is perceived as a dualist subject. The perception is probably because of the structure of textbooks and the methodology of instruction employed by most instructors. However, experts in the field perceive the subject as non-dualistic. To corroborate the hypothesis that motivates the present study is that Perry (1970) found that science students tended to score lower on the scheme. So maybe one of the purposes of chemistry instruction is to move students along on the scheme and not allow students to regress in the sciences. It has been found that some students are high on the scheme in some subjects but lower on the sciences. For example, a student may be on Position 4 in an English class but Position 2 in a science class. For the reasons stated above, Finster (1991) proposed that “the main challenge is to slowly remove the veil of simplicity from their image of science by introducing multiple perspectives in science and eliminating science as authority” (p. 755).

Methodology of teaching should present chemistry as a process. Community colleges are indispensable parts of higher education because many students enrolled in universities and
colleges may have commenced their higher education at a community college. It becomes imperative that educational practices at these institutions be rigorous and aligned with the goals of the rest of higher education.
CHAPTER III

RESEARCH METHOD

Materials and Procedure

The research method is quantitative in nature. Data collection was conducted in the spring 2011 semester. The three instruments were administered to students enrolled in the General Chemistry 1 and 2 classes, also known as General Chemistry 1411 and 1412, respectively. The following is a description of the three instruments in terms of their reliability and validity.

The first instrument that measured approaches to studying of the general chemistry student was the Approaches and Study Skills Inventory for Students (ASSIST). The instrument has four sections. The first section consists of 6 items that measures what learning means to students. This is a measure of their epistemological stance. The second section measures their approaches to learning; it consists of 52 items. Students were instructed to answer the questions using a 5-point Likert scale (5, agree; 1, disagree). They were instructed not to use 3 (i.e., unsure) unless they really had to or if it did not apply to them or the course. The third section consists of 8 items that measure preferences for different types of course and teaching. The fourth section asks students to assess their overall work thus far, including past grades on a scale from 9 (very well) to 1 (rather badly). The reliability of the ASSIST as determined by several studies described above had yielded a Cronbach’s coefficient alpha, $\alpha = .59 - .87$. It has been validated by several studies and found to be a valid measure of the approaches to studying of students.

The second instrument utilized to measure the metacognitive activities of students was the Executive Process Questionnaire (EPQ). The advantage of this measure was that it was
developed specifically to measure the metacognition of college students by Hall (1994). It is a 40-item self-rated measure. It includes planning strategies, effort expended, inconsistency between plans and behaviors, metacognitive applications, and the impact and control of external variables. The internal consistency was determined to yield a Cronbach \( \alpha = .72 \). Test–retest reliability was determined to yield high reliability. A strong coefficient of determination between the first and second testing, \( r = .80 \) (Hall, 2005). EPQ may help identify areas of weakness in ability to go beyond the early stages of learning. It is an extremely useful instrument that may provide information that will enable students to become more effective learners.

The instrument that was utilized to measure the intellectual or epistemological development of the students is the LEP. According to Moore (1989):

The LEP focuses on the four positions of the Perry scheme most directly salient to a higher education population across five specific domains related to epistemology and approaches to learning: (a) view of knowledge and course content, (b) role of the instructor, (c) role of the student and peers in the classroom, (d) the classroom atmosphere, and (e) the role of evaluation. (p. 506)

Position 1 is ignored in the LEP because it is irrelevant to college students. So the LEP measured Positions 2 to 5, which are the intellectual portions of the Perry scheme. The internal consistency of the LEP was found by several studies to have Cronbach’s alpha for Position 2, .81; Position 3, .72; Position 4, .84; and Position 5, .84. The test-retest reliability is high as .89. The instrument consists of 65 items with 13 specific statements on each domain, ranging from the least complex items to a mixture of more complex items. By all indications, the LEP is an
accurate and reliable measure of Perry’s positions of intellectual development of college students.

Research Questions

1. What approaches to studying do students enrolled in general chemistry employ?
2. What is the level of intellectual development of a sample of students enrolled in general chemistry?
3. Is there a correlation between approaches to studying and ability to metacognate?
4. Which of the three variables, namely approaches to studying, ability to metacognate, and level of intellectual development, is more salient in predicting chemistry success?

The first and second questions were answered by descriptive statistics, the third by Pearson Product Moment Correlation and the last question was answered by multiple logistic regression analysis to determine the salient predictor of chemistry success among the three variables investigated. Since the use of the three instruments above yielded continuous scores, the product moment correlation, r, was used to determine the degree of relationship between the three constructs. The obtained data were analyzed by using SPSS.

Participants

The starting sample of students utilized for the study consisted of (N = 150), but ended with (N = 138) students-registered for General Chemistry 1411 and 1412 at a community college. The rationale for selection of this sample was that there is an underlying assumption that these students typify students enrolled in a general chemistry classes. The general chemistry classes at this campus were taught with the rigor of an equivalent class at a 4-year college or university). The sample was comprised of students whose declared majors were science-related fields such as medicine, dentistry, physical therapy, engineering, etc. The course description is
that it is chemistry for science majors. Some of the students have acquired degrees in other fields but have the aspiration of admission into science or health-related fields. Some of the students in the sample were of the traditional college age, but some were of the non-traditional age that were already in the workforce and have returned to college in pursuance of a second career. Most of the students in the sample were transfer students. Many were concurrently registered and attending college at a 4-year college or university but chose to take the chemistry class and transfer it to the institution from where they expected to acquire their degree. Also, it is more convenient to take a course close to home. Albeit the sample is one of convenience, but based on the description of the students in the sample, this study may find generalizability to other contexts in higher education.
CHAPTER IV
RESULTS

Summary of Research and Instruments

The three instruments used to collect the data for the present study were the Approaches and Study Skills Inventory for Students (ASSIST), Executive Process Questionnaire (EPQ), and Learning Environment Preferences (LEP). The ASSIST is a 52-item instrument consisting of four sections; in the present study, it measures the approaches to studying that students employ during studying, especially as it is relevant to their study of general chemistry. The second instrument is the EPQ, which is used to measure college students’ metacognitive activities during studying. The 40-item instrument includes aspects of study behavior such as planning strategies, effort expended, inconsistency between plans and actual behaviors, metacognitive applications, and the impact and control of external variables. The third instrument, the LEP based on Perry’s (1970) scheme of intellectual development, is a 65-item instrument that measures the intellectual development of college students. It is a measure of how students view knowledge and how this epistemological stance influences their acquisition of information. All three instruments were assessed for reliability and ascertained to be reliable and valid measures of what they purport to measure. The reliability coefficient as measured by Cronbach’s alpha corresponds to those obtained in previous research studies that utilized the three instruments.

Descriptive Analyses

The sample for the present study was students registered for General Chemistry 1411 and 1412 during the Spring 2011 semester plus a few students from the same courses during the Summer 2011 semester at one campus of a community college. The starting sample was \( N = 150 \), but the ending sample was \( N = 138 \). The age of the participants ranged from 17 years to 44 years, with an average age of 23.81 \( (SD = 5.39) \). The descriptive statistics of the
other demographic data are as follows. Of the sample a majority of the students were male (56.5%). Only one student indicated another institution other than the particular community college campus (0.7%). Under faculty, Professor H had the most participants (34.1%), followed by Professor E (20.3%), Professor Lr (11.6%), and Professor K (10.9%). The remaining participants were with Professor D (8.0%), Professor Li (9.4%), and Professor B (5.8%). A majority of participants were enrolled in the 1412 chemistry course (51.4%). Of those students who reported during that year of study, most participants were sophomores (38.1%), followed by freshmen (23.7%), and juniors (19.6%). A majority of participants (53.3%) had a final grade of A or B (i.e., success in chemistry), whereas 46.7% of participants failed chemistry, as defined by having a grade of C or below.

Preliminary analysis was conducted to assess the general approach to studying of this sample of students. Section (A) on the ASSIST assesses the participants’ epistemological stance scores that were obtained from the present sample and that ranged from 9.00 to 30.00, with an average score of 25.83 \( (SD = 3.43) \). The sample’s scores for deep approach ranged from 30.00 to 79.00, with an average score of 58.08 \( (SD = 1.79) \). Scores for strategic approach ranged from 37.00 to 123.00, with an average score of 72.05 \( (SD = 14.29) \). Finally, scores for surface approach ranged from 25.00 to 79.00, with an average score of 47.92 \( (SD = 11.24) \). Scores for participants’ preference for different types of course and teaching ranged from 18.00 to 40.00, with an average score of 31.51 \( (SD = 4.50) \). Participants were also asked to assess how well they were doing overall in their class work. Participants’ responses ranged from 1.00 to 9.00, with an average assessment score of 6.16 \( (SD = 1.83) \). Interestingly, academic standing significantly affected deep approach to studying. Sophomores had significantly higher scores for deep
approach than did freshmen. Gender significantly affected strategic approach scores. Females had significantly higher scores for strategic approach to study than did males.

Part of the preliminary analysis was an evaluation of the intellectual development of students as measured by the LEP. LEP scores are based on Perry’s (1970) position and the Cognitive Complexity Index (CCI) scores. The CCI scores reflect a single numerical index along a continuous scale of intellectual development. The following is the result of the analysis of the sample from the LEP:

- Position 2 (Dualism) had an average score of 40.08, \( (SD = 21.97) \).
- Position 3 (Multiplicity) had an average score of 28.64, \( (SD = 14.14) \).
- Position 4 (Multiplicity) had an average score of 14.46, \( (SD = 15.21) \).
- Position 5 (Contextual Relativism) had an average score of 16.86, \( (SD = 10.68) \).
- CCI Index position had an average score of 3.05; \( SD = 1.11 \).

The participants’ scores for the CCI ranged from 213 to 423, with an average score of 308.15 \( (SD = 49.00) \).

Additionally, part of the preliminary analysis assessed the present metacognitive activities of the present sample of students. The total responses on the EPQ questionnaire ranged from 80.00 to 138.00, with an average score of 108.43 \( (SD = 12.93) \). Gender significantly affected participants’ responses on the EPQ. The results indicated that female students had significantly higher scores on total EPQ. Also, age significantly affected participant’s EPQ scores. Participants who were 23 years and older had significantly higher EPQ scores than did those who were 19 to 22 years old.
Primary Analyses

Research Question 1

The first research question asked about the approaches to studying, as measured by the ASSIST scale, that are employed by students enrolled in general chemistry. It is imperative to authenticate the reliability of the instruments of a study. The reliability of the ASSIST was authenticated using Cronbach’s alpha coefficient for the deep approach ($\alpha = .86$), strategic approach ($\alpha = .80$), surface apathetic approach ($\alpha = .72$), and Preference for Different Types ($\alpha = .57$). A descriptive analysis was conducted for all general chemistry students and then was split by course: students in 1411 and 1412. Table 2 reveals the results of the descriptive analysis. For all general chemistry students, participants demonstrated a preference for strategic approaches to studying, with an average score of 72.05 ($SD = 14.29$). Assessing students according to course, the results revealed that preference for the strategic approach was consistent with both chemistry 1411 students ($M = 70.65; SD = 16.11$) and chemistry 1412 students ($M = 73.42; SD = 12.25$).

Table 2

Means and Standard Deviations of ASSIST Scores of Students Enrolled in Chemistry Courses

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</tr>
<tr>
<td>Epistemological Stance</td>
<td>138</td>
<td>25.83</td>
<td>3.43</td>
<td>9</td>
<td>30</td>
</tr>
<tr>
<td>Deep Approach</td>
<td>135</td>
<td>58.08</td>
<td>11.79</td>
<td>30</td>
<td>79</td>
</tr>
<tr>
<td>Strategic Approach</td>
<td>132</td>
<td>70.05</td>
<td>14.29</td>
<td>37</td>
<td>123</td>
</tr>
<tr>
<td>Surface Apathetic Approach</td>
<td>136</td>
<td>47.92</td>
<td>11.24</td>
<td>25</td>
<td>79</td>
</tr>
<tr>
<td>Preference</td>
<td>138</td>
<td>31.51</td>
<td>4.50</td>
<td>18</td>
<td>40</td>
</tr>
<tr>
<td>Overall Assessment of Self</td>
<td>128</td>
<td>6.16</td>
<td>1.83</td>
<td>1</td>
<td>9</td>
</tr>
</tbody>
</table>
Research Question 2

The second research question asked about the level of intellectual development, as measured by LEP, of the sample of students enrolled in general chemistry. Cronbach’s coefficient for responses in Position 2 had a reliability rating of .81. Descriptive analysis was conducted for all students in general chemistry and then divided by course. Participants’ scores for the LEP position and the overall CCI are displayed in Table 3. All general chemistry students who participated in this study displayed an intellectual development of position 2 (dualism). Participants had an average position 2 score of 40.08 \((SD = 21.97)\). These results were consistent for both chemistry courses. Chemistry 1411 students had an average position 2 score of 44.47 \((SD = 23.29)\) and an average CCI score of 299.67 \((SD = 50.52)\). Chemistry 1412 students had an average position 2 score of 36.29 \((SD = 20.18)\) and an average CCI score of 315.48 \((SD = 46.80)\).

Table 3

*Means and Standard Deviations of Learning Environment Preferences (LEP) Scores of Students Enrolled in Chemistry Courses*

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General Chemistry</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>POS 2</td>
<td>123</td>
<td>40.08</td>
<td>21.97</td>
<td>0</td>
<td>90</td>
</tr>
<tr>
<td>POS 3</td>
<td>123</td>
<td>28.64</td>
<td>14.14</td>
<td>5</td>
<td>68</td>
</tr>
<tr>
<td>POS 4</td>
<td>123</td>
<td>14.46</td>
<td>15.21</td>
<td>0</td>
<td>76</td>
</tr>
<tr>
<td>POS 5</td>
<td>123</td>
<td>16.87</td>
<td>10.68</td>
<td>0</td>
<td>46</td>
</tr>
<tr>
<td>CCI Index Position</td>
<td>123</td>
<td>3.05</td>
<td>1.12</td>
<td>1</td>
<td>6</td>
</tr>
</tbody>
</table>
Research Question 3

The third research question 3 asked about the correlation between approaches to studying and metacognition as measured by the EPQ. The reliability of the ASSIST has been authenticated above. Similarly, the reliability of the EPQ was assessed for the present study and the Cronbach’s alpha for this 40-item survey is .68; an approximate Cronbach’s alpha of .72 was found by the instrument’s creator (Hall, 1994). Pearson Product Moment Correlations were conducted to examine the relationship between approaches to studying and metacognition. Table 4 reveals the findings of this analysis. The results revealed that there is positive correlation between several sections of the ASSIST and metacognition as assessed by EPQ. Total EPQ scores (i.e., scores for metacognition) for all general chemistry students were significantly positively related to scores for epistemology, scores for deep approach, scores for strategic approach, preference scores and assessment scores (rs ranging from .395 to .659 and ps < .01), indicating that participants with higher total EPQ scores (those students who are cognizant of their metacognition and who effectively utilize metacognitive skills during study) tended to have higher scores for epistemological stance, deep approach, strategic approach, preference, and assessment. However, the results reveal a negative correlation between metacognition and surface approach to studying. Total EPQ scores (i.e., scores for metacognition) were significantly and negatively related to surface approach (r = -.395; p < .01), indicating that participants with higher total EPQ scores tended to have lower surface approach scores. Those students espousing a surface approach to studying are probably incognizant of their metacognition or are ineffectively utilizing their metacognitive skills during studying.

Results that were split by chemistry course were similar to overall results obtained for all students. For chemistry 1411 students, total EPQ scores were significantly and positively related
to epistemological stance ($r = .406; p < .01$), deep approach ($r = .591; p < .01$), strategic approach ($r = .652; p < .01$), preference ($r = .429; p < .01$), and overall assessment of work ($r = .337; p < .05$). As in the overall result, total EPQ scores for chemistry 1411 students were significantly and negatively related to surface approach scores ($r = -.425; p < .01$). For chemistry 1412 students, total EPQ scores were significantly and positively related to epistemological stance ($r = .339; p < .05$), deep approach ($r = .550; p < .01$), strategic approach ($r = .672; p < .01$), preference ($r = .403; p < .01$), and overall assessment of work ($r = .532; p < .01$). As previously observed in the overall scores, total EPQ scores for chemistry 1412 students were significantly and negatively related to surface approach ($r = -.375; p < .01$).

Table 4

*Pearson Product Moment Correlations of Approaches to Studying and Metacognition for All Students in Chemistry Courses*

<table>
<thead>
<tr>
<th></th>
<th>Total EPQ Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epistemological Stance</td>
<td>.395 **</td>
</tr>
<tr>
<td>Deep Approach</td>
<td>.574 **</td>
</tr>
<tr>
<td>Strategic Approach</td>
<td>.659 **</td>
</tr>
<tr>
<td>Surface Apathetic Approach</td>
<td>-.395 **</td>
</tr>
<tr>
<td>Preference</td>
<td>.430 **</td>
</tr>
<tr>
<td>Overall Assessment of Self</td>
<td>.427 **</td>
</tr>
</tbody>
</table>

*Note.* ** $p < .01$. 

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Research Question 4

The fourth research question asked about which of the three variables, namely approaches to studying, abilities to metacognate, and levels of intellectual development, is most salient in predicting the academic success of chemistry students. Several multiple logistic regression analyses were conducted, and Table 5 displays the results of the logistic regression analyses for all participants, predicting success in chemistry from approaches to studying, abilities to metacognate, and levels of intellectual or epistemological development for all participants. The overall multiple logistic regression model predicting academic success in chemistry courses from approaches to studying, abilities to metacognate, and levels of intellectual development was significant, $\chi^2(5) = 15.15; p = .010$, and explained approximately 20.10% of the total variance. A closer examination of the results evinced that participants with higher scores for surface approach had greater odds of failure, having a grade of C or below, in a chemistry course than did those who had lower scores for surface approach ($Odds Ratio = 1.07; p = .006$). For the divided sample, the overall model predicting academic success was significant, $\chi^2(5) = 15.19; p = .007$, and explained 41.20% of the variance. Participants with higher scores for surface approach had significantly greater odds of failure in a chemistry course than did those who had lower scores for surface approach ($Odds Ratio = 1.11; p = .022$). Furthermore, participants with strategic approaches to studying had significantly lesser odds of failing a chemistry class than did those who had a lower scores for strategic approach ($Odds Ratio = .91; p = .046$). Results revealed that the model predicting success in chemistry from approaches to studying, abilities to metacognate, and levels of intellectual development was not significant ($\chi^2 (5) = 6.96; p = .223$) and explained only 17.7% of the total variance. There was no significant predictor of success in chemistry, all $ps ns$. 
Table 5

Multiple Logistic Regression Predicting Failure in Chemistry Class from Approaches to Studying, Ability to Metacognate, and Epistemological Development for All Students

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>SE</th>
<th>Wald</th>
<th>Odds Ratio</th>
<th>p</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep Approach</td>
<td>.028</td>
<td>.02</td>
<td>1.33</td>
<td>1.029</td>
<td>.248</td>
<td>.980 - 1.080</td>
</tr>
<tr>
<td>Strategic Approach</td>
<td>-.027</td>
<td>.02</td>
<td>1.48</td>
<td>.973</td>
<td>.223</td>
<td>.932 - 1.017</td>
</tr>
<tr>
<td>Surface Approach</td>
<td>.064</td>
<td>.02</td>
<td>7.68</td>
<td>1.066</td>
<td>.006</td>
<td>1.019 - 1.115</td>
</tr>
<tr>
<td>EPQ Scores</td>
<td>-.011</td>
<td>.03</td>
<td>.17</td>
<td>.989</td>
<td>.682</td>
<td>.937 - 1.044</td>
</tr>
<tr>
<td>CCI Scores</td>
<td>-.002</td>
<td>.01</td>
<td>.17</td>
<td>.998</td>
<td>.677</td>
<td>.987 - 1.008</td>
</tr>
</tbody>
</table>

Note. Summary of Multiple Logistic Regression: $X^2 (5) = 15.15, =.010$, pseudo $R^2 = .201$.

Hypothesis 1

Hypothesis 1 states that there is a positive relationship between general chemistry students who engage in metacognition (EPQ) during studying (ASSIST) and who have high intellectual development (LEP). Several Pearson Product Moment Correlations were conducted. As shown in Table 6, scores for deep approach were significantly and positively correlated with scores for strategic approach, CCI, and total EPQ ($rs$ ranging from .214 to 574 and $p < .05$), indicating that participants with higher scores for deep approach tended to have higher scores for strategic approach, CCI, and total EPQ. Scores for deep approach were, however, significantly and negatively correlated with scores for surface approach ($r = -.174; p < .05$), indicating that participants with higher scores for deep approach tended to have lower scores for surface approach. Scores for strategic approach were significantly and positively correlated with scores for total EPQ ($r = .659; p < .01$), indicating that participants with higher scores for strategic
approach tended to have higher scores for total EPQ. Finally, scores for surface approach were significantly and negatively correlated with scores for CCI and total EPQ ($r$ ranging from -.224 to -.395 and $p < .05$), indicating that participants with higher scores for surface approach tended to have lower scores for CCI and total EPQ. Table 6 shows that scores for total EPQ were not significantly correlated with scores for CCI ($r = .041$, $ns$).

Hypothesis 2

Hypothesis 2 states that deep approach to studying is related to employment of metacognition and intellectual development. Table 6 shows that the second hypothesis was confirmed in that scores for deep approach are significantly and positively related to scores for metacognition ($r = .574; p < .01$) and intellectual development ($r = .214; p < .05$), indicating that participants with higher scores for deep approach tended to have higher scores for both metacognition and intellectual development.

Table 6

*Pearson Product Moment Correlations of Approaches to Studying and Intellectual Development with Engagement in Metacognition for All Students*

<table>
<thead>
<tr>
<th></th>
<th>Deep Approach</th>
<th>Strategic Approach</th>
<th>Surface Apathetic Approach</th>
<th>Preference</th>
<th>CCI Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic Approach</td>
<td>.529 **</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface Apathetic Approach</td>
<td>-.174 *</td>
<td>-.138</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preference</td>
<td>.515 **</td>
<td>.372 **</td>
<td>-.055</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCI Scores</td>
<td>.214 *</td>
<td>-.137</td>
<td>-.224 *</td>
<td>-.038</td>
<td></td>
</tr>
<tr>
<td>Total EPQ Scores</td>
<td>.574 **</td>
<td>.659 **</td>
<td>-.395 **</td>
<td>.430 **</td>
<td>.041</td>
</tr>
</tbody>
</table>

*Note. * $p<.05$; ** $p<.01$.*
Additional analysis for hypothesis 2 revealed that scores for deep approach were positively and significantly related to scores for strategic approach, preference, CCI, and total EPQ ($r_s$ ranging from .371 to .591 and $p < .001$), indicating that participants with higher scores for deep approach tended to have higher scores for strategic approach, CCI, preference, and total EPQ. Scores for strategic approach were significantly and positively related to scores for preference and total EPQ ($r_s$ ranging from .363 to .672 and $p < .001$), indicating that participants with higher scores for strategic approach tended to have higher scores for preference and total EPQ. Scores for surface apathetic approach were significantly and negatively related to scores for total EPQ ($r = -.375; p < .01$), indicating that participants with higher scores for surface apathetic approach tended to have lower scores for total EPQ. Additionally, scores for preference were significantly and positively related to scores for total EPQ ($r = .403; p = .002$), indicating that participants with higher scores for preference tended to have higher scores for total EPQ. Scores for CCI were significantly and positively related to scores for deep approach ($r = .371; p = .002$), indicating that participants with higher scores for CCI tended to have higher scores for deep approach. Finally, scores for total EPQ were significantly and positively related to scores for deep approach, strategic approach, and preference ($r_s$ ranging from .403 to .672 and $p < .01$), indicating that participants with higher scores for total EPQ tended to have higher scores for deep approach, strategic approach, and preference. Scores for total EPQ were, however, significantly and negatively related to scores for surface apathetic approach ($r = -.375; p = .005$), indicating that participants with higher scores for total EPQ tended to have lower scores for surface apathetic approach.
Additional Analyses

Additional analyses were conducted due to covariates of academic standing and gender. Table 7 shows the results of the overall multiple logistic regression model that predict academic success in chemistry courses from approaches to studying, abilities to metacognate, levels of intellectual development, gender, age, and academic standing. The overall model was not significant, $\chi^2(8) = 11.33; p = .184$, and only explained 21.7% of the total variance. There were no significant predictors of success in the overall model for chemistry courses, all $ps \ ns$.

Further analyses split the participants into chemistry course (i.e., 1411 and 1412). The multiple logistic regression model that predicted chemistry success from approaches to studying, abilities to metacognate, levels of intellectual development, gender, age, and academic standing for participants in Chemistry 1411 was significant ($\chi^2(8) = 23.90; p = .002$) and explained 66.4% of the total variance. A deeper examination of the results revealed that surface approach was a significant predictor of failure in chemistry 1411. Specifically, participants who had higher scores for surface approach had significantly greater odds of failing chemistry 1411 than did those who had lower scores for surface approach ($Odds \ Ratio = 1.19; p = .046$). However, results also revealed that the model predicting chemistry success from approaches to studying, abilities to metacognate, levels of intellectual development, gender, age, and academic standing for participants in Chemistry 1412 was not significant, $\chi^2(8) = 8.96, p = .346$, and only explained 35.4% of the total variance. Upon further examination, results revealed that scores for total EPQ were significantly predicted academic success in Chemistry 1412. Specifically, participants with higher scores for total EPQ had significantly lesser odds of receiving a grade of C or below than did those who had lower scores for total EPQ ($Odds \ Ratio = .84; p = .035$).
Table 7

*Multiple Logistic Regression Predicting Failure in Chemistry Class from Approaches to Studying, Ability to Metacognate, and Epistemological Development for All Students*

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>SE</th>
<th>Wald</th>
<th>Odds Ratio</th>
<th>p</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep Approach</td>
<td>.017</td>
<td>.03</td>
<td>.32</td>
<td>1.018</td>
<td>.572</td>
<td>.958 - 1.081</td>
</tr>
<tr>
<td>Strategic Approach</td>
<td>-.027</td>
<td>.03</td>
<td>.98</td>
<td>.974</td>
<td>.322</td>
<td>.924 - 1.026</td>
</tr>
<tr>
<td>Surface Apathetic</td>
<td>.021</td>
<td>.03</td>
<td>.52</td>
<td>1.021</td>
<td>.472</td>
<td>.965 - 1.081</td>
</tr>
<tr>
<td>EPQ Scores</td>
<td>-.046</td>
<td>.03</td>
<td>1.85</td>
<td>.955</td>
<td>.174</td>
<td>.894 - 1.020</td>
</tr>
<tr>
<td>CCI Scores</td>
<td>.002</td>
<td>.01</td>
<td>.11</td>
<td>1.002</td>
<td>.745</td>
<td>.989 - 1.015</td>
</tr>
<tr>
<td>Females, Compared</td>
<td>.243</td>
<td>.63</td>
<td>.15</td>
<td>1.275</td>
<td>.701</td>
<td>.369 - 4.406</td>
</tr>
<tr>
<td>Freshmen, Compared</td>
<td>-.964</td>
<td>.79</td>
<td>1.50</td>
<td>.381</td>
<td>.220</td>
<td>.082 - 1.780</td>
</tr>
<tr>
<td>Sophomores,</td>
<td>.202</td>
<td>.66</td>
<td>.10</td>
<td>1.223</td>
<td>.748</td>
<td>.339 - 4.417</td>
</tr>
</tbody>
</table>

*Note.* Summary of Multiple Logistic Regression: $X^2(8)=11.33$, $p=.184$, pseudo $R^2=.217$. 

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CHAPTER V
DISCUSSION

Introduction

The final chapter of this dissertation will be (a) a restatement of the purpose of this study, (b) a review of the methodology of this study, (c) a discussion, according to the research questions and hypotheses, of the implications of the results enumerated in the previous chapter of this study, and (d) some recommendations for further study in this research area.

Statement of Problem

Chemistry is a rigorous subject, and academic success in chemistry requires skills that students employ while studying. Many students find chemistry difficult and fail because of lack of these skills. These skills enable effective learning that augments instructor behavior in classrooms. Students’ academic success in chemistry in particular and in college career in general may be achieved if they employ these skills during their personal studying. The problem is that students’ intellectual development, their ability to metacognate, and how they approach their studying is not known. Knowledge of these aspects of student behavior will inform instruction and, if necessary, facilitate remediation.

Purpose of the Study

The purpose of this study was to determine the relationships among the approaches to studying that students employ while studying, the metacognitive skills that students use in their studying, and the levels of students’ intellectual development. The sample for this study was general chemistry students at a community college. Ascertaining these relationships will enable teachers to enhance their instruction and to address specific areas of students’ needs. A paucity of research about how students study for general chemistry and about whether these students
employ aspects of metacognition during their studying is the motivation for this study. Additionally, this study investigated whether students’ levels of intellectual development are related to their approaches to studying and to their metacognitive abilities.

**Review of the Methodology**

Data were collected via the three instruments described in Chapter 4. The first instrument is the Approaches and Study Skills Inventory for Students (ASSIST), which has four sections. Section A asks, “What is Learning?” It is comprised of six items that attempt to elicit from students their epistemological views of learning, either as an instrumental approach of reproducing knowledge or as a means of acquiring information for personal understanding and development. Section B is “The Approaches” to studying section and consists of 52 items that make statements about how students go about their studying. Students are asked to respond using a 5-point Likert scale, where 1 = *disagree* and 5 = *agree*. This section is the most crucial section of the entire instrument because this section determines students’ preferred approaches to studying: deep approach, strategic approach, or surface apathetic approach. The deep approach to studying emphasizes comprehension as the primary objective of learning. Because comprehension facilitates retention and requires a confluence of related concepts rather than superficial memorization of isolated information, the deep approach to studying is the preferred approach to studying chemistry. The strategic approach to studying involves a concerted effort at organized studying, at time management, of alertness to assessment cues, and even at competition, resorting to any means necessary to achieve the best grade possible. Surface apathetic approach involves a minimalistic approach to studying, and rote memorization is the mode of knowledge acquisition. Student who use this approach lack purpose, are very syllabus-bound, do the minimum required in the course, and have an underlining fear of failure. Learners
who use the surface approach to studying possibly possess an inferiority complex regarding their ability to orchestrate their studying. The ultimate goal of instruction is to encourage a deep approach to studying. Section C of the ASSIST is entitled “Preferences for different types of courses and teaching.” It consists of eight items. The first four items are statements that support understanding, so they are related to a deep approach. The last four items are statements that involve a surface approach to studying because they elicit from students their preferred types of instructors. Students who use a surface approach to studying would prefer instructors who tell students exactly what to put in their notes, who give exams and tests that require the information they provided, and who use books with definite facts and information to be learned. In the fourth section of the ASSIST, students are asked to rate how well they think that they are doing overall in their courses thus far. The ratings are 9 (very well), 8, 7 (quite well), 6, 5 (about average), 4, 3 (not so well), 2, and 1 (rather badly). Figure 1 is a summary of the three approaches to studying as measured by the ASSIST.

The second instrument used was the Executive Process Questionnaire (EPQ). This 40-item instrument measures the metacognition skills of college students. EPQ measures several aspects of metacognition, such as knowledge of one’s limits regarding learning and memory capability, knowledge of effective strategies and approaches that are suitable for contextual learning, and knowledge of how to monitor comprehension. These aspects of EPQ measure how students set goals, plan their studying, and carry out their planned courses of action. The importance of the information gained from the EPQ could be used to advise students about best practices to maximize comprehension and to monitor learning in order to ensure successful outcomes in chemistry and beyond.
Figure 1. Conceptual mapping of components of effective studying from ASSIST. Retrieved from http://www.tla.edu.ac.uk/etl/questionnaire/ASSIST.pdf.
The third instrument used in this study was the Learning environment preferences (LEP), which is based on Perry’s 1970 and 1980 models of intellectual and ethical development in college students. This 65-item instrument consists of five domains, each representing an aspect of learning environments:

- Domain 1: Course content/View of learning;
- Domain 2: Role of instructor;
- Domain 3: Role of students/peers;
- Domain 4: Classroom atmosphere/activities;
- Domain 5: Evaluation procedures.

Participants were asked to rate on a 4-point Likert scale all the items within each domain. Each domain is rated according to its significance to students’ ideal learning environments. In addition, students were asked to rank the three most significant statements for each domain. The estimated time for the completion of this instrument is approximately 1 hour. As they responded, students were asked to think about their ideal learning environments, not any specific course. Some students were confused about the instructions and failed to complete the final sheet on which they had to rank the three most significant statements of each domain; because of this, some of the instruments were rendered unusable. When queried about the reason for not completing the last page, which is the LEP answer sheet, students retorted that they were under the impression that the ranking under each domain was sufficient and that they did not understand the point of ranking the responses again. The useable responses for this instrument were entered into an Excel spreadsheet and sent to Dr. William S. Moore, coordinator of the Center for the Study of Intellectual Development (CSID) in Olympia, WA, to score via email. The scored instruments were returned with the LEP score report listed as Cognitive Complexity.
Index (CCI). The CCI is the primary score index for the LEP and is a single numerical index along a continuous scale of intellectual development from 200 (Position 2) to 500 (Position 5). The developer cautions against equating CCI scores directly with the Perry continuum of positions. While the two approximate one another it is more appropriate to think of the CCI as a more general indicator of increasing cognitive complexity or intellectual development” (Moore, 2011, p.2). Dualism Position 2 would have a CCI score of 200–240. This position is characterized by dichotomy and dualism (i.e., right or wrong); authorities know the answers, and students are to find the right answer. Dualism Transition 2 to 3 would have a score of 241–284. All the answers may not be known yet, even by authorities. Multiplicity Position 3 would have a score of 285–328. Participants in this study had average scores within this range. Multiplicity Position 3 is characterized by a transitory acknowledgement of uncertainty and different opinions. The authorities are trying to find the correct answers. Multiplicity Transition 3–4 would have a score of 329–372. This position is characterized by overwhelming perception of the multitude of unknowns but knowing that answers are possible. The goal of learning is to discern the proper methods or procedures to finding the correct answer. Multiplicity Position 4 with score of 373–416 is characterized by divergent modes of thinking. Correct answers are not necessarily the goal of learning; rather, the ability to rationalize and support opinions with data is the goal of learning. Multiplicity Position transition 4–5 with score of 417–460 is characterized by the ability to discriminate and adjust reasoning. Relativism Position 5 with scores of 461–500 is characterized by elements of metacognition: one is required to be adaptable and contextual in reasoning. Evidence must support opinion. The last four positions of the Perry (1970) scale, commitment within relativism, Positions 6–9, is not part of the LEP. The explicit goal of the LEP is to investigate the intellectual development of students from rudimentary views about
knowledge as established immutable information whose answers are known by the privileged few to a multiplicity of views about uncertainty, and eventually, to a more intricate view of knowledge as determined by context and supported by evidence. Also, LEP investigates the personal development of students from regarding themselves as passive receptacles to be filled by information from the instructor to more confident individuals who assume responsibility to determine and control their own learning.

Summary of the Results

This section of the discussion chapter will summarize the results according to the research questions and hypothesis and how the findings are related to the current literature on the subject.

Research Question 1

The first question asked “What approaches to studying, as measured by the ASSIST, do students in general chemistry employ?” The results of this study revealed that this sample of general chemistry students had a predilection for the strategic approach to studying. Regardless of whether they were registered for general chemistry 1411 or general chemistry 1412, the students who participated in this study exhibited a pattern that was similar to the overall findings. Deep approach to learning, which epitomizes the archetype of study approach, was the second approach used by these students. It was gratifying to note that this sample of students utilized the surface apathetic approach the least of all the approaches to studying. The surface apathetic approach to studying connotes a lack of interest in the subject matter and a lack of motivation to attempt in-depth learning of the subject. Students who use the surface apathetic approach to studying make perfunctory and superficial attempts to comprehend the subject matter. This approach to studying should be discouraged. Previous studies using the ASSIST have
corroborated the results of this study. Lovatt and Finlayson (2008), at the beginning of the year of study, found that chemistry students seem to favor deep and strategic approaches over the surface approach because of a motivation to succeed in their goals for their careers and their personal development. Interestingly, these researchers found that toward the end of semesters, both use of deep and strategic approaches decreased while use of surface approach increased. Although use of surface approach was in this study and placed third for use of approaches to study, use of surface approach was not very far behind use of deep approach. Several explanations have been proposed to explain this trend. Diseth (2007) found that inappropriate workload encourages utilization of surface approach. Fransson (1977) attributed use of surface approach to lack of motivation and test anxiety. It is possible that the nature of science study predisposes the discipline to surface approach? Watters, D.J. and Watters (2007) found that biology students predominately used the surface approach. Zeegers (2001) found that first year chemistry students also used the surface approach; Kelly (2005) found the same in a chemistry laboratory context. Kreber (2003) asserted that use surface approach by science students, including chemistry students, may be attributed to heavy workload and inappropriate assessment. Even in more advanced chemistry courses, students seemed to display a proclivity for surface approach. Minasian-Batmanian, Lingard, and Prosser (2006) found that 83% of the students in a biochemistry class reported using surface approach during studying. However, the argument that the nature of biochemistry predisposes it to a surface approach may not be valid because there is conflicting evidence concerning the veracity of the nature of science encouraging surface approach. Laird et al. (2008) found that discipline does make a difference; chemistry, physics, and mathematics student were predisposed to use surface approach to studying. In contrast, Byrne (2010) found that science students had higher scores for deep approach than did
accounting students. Long (2003) found that discipline did not affect or determine the use of study approaches.

The observed result for this sample of students may be due to the nature of the students. Many of the students in this sample are transfer students who are motivated to achieve and maintain a high GPA to gain admission into professional schools for further studies. Strategic approach to studying is utilized by students who perceive it as an efficient means of maximizing their grades in a course. Rather than using strategic approach, these students should be espousing a deep approach to their studying. In addition to ensuring higher grades, using a deep approach to studying will also facilitate retention of the vast amount of information needed for examinations at professional schools.

Research Question 2

Research Question 2 asked, “What is the level of intellectual development, as measured by the LEP, of a sample of students in general chemistry?” The results of this study indicate that students who participated in this study were predominantly in Position 2, which meant that they were dualists. There was an anomaly with the results obtained for this research question: incongruence between Position results and CCI results. Based on the means for each Position, the students in this sample are dualists, but the results of the CCI scores suggest that Position 3 implies multiplicity. Based on the conflicting results and the knowledge of this population, the assertion is that this sample of students is mostly dualists but that they are in transition to Position 3, multiplicity. Though dualists would see the subject of chemistry, the chemistry instructor, and the chemistry textbook as the authorities with all the answers, students in transition to multiplicity (Position 3) would acknowledge “absolute certainty about some things and temporary uncertainty about some things” (Wilson, 1996, p. 4). To these students the
authorities are working on finding the correct answer. The findings here are corroborated by Perry (1970) who found that science students tended to be dualists. Lovell and Nunnery (2004) found that students who are in Position 2 may display traits of Position 3; for example, group 3 is not only interested in knowledge (Position 2) but is also interested in academic benefits and the process of going about learning. The dualistic nature of science students may be attributed to the students’ perceptions about the nature of the subject that are in opposition to the perceptions of most chemistry instructors, who perceive the subject as dynamic. Finster (1991) also found that chemistry students are dualist, and he proposed removing “the veil of simplicity from their image of science by introducing multiple perspectives in science and eliminating science as authority” (p.755). He proposes teaching chemistry as a process. His argument is valid, but it seems impractical to discount the basic algorithmic and formulaic nature of the subject, which forms the basis for more advanced study of the subject. However, it is imperative to teach chemistry by methodologies that will advance students along the continuum of intellect development from mere dualists to students of more advanced methods of rationalization. After all, this is the ultimate goal of higher education, regardless of the context.

Research Question 3

Research Question 3 asks, “Is there a correlation between approaches to studying and metacognition as measured by the EPQ?” The results revealed that for all of the students who participated in this study, there was a significant relationship between approaches to studying and metacognition. Results from some sections of the ASSIST were significantly and positively related to each other and to total EPQ scores, indicating that participants who had high scores on epistemological stance, deep approach, strategic approach, preference, and overall assessment of self-sections of the ASSIST also had high scores on the EPQ. Thus, participants who had higher
scores for deep approach also had higher scores for strategic approach, preference, assessment, and EPQ. It had been previously established that deep approach and surface approach are incompatible. Not surprisingly, the results of this study revealed that scores for deep approach were significantly and negatively related to scores for surface approach, indicating that participants with higher scores for deep approach tended to have lower scores for surface approach. Because deep approach is negatively related to surface approach, it is reasonable to infer that surface approach scores would be significantly and negatively related to EPQ scores. These were the findings: participants with higher scores for total EPQ tended to have lower scores for surface approach, suggesting that participants espousing a surface approach are not metacognating. These students are either unaware of metacognitive skills or are unable to utilize these skills effectively. Hall (2001) found similar results. Although Hall’s (2001) study used an earlier version of the ASSIST called the Study Process Questionnaire (SPQ), she found that there was not a significant correlation between scores for EPQ and surface approach. Part of the instruction for students who use surface approach should be the use of EPQ to evaluate and monitor how these students orchestrate their studying—how they plan their studying, how they choose strategies to study, how they actually carry out their study plans, how they retrieve stored information, and how they evaluate their own comprehension.

One of the criticisms of allotting students to study approaches is the premise that study behavior cannot be categorized that students will usually assess the learning task and select strategies that will enable them to accomplish the task. On the contrary, Case and Gunstone (2002) proposed that metacognition and study approach are related, and study approaches are mutable and subject to learning environments. However, these researchers found that risk-taking (which is necessary for metacognition) is precluded in “time-pressed assessment.” The
conclusion is that conceptual shift is difficult and that students tend to resist change from surface to deep conceptual reasoning because this change requires major cognitive shifts to metacognitive skills. Despite resistance from students to change from surface approach to deep approach by incorporating metacognition in their studying, it is imperative that instructors structure chemistry classes to allow students to metacognate, thereby employing deep approach to learning in their study behaviors.

There are other dimensions in student learning that explain approaches to learning and how these are related to metacognition. Heikkilä et al. (2011) investigated the interrelation among approaches to studying, metacognition, and attributional strategies and found that deep approach to studying correlated positively with critical evaluation, self-regulation, and success expectation, “indicating an optimistic strategy” (p. 520). Surface approach correlated negatively with these tenets of metacognition and success expectation. Spada and colleagues (2006) investigated the test anxiety dimension and concluded that adoption of a surface approach was related to test anxiety and that test anxiety was related to “general maladaptive metacognitive beliefs” (p.616). Spada and colleagues (2006) concluded that reduction of test anxiety prevents students from resorting to surface approach and depends on metacognitive intervention. The intricate connection between deep approach with high degree of metacognition, intrinsic motivation, and adjustment of studying to align with courses and examinations led to the term ‘studax’ by Janssen (1996). The student who exemplifies all these traits is regarded as the successful or expert student. Downing and colleagues (2009) investigated chemistry instruction and the use of active learning and a reflection model and concluded that problem-based learning requires students engaging in learning environments and developing the ability to solve chemical problems, which requires the development of metacognitive skills. To solve chemical problems
without metacognition makes problem-based learning difficult. However, simply telling students to use metacognition in their studying to enhance academic achievement may not be enough (Romainville, 1994). For maximum effect and utility, overt training in the art of metacognition may be beneficial to both students and instructors because the development of metacognition for students is intricately connected to instructor utilization of metacognition. (Masui & De Corte, 1999; McAlpine et al., 1999).

Previous research studies and this study support awareness of the relationship between deep approach to studying and employment of metacognitive skills during studying. Reiterating the assertion above that conceptual change is difficult and that student resistance and individual character work counteract the goals of instructors in classrooms, it is necessary to incorporate metacognition in chemistry instruction. Application of metacognition in chemistry classes is limitless; areas in which metacognition may assist the instructor in aiding students to develop a deep approach to learning range from enhancing metacognition development in students who are academically weak to instilling in students confidence and a sense of ownership in the learning process by choosing approaches that emphasize comprehension (Coutinho, 2008).

Research Question 4

Research Question 4 asks, “Which of the three variables, namely approaches to studying, abilities to metacognate, and levels of intellectual development, is more salient in predicting academic success in chemistry?” Academic success in chemistry has been defined as an end-of-course grade of an A or B; failure would be considered a grade of C, D, or F. The overall model which combined both chemistry 1 and 11 students was found to be significant and explained a portion of the variance. The results showed that participants with high scores for surface approach to studying had greater odds of failure in chemistry courses than did those with lower
scores to surface approach. For the divided sample, the model predicting success in general chemistry 1411 was significant. For this, participants with higher scores for surface approach had significantly greater odds of failure in the class. For these participants, those with high scores for strategic approach to studying had significantly lesser odds of failure in the chemistry course than did others with lower scores for strategic approach. For general chemistry 1412, the model predicting success for these participants was not significant. There were no predictors of success for the chemistry 1412 students. The surface approach predicting failure is not surprising, but it is perplexing that deep approach did not predict chemistry success. The plausible explanation for this incongruence could be that the structure of the examination questions reinforces strategic approach or surface approach strategies. Maybe examinations are designed not to assess comprehension but to have students recall and apply information that would require only surface or strategic approaches, not deep approaches.

Other previous studies have found similar results. Diseth and Martinsen (2003) found that deep approach to studying did not predict grades or academic performance. These researchers did find that strategic and surface approaches to studying were moderate predictors of grades or academic performance. There was a positive relationship between strategic approach to studying and academic performance and a negative relationship between surface approach to studying and academic performance. Similarly, Newble and Hejka (1991) found that there was a weak relationship between deep approach to studying and superior performance but that strategic approach was the best predictor of academic performance. Walker and colleagues (2010) found that high performance in a biology context on examinations was related to a surface approach to studying, but the course was structured to teach deep approach to studying. These researchers were encouraged by the fact that by the end of the school year, more
students were using deep or strategic approach and less surface approach. Strategic approach has been found to predict academic achievement (Jungert & Rosander, 2009). Also, Almeida, Teixeira-Dias, Martinho, and Balasooriya (2011) found that surface approach does predispose students to academic failure, as also evidenced by the results of this study. Even when instructors’ intentions are to encourage deep approach, students may misunderstand, and the disconnect between students and teachers is exacerbated by students’ inability to abandon old ways. Those entrenched study behaviors are difficult to change because of flawed perceptions about knowledge and its acquisition. The cognitive dissonance or disequilibrium necessary for change to take place is disturbing, and, in an attempt to deal with the uncertainty, students revert back to a mode that is familiar, even if ineffective. In contrast to the above studies, Saouma and Giuliano (1991) found that deep approach was a significant predictor of academic success in chemistry. Deep approach should lead to success, but for some reason this not always the achieved result.

Effective utilization of metacognitive skills should predict academic success in chemistry, but this was not the finding from this study. Hartman (2001) found that metacognition is a marginal predictor of achievement and proposed that her findings should be considered exploratory and subject to further investigation. Hall (2001) had found that the EPQ not only predicts end-of-semester GPA but could also predict future GPA, in conjunction with SAT scores. Hall and Bahrick (1998) recognized the validity of the predictability of metacognition in retention but cautioned that aspects of metacognition that allow accurate prediction may not be emphasized in metacognitive training.

The inability of the LEP to predict chemistry success corroborates Perry’s (1970) impression that science students tended to score lower on the intellectual and ethical
development scheme. Additionally, chemistry is perceived as a dualist subject. This perception is probably a result of the structure of the science textbooks and methodologies of instruction employed by most science instructors. However, experts in the field perceive science as non-dualistic. In their opinion, the purpose of chemistry instruction is to move students along on the Intellectual and ethical development scheme and not to allow students to regress in the sciences. It has been found that some students are high on the scheme named above in some subjects but lower in the sciences. For example, a student may be on Position 4 in an English class but on Position 2 in a science class. For the reasons stated above, Finster (1991) proposed removing “the veil of simplicity from their image of science by introducing multiple perspectives in science and eliminating science as authority.” (p. 755). Methodologies of teaching should present chemistry as a process.

The lack of a predictor for academic success in chemistry among the variables investigated in this study is rather disappointing and necessitates further investigation into this phenomenon. Education is that educating college students is replete with complexities and that prudent instructors should be cognizant that one variable may not guarantee academic success for all students in all contexts. It seems that a plethora of variables lead to successful academic outcomes for college students.

Hypothesis 1

The hypothesis states that there is a positive relationship between general chemistry students who engage in metacognition during studying and high intellectual development. The results of this study revealed that some sections of the ASSIST were positively related to each other. For all the students, scores for deep approach were significantly and positively related to scores for strategic approach, preference, CCI, and EPQ. This means that participants with
higher scores for deep approach tended to have higher scores for strategic approach, preference, CCI, and EPQ. Students who utilized deep approach strategies and who were likely to use strategic approach strategies were in Position 3 or higher in their intellectual development and were metacognating during studying. Additionally, the findings of this study revealed that scores for surface approach were significantly and negatively correlated to scores for deep approach, CCI, and EPQ, indicating that participants with higher scores for deep approach, CCI, and EPQ tended to have lower scores for surface approach. Allocation by chemistry class yielded the same pattern as observed in the overall model. Specifically, there was a significant and positive relationship between scores for metacognition during studying and approaches to studying, including deep approach, strategic approach, and preference for different types of courses and teaching. This indicates that participants who engage in metacognition during studying tended to have higher scores for approaches to study for deep approach, strategic approach, and preference for different types of course and teaching. However, there was a negative relationship between scores for metacognition during studying and surface approach to studying, indicating that being more engaged in metacognition during studying tends to result in lower scores for surface approach. This is not surprising because studies have shown that surface approach to studying precludes metacognition (Case & Gunstone, 2002; Hammouri, 2003; Spada et al., 2006). Surface approach students do not metacognate during studying, either through their own volition or through ignorance of the advantages of metacognition.

Hypothesis 2

The second hypothesis states that deep approach to studying is related to employment of metacognition and to intellectual development. This hypothesis was confirmed because the results revealed that deep approach to studying was significantly and positively related to
metacognition and intellectual development, indicating that participants with higher scores for deep approach to studying tended to have higher scores for metacognition and intellectual development. These results were not surprising at all. Prerequisite knowledge of metacognition is necessary for deep approach to studying. The purpose of deep approach is to comprehend the concept by relating different ideas to previous knowledge and by checking understanding in an active manner, which is what is also involved in metacognition. The relationship of deep approach to intellectual development is also unsurprising because Position 5 is metacognition itself; at this position, students are required to think about their thinking and to develop contextual thinking skills. Thinking cannot be linear but has to be divergently tolerant of complexity.

Additional analyses were conducted to ascertain whether other covariates may predict students’ academic success in chemistry. It was discovered that the overall model predicting chemistry success from approaches to studying, abilities to metacognate, levels of intellectual development, gender, age, and academic standing was not significant. There were no significant predictors of academic success in chemistry. However, there was statistical significance for students in chemistry 1411. The results for these students revealed that surface approach to learning was a significant predictor of failure in chemistry 1411. Specifically, students who had higher scores for surface approach had significantly greater odds of failing chemistry 1411, compared to those who had lower scores for surface approach. This is not surprising because this trend had been observed before. It is an established fact that surface approach predisposes students to failing classes. In chemistry 1412, the findings in this study revealed that scores for metacognition, or scores for EPQ, significantly predicted academic success in a chemistry course. Specifically, participants with higher scores for EPQ had a significantly lesser odd of
receiving a grade of a C or below than did those with lower scores for EPQ. This finding reiterates the importance of metacognition in studying.

The rationale for the inclusion of age, gender, and academic standing as variables in this study is that previous studies have investigated the impact of these variables on study behavior. Age has been studied in relationship to study approaches, and the findings were inconclusive. Some researchers found that age was a factor in study behavior, specifically that older students tended to adopt deep and strategic approaches to their studying, but others refute the influence of age on study behavior. Gender has also been investigated, and researchers found that males utilize deep approaches while females predominantly use strategic approaches; other studies refute these findings and assert that study behavior is independent of gender. The fact that academic standing could not predict academic success in chemistry was interesting because the expectation is that students who are juniors and seniors should have an advantage over those who freshmen and sophomores; their intellectual development should be higher, and experience may provide them the skills necessary to be effective learners.

Conclusion and Implication for Further Study

In conclusion, despite the finding in this study that strategic approach may mean higher grades in courses, chemistry instruction should be geared toward encouraging deep approach to learning. The findings of this study may be indicative of a unique feature of this sample of students in this study. The students who participated in this study are motivated by the pursuit of career goals. They are working hard to maintain the highest grades possible to enable their transfer to college or university. My suggestion is that chemistry instruction should be oriented toward deep approach. The promotion of deep approaches to studying should lead to successful outcomes in terms of terminal course grades. As gleaned from the results of this study,
employment of deep approach does not lead to higher grades. The reason for this dilemma should be a topic for further studies. The problem may be that current assessment tools, especially the preponderant use of multiple choice questions and poorly written essay questions, measure lower-level learning tasks. In Bloom’s (1956) taxonomy, remembering, understanding, and, maybe, applying, in Perry’s (1970) Position (2 and 3)-dualist and multiplicity, and in study approach–surface. Related to the issue of examinations that test lower-order knowledge is timed tests; the idea is that if one cannot recall the information in the time-frame, then one has not understood the information. Reflection and opportunity to function at higher levels of intellectual processing is inhibited because of time constraints. I am fully cognizant of institutional needs for assessment by and accountability to various stakeholders, but if the goal of chemistry instruction is attaining comprehension, conceptual knowledge, and relativistic and committed relativistic intellectual development, then learning and instruction should be structured to actualize these objectives.

There are specific methods for promoting deep approach in the chemistry classroom. Deep approach can be enhanced by using flow diagrams, concept maps, and vee diagrams, by introducing true cooperative learning in which students must assume responsibility for their learning, by innovative teaching and learning in the classroom and beyond, all of which are necessary for encouraging deep approach to learning. Relevance and applicability to student life are the buzz words in current conversations in higher education. These require students who learn to understand rather than to memorize isolated facts by rote. Relevance to future learning and career should be emphasized so as to expedite the intellectual development of the students. Other methods of encouraging deep approach to learning in chemistry classrooms are
incorporating specific instructions on how to use metacognition in studying and modeling metacognition by faculty of as part of their instructional strategies.

Another dimension to encouraging deep approach to learning is instructors’ perceptions of their students. Psychologically, instructors have to teach from an empathetic premise because learners who use surface approach to learning are plagued by lack of confidence in their abilities to cope with learning, especially in chemistry. Because of this, learners who use surface approach to learning will function more effectively and efficiently in supportive educational environments. Educational environments replete with opportunities for safe exploration should allow apprehensive learners who use surface approach to learning to advance to deep approach. Recall that metacognition and deep approach to learning require risk-taking behaviors, which is only possible if students perceive that they are in psychologically safe environments. Also part of teaching with empathy and validation of the uniqueness of each individual student is the recognition that entrenched study behaviors are difficult to change. Thus entrenched behavior transformation and paradigm changes have elements of disequilibrium, cognitive dissonance, and apprehension. These must be addressed in the chemistry classroom for successful outcomes in learning. The implications of this are numerous, but the most cogent is the confidence that it will instill anxious students who, without trepidation, persist to completion.

Other reasons have been proposed as contributory factors that may cause students to resort to surface approach in their studying include inordinate amounts of course material and accentuation of factual knowledge. Adjustments of course load are necessary because studies have found that students who regularly use deep approach or strategic approach will resort to surface approach if workload becomes inappropriate. In addition, promoting the scientific method of inquiry and active learning rather than the rigid algorithmic and formulaic method of
learning chemistry and allowing flexibility in content may enhance conceptual knowledge, retention, and satisfaction with science courses. Accentuate learning as a process of individual and community growth. This may change the invalid perception of chemistry as an irksome and abstruse subject.

To maintain interest, motivate, and actively engage students who will be the next generation of medical professionals, it is crucial that we reexamine and configure our mode of operation in chemistry classrooms to enable students to succeed. Infuse elements of metacognition within the instructional aspect of instructor behavior. Literally, teach students how to metacognate and the advantages of metacognition in their personal studying. These students are the future doctors, pharmacists, and dentists. They should be provided with an education grounded in profound understanding of the body not one which emphasizes the memorization of isolated pieces of information, which are forgotten soon after the board exam?

Limitations of the Study

There are several limitations associated with this study. The first is that the sample is a convenience sample of students enrolled for the semester in a general chemistry class. Data collection was a one-time event. The second limitation is related to the use of the LEP, an instrument based on Perry’s (1970) form of intellectual and ethical scheme as a determinant of intellectual development in this sample of students from community college. Perry’s (1970) scheme is problematic because it was validated with a Harvard University sample of mostly male white students from the 1950s. The relevance to this sample of present-day students of mixed demography is questionable. However, the instrument has been validated in several contexts and has both high reliability and validity. The instrument’s developer suggested that the LEP could be taken home by students and completed outside of classrooms because of the large number of
items on the survey. In retrospect, this was not a good idea because most of the instruments that went home were not returned or were completed in a desultory manner, thus invalidating the instrument.

Another limitation to this study is the self-report nature of the instruments. The veracity of some of the responses is questionable. Some students did not complete the questionnaire as instructed, and several instruments were invalidated and were not subject to analysis for this reason. Another assumption is that students’ majors and the nature of the institution are irrelevant.

Delimitations

The present study is limited to students enrolled in general chemistry classes at a single community college campus during one semester, spring 2011.

Future Research

This study was limited to students on one campus. The results may differ if the sample included students from other campuses. This study could also be replicated with a sample of four-year college or university students. Also, an experimental design with intervention, such as explicit instructions and demonstrations of the practical use of metacognition, deep approach, and multiplicity, and even contextual relativism, in students’ studying may yield a different result. If not statistical significance, at least practical significance may facilitate students’ successful adaptation and learning in any context. A longitudinal study with all three instruments may inform practice better than does a one-time event, such as this study. Additionally, the inability of deep approach to studying to predict academic success in chemistry from these results should be the subject of further study. I conjecture that the inability of deep approach to predict chemistry success maybe was due to an incongruence between what the
exam purports to measure and definition of deep approach. Utilizing qualitative research method may add to the richness of future studies.
REFERENCES


