STUDENTS’ TASK INTERPRETATION AND CONCEPTUAL UNDERSTANDING
IN ELECTRONICS LABORATORY WORK

by

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ABSTRACT

Students’ Task Interpretation and Conceptual Understanding in Electronics Laboratory Work

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Task interpretation is a critical first step in the process of self-regulated learning and a key determinant of the goals students set while learning and the criteria used in selecting the strategy in their work. Laboratory activities have been proposed to improve students’ conceptual understanding when working independently and alongside peers while integrating new experiences in a lab setting. The purpose of this study was to investigate how the explicit and implicit aspects of student’s interpretation of the task assigned during laboratory work may change during the task process, and how that interpretation may influence the student’s coregulation and conceptual understanding.

One-hundred and forty-three sophomore students enrolled in the course of Fundamental Electronics for Engineers participated in this study. Instruments designed to measure task interpretation and conceptual understanding were created and validated in a pilot study. They were applied before and after selected laboratory activities during the
semester. The instrument used to measure correlation was applied at the end of every selected laboratory activity.

Statistical analysis indicated differences between the student’s task interpretation before and after the laboratory activity. Students improved in approximately 15% in the level of task interpretation. From the 143 students, only 37 of them were identified with high levels of task interpretation and coregulation. Moreover, Pearson correlations identified a positive correlation between the students’ task interpretation and conceptual understanding of the students during laboratory work.

Findings suggested students’ task interpretation changed during the task process and increased after the completion of laboratory activity. Overall, the findings showed a low level of task interpretation. However, students with a high level of task interpretation reached high levels of coregulation. Findings confirmed previous research that found students generally have an incomplete understanding of the assigned tasks, and struggle to establish a connection between laboratory activities and theory. Lastly, this study reported a significant relationship between students’ task interpretation and conceptual understanding in laboratory work which has not been reported in the most recent published reports. Further investigation is necessary to unveil other factors related to these constructs in order to engage students in laboratory work.

(171 pages)
Students’ interpretation of an assigned task is a key determinant of setting goals, choosing strategies to accomplish those goals, monitoring, and self-evaluating outcomes. Laboratory activities, including worksheets, quizzes, and other assignment are designed to improve the understanding of concepts taught in the classroom. The main concern of many laboratory students is simply completion of the task because it is critical to their success. Three objectives were proposed in this study, to investigate: (1) the students’ interpretation of the task before and after the completion of the laboratory activity, (2) the interpretation of the task differs between high- and low-coregulated students, and (3) the relationship between the students’ task interpretation and conceptual understanding in laboratory work. One-hundred and forty-three engineering students enrolled in the course of Fundamental Electronics for Engineers participated in the study.

This study utilized self-regulated learning as a framework in the context of laboratory activities. The specific focus was to understand students’ task interpretation and coregulation and their relationship to students’ conceptual understanding while working in the laboratory. Data were collected using questionnaires and surveys designed to measure students’ task interpretation before and after the completion of selected
laboratory activities during the fall semester of 2014. Moreover, a questionnaire to
measure the level of coregulation was administrated at the end of each selected laboratory
activity.

Findings revealed that a students’ better interpretation of the tasks once they
completed it. Also, students with a higher understanding of the task were responsive to
their own and team members’ engagement in the assigned tasks. Finally, findings
reported a significant relationship between students’ task interpretation and conceptual
understanding in laboratory work. When students had a better understanding of what they
were to do in the laboratory, they showed an improved comprehension of the concepts
involved in the laboratory activity. The study provided new information about the
regulated processes of engineering students during laboratory activities. As a
consequence, the study may benefit researchers and curriculum developers who are
interested in conducting studies to improve engineering curriculum based on how
engineering students think about their learning process in a laboratory context.
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CHAPTER I

INTRODUCTION

Background of Study

Laboratory activities can help students move from abstract ideas to actual illustrations at a time when the mind needs concrete representations for understanding (Gage & Berliner, 1984; Lawson, 1995; Piaget, 1973). Laboratory activities have been proposed to improve students’ conceptual knowledge (Ruby, 2001) as they strive to integrate new experiences with prior knowledge, establish a context for the purpose of the laboratory activity, and determine the activity relevant to them (Novak & Gowin, 1984). When Lynch and Ndyetabura (1983) asked 257 science teachers and 459 secondary school students to select 4 criteria from a list of 10 to support successful laboratory work, those that made theory more understandable were selected. In a laboratory, students must consider facts, principles, conceptual models, theories, and laws to understand science and be able to apply it. Ruby called this “the use of conceptual knowledge” (also known as “declarative” or “content knowledge”), which students are expected to understand and remember during lab activities.

Laboratory activities require good teamwork skills and management of constrained resources such as time, and encourage social skills such as cooperation (Hart, Mulhall, Berry, Loughran, & Gunstone, 2000). Hart et al. (2000) suggested that laboratory activities help students to focus on the importance of communicating, publicizing, and verifying the results obtained in the experiments. Although some laboratory practices depend more on logistics than social purpose, laboratory work
promotes cooperation as students work as peers in a group.

Researchers have suggested that engineering students often do not involve enough mental engagement in laboratory activities (Hart et al., 2000). White (1996) argued that students follow directions without thinking about the purpose of how the experiment relates to other information they have learned. The result could be a mindless laboratory activity and lack of mental engagement in which students fail to link the activities with the material covered in lectures (Davidowitz & Rollnick, 2003; Domin 1999). Also, Hart et al. (2000) conducted research on laboratory work and found little evidence that students reflect on their observations or successfully link them to what they already know. Therefore, the need to establish a connection between laboratory activities and the material covered in the classroom is a unique feature in the laboratory context and a relevant area for research.

Similar to classroom time, students spend lab time working on tasks assigned by instructors, such as completing worksheets, assignments, or quizzes (Helm, 2011). Some studies have concluded that the fundamental concern of many lab students is simply completion of the task because it is critical to their success (Berry, Mulhall, Loughran, & Gunstone, 1999; Edmonson & Novak, 1993; Hart et al., 2000). They must link the different components of laboratory work and theory and develop their own understanding in order to engage with the material and achieve a sense of academic success and satisfaction from interpreting and understanding the task assigned (Hart et al., 2000).

Many researchers have studied how to improve conceptual understanding through regulated learning processes. Models of self-regulated learning (SRL) and coregulated
learning (CRL) are most often applied to understanding student engagement in a team-based format of learning (Jarvela & Hadwin, 2013). These regulated processes occur when students work independently or collaboratively on tasks (Jarvela & Hadwin, 2013). SRL requires an awareness of the context in which it occurs, and interpretation of research results requires sensitivity to the context in which a study was conducted (Butler & Cartier, 2004). CRL occurs in a specific context when the SRL process of students is influenced in a collaborative group (DiDonato, 2013). Thus, those models may help students to improve their understanding of laboratory activities.

SRL refers to how students strategically engage, evaluate, and regulate their cognitive, motivational, and behavioral strategies to optimize learning in a given environment (Butler & Cartier, 2004; Hadwin, 2001). Students must consider what they are being asked to do, activate prior knowledge, concepts, and perceptions derived from prior learning experiences that are relevant to the assignment, and construct a personal plan to complete the assigned task (Hadwin, Oshige, Miller, & Wild, 2009; Lawanto, 2011). Task interpretation is the critical first step in the SRL process because it is a key determinant of the goals set, the strategies selected to accomplish those goals, and the criteria used to self-evaluate outcomes (Butler & Cartier, 2004; Butler & Winne, 1995; Lawanto, Goodridge, & Santoso, 2011). Therefore, successful task interpretation is the foundation of focused engagement (Butler & Cartier, 2004). Task interpretation depends on student engagement in a wide range of cognitive, metacognitive, and motivational process to assess and interpret task information provided by an instructor in a particular context (Hadwin et al., 2009). In order to interpret a task, engineering students must
decipher the information about explicit task instruction and criteria, implicit task information, as well as sociocontextual cues about the task (Hadwin et al., 2009; Oshige, 2009). Hadwin defined a model of task interpretation by suggesting that tasks are comprised of three layers or spheres of information and that construction of accurate and complete task interpretation demands that students interpret and synthesize information across the three spheres of information (Hadwin, 2006; Hadwin et al., 2009; Oshige, Hadwin, Fior, Tupper, and Miller, 2007). The three layers of Hadwin’s model are: explicit, implicit, and social contextual. Overall, students must identify each of the features in order to choose appropriate strategies and make effective judgments regarding future academic success (Broekkamp, van Hout-Wolters, Rijlaarsdam, & van den Bergh, 2002; Greene, Hutchison, Costa, & Crompton, 2012; Winne & Hadwin, 1998).

Coregulation (CRL) refers to a transitional process in a learner’s acquisition of SRL, within which learners share a common problem-solving plane, and SRL is gradually appropriated by the individual learner through interactions (Hadwin & Oshige, 2011). Chan (2012) explained coregulation in terms of individuals working together as self-regulated learners who regulate each other’s learning. In the context of CRL, students bring their own ideas, concepts, and self-regulated skills to the group, all of whom play an important role in the personal and team engagement in the activity. McCaslin (2009) emphasized that coregulation occurs through activity, engagement, and mutual relationships in which individuals bring areas of expertise to novel learning. One example of coregulation is when peers in a group assume different roles associated with SRL for an individual or collective task. One peer engages the others to discuss task
interpretation, a second peer reminds them to stop and check how they are doing (monitoring and evaluating), and a third peer engages students in a discussion about task goals and strategies of how to complete the activity (Hadwin & Oshige, 2011). CRL is a process of interaction between peers where one is more capable or advanced, with a higher awareness of the SRL process. For a more advanced coregulated peers, CRL may help them to recognize, refine, and modify inconsistencies in their regulatory strategy which they can use to advance their SRL. For less advanced coregulated peers, working with more regulated peers could help them to learn strategies for future use (DiDonato, 2013).

The focus of this study was on task interpretation as defined by Hadwin (2006), which is a critical feature and the heart of the SRL model. Task interpretation has been under-researched, particularly in the context of complex and ill-structured task contexts (Hadwin, 2006), in engineering design and project management (Lawanto, Butler, Cartier, Santoso, & Goodridge, 2013). The contexts have been identified as particularly good candidates for studying task interpretation because tasks are generally ill-structured, complex, and require a high degree of cognitive ability (Lawanto et al., 2013). Task interpretation has not been studied in the context of laboratory work. Laboratory activities require the use of conceptual understanding (Ruby, 2001) because they include the facts, principles, conceptual models, theories, and laws that students are expected to understand and remember. In the laboratory context, students must integrate new experiences with prior knowledge, establish a context for the purpose of the laboratory activity, and determine the activity’s relevance to them (Novak & Gowin, 1984).
Although there are several features unique to laboratory activities such as the need to establish a link between lab activities and classroom material, the similarity of skills required for successful engagement in complex and ill-structured task contexts, engineering design, project management, and laboratory activities suggest that a study in the laboratory context is an area of unique research for this dissertation.

**Purpose Statement**

The purpose of this study was to investigate how students’ task interpretation of laboratory work may change during the task process, and how it may influence coregulation and conceptual understanding. This study was focused on the explicit and implicit aspects of task interpretation based on the model of Hadwin (2006). The aspects of task interpretation and conceptual understanding were analyzed before and after the laboratory activity. Coregulation was evaluated after the completion of the task assigned in the laboratory.

**Research Questions**

Previous research has suggested that task interpretation is related to academic success, and also that laboratory activities improve conceptual understanding for academic success. However, it is not yet clear that task interpretation is a good predictor for students’ task completion and conceptual understanding needed to succeed in
laboratory work. Researchers have related task interpretation to engineering design, project management, and engineering projects in general, but not in the specific context of laboratory work. In addition, there is limited information regarding students’ task interpretation as a part of the SRL in the laboratory context. Moreover, coregulation occurs in a specific context when the students acquire the SRL process by bringing their own ideas and engaging in their assigned tasks. High-coregulated students may improve their understanding in interpreting laboratory-related tasks. But similarly to task interpretation, there is limited information regarding coregulation in the laboratory context. Researchers usually develop studies considering the students in the classroom without making a distinction between classroom and laboratory activities. For these reasons, this study related the task interpretation, coregulation, and conceptual understanding in the context of laboratory work. The following questions constituted the foundation of the research:

1. Does students’ task interpretation change during the task completion process?
2. How is students’ task interpretation different between high- and low-coregulated students?
3. How is students’ task interpretation related to conceptual understanding?

**Research Design**

The research design of this study provided the procedures of how to collect and analyze the data to answer the research questions. The study considered the general rule
of using the largest sample possible. The larger the sample, the more likely the participants’ scores on the measured variables are representative of the wider population. One hundred and forty-six sophomore students registered for the class and laboratory for the course, Fundamental Electronics for Engineers, for the fall semester of 2014. Data collection included surveys that were applied before and after selected laboratory activity to measure task interpretation, coregulation, and conceptual understanding.

This study used different statistical approaches to describe students’ task interpretation, coregulation, and conceptual understanding. An analysis to compare the means of the variables was used to describe the students’ task interpretation during the task process. A descriptive statistical analysis and comparison of means were used to analyze the process of coregulation during laboratory activities. Finally, a correlation analysis was used to determine the influence of students’ task interpretation in students’ conceptual understanding. The quantitative analysis of the study included an analysis of variances (descriptive statistics), t-test and correlation analysis (parametric statistics).

**Significance of the Study**

The results of this study identified how students’ interpretation of the task assigned during laboratory work may change during the task process, and how it may influence coregulation and conceptual understanding. The study provided new information about the regulated processes of engineering students during laboratory activities. As a consequence, the study may benefit researchers and developers who are
interested in conducting studies to improve curriculum based on how engineering students think about their learning process in a lab context. The outcomes of this study may provide insights to help instructors actively support students in completing tasks assigned during laboratory work.

Furthermore, the researcher expects that the outcomes will serve as a reference for other researchers in associating and differentiating the unique features of classroom versus laboratory work. A focus on laboratory activities may be especially useful for researchers because experiences in a laboratory context have received little attention in the literature in the field of engineering.

**Limitations of the Study**

The limitations of this study are those characteristics of design or methodology that might impact or influence the interpretation of the results. They are:

1. **Time constraints:** because participants took two quizzes before and three quizzes after each lab activity, it is possible that participants will respond simply “idem” or “same” after each.

2. **Due to time constraints,** the instruments to measure conceptual understanding consisted of true-false questions. Although there is a 0.5 probability of answering incorrectly by chance, this was minimized adding an extra question to measure the same concept by rephrasing the original question.
3. Participants took two quizzes to measure the conceptual knowledge (before and after). Because the duration of lab activity is approximately 30 minutes, it is possible that participants may have recalled their answer from the previous quiz. The researcher changed the order of the questions in the after-quiz to minimize the impact of this limitation.

**Assumptions of the Study**

Assumptions of this study are listed below:

1. Participants were engineering students registered in their second year of college. The researcher expected all the participants to have similar skills in English, calculus, and science as a requirement for registering for the selected course.

2. Participants provided authentic or honest answers to the survey and quizzes. Participants were volunteers during the study and their anonymity and confidentiality influenced them to give accurate and truthful responses.

3. The responses of participants focused on the research problem and allowed the researcher to answer the research questions.

4. This study assumed that the statistical analysis was conducted following the criteria of type I error rate at .05 level and intervals of confidence at 95%. The selected sample of sophomore students was sufficient to conduct this study and safely extrapolated the results to infer how much the outcomes of this study were
applied to represent the participants as a whole. Researcher considered this assumption as a key to a robust power analysis.

5. As a quantitative study, the researcher assumed that all the facts and experiences in the context of this study were quantifiable and measurable.

Definition of Key Terms

For the purposes of this study, the following terms are defined.

**Conceptual knowledge:** Characterized most clearly as knowledge that is rich in relationships. It can be thought of as a connected web of knowledge, a network in which the linking relationships are as prominent as the discrete pieces of information (Hiebert & Lefevre, 1986). It is also known as declarative knowledge.

**Coregulated learning:** A transitional process in a learner’s acquisition of self-regulated learning (SRL) in which learners and others share a common problem-solving plane, and SRL is gradually appropriated by individual learners through interactions (Hadwin & Oshige, 2011).

**Engagement:** The students’ active and reflective coordination of learning processes (i.e., self-regulation) in light of metacognitive knowledge and motivational beliefs and in the context of academic work. Thus, we associate engagement with self-regulation in action, as situated within an instructional context (Zimmerman & Schunk, 2001).

**Laboratory session (lab session):** Consists of a specific number of activities that
students should conduct during laboratory time.

*Laboratory activity (lab activity):* An assigned activity as part of laboratory session that students should develop during laboratory work.

*Laboratory guide (lab guide):* A document containing the list of objectives, materials, instruments, instructions, and procedures needed to complete the laboratory activity.

*Laboratory work (lab work):* Hands-on activities that students should experience in the laboratory room.

*Self-regulated learning:* An iterative and dynamic process with goal-directed activities that involves interpreting tasks, setting goals, selecting and adapting effective strategies for achieving those goals, monitoring progress, and adjusting approaches as needed (Butler & Cartier, 2004; Pintrich, 2000; Zimmerman, 2006; Zumbrunn, Tadlock, & Roberts, 2011).

*Task assigned:* Instructions given to students before starting a laboratory activity.

*Task interpretation or task understanding:* Students’ construction of an internal representation of the externally assigned task (Butler & Cartier, 2004; Butler & Winne, 1995; Hadwin et al., 2009; Lawanto et al., 2011).

**Dissertation Outline**

The organization of this dissertation is as follows: Chapter I provides a background and introduction to the study. Chapter II provides a review of literature of
each of the constructs and context of this research. Chapter III provides a discussion of the objectives and findings from the pilot study. Chapter IV presents the research design and methodology. Chapter V provides the findings of the study. Finally, Chapter VI discusses the conclusions, implications, and recommendations for future work.
CHAPTER II
LITERATURE REVIEW

Introduction

Research in the field of Engineering Education has evolved to include a greater emphasis on the role of the student in the learning process. It represents the “recognition of the importance of the personal initiative in learning” (Zimmerman, 1989) that has led to the interest in the process of self-regulated learning (SRL) in the context of engineering design and project management (Lawanto et al., 2013). Self-regulated learning might be researched in the context of laboratory work where students are expected to understand, and connect experiences with previous knowledge (Novak & Gowin, 1984). One of the most unique features of laboratory activities is the need to establish a link between laboratory activities and the material covered in the classroom (Davidowitz & Rollnick, 2003). Therefore, this research illustrates the importance of SRL in laboratory work. Understanding how students engage in the process of SRL and how they interpret the assigned task to complete the laboratory work assigned is recognized by experts in this field as an important research avenue.

The purpose of the review of literature is to present a critical review of the research in laboratory activities, task interpretation, and collaborative regulated learning or coregulation (CRL). The objectives of this review are to:

- Discuss the issues in laboratory activities and conceptual knowledge.
• Discuss task interpretation as part of the SRL process.
• Discuss what CRL is and how to measure it.

Laboratory Activities

Definition

By tradition, the term “laboratory” work has been used to describe the practical activities done by students instead of other methods of teaching such as lecture or recitation in a classroom. According to Ruby (2001) the term is somewhat limited for two reasons: first, many students, especially in primary and middle school, do not have access to a laboratory, but instead perform hands-on activities in a regular classroom; second, students may carry out hands-on activities that are not actual experiments, for example, observation and measurement (2001). The term “hands-on” includes all activities carried out by students themselves that they do in the classroom or in a laboratory (Ruby, 2001). The term includes a specific method of instruction, based on activities carried out by students, but its use does not exclude other instructional methods often used in conjunction with them. Similarly, lab activities includes contrived learning experiences in which students interact with materials to observe phenomena (Hofstein & Lunetta, 1982). The contrived experiences may include cognitive phases such as planning, analysis, interpretation, and application as well as the central performance phase. For the remainder of this dissertation, the term hands-on activities and laboratory work will be synonymous with laboratory activities.
Laboratory Activities and Conceptual Knowledge

Laboratory work has long been used to involve students in concrete experiences with objects and concepts. John Dewey, leader of the progressive education movement, advocated an investigation approach, “learning by doing” (Tamir, 1976). Contemporary science educators (e.g., Hurd, 1969; Lunetta & Tamir, 1978; and Schwab, 1962) expressed the view that the uniqueness of the laboratory lies principally in providing students with opportunities to engage in the processes of investigation and inquiry.

According to Ausubel (1968), the laboratory "gives the students an appreciation of the spirit and method of science, promotes problem-solving, analytic and generalizability ability, and provides students with some understanding of the nature of science" (p. 345). In a review of the literature, Shulman and Tamir (1973) proposed a classification of goals for laboratory instruction in science education. They indicated laboratory activities develop creative thinking, conceptual understanding, and intellectual ability. Anderson (1976) summarized the goals of laboratory work as fostering the knowledge of humans to enhance student intellect and understanding. From the findings of John Dewey, laboratory work has long been used to involve students in concrete experiences with objects and concepts to improve their understanding of the science (Shulman & Tamir, 1973).

Hofstein and Lunetta (1982) claimed that laboratory work was one of the important vehicles for teaching and understanding the processes of “scientific thinking.” They cited Lucas (1971) who said that students can understand how scientists work and how to acquire new knowledge themselves by personally practicing the use of inquiry in
laboratory work. Hofstein and Lunetta also cited Burmester (1953), who designed a carefully validated paper-and-pencil test to measure some aspects of students' ability to think scientifically in laboratory work. Under the heading "scientific thinking," she included the ability to: (1) recognize problems, (2) understand experimental methods, (3) understand the relation of facts to the solution of problems, and (4) make generalizations and assumptions (Hofstein & Lunetta, 1982). A research study conducted by Kaplan (1967) showed student pretest/posttest “gains” in knowledge on Burmester's test resulting at least in part from the use of a laboratory manual designed to teach explicit aspects of scientific thinking. Hofstein and Lunetta (1982) concluded that laboratory activities provide a unique medium of learning in science. However, Ruby (2001) maintained that researchers have not carefully examined all of the aspects related to when students work in a laboratory, one of the aspects being a conceptual understanding as part of the “gains.” Although researchers started describing aspects of the learning process through laboratory work, the evidence of the relation to conceptual understanding is unclear.

Moreover, Ruby (2001) stated that laboratory activities have been proposed as a means to improve students’ understanding of conceptual knowledge. Examining objects may make the abstract knowledge more concrete and clear, and through laboratory activities students are able to see real-life illustrations of the knowledge and observe the effects of changes in different variables. This statement was supported by Ruby (2001) who stated that the idea of laboratory activities supports an understanding of content knowledge. It is consistent with Piaget’s (1973) developmental theory that posited the successive stages (three to five) of mental development through which humans pass. The
highest stage includes the ability to work with abstractions. Before this stage can be reached, humans first pass through a stage in which thinking is confined to concrete matters. Interactions with the physical environment (along with other factors) support the mind’s passage through these stages (Piaget, 1973; Gage & Berliner, 1994; Lawson, 1995). It may be concluded that laboratory activities can help students move from the second highest stage to the highest stage as it offers a concrete illustration of abstract ideas at a time when the mind needs concrete representations for understanding (Ruby, 2001). Laboratory activities may also be used to address faults in information processing. According to the cognitive theory of Piaget, the separate bits of knowledge held in long-term memory are organized using broader concepts known as schema. Schemas are organizing principles that guide an individual’s understanding of separate pieces of information and are used to organize and integrate new information (Ruby, 2001). This is consistent with the definition of conceptual understanding stated by Hiebert & Lefevre (1986) as a connected web of knowledge, a network in which linking relationships are as prominent as discrete pieces of information.

Cartensen and Bernhard (2009) developed a problem-solving laboratory for learning transient response in electric circuits, a momentary short burst of energy in the response of the circuit in a rapid change of state. In their design, problem-solving classes and laboratories were replaced by extended “problem-solving” laboratories and variation theories as a main analytical tool. Variation theories state that the experience of discernment, simultaneity, and variations are conditions for learning (e.g., Marton & Booth, 1997; Marton & Tsui, 2004; Marton & Pang, 2006). The purpose of this
experiment was to understand the transient response of a circuit using a problem-solving laboratory. The idea behind the laboratory was that knowledge is built by learning the component pieces and making explicit links. Hence, the more links that are made, the more complete the knowledge becomes. The integrated use of tools in the problem-solving laboratories is crucial when students establish the links between the “world” of theories/models and the “world” of objects/events (Cartensen & Bernhard, 2009). Cartensen and Bernhard used the variation theory in participants successfully, and their students improved in conceptual understanding. Although they used a modified curriculum with several tools such as MATLAB®, Spice, and tools for computer-based measurement on real circuits, they also concluded that these tools have to be used in order to understand the links between theories/models and object/events.

Kolloffel and de Jong (2013) developed a study with secondary vocational engineering education students about electrical circuits. They stated that a proper conceptual understanding enables students to think through concepts of electrical circuits such as voltage and current (2013). They cited Swaak and de Jong (1996, 2001) who contended that as students’ conceptual understanding deepens, the accuracy with which they assess the causal relationships increases between quantities in problem situations, as does the accuracy of their predictions of how these quantities will respond to changes. Students were randomly assigned to one of two conditions in a quasi-experimental study. The first was a traditional curriculum (class and lab); the second was a nontraditional curriculum (class and virtual lab). Although the purpose of the experiment was to compare the different curriculums in laboratory activities, the authors emphasized how
conceptual knowledge helps learners to recognize and identify key concepts when studying or diagnosing a problem (2013). As a result, a better conceptual understanding of the problem increases the likelihood that the learner will select the appropriate problem-solving procedure.

**Laboratory Activities and Challenges**

Researchers have suggested that engineering students often fail to engage during lab work because they do not involve sufficient mental engagement in laboratory activities (Hart et al., 2000). White (1996) argued that students follow directions without thinking about the purpose of how the experiment relates to information learned previously. This leads to a mindless laboratory activity in which students fail to engage in the task assigned. There are several challenges related to lab activities: (1) a student follows directions without thinking about the purpose and the concepts related to the experiment (White, 1996), (2) the instructor cognitively overloads students with too many things to recall (Johnstone & Wham, 1982), and (3) a student often fails to relate the laboratory work to other aspects of her/his learning (Hodson, 1990). Perhaps the most important and unique feature of laboratory activities is the need to establish a link between lab activities and the material covered in the classroom (Davidowitz & Rollnick, 2003). In university laboratories, there are often challenges associated with the articulation of the teaching content and the practical work based on that content. Even though overt links are sometimes made, students frequently are unable to link the laboratory activities with the material covered in lectures (Davidowitz & Rollnick, 2003;
Domin, 1999; Hart et al., 2000).

Domin (1999) stated two reasons for students’ inability to connect laboratory and class material. First, he contended that in laboratory activities students are more often concerned with correct results than thinking about planning and organizing the experiment. Second, not enough time is allowed for students to actually think about the science principles being applied in the laboratory (Domin, 1999; Stewart & Collin, 1988). Therefore, students are not afforded the time necessary for the deep processing of information. Consequently, they often struggle to establish a connection between laboratory activities and the material covered in the classroom.

Hart, Mulhall, Berry, Loughran, & Gunstone (2000) stated the same conclusion based on their observations of students during a range of laboratory classes. They designed a unit of 10 classes that involved students planning and conducting chemistry experiments and then writing about them in such a way that other students could repeat the same experiments. The purpose was to develop students’ understanding about the role of experimental work in establishing scientific knowledge (Hart et al., 2000). This researcher’s focus was to determine whether students made the link between the tasks involved in the unit and the purpose of the laboratory experiment. The second part of this study was to find if students learned something from the unit of work (laboratory work). Students’ learning was monitored and documented throughout the unit of work. The data sources were: copies of all laboratory reports, individual interviews at the completion of the selected units focusing on students' perceptions of the purpose of the lab activities (i.e. tasks), and laboratory group interviews post unit of work. Audiotaped data from the
survey illustrated the range and frequency of responses offered by students, the data from the laboratory groups indicated students' responses from the particular group and illustrated the nature of their thinking in relation to particular questions/prompts/issues. At the end, the researcher concluded that students need to have sufficient relevant conceptual knowledge prior to the laboratory activity in order to link the concepts with the theory.

Davidowitz and Rollnick (2003) conducted a study with the fundamental purpose to investigate student metacognition in a chemistry laboratory. They stated that to help students engage in deep processing, a key issue is to reach an understanding of students’ thought processes in the lab. Traditional laboratory sessions may not allow students sufficient time for deep processing of information (Rollnick, Zwane, Staskun, Letz, & Green, 2001). Part of the difficulty in processing the information was alluded to by Johnstone (1997) who presented an information processing model which clearly showed how students are limited by the amount of information they can process at one time. Furthermore, what students process is impacted by what he called a perception filter which is influenced by students’ existing schema (1997). An alternative theoretical model of laboratory work was offered by Rollnick, Allie, Buffler, Kaunda, Campbell, and Lubben (1999) who isolated three factors as keys to determining students’ thought processes in a laboratory: conceptual knowledge, procedural knowledge, and communicative competence. The model is termed the Competence Tripod. By engaging the model, students reflect on how they learn in the laboratory and extend their awareness to the various aspects which lead to the successful execution of a practical exercise. Thus,
the Competence Tripod model is intended as a resource which enables metacognition (Rickey & Stacy, 2000; White, 1992). During the first practical session of the period, both the Competence Tripod and flow diagrams were introduced to students. To encourage students to include the model in their thinking, they were asked to classify the postlaboratory questions from selected experiments to test conceptual knowledge, procedural knowledge, or communicative competence. Because this was a case study, four selected students’ statements in interviews and questionnaires, and their performance in practical reports, examinations, and tests were collected as data to be analyzed. An examination of the data showed that all students understood the model of the Competence Tripod and were aware of the importance to link theory and practice. But its comprehension did not necessarily imply adoption. The researchers concluded that further investigation is necessary based on the mixed results obtained from students.

Pfaff and Weinberg (2009) conducted a study of design, implementation, and assessment of four hands-on activities in an introductory college statistics course. As an essential component of statistical literacy, researchers wanted their students to move beyond simply computing confidence intervals and $p$-values to understanding what the concepts actually mean and where they come from (2009). Their goal was to design in-class hands-on activities (which they called "modules") that would help their students develop an understanding of important statistical ideas. Several researchers (e.g. delMas, Garfield, & Chance, 1999; Hodgson, 1996; Schwartz, Goldman, and Vye & Barron, 1997) found that introducing computer simulation activities into their classes increased students’ understanding, but that the increase, while statistically significant, was not
dramatic. Instead of using computer-based simulations, they incorporated physical objects into their activities. Researchers hypothesized that by using concrete objects, the activity would afford more opportunities to create and structure cognitive conflict and facilitate students’ active prediction and reflection. The modules were designed to engage the students in making sense of the “big ideas” of the course. During the semester, researchers administered five written assessments to the class, the goal of which was to evaluate students’ understanding of the "big ideas" before using the modules, soon after using the corresponding module, and again near the end of the semester. Even though researchers thought they had designed and implemented the modules in a way that would help the students understand the "big ideas," their assessment showed that they did not accomplish their goal. Although the modules did not effectively foster understanding, they engaged the students in the course. Pfaff and Weinberg (2009) stated that regardless of how innovative or stimulating a pedagogical idea may seem and no matter how much the students seem to enjoy the class, it may be insufficient to develop students’ understanding. Because the modules were implemented only in one class period, perhaps students may have classified the class discussion of the modules as distinct from the rest of the course. It also could be that students were in some way unprepared to successfully reflect on their activities.
Introducing Self-regulated Learning

Self-regulated learning (SRL) is defined as a form of iterative, goal-directed activity that involves interpreting tasks, setting goals, selecting, adapting, or inventing strategies that are effective for achieving those goals, monitoring progress, and adjusting approaches as needed (Lawanto et al., 2011; Zimmerman, 2006). SRL was also defined by Pintrich (2000) as “an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior, guided and constrained by their goals and the contextual features of the environment” (p. 453). Although there are differences between various theoretical definitions, self-regulated learners are generally characterized as active, efficient managers of their own learning through the use of monitoring and strategy (Boekaerts, Pintrich, & Zeidner, 2000; Butler & Winne, 1995; Paris & Paris, 2001; Pintrich, 2000; Winne, 2001; Winne & Hadwin, 1998; Winne & Perry, 2000; Zimmerman, 2000). Self-regulated learning is an important area of research (Pintrich, 2000) because it enables students to be self-aware, knowledgeable, and decisive in their approach to learning.

This study uses the 2004 model of SRL of Butler and Cartier (Figure 2-1). According to Butler and Cartier, the model represents an attempt to summarize factors that have been associated with SRL in the research literature (Butler & Winne, 1995; Pintrich, 2000; Schunk & Zimmerman, 1994; Zimmerman & Schunk, 2001). The eight features of the model are: (1) layers of context, (2) what individuals bring to contexts, (3)
mediating variables, (4) task interpretation, (5) personal objectives, (6) cognitive strategies, (7) self-regulated strategies, and (8) performance criteria (Butler & Cartier, 2004; Lawanto, Butler, Cartier, Santoso & Goodridge, 2013). The remainder of this section describes seven of the eight features of the model of Butler and Cartier. The eighth feature, task interpretation, is explained in detail in the next section as part of one of the constructs of this study.

Figure 2-1. Model of Self-regulated Learning by Butler & Cartier (2004).
The layers of context include the learning environments such as school, classroom, laboratory room, teachers, instructional approaches, curricula, and learning activities (e.g., reading, writing, and problem-solving). Recognizing the ways in which multiple interlocking contexts shape and constrain the quality of student engagement in learning is essential for understanding SRL (Lawanto, Butler, et al., 2013). What individuals bring to the context includes a variety of strengths, challenges, interests, and preferences brought to an educational environment (Butler & Cartier, 2004; Schoenfeld, 1988). Insofar as mediating variables, when students are involved in academic work, their SRL process is mediated by their knowledge about the topic, perception about the activity, conceptions, self-perception about their competence, control over learning, and the emotions experienced before, during, and after completing the task (Butler & Cartier, 2004). A personal objective involves students interpreting a task influenced by mediated variables and in a specific context, and setting personal goals to formulate their engagement (Lawanto, Butler, et al., 2013). Cognitive strategies refer to students’ cognitive activities employed as they go about the work of designing tasks, and planning, monitoring, and adjusting those designs through metacognitive activity (Butler & Cartier, 2004; Lawanto, Butler, et al., 2013). Self-regulated strategies refer to students planning of how to use available resources (e.g., time and materials) and selecting strategies for task completion. It also involves self-monitoring progress and adjusting goals, plans, or strategies based on the self-perceptions of progress and, lastly, how self-evaluating performance. Performance criteria form the basis by which students judge their
achievements while working on a particular task. The achievement criteria are related to their understanding of a design task (Lawanto, Butler, et al., 2013).

SRL is situated in several layers of context (Butler & Cartier, 2004). Understanding SRL requires awareness of the context in which it occurs, and interpretation of research results requires sensitivity to the context in which a particular study was conducted. Butler and Cartier (2005) suggested that the meaning of any given aspect of SRL in context (e.g., use of a given strategy, an emotion experienced) is meaningful only in that context. SRL has been studied within the contexts of engineering design and project management. These two contexts have been identified as particularly beneficial in studying SRL because effective SRL is critical for tasks that are ill-structured, complex, and require a high amount of cognitive ability (Lawanto et al., 2013; Lawanto & Johnson, 2009). Engineering design and project management require students to iteratively identify, plan, act, evaluate, and make adjustments; project management additionally requires good teamwork skills and management of multiple constrained resources (Lawanto et al., 2013).

Defining Task Interpretation

Task interpretation is defined by Butler and Cartier as the critical first feature of SRL. It is the heart of the SRL model. Students’ task interpretation is a key determinant of the goals they set while learning, the strategies they select to achieve those goals, and the criteria they use to self-evaluate outcomes (Butler & Cartier, 2004; Butler & Winne, 1995; Lawanto, Goodridge, & Santoso, 2011). Hadwin, Miller, and Wild (2009) stated
that task interpretation refers to students’ construction of an internal representation of the externally assigned task. Accurate and complete task interpretation depends on a student’s engagement in a range of cognitive, metacognitive, and motivational processes to assess and interpret task information provided or implied by an instructor within a particular context (Hadwin et al., 2009). Therefore, successful task interpretation is foundational to focused engagement in tasks assigned (Butler & Cartier, 2004). The importance of task interpretation in SRL for academic success has been pointed out by several researchers (e.g., Butler & Cartier, 2004, 2005; Hadwin et al., 2009; Lawanto et al., 2013).

Model of Task Interpretation

This research study was guided by Hadwin’s model of task interpretation, who suggested that assigned tasks are comprised of three layers or aspects of information and that construction of accurate and complete task interpretation demands that students interpret and synthesize information across the three layers (Hadwin, 2006; Hadwin et al., 2009; Oshige, Hadwin, Fior, Tupper, Miller, 2007). The layers of Hadwin’s model are: explicit, implicit, and social contextual (see Figure 2-2).
Research about task interpretation can be centered into two foci. The first focus is the understanding of explicit and implicit aspects of task interpretation in the forms of text decoding and perceptions of tasks or instructional practices (e.g., Broekkamp, van Hout-Wolters, Rijlaarsdam, & van den Bergh, 2002; Jamieson-Noel, 2004; Luyten, Lowyck, & Turelinckx, 2001; Mayer 1988; Reynolds, Wade, Trathen, & Lapan, 1988; Schellings & Van Hout-Wolters, 1995; Schellings, Van Hout-Wolters, & Vermunt, 1996). The second focus is the understanding of the socio-contextual aspects of task interpretation which taps into what is valued for students such as beliefs about knowledge and expertise, discipline-specific expectations for presentation, and beliefs about ability (e.g., Cano & Cardelle-Elawar, 2004; Dahl, Bals, & Turi, 2005; Schommer, 1993; Schommer, Calvert, Gariglietti, & Bajaj, 1997; Schommer-Aikins, Duell, & Hutter, 2005). This study measured only the explicit and implicit layers of the model of Hadwin.
It should be pointed out that this researcher considered that a more thorough exploration of socio-contextual features might be part of another study.

According to Oshige (2009), the explicit features of a task are typically described in the instructions of an assignment and include: (a) criteria, (b) grading, (c) standards, and (d) language. Criteria refers to things that are part of the final product of an assignment. For example, when an assignment is to write a research paper, the instruction might indicate what the paper should include, such as its topic, format, and style of writing such as APA, MLA, etc. Grading refers to instructor’s evaluation of the assigned task and is reflected in a numerical or letter scales. Standards are what numerical or letter grades represent (2009). Task instructions often state the weight of the assignment with relation to the course grades. As these features are often explicitly noted in the written instructions to complete the task, students may refer to them to understand the assignment.

Oshige (2009) also defined implicit task features as those which include (a) the purpose of the assignment, (b) the effective strategies for the assignment, (c) relevant course constructs or the way this task connects with other aspects of a course or instruction, (d) timing, (e) connection to available resources to complete the task, and (f) a picture of a top-quality task. In the purpose of the assignment, the instructor often specifies why he/she has assigned the task. Even though students may have complete understanding of the assignment description, failure to understand the purpose of the task might lead the student take a wrong direction for solving the task. The effective strategies refer to learning and studying skills that are effective for successful completion of a
specific task. If students were to take a chapter quiz, understanding core chapter concepts by making connections among them would be a more effective strategy than merely memorizing the definition of terms. Timing refers to the specific point in time where students is located working in a specific task and reflecting on the previous completed tasks and the future assigned tasks. This provides student instructional cues to where to look for relevant information to be included in the assigned task. Connection ties the task to overall course objectives and course concepts. Understanding the resources that students are expected to use for the final product would also enhance their understanding of what the task is about (Hadwin, 2006).

Butler and Cartier (2004) argued that to be successful in an academic arena, students must adopt a consistent approach to completing academic work that includes interpreting carefully the demands of tasks. To clarify why task interpretation is so critical to student success, they suggested that it should be a reflective activity as part of self-regulated learning in action and that it becomes part of how students habitually approach and engage in academic tasks (2004). However, successful task interpretation requires a number of reflective and strategic activities: searching for clues that might reveal task demands, interpreting written materials or instructions to decipher expectations, assessing and evaluating the applicability of previously constructed metacognitive task knowledge, thinking about a particular teacher’s usual expectations, and integrating these sources of information to derive criteria for planning, directing, and evaluating performance. It follows that, to be effective, learners need to develop explicit strategies for task interpretation (Butler & Cartier, 2004). The problem in some students’
experience in interpreting tasks can be explained by faulty metacognitive knowledge relative to the task assigned and a limited knowledge about the task assigned. Some students are unable to explain the purpose of a task, focusing more on decoding words or reading accurately than extracting meaning information from the text.

The following section reviews previous studies that have explored issues surrounding task interpretation:

Miller (2009) developed a study using a correlation design to examine the contribution of university students’ task interpretation and self-efficacy to performance on a grade-bearing course assignment. Participants were 38 undergraduate students enrolled in a first-year elective course. Task interpretation for explicit, implicit, and contextual task features was measured using a forced-choice task analyzer quiz developed by the researcher that included 43 items, 10 of which targeted explicit task interpretation and 33 targeted implicit task interpretation. The task analyzer was developed based on the course assignment defined as important by the assignment grading rubric and the course syllabus. The final grade on a major course assignment was used as a measure of task performance. Results of hierarchical regression analysis indicated a lack of task interpretation in participants with low task performance. Otherwise, task interpretation significantly predicted task performance, and task interpretation moderated the influence of self-efficacy on task performance.

Hadwin, Oshige, Miller, and Wild (2009) developed a study to measure task interpretation in an engineering design course. The assignment was a complex, problem-based collaborative design task completed by groups of three to four students. Task
interpretation was measured with an instrument called a task analyzer which was
designed to engage students in self-regulatory thinking about tasks and to elicit data
about task perceptions. Open-ended questions based on students’ input were part of the
instrument and addressed three aspects of task interpretation of the assigned task: explicit
(three questions), implicit (six questions) and socio-contextual interpretation (two
questions). Findings indicated that students often had an incomplete understanding of the
explicit, implicit, and socio-contextual aspects of the task. Students who were better
attuned with the professor insofar as task interpretations tended to perform better in the
course (Hadwin et al., 2009).

Helm (2011) conducted a study to explore young elementary students’ task
interpretation and its relationship to learning. Although the study included participants of
an elementary school, the instrument developed by the researcher to measure task
interpretation was based on the model of task interpretation of Hadwin. Participants
learned about the lifecycle of animals during 5-hour-long sessions. The instrument was
specifically structured in a manner similar to Miller’s (2009) version, which used forced-
choice as opposed to open-ended questions to assess students’ task interpretation
accuracy for a particular course assignment based on the previous input of participants.
This instrument was administered at the end of each session. Findings indicated young
students’ task interpretation accuracy varied. Students demonstrated strong, improved,
and weak task perceptions (Helm, 2011). Some students struggled to understand the task
because they missed identifying important instructions of how to better understand the
tasks while other students showed weak task understanding because they assumed all
instructions were important. Task interpretation was also associated with learning outcomes. For students with limited prior knowledge, accurate task interpretation was related to successful learning.

Oshige (2009) conducted a study with the purpose to investigate how overall task interpretation contributes to students’ academic success. Ninety-eight undergraduate students participated in the study. First, this study explored the kinds of tasks students identified as challenging, the disciplines in which the tasks were situated, and challenges found in students’ task analysis activity. Second, the study examined the relationships between students’ task interpretation and academic performance. The task analyzer assignment was based on the task analyzer implemented by Hadwin and Jamieson-Noel (2004) in their study measuring task interpretation. The task analysis assignment during the course named Learning Strategies for University Success (ED-101) was the target activity of this research. The task analysis assignment involved students’ analysis of a course task, students’ report of an interview with their course instructor who assigned the task, and students’ self-evaluation of their analysis of a course task by comparing their interview results. Academic performance was measured by students’ final grade in ED-101 and the grade for the target course from which students’ task-analyzed tasks came. The results of this study showed that task interpretation was statistically significantly and correlated to academic performance and task interpretation, particularly, implicit aspect of task interpretation, and predicted students’ academic performance (Oshige, 2009).

Although the studies of Miller (2009), Hadwin et al. (2009), and Helm (2011) indicated students had an incomplete understanding of the task assigned, a study
conducted by Lawanto, Goodridge, and Santoso (2011) showed that students were aware of all aspects of the task. They conducted a study to evaluate the extent to which students’ task interpretation of the design project was reflected in their working plans and monitoring/regulating strategies. Twelve freshman engineering students participated in the study while engaged in an engineering design project for a mechanical engineering course. The researchers based their study in the model of SRL by Butler and Cartier (2004). They stated that task interpretation is the heart of the SRL mode insofar as it shapes key dynamic and recursive self-regulatory processes (2004). Students were given an assignment to mechanically design and model a “gripper” and accompanying robotic arm for a pneumatically activated robot. Data were collected from the Engineering Design Questionnaire (EDQ) at the early, middle, and final stages of the design task. The EDQ was adapted from the Inquiry Learning Questionnaire by Butler and Cartier based on their theoretical model (2004). Results showed that students scored high in overall aspects of task interpretation. Students were particularly aware of what they needed to do to solve the design task: overview, understanding key information, identifying concepts, mechanism, and seeing how all information about the design task fit together.

Venkatesh and Shaikh (2011) conducted an experimental study to identify the relationship between task interpretation and academic tasks performance. They stated that although it is often assumed that the teacher’s objectives for a specific assignment are well aligned with the students’ understanding of the assigned task, there may often be significant discrepancies between teachers’/students’ task perceptions and definitions. Fifty-five undergraduate students participated in this study. Researchers used “thinking
aloud protocol” to measure task interpretation because it has been determined that thinking-aloud during learning does not significantly affect cognitive processes (Venkatesh & Shaikh, 2011). Also, the participants completed a paper-and-pencil pretest and posttest as measures of their understanding of the topic. Although the purpose of the study was to measure SRL (including task interpretation) with a computer-based tool and hyperlink connections that compared with traditional teaching, researchers found that participants’ task interpretation improved over the study, and a positive relationship between task interpretation and learning outcomes resulted.

**Collaborative Regulated Learning**

**Definition**

Learning collaboratively is now commonplace in schools, and students increasingly need to learn how to solve problems and construct knowledge by working with others. Although collaboration in small groups is expected to enhance learning, simply putting students together does not automatically bring about collaboration and productive learning. For that reason, students need to know how to regulate their learning and collaboration (Chan, 2012). Collaborative regulated learning or coregulation (CRL) is defined by Hadwin and Oshige (2011) as a transitional process in a learner’s acquisition of SRL, within which learners and others share a common problem-solving plane, and SRL is gradually appropriated by the individual learner through interactions. Coregulation occurs when an individual’s regulatory activities are guided, supported,
shaped, or constrained by and with others (Jarvela & Hadwin, 2013). It requires team members to be aware of one another’s goals and progress and to consider those in relation to the shared task. Students support each other’s regulation in the process of task perception for a specific task, awareness of the engagement of others in the task, and progress (Jarvela & Hadwin, 2013). Oftentimes, in the CRL process, one of the team members is more capable or advanced than the other students, with a higher awareness of the SRL process. This team member is identified as more capable or more regulated peer (MRP). Similarly, the other members of the team are identified as less capable or less regulated peers (LRP). For a more coregulated peers (MRP), the CRL may help them to recognize, refine, and modify inconsistencies in their regulatory strategy, which they can use to advance their SRL. For less coregulated peers, working with more regulated peers could help them to learn strategies for future use (DiDonato, 2013; Jarvela & Hadwin, 2013).

DiDonato (2013) defined coregulation as an interaction between two or more peers that coordinate SRL processes (McCaslin & Hickey, 2001; Yowell & Smylie, 1999). DiDonato stated that an MRP assumes responsibility for regulating an LRP. A goal of this type of CRL is for the LRP to move toward autonomous SRL by working with an MRP who has a repertoire of SRL strategies and is skilled in implementing these strategies under varied conditions (DiDonato, 2013). Chan (2012) explained coregulation in terms of individuals working together as multiple self-regulating agents socially regulating each other’s learning. The emphasis here is that coregulation processes may be examined as collective regulation, involving students’ efforts to advance the whole team.
(i.e., “I” to “we” perspective). During collaborative learning, the regulation of activities can occur at individual or group levels of social interaction (Hadwin & Oshige, 2011; Iiskala, Vauras, & Lehtinen, 2004; Volet, Summers, & Thurman, 2009). Individual regulation can be thought of as an intrapersonal process that regulates the individual cognitive processes during collaborative learning. Regulating the activities at the group level means that someone in the group regulates the individual activities of another member. Grau and Whitebread (2012) agreed that in the context of collaborative learning, students bring their own ideas, concepts, and self-regulatory abilities to the group work and that all of these personal characteristics play a role in their engagement in the group activity. However, the extent to which a group works effectively and productively cannot be predicted by the addition of these individual characteristics. Therefore, it is necessary to integrate the accounts of individual SRL with those of the joint regulation of the group activity.

**Measuring Coregulation**

Measuring coregulation can be challenging for researchers because it consists of observing, capturing, and summarizing complex individual and group behaviors with which researchers are interested in order to make inferences related to learning processes. There are different ways to measure coregulation, such as self-reports (questionnaires or surveys), interviews, observations, process data, discussions, and other feedback from participants using computer tools (Gress, Fior, Hadwin, & Winne, 2010). Gress et al. (2010) evaluated 186 empirical articles and determined that the studies incorporated 340
measures (and methods) of collaborative constructs. The majority of the measures were made with inexpensive and easy-to-apply self-report questionnaires (33%). Also, most of the studies (51%) were administrated after the collaborative activity (Gress et al., 2010).

The following section reviews previous studies related to CRL emphasizing the applied instrument in order to respond to the research question of each one of them:

Grau and Whitebread (2012) guided research to explore the occurrence of self and group aspects of regulation during collaborative activities within regular primary science classes. According to their findings, it is generally acknowledged that when group work in real-life educational contexts is researched, investigating regulatory processes become challenging. It has been observed that during episodes of collaboration, cognitive regulation processes fluctuate among three levels: self, collaborative, and shared (2012). Through a multiple case study approach, eight students organized into two work groups of collaborative activities were videotaped during one academic semester. Group-work videos were observed and coded to examine episodes of coregulation. The coding was based on theoretical models of SRL developed by Pintrich (2000), Zimmerman (2000), and Whitebread, Bingham, Grau, Pino Pasternak, & Sangster (2007). Four regulation processes were analyzed: planning, monitoring, regulation-control, and evaluation; and several types of subcodes were created to specify the function of each of the four regular processes. Each event was coded as *self-regulation* behavior when it was oriented to regulate the participant’s individual activity, and *coregulation* when the behavior was directed to regulate that of another participant in the group. The five sessions of collaborative activities were designed in collaboration with the science teacher, related to the curriculum, and videotaped in the classroom. An analysis of data suggested that
participants were engaged in the events of regulation related to the fundamental aspects of the task. Also, the coding of the data revealed the percentage of the regulatory activity directed to achieve coregulation as well as self-regulation.

DiDonato (2012) conducted a study to examine the use of collaborative tasks as a context in which learners used self-regulated learning (SRL) processes. He described coregulation as interactions between two or more peers that can coordinate SRL process and can vary from other regulation to shared regulation. Providing opportunities for students to develop the ability to coregulate may be particularly effective during instruction if it facilitates a student’s self-regulation. Participants included 64 students in a U.S. middle school. They worked collaboratively in groups to design and carry out a project that included the features of high-SRL tasks, requiring them to engage routinely in decision making in order to optimize their use of time and resources. In DiDonato’s study, there were multiple opportunities for students to engage in self- and peer evaluations of plans, processes, and products. SRL questionnaires consisting of 13 items as well as a 19-item CRL questionnaire were applied to students. Because there was no existing CRL survey available, a similar procedure used by Goddard (2002) to change a self-efficacy scale to a collective efficacy scale by replacing “I” as the object of the efficacy items to “we” was used. For example, statements such as, “Before we started working on our project, I set goals to guide what steps I will take” was restated as “Before we started working on our project, our group set goals to guide what steps we would take.” Means and standard deviations were calculated for CRL, and a case study was developed to describe how the CRL learning process can lead to an increase in
students’ independent SRL. Findings suggested that CRL moderated the individual SRL over the duration of the project. When group members were coregulated, it may have supported their acquisition of SRL skills and contributed to the increase of their SRL over the project period. That is, as coregulation occurred, it influenced SRL in the collaborative group.

**Summary**

In this chapter, three key constructs were reviewed: laboratory activities, task interpretation, and collaborative regulated learning (CRL).

A review of laboratory activities provided the foundational theory of this construct. It also detailed its relationship with conceptual knowledge. Few studies discuss the association between laboratory activities and conceptual knowledge. Some researchers have suggested that laboratory activities are related to conceptual knowledge. Others researchers have recommended modifying the laboratory curriculum. However, researchers have concluded generally that a better conceptual understanding of the problem increases the likelihood that learners will select the appropriate problem-solving procedure (e.g., Kolloffel & Jong, 2013). Other researchers have suggested that students are not mentally engaged during laboratory activities, and that the lack of engagement leads to a disconnection between laboratory activities and the material covered in the classroom.

A review of task interpretation revealed how critical this construct is in the
process of SRL. It is especially important in the context of problem solving and engineering design. Studies applying the task interpretation model of Hadwin (2006), have suggested that students often fail to engage in a cognitive process that defines and interprets the task. Other studies that measured task interpretation, those not utilizing Hadwin’s model, have shown more promising findings in which students demonstrated more awareness to interpret and understand the task assigned. Regardless of the technique chosen to measure this construct, researchers have agreed that task interpretation is a key factor in enhancing students’ learning. Every study highlighted in this review used different instruments to measure students’ task interpretation.

Studies related to CRL were also reviewed. Researchers suggest that CRL leads to increase independent SRL and that there are different ways to measure CRL. Recent publications recommend the use of iterative software to measure CRL in real-time such as synchronous chat, asynchronous discussion threads, and group workspaces to support what the researchers have defined as computer-supported collaborative learning (CSCL), a dynamic area of research drawing upon a wide array of implementation tools, assessment methodologies, definitions of collaboration, and learning tasks to measure CRL (Gress & Hadwin, 2010; Gress, Fior, Hadwin, & Winnie, 2010; Kumar, Gress, Hadwin, & Winne, 2009; Lajoie & Lu, 2011; Morris, Hadwin, Gress, Miller, Fior, Church, & Winne, 2009; Winne, Hadwin, & Gress, 2010). However, due to the context of this study, this review focused on studies that measure CRL with questionnaires completed immediately following the termination of an activity. So in this study, CRL
questionnaires immediately following the activity were completed without the use of iterative software.

Based on the findings revealed in the review of literature, this study provides new information on how students’ task interpretation influences task process, CRL, and conceptual knowledge during laboratory activities. As such, this study began the research of SRL processes in the context of laboratory activities. It added to the emergent literature to investigate empirically the understanding of the explicit and implicit aspects of students’ task interpretation within a framework of SRL in the context of laboratory activities. Findings from this study will assist researchers and designers in improving and/or developing curriculum for laboratory activities designed to support course content.
CHAPTER III

PILOT STUDY

Purpose and Overview

The term “pilot study” refers to a mini version of full-scale study, as well as the specific pretesting of a particular research instrument such as a questionnaire or interview schedule (Van Teijlingen & Hundley, 2002). The purpose of this pilot study was to test the instruments to be used for the main study and to become familiar with how to evaluate the data collected.

The pilot study was conducted during the spring semester and summer session of 2014. Thirty-eight students participated during the spring; 17 students participated during the summer. Participants were sophomore students registered in the course, Fundamental Electronics for Engineers, which is a required course for majors in Biological, Civil, and Mechanical Engineering. Students registered for the course were required to complete classroom instruction as well as seven lab sessions during the spring semester) or six lab sessions during the summer session. This pilot study included three tasks: (1) to conduct face-validity of the instruments, (2) to test the internal reliability of the instruments, and (3) to practice how to analyze and interpret the data.

An instrument entitled Task Analyzer Questionnaire (TAQ) was developed by the researcher and the professor of the course to measure the participants’ level of task interpretation. The instrument was developed for three different lab activities: lab activity
Another instrument, the Conceptual Survey (CS), was also developed by the researcher and the professor of the course to measure the participants’ level of conceptual understanding. Similarly, the CS instrument was developed for the same three lab activities selected by the researcher.

**Face-Validity Test of the Instruments**

A face-validity test involves an inspection of the test questions to judge whether they cover the content that the test purports to measure (Gall, Gall, & Borg, 2007; Nevo, 1985). The test is important because the TAQ and CQ instruments have never been tested previously in laboratory work. The purpose of the task is to ensure that participants understand every question of the instruments in order to avoid misinterpretation. The pilot study was conducted in three different lab activities of three lab sessions: (1) lab activity 3.1 – Measuring Thevenin Equivalent Circuit, (2) lab activity 4.1 – RC Circuit Charging Phase Conditions, and (3) lab activity 6.3 – Capacitive Reactance and Frequency. Table 3-1 below outlines the selected lab activities.
Table 3-1

*Lab Activities Selected for the Pilot Study*

<table>
<thead>
<tr>
<th>Lab session</th>
<th>Lab activity</th>
<th>Name of the lab activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>1</td>
<td>Measuring Thevenin Equivalent Circuit</td>
</tr>
<tr>
<td>4.1</td>
<td>2</td>
<td>RC Circuit Charging Phase Conditions</td>
</tr>
<tr>
<td>6.3</td>
<td>3</td>
<td>Capacitive Reactance and Frequency</td>
</tr>
</tbody>
</table>

Because three different lab activities were selected for the pilot study, three different versions of the TAQ were developed for those activities. Similarly, three versions of the CS were developed to be applied in every one of the three lab activities selected by the researcher.

At the beginning of the lab session, the researcher asked students to participate in the pilot study by filling out the TAQ instrument before and after the lab activity. The TAQ instrument consisted of eight questions (five questions to measure the explicit and three questions to measure the implicit aspects of task interpretation). The TAQ *Version A* was applied before the lab activity; TAQ *Version B* was applied after the lab activity. Basically, the difference between those versions is that questions 2, 3, and 7 in *Version A* were written in “future tense” and *Version B* questions were written in “past tense” according to the time that the TAQ was applied in the laboratory work. For every question of the TAQ, each participant was asked to respond to the following subquestions:
1. What do you think the question is trying to ask?

2. Do you think the question is clear? Yes or No

3. How would you suggest changing or rephrasing the question to make it clear?

Responses of the participants were analyzed calculating the percentage of similar answers agreeing/disagreeing with the questions. Nevo (1985) discussed a technique involving the measurement of face-validity where raters are usually “rather pleased at having the opportunity to express their opinions in this matter” (p. 63). Thus, this researcher considered it significant to ask participants to reflect on how to change or rephrase the question. The researcher was careful to analyze any suggestion by participants in which more than 80% of them disagreed (i.e., answered “No”) to a question. Other suggestions by participants were grouped if a pattern of suggestions emerged.

As in the case of the TAQ instrument, the researcher asked participants to complete the CS instrument at the beginning and end of the lab activity. The CS instrument consisted of seven true-false questions for lab activity 3.1, and eight true-false questions for lab activities 4.1 and 6.3 to measure the level of conceptual understanding of the participant. The CQ Version A was applied at the beginning of the lab activity; CS Version B was applied at the end of the lab activity. Both CS versions consisted of the same questions but were organized differently. For every question of the CQ instrument, participants were asked to respond the same four subquestions of the TAQ instrument in
order to validate the CS instrument. A similar criterion was applied to analyze the suggestions of participants as to how to change or rephrase the question.

Lab activity 3.1: The instrument used to measure the task interpretation and conceptual understandings of lab activity 3.1 were named TAQ#3.1 and CS#3.1, respectively. The instruments were applied during the summer session of 2014. For every question of the TAQ#3.1 Version A, more than 80% of participants understood what the question asked. Similarly, more than 80% of participants responded that the question was clear (answered “Yes”). A few comments were made by the participants suggesting changes or rephrasing of questions #2, #5, #6, and #7 (see Table 3-2).

Table 3-2

Responses of Participants to Questions of the Task Analyzer TAQ#3.1 Version A

<table>
<thead>
<tr>
<th>Questions of the TAQ#3.1 Version A</th>
<th>Subquestions to participants to validate the instrument</th>
<th>Percentage of participants understood the question</th>
<th>Percentage of participants answered YES</th>
<th>Comments of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>What do you think the question is trying to ask?</td>
<td>100%</td>
<td>100%</td>
<td>No suggestions</td>
</tr>
<tr>
<td>2</td>
<td>Do you think the question is clear?</td>
<td></td>
<td>87%</td>
<td>“Change word formula for theory”</td>
</tr>
<tr>
<td>3</td>
<td>How would you suggest changing or rephrasing the question to make it clear?</td>
<td></td>
<td>100%</td>
<td>No suggestions</td>
</tr>
<tr>
<td>4</td>
<td>Percentage of participants answered YES</td>
<td></td>
<td>93%</td>
<td>No suggestions</td>
</tr>
<tr>
<td>5</td>
<td>100%</td>
<td></td>
<td>93%</td>
<td>“Maybe change for an example or set-up word”</td>
</tr>
<tr>
<td>6</td>
<td>100%</td>
<td></td>
<td>93%</td>
<td>“Which lab activity, it isn’t specified”</td>
</tr>
<tr>
<td>7</td>
<td>100%</td>
<td></td>
<td>93%</td>
<td>“Change the punctuation of parenthesis”</td>
</tr>
<tr>
<td>8</td>
<td>100%</td>
<td></td>
<td>100%</td>
<td>No suggestions</td>
</tr>
</tbody>
</table>
Table 3-3

*Responses of Participants to Questions of the Task Analyzer TAQ#3.1 Version B*

<table>
<thead>
<tr>
<th>Questions of the TAQ#3.1 Version B</th>
<th>Subquestions to participants to validate the instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>What do you think the question is trying to ask?</td>
</tr>
<tr>
<td></td>
<td>Do you think the question is clear?</td>
</tr>
<tr>
<td></td>
<td>How would you suggest changing or rephrasing the question to make it clear?</td>
</tr>
<tr>
<td></td>
<td>Percentage of participants understood the question</td>
</tr>
<tr>
<td>1</td>
<td>100%</td>
</tr>
<tr>
<td>2</td>
<td>100%</td>
</tr>
<tr>
<td>3</td>
<td>100%</td>
</tr>
<tr>
<td>4</td>
<td>100%</td>
</tr>
<tr>
<td>5</td>
<td>90%</td>
</tr>
<tr>
<td>6</td>
<td>90%</td>
</tr>
<tr>
<td>7</td>
<td>100%</td>
</tr>
<tr>
<td>8</td>
<td>100%</td>
</tr>
</tbody>
</table>

The results of the CS#3.1 are shown in Table 3-4. More than of 80% of participants understood what the question asked. In question #6, participants were asked to infer the value of the power when the load voltage increases to $E_{TH}/2$. It is possible that there was some confusion on the students’ part with regards to that value. Seventy-nine percent of participants understood what the question asked, and 93% of them considered the question to be clear, and they suggested no changes to that question. More than 80% of participants responded that the questions were clear, except for question #3, with 69%.
In question #3, participants were asked to respond based on a box “N” representing a linear circuit. There might have been some confusion with the box suggesting to change it for a “real” circuit. However, all of them, 100%, understood the question. For the remainder of the questions, participants suggested changes or rephrasing, except for question #2.

*Lab activity 4.1:* The instruments used to measure the task interpretation and conceptual understandings of lab activity 4.1 were named TAQ#4.1 and CQ#4.1, respectively. The instruments were applied during the summer session of 2014. Results of the TAQ#4.1 are shown in Table 3-5. For every question of the TAQ#4.1 *Version A*, more than 80% of participants understood what the question asked. Similarly, 100% of participants responded that the question was clear (answered “Yes”), except for question #4, for which only 76% responded that it was clear. For question #4, participants were asked to respond to the procedure to measure $V_c$ at different times. There may have been some confusion on the part of the students at the beginning because of the two parallel arrangement of capacitors. A few comments were made by the participants without suggesting changes or rephrasing of questions #1, #3, and #6.
Table 3-4

**Responses of Participants to Questions of the Conceptual Survey CS#3.1**

<table>
<thead>
<tr>
<th>Questions of the CS#3.1</th>
<th>Subquestions to participants to validate the instrument</th>
<th>Percentage of participants understood the question</th>
<th>Percentage of participants answered YES</th>
<th>Comments of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>What do you think the question is trying to ask?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Do you think the question is clear?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>How would you suggest changing or rephrasing the question to make it clear?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>100%</td>
<td>87%</td>
<td></td>
<td>“Instead of these terminals, use a and b”; “Confusing in language between short and open”</td>
</tr>
<tr>
<td>2</td>
<td>100%</td>
<td>100%</td>
<td></td>
<td>No suggestions</td>
</tr>
<tr>
<td>3</td>
<td>100%</td>
<td>69%</td>
<td></td>
<td>“Does N stand for Norton?”, “Put some values”, “Give a real problem”, “I think I am confused in general”</td>
</tr>
<tr>
<td>4</td>
<td>88%</td>
<td>87%</td>
<td></td>
<td>“Pose a question to which students can respond. . .”, “I am a little confused between R’s, or the $P_{\text{max}}=V^2/4R$”, “Don’t say increase to, say equals”</td>
</tr>
<tr>
<td>5</td>
<td>100%</td>
<td>88%</td>
<td></td>
<td>“Smaller values of $R_L$ cause increase in $P_L$”</td>
</tr>
<tr>
<td>6</td>
<td>79%</td>
<td>93%</td>
<td></td>
<td>“$V_L$ isn’t increasing, is it?”, “I don’t know what $E_{\text{meas}}$ means”</td>
</tr>
<tr>
<td>7</td>
<td>93%</td>
<td>93%</td>
<td></td>
<td>“I am not sure what the question is”, “Change open to short circuit”</td>
</tr>
</tbody>
</table>
Table 3-5
Responses of Participants to Questions of the Task Analyzer TAQ#4.1 Version A

<table>
<thead>
<tr>
<th>Questions of the TAQ#4.1 Version A</th>
<th>Subquestions to participants to validate the instrument</th>
<th>Percentage of participants understood the question</th>
<th>Percentage of participants answered YES</th>
<th>Comments of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>What do you think the question is trying to ask?</td>
<td>100%</td>
<td>100%</td>
<td>“I don’t know if this is important”</td>
</tr>
<tr>
<td>2</td>
<td>Do you think the question is clear?</td>
<td>100%</td>
<td>100%</td>
<td>No suggestions</td>
</tr>
<tr>
<td>3</td>
<td>How would you suggest changing or rephrasing the question to make it clear?</td>
<td>100%</td>
<td>76%</td>
<td>“Split the question in parts, first, measure Vc in C1, then C2” “Describe process to measure V across C1 and C2 if/case C1 and C2 are charged at different times”, “While charging at different locations?”</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td>“Important to recall info?”, “Same as question #1”</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The results of TAQ#4.1 Version B are shown in Table 3-6. All of the participants reported understanding the questions. Also, more than 80% considered the questions to be clear. In question #4, 83% of the participants considered the question to be clear, which is consistent with the TAQ#4.1 Version A, in which question #4 was the only one
with a percentage < 100%. Participants made no suggestions for changes or rephrasing in the TAQ#4.1 Version B.

Table 3-6

Responses of Participants to Questions of the Task Analyzer TAQ#4.1 Version B

<table>
<thead>
<tr>
<th>Questions of the TAQ #4.1 Version B</th>
<th>Sub-questions to participants to validate the instrument</th>
<th>Percentage of participants understood the question</th>
<th>Percentage of participants answered YES</th>
<th>Comments of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>What do you think the question is trying to ask?</td>
<td>Do you think the question is clear?</td>
<td>How would you suggest changing or rephrasing the question to make it clear?</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>1</td>
<td>100%</td>
<td>100%</td>
<td>No suggestions</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>100%</td>
<td>100%</td>
<td>No suggestions</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>100%</td>
<td>100%</td>
<td>No suggestions</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>100%</td>
<td>100%</td>
<td>No suggestions</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>100%</td>
<td>100%</td>
<td>No suggestions</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>100%</td>
<td>100%</td>
<td>No suggestions</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>100%</td>
<td>100%</td>
<td>No suggestions</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>100%</td>
<td>100%</td>
<td>No suggestions</td>
<td></td>
</tr>
</tbody>
</table>

Table 3-7 shows the results of the CS#4.1. All of the participants (100%) reported understanding the questions. Also, most of them considered the questions to be clear except for question #7 (71%). For question #7, participants were required to relate RC
circuits with the graphs’ responses of $V_C$’s at different values of capacitance. Although participants understood the questions and considered them to be clear, they nonetheless suggested changes or rephrasing of questions #2, #4, #7, and #8.

Table 3-7

Responses of Participants to the Conceptual Survey CS#4.1

<table>
<thead>
<tr>
<th>Questions of the CS#4.1</th>
<th>Subquestions to participants to validate the instrument</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>What do you think the question is trying to ask?</td>
<td>Do you think the question is clear?</td>
<td>How would you suggest changing or rephrasing the question to make it clear?</td>
</tr>
<tr>
<td></td>
<td>Percentage of participants understood the question</td>
<td>Percentage of participants answered YES</td>
<td>Comments of participants</td>
</tr>
<tr>
<td>1</td>
<td>100%</td>
<td>100%</td>
<td>No suggestions</td>
</tr>
<tr>
<td>2</td>
<td>100%</td>
<td>100%</td>
<td>“Starting with an uncharged capacitor. After one tau, the voltage = 90% capacity”</td>
</tr>
<tr>
<td>3</td>
<td>100%</td>
<td>100%</td>
<td>No suggestions</td>
</tr>
<tr>
<td>4</td>
<td>100%</td>
<td>100%</td>
<td>“The large the capacitance, the large the time constant”</td>
</tr>
<tr>
<td>5</td>
<td>100%</td>
<td>100%</td>
<td>No suggestions</td>
</tr>
<tr>
<td>6</td>
<td>100%</td>
<td>100%</td>
<td>No suggestions</td>
</tr>
<tr>
<td>7</td>
<td>100%</td>
<td>71%</td>
<td>“Not sure”, Less words. I usually have to go back through longer question to make sure I understand”, “Rephrase the last sentence. Its wording. If $R_1$ and $R_2$ have equal value, will $C_1$ be smaller than $C_2$?”</td>
</tr>
<tr>
<td>8</td>
<td>100%</td>
<td>100%</td>
<td>“Again, it’s wordy and convoluted. Simplify. Take out redundant words”</td>
</tr>
</tbody>
</table>
Lab activity 6.3: The instruments used to measure the task interpretation and conceptual understandings of lab activity 6.3 were named TAQ#6.3 and CS#6.3, respectively. The TAQ#6.3 was applied during the spring semester of 2014, then revised, and again applied during the summer session of 2014. In the results of the pilot study, the researcher included only the results of the spring semester because the participants had made more meaningful comments than in the summer session. The intent of the TAQ#6.3 of the spring semester was to improve the activity for the summer session and to develop the TAQ#3.1 and TAQ#4.1 for the summer session. The CS#6.3 was applied during the summer session of 2014. For every question of the TAQ#6.3 Version A, more than 80% of participants understood what the question asked. More than 80% of participants responded that the question was clear (answered “yes”), except for question #8, for which 63% thought it was clear. For question #8, there was an issue of wording, and most of participants recognized that mistake. A few comments were made by the participants on questions #1, #3, #4, #5, and #6 (see Table 3-8).

In the TAQ#6.3 Version B more than 80% of participants understood what the question asked. Similar to Version A, more than 80% of participants responded that the question was clear (answered “Yes”) except for question #8, for which 74% thought it was clear. For question #8, participants mentioned again the same issue of wording described in Version A. Although participants understood the questions, they made numerous comments about the questions suggesting changes or rephrasing (see Tables 3-9 & 3-10).
Table 3-8  
Responses of Participants to Questions of the Task Analyzer TAQ#6.3 Version A

<table>
<thead>
<tr>
<th>Questions of the TAQ#6.3 Version A</th>
<th>Subquestions to participants to validate the instrument</th>
<th>Percentage of participants understood the question</th>
<th>Percentage of participants answered YES</th>
<th>Comments of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>What do you think the question is trying to ask?</td>
<td>100%</td>
<td>100%</td>
<td>“I would ask what do you think the learning objectives of this lab activity are?”</td>
</tr>
<tr>
<td>1</td>
<td>Do you think the question is clear?</td>
<td></td>
<td></td>
<td>No suggestions</td>
</tr>
<tr>
<td>2</td>
<td>How would you suggest changing or rephrasing the question to make it clear?</td>
<td></td>
<td></td>
<td>“Make it shorter and more concise”</td>
</tr>
<tr>
<td>3</td>
<td>Percentage of participants answered YES</td>
<td></td>
<td></td>
<td>“More clear needed”</td>
</tr>
<tr>
<td>4</td>
<td>100%</td>
<td>100%</td>
<td>92%</td>
<td>“Make the question shorter”, “How do you find the value of C?”</td>
</tr>
<tr>
<td>5</td>
<td>100%</td>
<td>95%</td>
<td></td>
<td>“This question is similar to #1”</td>
</tr>
<tr>
<td>6</td>
<td>100%</td>
<td>89%</td>
<td></td>
<td>No suggestions</td>
</tr>
<tr>
<td>7</td>
<td>100%</td>
<td>89%</td>
<td></td>
<td>Most students said takeoff word “been” of question (wording issue)</td>
</tr>
</tbody>
</table>
Table 3-9

Responses of Participants to Questions 1-4 of the Task Analyzer TAQ#6.3 Version B

<table>
<thead>
<tr>
<th>Questions of the TAQ#6.3 Version B</th>
<th>Subquestions to participants to validate the instrument</th>
<th>Percentage of participants understood the question</th>
<th>Percentage of participants answered YES</th>
<th>Comments of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>What do you think the question is trying to ask?</td>
<td>100%</td>
<td>97%</td>
<td>“I would ask what do you think the learning objectives of this lab activity are?”, “What did you learn?”</td>
</tr>
<tr>
<td>2</td>
<td>Do you think the question is clear?</td>
<td></td>
<td>100%</td>
<td>“Less words”, “Which formulas?”, “What equations were involved in this lab activity?” , “What formulas do you need to complete this lab?”, “What are the key equations?”</td>
</tr>
<tr>
<td>3</td>
<td>How would you suggest changing or rephrasing the question to make it clear?</td>
<td></td>
<td>97%</td>
<td>“Call it equipment”, “What equipment do you need?”, “Why is it important to know?”, “Make it shorter and more concise”, “Take out the parenthesis comment”, “What will you need for this activity?”</td>
</tr>
<tr>
<td>4</td>
<td>100%</td>
<td>89%</td>
<td></td>
<td>“Why do we need to restate it?”, “Explain how to measure $Xc$ at different values of frequency”, “Too long”, “What is the process of lab?”, “Step by step, what is the process?”</td>
</tr>
<tr>
<td>Questions of the TAQ#6.3 Version B</td>
<td>Subquestions to participants to validate the instrument</td>
<td>Percentage of participants understood the question</td>
<td>Percentage of participants answered YES</td>
<td>Comments of participants</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>-----------------------------------------------------</td>
<td>-----------------------------------------------</td>
<td>---------------------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>5</td>
<td>What do you think the question is trying to ask?</td>
<td>100%</td>
<td>80%</td>
<td>“Too long”, “How much detail”, “Could be clearer like look at the graph, find Xc then calculate capacitance”, “Make the question shorter”, “Less words”, “Will you find Xc with the equation C=½πfXc?”, “Interpolate the value?”, “What process did you take to find the capacitance based on the plot?”</td>
</tr>
<tr>
<td>6</td>
<td>Do you think the question is clear?</td>
<td></td>
<td>94%</td>
<td>“Just ask for the purpose”, “It’s very broad question”, “I think it’s the same that first question”</td>
</tr>
<tr>
<td>7</td>
<td>How would you suggest changing or rephrasing the question to make it clear?</td>
<td></td>
<td>92%</td>
<td>“Simplify”, “What concepts are we applying in this class?”, “Main concepts or ideas that were used?”, “Less words”, “Ask for concepts”</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td>74%</td>
<td>“Don’t know what type of resources to complete lab or understand better”, “There is no question, ask something”, “What are some videos or readings that you have seen that will help you?”, “How did you learn this?”, “List learning resources that are helpful to complete this activity?”, “It’s too wordy, could be more simply”, Take off the word “been”, “What have you seen in the past that will help with this activity?”, “delete word been”</td>
</tr>
</tbody>
</table>
The results of the CS#6.3 are shown in Table 3-11. All of the participants understood the questions. Also, most of them considered the questions to be clear (answered “yes”). Although participants understood the questions and they considered the questions to be clear, they suggested changes or rephrasing of questions #1, #5, and #8 (see Table 3-11).

Table 3-11

**Responses of Participants to Questions of the Conceptual Survey CS#6.3**

<table>
<thead>
<tr>
<th>Questions of the CS#6.3</th>
<th>What do you think the question is trying to ask?</th>
<th>Do you think the question is clear?</th>
<th>How would you suggest changing or rephrasing the question to make it clear?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percentage of participants understood the question</td>
<td>Percentage of participants answered YES</td>
<td>Comments of participants</td>
</tr>
<tr>
<td>1</td>
<td>100%</td>
<td>92%</td>
<td>“Include in the current position”</td>
</tr>
<tr>
<td>2</td>
<td>100%</td>
<td>92%</td>
<td>No suggestions</td>
</tr>
<tr>
<td>3</td>
<td>100%</td>
<td>100%</td>
<td>No suggestions</td>
</tr>
<tr>
<td>4</td>
<td>100%</td>
<td>100%</td>
<td>No suggestions</td>
</tr>
<tr>
<td>5</td>
<td>100%</td>
<td>92%</td>
<td>“That there is a linear relationship between C₁ and C₂ through the differing frequencies”</td>
</tr>
<tr>
<td>6</td>
<td>100%</td>
<td>100%</td>
<td>No suggestions</td>
</tr>
<tr>
<td>7</td>
<td>100%</td>
<td>100%</td>
<td>No suggestions</td>
</tr>
<tr>
<td>8</td>
<td>100%</td>
<td>83%</td>
<td>“Where are figures 5a and 5b”, “The value of the capacitor for each of the…”, “The Xc vs. freq of figures 8a and 8b are the same type (linear, hyperbolic, parabola, etc)”</td>
</tr>
</tbody>
</table>
The CQ instruments revised by experts: as part of the process of validity of the CS instruments, two experts revised the CS#3.1, CS#4.1, and CS#6.3. They were asked to respond the same three subquestions that were asked of participants previously in the pilot study. Expert #1 has worked as a lecturer and assistant professor in the Department of Electrical Engineering and has 8 years’ experience teaching courses related to electrical circuits, such as Engineering Design, Engineering Communications, and Control Systems, to sophomore, junior, and senior students. Expert #2 has worked as an assistant professor in the Department of Engineering Education and has 5 years’ experience teaching courses of electronics to sophomore students. Both experts also have experience in developing curriculum for courses for engineering majors.

The results of the CS#3.1 instrument showed that both experts understood the questions and considered the questions to be clear. Only expert #1 suggested a change in question #1 (see Table 3-12).
### Table 3-12

**Responses of Experts to Questions of the Conceptual Survey CS#3.1**

<table>
<thead>
<tr>
<th>Questions of the CS#3.1</th>
<th>Subquestions to participants to validate the instrument</th>
<th>Comments of experts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Do you think the question is clear? Yes or No</td>
<td>How would you suggest changing or rephrasing the question to make it clear?</td>
</tr>
<tr>
<td>1</td>
<td>Expert #1</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Expert #2</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>Expert #1</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Expert #2</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>Expert #1</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Expert #2</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>Expert #1</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Expert #2</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>Expert #1</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Expert #2</td>
<td>Yes</td>
</tr>
<tr>
<td>6</td>
<td>Expert #1</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Expert #2</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>Expert #1</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Expert #2</td>
<td>Yes</td>
</tr>
</tbody>
</table>

In the instrument CS#4.1, both experts suggested minor changes. In the case of question #7, expert #1 considered the question to be unclear. Also, expert #1 suggested changes in questions #6 and #7. Expert #2 suggested changes in questions #7 and #8 (see Table 3-13).
Table 3-13

Responses of Experts to Questions of the Conceptual Survey CS#4.1

<table>
<thead>
<tr>
<th>Questions of the CS#4.1</th>
<th>Subquestions to participants to validate the instrument</th>
<th>How would you suggest changing or rephrasing the question to make it clear?</th>
<th>Comments of experts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Do you think the question is clear? Yes or No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Expert #1: Yes</td>
<td>No suggestions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Expert #2: Yes</td>
<td>No suggestions</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Expert #1: Yes</td>
<td>No suggestions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Expert #2: Yes</td>
<td>No suggestions</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Expert #1: Yes</td>
<td>No suggestions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Expert #2: Yes</td>
<td>No suggestions</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Expert #1: Yes</td>
<td>No suggestions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Expert #2: Yes</td>
<td>No suggestions</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Expert #1: Yes</td>
<td>No suggestions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Expert #2: Yes</td>
<td>No suggestions</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Expert #1: Yes</td>
<td>The use of a diagram to identify the “applied voltage”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Expert #2: Yes</td>
<td>No suggestions</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Expert #1: No</td>
<td>“Are ( R_1 ) and ( R_2 ) equals?”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Expert #2: Yes</td>
<td>“You may say equal resistance value for both resistors rather than fixed”</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Expert #1: Yes</td>
<td>No suggestions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Expert #2: Yes</td>
<td>“You may say equal resistance value for both resistors rather than fixed”</td>
<td></td>
</tr>
</tbody>
</table>
Insofar as the results of the CS#6.3 instrument, both experts suggested minor changes. Expert #1 considered questions #1, #2, #4, and #6 to be clear. This expert #1 thought that questions #3, #5, #7, and #8 were unclear and suggested changes or rephrasing. Although expert #1 considered question #3 was clear, he also suggested some changes (see Table 3-12). Expert #2 considered all the questions to be clear; however, expert #2 suggested rephrasing of question #5 (see Table 3-14).

Table 3-14
Responses of Experts to Questions of the Conceptual Survey CS#6.3

<table>
<thead>
<tr>
<th>Questions of the CS#6.3</th>
<th>Subquestions to participants to validate the instrument</th>
<th>Comments of experts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Do you think the question is clear?</td>
<td>How would you suggest changing or rephrasing the question to make it clear?</td>
</tr>
<tr>
<td></td>
<td>Yes or No</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Expert #1 Yes</td>
<td>No suggestions</td>
</tr>
<tr>
<td></td>
<td>Expert #2 Yes</td>
<td>No suggestions</td>
</tr>
<tr>
<td>2</td>
<td>Expert #1 Yes</td>
<td>No suggestions</td>
</tr>
<tr>
<td></td>
<td>Expert #2 Yes</td>
<td>No suggestions</td>
</tr>
<tr>
<td>3</td>
<td>Expert #1 No</td>
<td>“by measuring the voltage across R\textsubscript{S} and determining the current through R\textsubscript{S} by Ohm’s Law the current through V\textsubscript{C} can be determined”</td>
</tr>
<tr>
<td></td>
<td>Expert #2 Yes</td>
<td>No suggestions</td>
</tr>
<tr>
<td>4</td>
<td>Expert #1 Yes</td>
<td>No suggestions</td>
</tr>
<tr>
<td></td>
<td>Expert #2 Yes</td>
<td>No suggestions</td>
</tr>
<tr>
<td>5</td>
<td>Expert #1 No</td>
<td>“I am not sure what is wanted here”</td>
</tr>
<tr>
<td></td>
<td>Expert #2 Yes</td>
<td>“Are they at the same frequency??”</td>
</tr>
<tr>
<td>6</td>
<td>Expert #1 Yes</td>
<td>“Applied voltage” (Use of diagram)</td>
</tr>
<tr>
<td></td>
<td>Expert #2 Yes</td>
<td>No suggestions</td>
</tr>
<tr>
<td>7</td>
<td>Expert #1 No</td>
<td>No suggestions</td>
</tr>
<tr>
<td></td>
<td>Expert #2 Yes</td>
<td>No suggestions</td>
</tr>
<tr>
<td>8</td>
<td>Expert #1 No</td>
<td>“I am not sure what you want to get out of this question”</td>
</tr>
<tr>
<td></td>
<td>Expert #2 Yes</td>
<td>No suggestions</td>
</tr>
</tbody>
</table>
Testing of the Internal Reliability of the Instruments

The second activity of the pilot study was to test the internal reliability of the instruments. The Statistical Package for Social Science® (SPSS) software was used to conduct the test. The highest score was found in the instrument TAQ#4.1, Version A ($r = .855$), and the lowest score was found in the instrument TAQ#3.1, Version B ($r = .663$). According to the rule proposed by George and Mallery (2003) and Kline (1999), the TAQ instruments in the study had acceptable Cronbach’s Alpha scores (see Table 3-15).

Table 3-15
Internal Reliability Scores for the Task Analyzer (TAQ) Instruments

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Cronbach’s Alpha</th>
<th>Number of Questions</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAQ#3.1 Version A</td>
<td>.812</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>TAQ#3.1 Version B</td>
<td>.663</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td>TAQ#4.1 Version A</td>
<td>.855</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>TAQ#4.1 Version B</td>
<td>.712</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>TAQ#6.3 Version A</td>
<td>.799</td>
<td>8</td>
<td>36</td>
</tr>
<tr>
<td>TAQ#6.3 Version B</td>
<td>.832</td>
<td>8</td>
<td>37</td>
</tr>
</tbody>
</table>

The internal consistencies of the CS instruments were calculated using the same software SPSS. Because Version A and Version B contained the same questions, the
internal reliability scores were calculated only for Version A. The findings revealed different scores of internal reliability for the CS instruments. Although an acceptable score was found in CS#4.1 (r = .816), low scores of Cronbach’s Alpha were found in instruments CS#3.1 (r = .134) and CS#6.3 (r = .415), revealing poor consistency between the questions of these two instruments (George & Mallery, 2003; Kline, 1999). Table 3-16 shows the values of Cronbach’s Alpha for each of the CS instruments.

Table 3-16

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Cronbach’s Alpha</th>
<th>Number of Questions</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS#3.1 Version A</td>
<td>.134</td>
<td>7</td>
<td>16</td>
</tr>
<tr>
<td>CS#4.1 Version A</td>
<td>.804</td>
<td>8</td>
<td>17</td>
</tr>
<tr>
<td>CS#6.3 Version A</td>
<td>.415</td>
<td>8</td>
<td>38</td>
</tr>
</tbody>
</table>

It is not surprising that there was little inconsistency between questions in the CS instruments because of their true-false format. When the questions are dichotomous, alpha formulas are used to yield lower reliability coefficients (Gall, Gall, & Borg, 2007, p. 202) because of the 50% chance of guessing. Including multiple questions in each question may have increased the internal consistency of the CS instruments (Gronlund & Waugh, 2009, p. 93). However, CS instruments were developed by the researcher and the
professor of the class who have been teaching the course for more than 5 years. Also, the validity of the CS instruments was assessed by experts to determine whether questions for these instruments were representative of the area of interest of the researcher. Finally, possible time constraints in applying the instruments during the lab activity influenced the researcher in his decision to use this instrument.

**The Original and Modified Instruments**

Table 3-17 shows the original and modified questions of the TAQ instruments. Questions #1, #3, and #6 did not change from the original questions. Questions #2, #7, and #8 were rephrased to facilitate their understanding by the participants. Finally, questions #5 and #6 were rephrased to include diagrams to better explain the questions.

Table 3-18 shows the original and modified questions of instrument CS#3.1. Questions #2, #3, #6, and #7 remained unchanged from the original. Questions #1, #4, and #5 were rephrased to help participants to better understand the question.

Tables 3-19 and 3-20 show the original and modified questions of instrument CS#4.1. Questions #3, #4, and #5 remained unchanged. Questions #1, #2, #6, #7, and #8 were rephrased to facilitate understanding by the participants. Also, for question #7, a graphic representation was added.
Table 3-17
The Original and Modified Questions of the Task Analyzer (TAQ) Instruments

<table>
<thead>
<tr>
<th>Question</th>
<th>Original question</th>
<th>Modified question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>What are the learning objectives of this lab activity?</td>
<td>SAME</td>
</tr>
<tr>
<td>2</td>
<td>What formulas will (were) you use during this lab activity?</td>
<td>What formulas will be (were) involved in this lab activity?</td>
</tr>
<tr>
<td>3</td>
<td>What materials (or components) and instruments will be (were) needed for this lab activity?</td>
<td>SAME</td>
</tr>
<tr>
<td>4</td>
<td>It depends on every lab activity.</td>
<td>Graphic representations were included to facilitate understanding of the question.</td>
</tr>
<tr>
<td>5</td>
<td>It depends on every lab activity.</td>
<td>Graphic representations were included to facilitate understanding of the question.</td>
</tr>
<tr>
<td>6</td>
<td>What is the main purpose of this lab activity?</td>
<td>SAME</td>
</tr>
<tr>
<td>7</td>
<td>List the main concepts from the class that will be (were) used in this lab activity.</td>
<td>List the main concepts discussed in the class that will be (were) used in this lab activity.</td>
</tr>
<tr>
<td>8</td>
<td>List external reading/audio/video resources that are relevant for this lab activity.</td>
<td>List learning resources (e.g., readings/audio/video) that you consider relevant to help you to complete this lab activity.</td>
</tr>
</tbody>
</table>

Table 3-21 shows the original and modified questions of the instrument CS#6.1. Questions #2 did not change from the original. The remaining questions were rephrased and graphic representations also were added to help the participants better understand the questions.
Table 3-18

The Original and Modified Questions of the Conceptual Survey CS#3.1

<table>
<thead>
<tr>
<th>Question</th>
<th>Original question</th>
<th>Modified question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>In Figure 1 below, the Thevenin’s voltage viewed from terminals a and b can be determined by measuring the voltage across the load resistance $R_L$. [Figure 1]</td>
<td>In Figure 1 below, the Thevenin’s voltage viewed from terminals a and b can be determined by replacing $R_L$ with a short and measuring the voltage across these terminals. [Figure 1]</td>
</tr>
<tr>
<td>2</td>
<td>Thevenin’s theorem permits the reduction of complex networks to a simpler form for analysis.</td>
<td>SAME</td>
</tr>
<tr>
<td>3</td>
<td>The network N shown in Figure 2a below consists of a DC voltage source and resistors. It can be reduced to a two-terminal circuit having a single voltage source $E_{TH}$ and a series resistor $R_{TH}$ as shown in Figure 2b below. [Figure 2a] [Figure 2b]</td>
<td>SAME</td>
</tr>
<tr>
<td>4</td>
<td>In Figure 4 below, maximum power is drawn from the source $E_S$ when the load resistance $R_L$ equals the equivalent resistor $R_{EQ}$ of the circuit. [Figure 4]</td>
<td>The value of $R_T$ of the circuit shown in Figure 4 below is specified. Maximum power is drawn from the source $E_S$ when the load resistance $R_L$ equals the resistance $R_T$ of the circuit. [Figure 4]</td>
</tr>
<tr>
<td>5</td>
<td>In Figure 5 below, larger values of the load resistance $R_L$ ($R_L &gt;&gt; R_{TH}$) causes the value of power $P_L$ increases. [Figure 5]</td>
<td>In Figure 5 below, larger values of the load resistance $R_L$ ($R_L &gt;&gt; R_{TH}$) cause the value of power $P_L$ to increase. [Figure 5]</td>
</tr>
<tr>
<td>6</td>
<td>In Figure 5 above, if the value of $V_L$ increases to $E_{TH}/2$, it can be inferred that the value of $P_L$ increases to its maximum value.</td>
<td>SAME</td>
</tr>
<tr>
<td>7</td>
<td>In Figure 7 below, voltage source $E_S$ has to be replaced by an open circuit in order to determine the Thevenin resistance $R_{TH}$ between terminals a and b. [Figure 7]</td>
<td>SAME</td>
</tr>
</tbody>
</table>
Table 3-19

*The Original and Modified Questions 1-5 of the Conceptual Survey CS#4.1*

<table>
<thead>
<tr>
<th>Question</th>
<th>Original question</th>
<th>Modified question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The charging phase of a capacitor has essentially ended after 25 time constants.</td>
<td>The charging phase of a capacitor has essentially ended after five time constants.</td>
</tr>
<tr>
<td>2</td>
<td>The time constant of a capacitive circuit is the time it takes the voltage of a previously uncharged capacitor to rise to 90 percent of its full-charge value.</td>
<td>One time constant (1τ) of a capacitive circuit is the time it takes the voltage of a previously uncharged capacitor to rise to 90 percent of its full-charge value.</td>
</tr>
<tr>
<td>3</td>
<td>In Figure 3 below, the time constant τ of the circuit is τ = R1/C2 [Figure 3]</td>
<td>SAME</td>
</tr>
<tr>
<td>4</td>
<td>See Figure 3 above. For a fixed-resistance R1, the larger the capacitance, the longer it takes the capacitor C2 to charge up.</td>
<td>SAME</td>
</tr>
<tr>
<td>5</td>
<td>In Figure 5 below, when the capacitor C2 has reached the applied voltage of Es, the voltage VR across the resistor R1 must drop to zero volts. [Figure 5]</td>
<td>SAME</td>
</tr>
</tbody>
</table>
Table 3-20  
*The Original and Modified Questions 6-8 of the Conceptual Survey CS#4.1*

<table>
<thead>
<tr>
<th>Question</th>
<th>Original question</th>
<th>Modified question</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>The voltage across a capacitor in a DC network is essentially equal to the applied voltage after five time constants of the charging phase have passed.</td>
<td>See Figure 5 above. The voltage across a capacitor $C_2$ is essentially equal to the applied voltage $E_S$ after five time constants of the charging phase have passed.</td>
</tr>
<tr>
<td>7</td>
<td>The curves of voltages across the capacitor $V_C$ of two different circuits are shown in Figure 7 below. For a fixed-resistance value, the capacitance of the curve 1 is smaller than the capacitance of the curve 2. [Figure 7]</td>
<td>Two RC circuits in Figure 7a below are specified. The curves of voltages $V_{C_1}$ and $V_{C_2}$ are shown in Figure 7b below. For equal resistance values for both resistors $R_1$ and $R_2$, the value of the capacitor $C_1$ is smaller than $C_2$. [Figure 7a] [Figure 7b]</td>
</tr>
<tr>
<td>8</td>
<td>See Figure 7 above, for a fixed-resistance value, it can be inferred that the voltage across the resistor of the curve 1 drops faster than the voltage in the resistor of the curve 2.</td>
<td>See Figure 7a and 7b above. For equal resistance values for both resistors $R_1$ and $R_2$, it can be inferred that the voltage $V_{R_1}$ across the resistor $R_1$ drops faster than the voltage $V_{R_2}$ across the resistor $R_2$.</td>
</tr>
</tbody>
</table>
Table 3-21

The Original and Modified Questions of the Conceptual Survey CS#6.1

<table>
<thead>
<tr>
<th>Question</th>
<th>Original question</th>
<th>Modified question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>There is a linear relationship between frequency and capacitive reactance.</td>
<td>The relationship between frequency and capacitive reactance is linear.</td>
</tr>
<tr>
<td>2</td>
<td>The formula to calculate the capacitive reactance is $X_C=2\pi fC$, where $X_C$</td>
<td>SAME</td>
</tr>
<tr>
<td></td>
<td>represents the capacitive reactance, $f$ represents the frequency, and $C$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>represents the value of the capacitance.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>The “sensing” resistor of the circuit is the component used to indirectly</td>
<td>The “sensing” resistor $R_S$ of the circuit shown in Figure 3 below can be used</td>
</tr>
<tr>
<td></td>
<td>measure the value of $X_C$.</td>
<td>to determine the current through the 1 μF capacitor by measuring the voltage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>across $R_S$ and applying Ohm’s law to calculate the current through $R_S$.</td>
</tr>
<tr>
<td>4</td>
<td>At low frequencies the value of capacitive reactance is quite low, and at</td>
<td>At very high frequencies, the 1 μF capacitor of the circuit shown in Figure 3</td>
</tr>
<tr>
<td></td>
<td>higher frequencies the value of capacitive reactance increases in a non-linear</td>
<td>above acts likes an open circuit.</td>
</tr>
<tr>
<td></td>
<td>manner.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>If the 1 μF capacitor is replaced by a 10 μF capacitor, it can be inferred that</td>
<td>The value of the capacitor of each of the circuits shown in Figures 5a and 5b</td>
</tr>
<tr>
<td></td>
<td>the new graph $X_C$ versus frequency should have the same shape.</td>
<td>below is specified. The general shape of the graph of capacitive reactance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>versus frequency corresponding to Figure 5a is the same as the shape of the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>graph of capacitive reactance versus frequency corresponding to Figure 5b.</td>
</tr>
<tr>
<td>6</td>
<td>If the capacitor is connected in parallel with a second capacitor, it can be</td>
<td>In Figure 6 below, it can be inferred that there is a linear relationship between</td>
</tr>
<tr>
<td></td>
<td>inferred that the relationship between the equivalent $X_C$ and the frequency is</td>
<td>frequency and the capacitive reactance of the equivalent capacitor ($C_T$).</td>
</tr>
<tr>
<td></td>
<td>similar with the first capacitor.</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>The capacitive reactance can be found using Ohm’s Law with the values of voltage</td>
<td>If the voltage ($V_C$) across the 1 μF capacitor and the current ($I_S$) through</td>
</tr>
<tr>
<td></td>
<td>and current in the capacitor.</td>
<td>the resistor ($R_S$) shown in Figure 7 below are known, then the capacitive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>reactance ($X_C$) can be calculated by applying Ohm’s Law.</td>
</tr>
<tr>
<td>8</td>
<td>If the signal generator is replaced by a DC power supply it can be inferred that</td>
<td>If the signal generator ($E_S$) shown in Figure 8a below is replaced by a DC</td>
</tr>
<tr>
<td></td>
<td>the new graph $X_C$ versus frequency should have the same shape.</td>
<td>power supply ($E$) as shown in Figure 8b below, the graph of capacitive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>reactance versus frequency of both figures should have the same shape.</td>
</tr>
</tbody>
</table>

[Figure 3] [Figure 5a] [Figure 5b] [Figure 6] [Figure 7] [Figure 8a] [Figure 8b]
Practice Data Analysis and Interpretation

The purpose of the pilot study was to analyze the data using a triangulation method. The objective of the researcher was to analyze the responses of the fourth subquestion in the TAQ and CS instruments: “What is your answer to the question?” Through this activity, the researcher identified relevant information regarding how to analyze the data. Descriptive statistics were utilized to calculate the mean for every instrument of the responses of the participants.

The responses of the TAQ instruments were scored by the researcher (lab instructor) on a scale from “0” to “3” points, where “0” was the lowest and “3” was the highest score. Because every TAQ instrument was comprised of eight questions, the maximum possible score was 24 points. The results indicated a difference in mean scores between Version A and Version B. The scores of the TAQ Version B were higher than those of Version A (see Table 3-22).

Table 3-22

Scores of Responses of the Task Analyzer (TAQ) Instruments

<table>
<thead>
<tr>
<th>TAQ Instrument</th>
<th>Mean scores</th>
<th>Number of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Version A</td>
<td>Version B</td>
</tr>
<tr>
<td>3.1</td>
<td>10.0^a</td>
<td>12.4^a</td>
</tr>
<tr>
<td>4.1</td>
<td>10.1^a</td>
<td>13.4^a</td>
</tr>
<tr>
<td>6.3</td>
<td>11.9^a</td>
<td>14.3^a</td>
</tr>
</tbody>
</table>

Note. ^a Maximum score is 24 points.
The responses of the CS instruments were scored with a “0” if the answer was incorrect and “1” if the answer was correct. The instrument CS#3.1 was comprised of seven questions with a maximum score of 7. Instruments CS#4.1 and CS#6.3 were comprised of eight questions with a maximum score of 8. The results indicated a difference between Version A and Version B of the TAQ instrument. The scores of the CS Version B were higher than those of Version A (see Table 3-23).

Table 3-23

Scores of Responses of the Conceptual Survey (CS) Instruments

<table>
<thead>
<tr>
<th>CS Instrument</th>
<th>Mean scores</th>
<th>Number of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Version A</td>
<td>Version B</td>
</tr>
<tr>
<td>3.1</td>
<td>4.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.9&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>4.1</td>
<td>6.5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.8&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>6.3</td>
<td>5.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.8&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

*Note.* <sup>a</sup> Maximum score is 7 points. <sup>b</sup> Maximum score is 8 points.

Implications of the Pilot Study

The pilot study aided the researcher to set in place quantitative tools to analyze students’ task interpretation and conceptual understanding in the context of lab activities. The researcher successfully evaluated the instruments developed for the main study and
analyzed the data collected. Thus, the experience of conducting a pilot study was particularly useful in establishing the foundation for conducting the main study.

The main study was conducted with a large number of participants, and the pilot study just provided an opportunity to establish specific actions for guiding the large number of students in the project. For example, getting participants to read the lab guide before they begin a lab activity is important to measure their task interpretation. Observations during the pilot study enabled the researcher to prepare and guide the students during the process of the lab activity in the main study. Researchers also identified a scale to measure the TAQ instruments. An additional evaluator will be needed to score the TAQ instruments with for the purpose of validating the open-ended questions of the instrument. A summary of activities in the pilot study is shown in Table 3-24.
Table 3-24

*Summary of Activities in the Pilot Study*

<table>
<thead>
<tr>
<th>Activity</th>
<th>Why</th>
<th>How</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>To conduct face-validity of the instruments</td>
<td>To ensure participants understand every question of the instruments and avoid any misinterpretation of participants</td>
<td>Applying the instruments to students</td>
<td>The researcher identified questions of the instruments that need rewording or rephrasing as a result of feedback from participants and experts.</td>
</tr>
<tr>
<td>To test the internal reliability of the instruments</td>
<td>To investigate whether the instruments have good internal reliability scores</td>
<td>Calculating the internal reliability using SPSS to find Cronbach’s Alpha scores</td>
<td>The researcher found the internal reliability scores. While TAQ instruments showed moderate Cronbach’s Alpha scores, CQ instruments showed low scores.</td>
</tr>
<tr>
<td>To practice how to analyze and interpret the data</td>
<td>To learn how to analyze the data collected</td>
<td>Scoring the answers of the instruments</td>
<td>The researcher identified a scale to measure the responses of the TAQ instruments. A second evaluator will be needed for the main study to score TAQ responses.</td>
</tr>
</tbody>
</table>
CHAPTER IV
RESEARCH METHODOLOGY

Purpose and Overview

The purpose of this study was to investigate how students’ task interpretation of lab work may change during the task process, and how it may influence coregulation and conceptual understanding. The study focused on explicit and implicit aspects of task interpretation based on the model of Hadwin (2006), and was analyzed before and after the task process during the lab activity. Coregulation was evaluated after the students finalized the lab assignment. Conceptual understanding was also analyzed before and after the task process. The researcher used a descriptive quantitative approach to answer the research questions. A descriptive parametric analysis was used to establish statistically significant conclusions about a representative sample selected for this study. The approach enabled the researcher to better understand how students interpret a task in lab work and how that interpretation relates to conceptual understanding. Some questions of the instruments were open-ended and, therefore, participants were asked to provide answers in their own words that would reflect their perception of the task assigned.

Research Questions

This research was guided by the following research questions:
1. Does students’ task interpretation change during the task completion process?

2. How is students’ task interpretation different between high- and low-coregulated students?

3. How is students’ task interpretation related to conceptual understanding?

Research Design and Participants

Course Selection

The course selected for this study was entitled Fundamental Electronics for Engineers. It is among the required preengineering courses for sophomore students enrolled in the majors of Biological, Civil, and Mechanical Engineering. Sophomore students were chosen for the study because research has shown about two-thirds (perhaps as much as 90 percent for cognitive skills) of the gains college students make in reading, math, science, the social sciences, and cognitive skills occur in the first 2 years of college (Pascarella & Terenzini, 2005). The purpose of the course is the study and application of circuit fundamentals, theorems, and laws for the analysis of direct current (DC) and alternating current (AC) circuits. The laboratory includes construction and analysis of DC/AC circuits, and the use of measuring instruments, power supplies, and signal generators. Lab activities are integrated as a part of the curriculum to provide students with the opportunity for hands-on exposure. Students registered for the course are required to take regular classes in a classroom and seven lab sessions (during spring or fall semesters) or six lab sessions (during the summer session).
**Participant Selection**

Sophomore students who were enrolled in the course of Fundamental Electronics for Engineers for the fall semester of 2014 were invited to participate in the study. Of the total of 146 students registered for the class, 143 signed up and participated in the study. Cohen (1992) stated that 85 participants is a sufficient number to conduct a significant test and correlation test with a medium effect size of .80 and significant criterion (alpha) at level .50. Participants were informed of the purpose of the study in the first lab session of the semester. The researcher encouraged students to participate in this study, offering compensation with extra credits for their participation. They received 8 extra credit points of the total points for examinations, and 8 extra credit points of the total points for laboratory. Students who chose not to participate in the research were given the opportunity to earn equivalent extra credits by working on other experiments. Participants received no information or training in advance on SRL, CRL, or conceptual understanding. Those who participated signed a consent form (Appendix A), which is part of the process that the researcher followed under the direction of the Institutional Review Board (IRB) to obtain permission to collect data from human subjects.

**Instrumentation**

Questionnaires are extensively used in educational research to collect data about phenomenon more conveniently than by direct observation. Questionnaires have two advantages over other methods of data collection: “the cost of sampling respondents over
a wide geographical area is lower, and the time required to collect the data is typically much less” (Gall et al., 2007, p. 228). The researcher developed and pilot-tested two instruments that were applied in this study: (1) the task analyzer questionnaire (TAQ) to measure the participants’ task interpretation, and (2) conceptual survey (CS) to measure the participants’ conceptual understanding. The TAQ was developed for three different lab activities: (1) #3.1 – Measuring Thevenin Equivalent Circuit, (2) #4.1– RC Circuit Charging Phase Conditions, and (3) #6.1– Capacitive Reactance and Frequency. Similarly, the instrument CS was developed for the three lab activities selected by the researcher. Lab activity #3.1 refers to lab session 3, activity 1. The task analyzer questionnaire (TAQ#3.1) was developed to measure the participants’ task interpretation of their lab assignment. The conceptual survey (CS#3.1) was developed to measure the participants’ conceptual understanding of the lab activity #3.1. The same format applied for lab activities #4.1 and #6.1. Lab activity #6.1 was originally #6.3, but was moved to be the first activity of lab session #6. Results of the pilot study indicated that the researcher might have better control managing participants when the activity is the first one of the lab session. The researcher considered that the objectives and goals of the lab session were not compromised when activity #3 was exchanged with activity #1. Thus, the instruments TAQ#6.3 and CS#6.3 were renamed TAQ#6.1 and CS#6.1.

The researcher selected the lab activities because they facilitate recognizing the conceptual knowledge that identifies specific pieces of information and their relationships (Hiebert & Lefevre, 1986). The activities included topics that emphasize specific concepts related to the content of the course, thus enabling the researcher to develop
precise questions to measure how students better understand the concepts. The lab
activities were explained in the lab guide for each specific lab session as part of the
curriculum and were taken from the lab manual, *Introductory Circuit Analysis* by Robert
Boylestad and Gabriel Kousourou (11th Ed., 2007). Each lab activity contained the
procedure of how to build a circuit, take measurements, make calculations, as well as a
question/answer section related to the topic of the activity. The lab guide included several
activities and the information related to the final objective, performance objective,
enabling objectives, laboratory hardware required, learning activities, and information
related to the summative evaluation. Lab activity #3.1 is included in Appendix B.
Improvements are made continuously to the lab sessions in order to update the
experiments including new hardware or tools (software) for the analysis of electrical
circuits.

**Task Analyzer Questionnaire (TAQ)**

The task analyzer questionnaire (TAQ) was developed based on a specific lab activity
of the lab session, and included the model of explicit and implicit aspects of task
interpretation by Hadwin (2006). Each TAQ consists of eight open-ended questions with
responses ranging from 0 to 3. A score of 0 was assigned to a *blank or incorrect answer*;
a score of 3 was given to a *correct answer*; and a score of 1 or 2 indicated an *incomplete
answer*. An incomplete answer was decided by the criterion of the researcher and
compared the answer of the participant with the rubric. Moreover, in order to validate the
grading by the researcher, a lab instructor also graded the quizzes. They both conducted
an inter-rater agreement to grade the quizzes in three stages: learn, grade, and conciliate. The purpose of the first stage learn was to develop the rubric and learn how the other grader applied the grading criteria during this activity:

1. Graders worked together in developing the rubric answering the questions of the quizzes.
2. The researcher made copies of the quizzes for the instructor in order to have another set of the quizzes.
3. They independently graded a small sample (the same) of the quizzes.
4. They met again to discuss and revise the grading of each one of them to identify any discrepancy in the scores of the quizzes of the sample.

During the second stage grade, the researcher and the instructor worked independently again to grade the rest of the quizzes. They used an Excel® table to fill it with the information of grading indicating the score for each one of the questions of the quizzes of participants.

In the final stage conciliate, they met again to conduct the agreement/disagreement discussion of the differences in the scores of the quizzes. They compared the answers with different scores of the tables arguing the reasons why they gave the points. Some of the scores were changed based on the agreement between the researcher and instructor. At the end, a percentage of agreement was calculated dividing the number of answers with the same score and the total number of answer of all the participants. The copies of the quizzes were shredded.
The first five questions measured the explicit aspects of task interpretation; the last three measured implicit aspects. All of the TAQ instruments included the same questions except for questions #4 and #5 which asked for a specific procedure in that lab activity. A Version A and Version B of the TAQ were developed by the researcher. Basically, the difference between the versions was that questions #2, #3, and #7 in Version A were written in the “future tense” whereas those on Version B were in the “past tense” according to the time that the TAQ was applied in a lab session. Thus, the TAQ Version A was applied before the start of the lab activity, and Version B was applied at the end of a lab activity.

The TAQ instruments were tested during the spring semester and summer session of 2014. Face-validity for the TAQ instruments was conducted to elicit feedback from students and one expert who used the TAQ instruments in lab work. Internal reliability was conducted for the TAQ instruments in a pilot study. The Cronbach’s alpha scores for the TAQ instruments ranged from .663 to .855. According to the rule of thumb proposed by George and Mallery (2003) and Kline (1999), the Cronbach’s alpha scores for the TAQ instruments were acceptable.

Conceptual Survey (CS)

The purpose of the CS instrument was to measure the level of conceptual understanding of participants. Instrument questions were developed based on the concepts evaluated in each lab activity selected by the researcher and the questions of the corresponding TAQ instrument. For example, the CS#4.1 evaluated the concepts
involved in “RC circuit charging phase,” and the TAQ#4.1 evaluated the interpretation of the task assigned of the lab activity related to these concepts. The researcher developed questions considering only the conceptual knowledge that participants must bring to a lab activity and avoiding questions related to procedural knowledge.

Each CS consisted of true-false questions. The original instruments, CS#3.1, CS#4.1, and CS#6.1 of the pilot study consisted of seven, eight, and eight questions, respectively. One question was removed from the CS#6.1 by the researcher and the instructor of the course because it duplicated another question in the same instrument. For the purpose of reliability, for every question of the CS instrument, an extra question was added that measured the same concept by rephrasing the original question. Therefore, a 0.5 probability of answering correctly by chance was minimized. For the purpose of grading, a score of 1 point was given if both answers were correct; a score of 0 was given if one of the answers was incorrect or left blank. At the end the instrument CS#3.1, 14 questions were included. Instrument CS#4.1 included 16 questions, and CS#6.1 included 14 questions. Table 4-1 shows the number of questions of each instrument and the concepts that the questions evaluated among the participants.
Table 4-1

*Description of the Conceptual Survey (CS) Instruments*

<table>
<thead>
<tr>
<th>CS Instrument</th>
<th>Number of questions</th>
<th>Concepts to evaluate</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>14</td>
<td>Thevenin equivalent circuit theorem, Maximum power transfer theorem</td>
</tr>
<tr>
<td>4.1</td>
<td>16</td>
<td>Time constant “τ” of RC circuits, transient (time-varying) response of a RC circuit under charging phase</td>
</tr>
<tr>
<td>6.1</td>
<td>14</td>
<td>Frequency response of capacitive reactance</td>
</tr>
</tbody>
</table>

Two versions of the CS instrument were also developed. *Version A* and *Version B* of the instruments included the same questions, the only difference being their order in the questionnaire. The reason for developing the two versions in such a manner was because the duration of lab activity was approximately 30 minutes, and participants were to respond to the questions of *Version B* based on their criteria and not on their recall about what they responded in *Version A*. The CS *Version A* was applied before the onset of the lab activity; CS *Version B* was applied at the end of the lab activity.

The CS instruments were tested during the pilot study in the spring semester and summer session of 2014. During the pilot study, the instruments #3.1, #4.1, and #6.1 consisted of seven, eight, and eight questions, respectively. A face-validity for the CS instruments was conducted to receive feedback from students and experts. Internal reliability was conducted for the CS instruments. Cronbach's alpha was calculated in the pilot study scoring the responses of participants who took the CS *Version A*. The results were tabulated in SPSS to calculate Cronbach’s alpha. The scores for instruments #3.1,
#4.1, and #6.3 were .134, .804, and .415, respectively. Although #4.1 reached a good of internal reliability \((r = .804)\), #3.1 and #6.3 ranged below .6 indicating a poor internal reliability (George & Mallery, 2003; Kline, 1999). Some of the CS instruments reflected poor consistency because of true-false scores, and more items were added to add the consistency to the instruments to achieve a better level of reliability (Grosse & Wright, 1985). The CS instruments were developed by the researcher and the professor of the class who have taught the course for more than 5 years. In addition, the validity of the CS instruments was assessed by two experts to determine whether questions were representative of the area of interest of the researcher.

**The Coregulated Learning Questionnaire (CLQ)**

This instrument was a modified version of the Coregulated Learning Survey developed and tested by DiDonato (2013) to measure CRL. It consisted of 19 statements, and a Cronbach’s alpha score of .83. The CLQ consisted of 14 statements with minor modifications from the original of DiDonato. In statements 3, 5, 6, 9, 10, and 13, the word “project” was replaced by the term “lab activity” because of the context of laboratory work. Statements 1, 2, 4, 7, 8, 11, and 12 did not change. Statement 14 was added at the end of the questionnaire and asked the participants if they had planned first, or just started working on the lab activity without any preplanning. Six statements were removed from the original because they were related to activities after hours. Students responded to statements based on a 4-point scale where the number indicated the degree to which the student believed she or he did what the item described. Choices included
always (4), most of the time (3), some of the time (2), or never (1). Figure 4-1 shows the list of the statements of the CLQ instrument.

<table>
<thead>
<tr>
<th></th>
<th>Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>In our group, we looked over each other’s work to see if we understood what each member was doing.</td>
</tr>
<tr>
<td>2.</td>
<td>In our group, we checked each other’s work to make sure each other’s research was correct.</td>
</tr>
<tr>
<td>3.</td>
<td>We made sure everyone understood before we moved on to the next part of our lab activity.</td>
</tr>
<tr>
<td>4.</td>
<td>We double-checked each other’s work to make sure we were all doing it right.</td>
</tr>
<tr>
<td>5.</td>
<td>If someone in our group became distracted, we were able to refocus everyone’s attention back on our lab activity.</td>
</tr>
<tr>
<td>6.</td>
<td>We worked hard on our lab activity even if we didn’t like all the parts.</td>
</tr>
<tr>
<td>7.</td>
<td>When we planned, we talked about if our plans were realistic.</td>
</tr>
<tr>
<td>8.</td>
<td>In our group, we all paid attention to what each other was working on.</td>
</tr>
<tr>
<td>9.</td>
<td>I knew what my other group members were working on during our lab activity.</td>
</tr>
<tr>
<td>10.</td>
<td>Our group did other things when we are supposed to be working on our lab activity.</td>
</tr>
<tr>
<td>11.</td>
<td>We managed our time efficiently so we were not rushing around to finish at the last minute.</td>
</tr>
<tr>
<td>12.</td>
<td>In our group, one group member knew what another one was working on.</td>
</tr>
<tr>
<td>13.</td>
<td>Members of our group were often distracted, which got in our way to work well on our lab activity.</td>
</tr>
<tr>
<td>14.</td>
<td>We did not plan, just started working on the lab activity.</td>
</tr>
</tbody>
</table>

Figure 4-1. List of statements of the Coregulated (CLQ) instrument.

Data Collection Procedures

This study involved data collection from human subjects. For that reason, the Institutional Review Board (IRB) at Utah State University (USU) reviewed the research to assess the issue of risk or legal harm; the Board provided approval for this study (Protocol #4924). The researcher obtained permission of the students who signed an
informed consent statement during the first lab session of the semester in order to participate. (See Appendix A). The researcher completed the CITI (Collaborative Institutional Training Initiative) certification and followed the steps in the web site of the IRB-USU in order to get the approval of the IRB:

- Answer all questions in the application form.
- Upload all instruments of this study to collect data.
- Upload a rough draft of the informed consent form.
- Upload a copy of the research proposal.

The instruments were administrated by the researcher and a teaching assistant and were completed by hand in paper-and-pencil. The questionnaires were collected and scored manually. The teaching assistant received training from the researcher for the purpose of the study, aspects of confidentiality, and how to collect the data from the participants. The CS and the CLQ were scored by the researcher.

In order to maintain the confidentiality of the data collected from the participants, their names were coded. Participants only had to write the last four digits of their college identification. The researcher had corroborated earlier to ensure no duplication in the last four digits. After the students completed the quizzes, the four digits of the quiz were crossed out and assigned a number that included the lab section and any number starting with 1 and ending with a number corresponding to the number of students registered in the lab section. For example, a participant was assigned with a number 503-12, meaning lab section 503, and the 12th student in the list of participants.
The questionnaires of the TAQ and CS were applied in the same order as the pilot study to ensure validity. The researcher gave students a hard copy of the lab guide after they took the CS Version A. Based on the pilot study conducted during the spring semester and summer session of 2014, the list below outlines the steps that participants followed when applying the TAQ, CS, and CRL instruments in the selected lab activities:

1. Researcher gave the CS Version A to participants.

2. After participants finished the CS Version A, researcher collected it and gave participants the lab guide.

3. Researcher asked participants to read the list of objectives, materials, instruments, and steps of the lab activity described in the lab guide.

4. Researcher requested participants to put aside the lab guide and any supportive material.

5. Researcher gave participants the TAQ Version A.

6. After participants finished the TAQ Version A, researcher collected it and instructed participants to return the lab guide and supportive material and begin working on the lab activity. Also, researcher gave instructions to participants to report when they completed the lab activity.

7. Researcher monitored that all the participants had completed the activity.

8. After participants completed the lab activity, the instructor again instructed them to put aside the lab guide and any supportive material.

9. Researcher gave participants the TAQ Version B.

10. After participants finished the TAQ Version B, researcher collected it and
distributed the CS Version B.

11. After participants finished the CS Version B, the researcher collected it and instructed participants to return the lab guide and any supportive material and continue working on the remaining lab activities.

Figure 4-2 is a schematic illustration of the order of administration of the TAQ, CS, and CLQ instruments before and after the lab activities. Participants took 4-6 minutes for each CS, 4-6 minutes to read the lab activity, 10-12 minutes to respond to each TAQ, CLQ, and 2-3 minutes for the CLQ (for a total of approximately 20 minutes). Participants spent 30-40 minutes working on the lab activity. The researcher verified that all of the participants included their last four identification numbers and lab section. Participants were instructed to raise their hand when they finished the questionnaire or survey.

![Figure 4-2](image)

*Figure 4-2. The order of how the instruments were applied to participants*
Data Analysis

Before answering the research questions, several steps were conducted by the researcher to handle missing data, validate the grading of the TAQ instrument, conduct the reliability test, and examine the normality of the data.

Missing data: some missing data were left blank by the researcher in the raw data, which is an accepted way of indicating missing system data in the data set. The software SPSS® automatically identified the missing data and it was not counted in the analysis to answer the research questions.

Validity of grading of the TAQ data: a percentage of agreement was calculated to validate the grading of the open-ended questions of the TAQ. An additional analysis to calculate the Kendall’s coefficient of concordance (W) was made to support the validity of the grading of the TAQ instrument.

Reliability: a reliability test entitled Kuder and Richardson-20 (KR-20) for dichotomous variable was conducted for the CS data including the additional paired questions for the study. A Cronbach’s alpha coefficient was calculated for the CLQ data collected after each lab activity.

Normality: the researcher analyzed each of the sets of data of the TAQ, CS, and CLQ. For the TAQ, data collected were discrete but continuous in the average values. A Shapiro-Wilk test was conducted to examine the normality and further, to help the researcher to decide whether to use a parametric approach. For the CS, data collected were dichotomous but continuous in the average values. Similarly, a Shapiro-Wilk test
was conducted to examine the normality of the data and to decide whether to use a parametric analysis. Because CLQ data provided by a Likert-scale is ordinal, for the purpose of this study it was considered as a continuous.

Addressing Research Questions

The first research question of this study was *does students’ task interpretation change during the task completion process?* To answer this research question, the instrument TAQ was applied in a paper-and-pencil format at the beginning and end of the following activities:

- Lab session 3, activity 1
- Lab session 4, activity 1
- Lab session 6, activity 1

Participants completed *Versions A* and *B* of the TAQ. First, a parametric statistical analysis in SPSS compared the means between the TAQ’s before and after the lab activity. Second, a paired-sample *t* test analysis in SPSS was conducted to answer the first research question. A cutoff value of .05 for the Type I error was used to determine whether the results of the TAQ before and after were significant.

The second research question of this study was *how is students’ task interpretation different between high- and low-coregulated students?* To address this research question a paper-and-pencil version of the CLQ was administered to participants to determine how they collaborated with their peers during the lab activity. The CLQ was administered after the CS *Version B* in each of the selected lab activities. First, a
descriptive statistical analysis in SPSS was conducted to analyze the average values of the responses of the CLQ instrument. Second, an analysis was conducted in Excel® to examine the scores of the CLQ to identify the group of participants with a high level of coregulation (scores below quartile 1) and the group of participants with a low level of coregulation (scores above quartile 3). This analysis was possible because the researcher considered the CLQ scores as normally distributed. Third, an independent sample t test analysis in SPSS was conducted to identify any significance in the scores of the TAQ associated to the high- and low-coregulated students.

The third research question of this study was how is students’ task interpretation related to conceptual understanding? To answer this question, the instrument Conceptual Survey (CS) was applied in a paper-and-pencil format at the beginning and end of the following activities.

- Lab session 3, activity 1
- Lab session 4, activity 1
- Lab session 6, activity 1

First, a parametric statistical analysis in SPSS compared the means between the CS before and after the lab activity. Second, a Pearson correlation analysis in SPSS was conducted to find the correlation between TAQ and CS before and after the lab activity.
CHAPTER V
FINDINGS

This chapter presents an analysis of the data collected from the instruments used in this study, including the task analyzer questionnaire (TAQ), conceptual survey (CS), and coregulated learning questionnaire (CLQ). The chapter is organized into two parts: first is a preliminary analysis to examine the composition of the data and an assessment of the suitability of the data for parametric analysis. The second presents a statistical analysis to address each of the research questions.

Preliminary Analysis

Participants

Sophomore students enrolled in the course of Fundamental Electronics for Engineers for the fall semester of 2014 participated in the study. Of the total of 146 students registered for the class, 143 signed up and participated in the study. Participants had to complete 7 questionnaire/surveys: TAQ before and after, CS before and after, and the CLQ after the completion of the lab activity. From the 143 participants, not all of them complete the set of 7 questionnaire/surveys due some reasons such as absence or arriving late at the lab session. From Table 5-1 to 5-3 above, there is a description of the number of participant that filled the TAQ, CS, and CLQ respectively. At least, all the participants completed a questionnaire/survey: TAQ#4.1 Version B, CS#4.1 Version A
and Version B, and CLQ lab #4.1. Consequently, an N number of 143 were considered for the statistical analysis because researcher considered the average values of each one of the instruments, before and after the lab activity.

Table 5-1
*Number of Participants that Filled the Task Analyzer (TAQ)*

<table>
<thead>
<tr>
<th></th>
<th>TAQ#3.1 Version A</th>
<th>TAQ#3.1 Version B</th>
<th>TAQ#4.1 Version A</th>
<th>TAQ#4.1 Version B</th>
<th>TAQ#6.1 Version A</th>
<th>TAQ#6.1 Version B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of</td>
<td>135</td>
<td>136</td>
<td>137</td>
<td>143</td>
<td>137</td>
<td>140</td>
</tr>
<tr>
<td>participants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5-2
*Number of Participants that Filled the Conceptual Survey (CS)*

<table>
<thead>
<tr>
<th></th>
<th>CS#3.1 Version A</th>
<th>CS#3.1 Version B</th>
<th>CS#4.1 Version A</th>
<th>CS#4.1 Version B</th>
<th>CS#6.1 Version A</th>
<th>CS#6.1 Version B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of</td>
<td>141</td>
<td>139</td>
<td>143</td>
<td>143</td>
<td>141</td>
<td>141</td>
</tr>
<tr>
<td>participants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5-3
*Number of Participants that Filled the Coregulated Learning Questionnaire (CLQ)*

<table>
<thead>
<tr>
<th></th>
<th>CLQ instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lab #3.1</td>
</tr>
<tr>
<td>Number of</td>
<td>138</td>
</tr>
<tr>
<td>participants</td>
<td></td>
</tr>
</tbody>
</table>
Validity of grading of the TAQ data

The questions on the TAQ instrument were open-ended. In order to validate the grading by the researcher, a second instructor also graded the quizzes. Both scored the quizzes following the three steps: learn, grade, and conciliate. In conciliating, at the end of grading of the quizzes, the graders calculated a percentage of agreement in scoring the TAQ instrument to determine how they agreed/disagreed in grading. Below is the formula used to calculate the percentage of agreement:

\[
\text{Percentage of agreement} = \frac{\text{Total number of agreed answers}}{\text{Total number of answers}}
\]

The total number of agreed answers represents all of the answers from the quizzes that received the same points, either by the graders’ criteria or because they reached an agreement. The total number of answers represents all of the answers from all quizzes: eight answers multiplied by the number of participants taking the quiz. Table 5-4 shows the results of the percentage of agreement for each of the TAQ instruments. The average value was 80.35%. In other words, the researcher and instructor consistently agreed with over 80% of the answers in all of the quizzes. This value was considered by the researcher as acceptable for the purpose of the study.
Table 5-4
Percentage of Agreements in Grading the Task Analyzer (TAQ)

<table>
<thead>
<tr>
<th>TAQ#3.1</th>
<th>TAQ#3.1</th>
<th>TAQ#4.1</th>
<th>TAQ#4.1</th>
<th>TAQ#6.1</th>
<th>TAQ#6.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of agreement</td>
<td>75.93%</td>
<td>79.60%</td>
<td>78.65%</td>
<td>82.60%</td>
<td>83.03%</td>
</tr>
<tr>
<td>N = 135</td>
<td>N = 136</td>
<td>N = 137</td>
<td>N = 143</td>
<td>N = 137</td>
<td>N = 140</td>
</tr>
</tbody>
</table>

In addition, a Kendall’s $W$ (coefficient of concordance) was calculated to identify the level of significance associated between graders. A Kendall’s $W$ is a correlation coefficient that measures the level of the agreement among several judges (researcher and instructor), who assess a given set of objects (Legendre, 2005). Kendall’s $W$ ranged from 0 (no agreement) to 1 (complete agreement). In this study, two graders assessed eight questions. Each grader provided a set of data consisting of the average values of the scores in every response for each TAQ, and then compared both sets by calculating the Kendall’s $W$. Table 5-5 shows the calculated values of Kendall’s $W$ ranging from .691 to .929. The values were considered by the researcher as acceptable (George & Mallery, 2003; Kline, 1999) for the purpose of the study. Therefore, the scores of the TAQ-graded quizzes provided by the researcher were suitable for the study.
Table 5-5

Level of Agreement in Grading the Task Analyzer (TAQ) Based on Kendall’s W

<table>
<thead>
<tr>
<th></th>
<th>TAQ#3.1 Version A</th>
<th>TAQ#3.1 Version B</th>
<th>TAQ#4.1 Version A</th>
<th>TAQ#4.1 Version B</th>
<th>TAQ#6.1 Version A</th>
<th>TAQ#6.1 Version B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kendall’s W</td>
<td>.909**</td>
<td>.982**</td>
<td>.691*</td>
<td>.857**</td>
<td>.929**</td>
<td>.929**</td>
</tr>
<tr>
<td>N = 8</td>
<td>N = 8</td>
<td>N = 8</td>
<td>N = 8</td>
<td>N = 8</td>
<td>N = 8</td>
<td>N = 8</td>
</tr>
</tbody>
</table>

Note. * Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

Reliability of the instruments

The reliability of the TAQ instruments was previously calculated and discussed in detail in the Chapters III and IV. The values ranged from .663 to .855 and were considered as acceptable by the researcher. The reliability of the CLQ instrument was determined as follows: average values were calculated for each of the 14 item from all three lab activities, and then calculated by Cronbach’s alpha for the 14 items. Cronbach’s alpha for the 143 participants across the 14 items was .763. The researcher considered this value as acceptable (George & Mallery, 2003; Kline, 1999). The reliability of the CS instruments was recalculated because more items were added to the instruments. In this case, the Kuder and Richardson (KR-20) coefficient was calculated. KR-20 is a specific case of Cronbach to measure the reliability of instruments with dichotomous variables such as true-false items (Vogt, 2005). Table 5-6 shows KR-20 coefficients in a range from .499 to .641. Compared to the results of the pilot study, the CS#3.1 increased from .134 to .499, and the CS#6.1 increased from .415 to .641. Although the CS#4.1 decreased
from .804 to .598, the results were found to be more consistent with each other, which makes sense considering the CS instruments all consisted of true-false items (George & Mallery, 2003; Groose & Wright, 1985; Kline, 1999).

### Table 5-6

*Internal Reliability Scores for the Conceptual Survey (CS) Instruments with KR-20*

<table>
<thead>
<tr>
<th>CS Instrument</th>
<th>KR-20</th>
<th>Number of Questions</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>.499</td>
<td>14</td>
<td>142</td>
</tr>
<tr>
<td>4.1</td>
<td>.598</td>
<td>16</td>
<td>143</td>
</tr>
<tr>
<td>6.1</td>
<td>.641</td>
<td>14</td>
<td>143</td>
</tr>
</tbody>
</table>

### Analysis of Normality

The researcher analyzed each of the sets of data of the TAQ instruments by checking the normality of the data to decide whether to use parametric or nonparametric analysis to answer the research questions. For this analysis, the researcher used the average value (based on a total score of 24 points) for the three TAQ’s before the lab activity (TAQ Version A) and after the lab activity (TAQ Version B). The researcher analyzed the normality of data by applying the Shapiro-Wilk test, which is typically tested at a significance value of .001. The Shapiro-Wilk test is a statistical test of the hypothesis that data have been drawn from a normally distributed population (Royston,
Results shown in Table 5-7 suggested that normality was a reasonable assumption for both sets of data. A well-shaped normal distribution shown in Figure 5-1 also suggested evidence of normality.

Table 5-7

*Shapiro-Wilk Test of Normality for Data Collected from the Task Analyzer (TAQ) Instruments*

<table>
<thead>
<tr>
<th>TAQ Instrument</th>
<th>Statistic</th>
<th>df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Version A</td>
<td>.987</td>
<td>143</td>
<td>.189*</td>
</tr>
<tr>
<td>Version B</td>
<td>.983</td>
<td>143</td>
<td>.072*</td>
</tr>
</tbody>
</table>

*Note. *p < .001.*
Similarly, an analysis of the set of data of the CS instruments was conducted to verify the normal distribution of the data. For this analysis, the researcher used the average value (based on seven points) of the total scores for the three CS before the lab activity (CS Version A) and after the lab activity (CS Version B). Because the results from the CS#4.1 were based on a maximum of eight points, they were normalized to seven points to calculate the average values with the other CS values. In Table 5-5, the Shapiro-Wilk test for the CS Version A ($S-W = .981$, $df = 143$, $p = .048$) was nonnormally distributed. However, the researcher assumed the data to be normally distributed because the $p$ value was close to .05 and there was a relatively well-shaped normal distribution shown in Figure 5-2 (CS Version A). In Table 5-8, the Shapiro-Wilk test for the CS
Version B \((S-W = .949, df = 143, p = .000)\) also suggested nonnormality of the distribution. This is also shown in Figure 5-2 (CS Version B). Moreover, Figure 5-3 shows the Q-Q Plot for CS Version B with most of the points adhered closely to the diagonal line, suggesting that an assumption of normality did not appear to be violated. Therefore, it was concluded that a parametric analysis was sufficient for answering the research questions.

Table 5-8

*Test of Normality Shapiro-Wilk of the Data Collected for the Conceptual Survey (CS) Instruments*

<table>
<thead>
<tr>
<th>CS Instrument</th>
<th>Statistic</th>
<th>df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Version A</td>
<td>.981</td>
<td>143</td>
<td>.048*</td>
</tr>
<tr>
<td>Version B</td>
<td>.949</td>
<td>143</td>
<td>.000*</td>
</tr>
</tbody>
</table>

*Note. *\(p < .001\).*
Figure 5-2. Histograms of the Conceptual Survey (CS) data

Figure 5-3. Q-Q plot of the Conceptual Survey (CS) Version B
The CLQ used in this study implemented a Likert-scale. Norman (2010) suggested that Likert data can be analyzed using parametric tests without “fear of coming to the wrong conclusion” as contended by Jamieson (2004). Based on this argument, the researcher conducted a parametric analysis to answer the research question in relation to the data from the CLQ instrument.

Addressing Research Questions

Research question #1

The first research question of this study was, does students’ task interpretation change during the task completion process? To answer this research question, an analysis of the TAQ data collected before and after the task process was conducted. First, the results of the quizzes for every lab activity were obtained to calculate the average value for each activity. In addition, average scores were calculated to determine the levels of explicit and implicit aspects of task interpretation. This was followed by a descriptive statistical analysis to identify differences between the TAQ versions A and B. Then, a t-test analysis was conducted to determine significant differences between versions A and B. Finally, an analysis of the scores in percentage was conducted to identify any significance of the scores. Table 5-9 shows the average values and the standard deviation of the results of the TAQ versions A and B. The average value of the TAQ Version A, which was done before starting the lab activity, was 10.38 points (SD = 2.66); for Version B, which was done after the lab activity, the average value was 13.90 points (SD = 2.49).
Findings indicated that students had improved TAQ scores after the lab activity. Similar results were found for the TAQ explicit and implicit aspects of task interpretation in the test. But the most relevant improvement was in the TAQ explicit Version A ($SD = 1.79$), in which scores changed from an average of 6.34 points to an average of 9.14 points on the TAQ explicit Version B ($SD = 1.73$).

### Table 5-9

*Descriptive Statistics of Task Analyzer (TAQ) Scores*

<table>
<thead>
<tr>
<th>Instruments</th>
<th>$N$</th>
<th>$M$</th>
<th>$SD$</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAQ Version A</td>
<td>143</td>
<td>10.38$^a$</td>
<td>2.66</td>
</tr>
<tr>
<td>TAQ Version B</td>
<td>143</td>
<td>13.90$^a$</td>
<td>2.49</td>
</tr>
<tr>
<td>TAQ Explicit Version A</td>
<td>143</td>
<td>6.34$^b$</td>
<td>1.79</td>
</tr>
<tr>
<td>TAQ Explicit Version B</td>
<td>143</td>
<td>9.14$^b$</td>
<td>1.73</td>
</tr>
<tr>
<td>TAQ Implicit Version A</td>
<td>143</td>
<td>4.04$^c$</td>
<td>1.24</td>
</tr>
<tr>
<td>TAQ Implicit Version B</td>
<td>143</td>
<td>4.76$^c$</td>
<td>1.10</td>
</tr>
</tbody>
</table>

*Note.* $^a$ Maximum score is 24 points. $^b$ Maximum score is 15 points. $^c$ Maximum score is 9 points.

A paired-sample $t$ test was conducted at an alpha level of .05 to determine if there was a significant difference between the TAQ before and after the lab activity. Also, the paired-sample $t$ test was extended to separately analyze the explicit and implicit aspects of the TAQ before and after the lab activity. Table 5-10 shows the results of the $t$ test
revealing a statistically difference between the TAQ Version A ($M = 10.38$, $SD = 2.66$) and the TAQ Version B ($M = 13.90$, $SD = 2.49$), $t(142) = -18.091$, $p = .000$, alpha = .05.

Similar results were found in the TAQ explicit and implicit aspects: a statistically significant difference existed between the TAQ explicit Version A ($M = 6.34$, $SD = 1.79$) and the TAQ explicit Version B ($M = 9.14$, $SD = 1.73$) with $t(142) = -20.08$, $p = .000$, alpha = .05, and a statistically significant difference between TAQ implicit Version A ($M = 4.04$, $SD = 1.24$) and TAQ implicit Version B ($M = 4.76$, $SD = 1.10$) with $t(142) = -7.93$, $p = .000$, alpha = .05.

Table 5-10

Paired-Sample t Test for the Task Analyzer (TAQ) Scores

<table>
<thead>
<tr>
<th>Instruments</th>
<th>T</th>
<th>Df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAQ Version A – TAQ Version B</td>
<td>142</td>
<td>-18.91</td>
<td>.000*</td>
</tr>
<tr>
<td>TAQ Explicit Version A – TAQ Explicit Version B</td>
<td>142</td>
<td>-20.08</td>
<td>.000*</td>
</tr>
<tr>
<td>TAQ Implicit Version A – TAQ Implicit Version B</td>
<td>142</td>
<td>-7.93</td>
<td>.000*</td>
</tr>
</tbody>
</table>

*Note. *$p < .05$.

Average scores of the TAQ were calculated as percentages to identify how much the participants improved in interpreting the task during the lab activity. Table 5-11 shows the average scores of the TAQ Version A (43.2%), in comparison to after the
participants finished the lab activity, in which the score of the TAQ Version B improved to 57.9%. The improvement of the TAQ explicit (18.6%) was more than twice that of the TAQ implicit (8.0%).

Table 5-11

*Average Values of the Task Analyzer (TAQ) Scores Based on 100%*

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Average scores</th>
<th>Improvement (Version B – Version A)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Version A</td>
<td>Version B</td>
</tr>
<tr>
<td>TAQ</td>
<td>43.2%</td>
<td>57.9%</td>
</tr>
<tr>
<td>TAQ Explicit</td>
<td>42.3%</td>
<td>60.9%</td>
</tr>
<tr>
<td>TAQ Implicit</td>
<td>44.9%</td>
<td>52.9%</td>
</tr>
</tbody>
</table>

**Research question #2**

The second research question of this study was *how is students’ task interpretation different between high- and low-coregulated students?* To answer this question, a statistical analysis of the student’s coregulation data (CLQ) was conducted to classify the groups of high- and low-coregulated students, and then identify any significance of these groups with the data of the students’ task interpretation (TAQ Version B). First, a descriptive statistical analysis was conducted with the test results of the CLQ. Data collected in the three laboratories were averaged to obtain a single value.
for the analysis. Table 5-12 shows the average and standard deviations values of CLQ for participants. For all the items, the closer the value was to 1, the better the coregulation of participants.

Table 5-12

Descriptive Statistics of the Coregulated (CLQ) Scores

<table>
<thead>
<tr>
<th>Item</th>
<th>Question</th>
<th>N</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>We looked each other’s work.</td>
<td>143</td>
<td>1.55</td>
<td>0.50</td>
</tr>
<tr>
<td>2</td>
<td>We checked each other’s work.</td>
<td>143</td>
<td>1.59</td>
<td>0.55</td>
</tr>
<tr>
<td>3</td>
<td>We made sure everybody understood.</td>
<td>143</td>
<td>1.61</td>
<td>0.57</td>
</tr>
<tr>
<td>4</td>
<td>We double-checked each other’s work.</td>
<td>143</td>
<td>1.65</td>
<td>0.57</td>
</tr>
<tr>
<td>5</td>
<td>When one became distracted, we refocused.</td>
<td>143</td>
<td>1.40</td>
<td>0.47</td>
</tr>
<tr>
<td>6</td>
<td>We worked hard.</td>
<td>143</td>
<td>1.28</td>
<td>0.39</td>
</tr>
<tr>
<td>7</td>
<td>We discussed our plans.</td>
<td>143</td>
<td>1.96</td>
<td>0.75</td>
</tr>
<tr>
<td>8</td>
<td>We paid attention to each other’s work.</td>
<td>143</td>
<td>1.62</td>
<td>0.60</td>
</tr>
<tr>
<td>9</td>
<td>I knew my group was working.</td>
<td>143</td>
<td>1.34</td>
<td>0.42</td>
</tr>
<tr>
<td>10</td>
<td>We managed our time efficiently.</td>
<td>143</td>
<td>1.47</td>
<td>0.61</td>
</tr>
<tr>
<td>11</td>
<td>Others knew what I was working on.</td>
<td>143</td>
<td>1.47</td>
<td>0.51</td>
</tr>
<tr>
<td>12</td>
<td>We did other things not related to lab.</td>
<td>143</td>
<td>1.42</td>
<td>0.47</td>
</tr>
<tr>
<td>13</td>
<td>We were distracted.</td>
<td>143</td>
<td>1.27</td>
<td>0.47</td>
</tr>
<tr>
<td>14</td>
<td>We did not plan, we just started working.</td>
<td>143</td>
<td>1.43</td>
<td>0.78</td>
</tr>
</tbody>
</table>

Note. Four points Likert-scale, (1) = All of the time, (2) = Most of the time, (3) = Sometimes, (4) = Never.

* Negative-worded items were reverse coded with the formula \[5 - \text{score}\].
Second, the researcher identified groups with high and low levels of coregulation after the lab activity, with scores below quartile 1, considered as high-coregulated, and above quartile 3, considered as low-coregulated. This was possible because the data of the CLQ was considered normal distributed. Table 5-13 shows the two groups of participants with high- and low-coregulation: 34 participants were located below quartile 1 with an average score of 1.19, and 36 participants were located above quartile 3 with an average score of 2.03.

<table>
<thead>
<tr>
<th>Participants</th>
<th>average score</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>High CLQ</td>
<td>1.19&lt;sup&gt;a&lt;/sup&gt;</td>
<td>34</td>
</tr>
<tr>
<td>Low CLQ</td>
<td>2.03&lt;sup&gt;a&lt;/sup&gt;</td>
<td>36</td>
</tr>
</tbody>
</table>

<sup>Note</sup>. <sup>a</sup>Scores based on a 4-point Liker scale (1) = All of the time, (2) = Most of the time, (3) = Sometimes, (4) = Never.

Finally, the researcher conducted a *t* test analysis to identify any statistical difference between the scores of the TAQ for high- and low-coregulated participants. Table 5-14 shows the results of an independent-sample *t* test indicating that scores were significantly different for the TAQ of high-CLQ-scoring participants (*M* = 14.46, *SD* =
1.79) as compared to the TAQ scores of low-scoring CLQ participants \((M = 13.09, SD = 2.44)\), \(t(68) = 2.66, p = .01\). In general, high-coregulated participants showed a better level of task interpretation than did low-coregulated participants.

Table 5-14

*Independent-Sample t Test of Task Analyzer (TAQ) Scores for High- and Low-Coregulated (CLQ) Participants*

<table>
<thead>
<tr>
<th>Participants</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAQ for High CLQ</td>
<td>34</td>
<td>14.46a</td>
<td>1.79</td>
<td>2.66</td>
<td>68</td>
<td>.01*</td>
</tr>
<tr>
<td>TAQ for Low CLQ</td>
<td>36</td>
<td>13.09a</td>
<td>2.44</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* a Maximum score is 24 points. *p < .05

Research question #3

The third research question of this study was *how is students’ task interpretation related to conceptual understanding?* To answer this question, first, a parametric statistical analysis was employed to compare the means between the CS versions A and B. Second, a Pearson correlation analysis was conducted to find the correlation between TAQ and CS scores before and after the lab activity. Third, an analysis of the scores was conducted to identify levels of statistical significance of the CS scores that ranged from 0 to 100%.
The CS scores for each lab were measured and calculated to determine their average value before (Version A) and after (Version B) the participants completed the lab activity. Because the CS#4.1 scores contained a different number of items, they were normalized to the scores of the other labs. Table 5-15 shows the average values and the standard deviation for results of the CS versions A and B. The average value of the CS Version A was 3.57 points; CS Version B was 4.86 points. Findings indicated that students’ CS scores increased.

Table 5-15
Descriptive Statistics of the Conceptual Survey (CS) Scores

<table>
<thead>
<tr>
<th>Instruments</th>
<th>N</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS Version A</td>
<td>143</td>
<td>3.57a</td>
<td>1.08</td>
</tr>
<tr>
<td>CS Version B</td>
<td>143</td>
<td>4.86a</td>
<td>1.08</td>
</tr>
</tbody>
</table>

*Note. aMaximum score is 7 points.*

A Pearson correlation was conducted to identify correlations between the scores of TAQ Version A and CS Version A, and TAQ Version B and CS Version B. Table 5-16 indicates a positive correlation between the scores of TAQ Version A and CS Version A, \( r(143) = .370, p < .01 \), and the scores of TAQ Version B and CS Version B, \( r(143) = .298, p < .01 \). The TAQ scores were split into explicit and implicit aspects to calculate the
Pearson correlation between the TAQ and CS scores. Table 5-16 also shows the Pearson correlations for the explicit and implicit aspects of the TAQ and CS scores before and after the lab activity, with positive correlations ranging from .210 to .390.

Table 5-16

*Correlations between Task Analyzer (TAQ) and Conceptual Survey (CS) Scores*

<table>
<thead>
<tr>
<th>Instruments</th>
<th>N</th>
<th>Pearson Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAQ Version A - CS Version A</td>
<td>143</td>
<td>.370**</td>
</tr>
<tr>
<td>TAQ Version B - CS Version B</td>
<td>143</td>
<td>.298**</td>
</tr>
<tr>
<td>TAQ Explicit Version A – CS Version A</td>
<td>143</td>
<td>.390**</td>
</tr>
<tr>
<td>TAQ Implicit Version A – CS Version A</td>
<td>143</td>
<td>.229**</td>
</tr>
<tr>
<td>TAQ Explicit Version B – CS Version B</td>
<td>143</td>
<td>.295**</td>
</tr>
<tr>
<td>TAQ Implicit Version B – CS Version B</td>
<td>143</td>
<td>.210*</td>
</tr>
</tbody>
</table>

*Note. * Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).*

Moreover, the researcher looked at the Pearson correlation for topics related to every item on the TAQ instrument and the CS scores after the lab activity. Table 5-17 shows the values of Pearson correlation between the explicit and implicit aspects of the TAQ and the CS scores: the questions related to formulas, lab materials needed, main purpose, and concepts – all indicated similar values of correlations as those in Table 5-16.
The questions related to objectives and resources needed to complete the lab activity were not correlated with the CS scores.

Table 5-9
_Correlations between the Topics of the Task Analyzer (TAQ) and Conceptual Survey (CS) Scores_

<table>
<thead>
<tr>
<th>Instruments</th>
<th>Item</th>
<th>Topic</th>
<th>N</th>
<th>Pearson Correlation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CS Version A</td>
<td>CS Version B</td>
</tr>
<tr>
<td>TAQ Explicit</td>
<td>1</td>
<td>Objectives</td>
<td>143</td>
<td>.087</td>
<td>.002</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Formulas</td>
<td>143</td>
<td>.290**</td>
<td>.183*</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Materials</td>
<td>143</td>
<td>.262**</td>
<td>.286**</td>
</tr>
<tr>
<td></td>
<td>4,5</td>
<td>Steps</td>
<td>143</td>
<td>.388**</td>
<td>.281**</td>
</tr>
<tr>
<td>TAQ Implicit</td>
<td>6</td>
<td>Main purpose</td>
<td>143</td>
<td>.264**</td>
<td>.209**</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Concepts</td>
<td>143</td>
<td>.221**</td>
<td>.237**</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Resources</td>
<td>143</td>
<td>.015</td>
<td>.016</td>
</tr>
</tbody>
</table>

*Note.* *Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

Finally, Table 5-18 shows the scores of the CS instrument based on a range from 0% to 100%. Interestingly, before starting the lab activity, the participants scored an average of 51.00%; after the lab activity, their score improved to 69.40%.
Table 5-18

*Averages Values of the Conceptual Survey (CS) Scores Based on 100%*

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Average scores</th>
<th>Increase (Version B – Version A)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Version A</td>
<td>Version B</td>
</tr>
<tr>
<td>CS</td>
<td>51.00%</td>
<td>69.40%</td>
</tr>
</tbody>
</table>
CHAPTER VI

CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

This chapter is divided into two sections. The first section discusses the findings of the study that were presented in the previous chapter and provides conclusions for each of the research questions. The second section provides implications of the findings and recommendations for future study.

Conclusions

Research question #1: Does students’ task interpretation change during the task completion process?

The descriptive statistics analysis showed differences between test scores before and after the laboratory activity. Students achieved higher average scores after the completion of the laboratory activity. Moreover, the analysis of the $t$ test revealed a significant difference between the students’ task interpretation before and after the laboratory activity. Thus, the students’ interpretation of the task assigned during lab work changed after the completion of the activity. That is, students had a better understanding of the requirements once they completed the assigned task. Some studies (Hadwin et al., 2009; Helm, 2011; Miller, 2009) measured students’ task interpretation before, during, and after the assigned tasks. In a study by Hadwin, Oshige, Miller, & Wild (2009), the
students’ task interpretation measured midway in the process was higher than at the beginning. However, after the assigned tasks were completed, the scores of students’ task interpretation decreased. Hadwin (2009) mentioned that students likely forgot some keywords needed to score better at the end of the project, and that the findings merited further research. In the same study, the researcher found that students’ task interpretation improved during the activities, but still showed a low level of understanding of the assigned tasks.

When the analyses of the findings were expressed as percentage from 0 to 100%, the students’ task interpretation improved by 18%, but the average scores after the laboratory activity were 57.9%. Similar to the study of Miller (2009), in which average scores of students’ task interpretation were below 60%, these scores did not evidence high levels of task interpretation by the students. These findings confirmed previous studies conducted by Hadwin et al. (2009), Helm (2011), Miller (2009), and Oshige (2009) which stated that students generally have an incomplete understanding of the assigned tasks.

When the students’ task interpretation was divided into explicit and implicit aspects, the values of the explicit aspect were similar to those of task interpretation, varying from 42.3% to 60.9%. But a remarkable finding was found in the implicit aspect, which increased from 44.9% to 52.9%, an improvement of only 8%, confirming the findings of a previous study by Oshige (2009) and Helm (2011) indicating that students listed the implicit task as challenging because they experienced difficulty trying to extrapolate the assigned tasks.
To conclude, the findings of this research question were consistent with previous findings of task interpretation discussed in the review of literature. The change in the students’ task interpretation before and after completing the assigned tasks was significant. The low level of students’ task interpretation after the laboratory activities could be interpreted as evidence of students’ inaccurate or incomplete understanding of the assigned tasks during laboratory work.

Research question #2: How is students’ task interpretation different between high- and low-coregulated students?

The descriptive statistical analysis showed in general that students were aware of their engagement working in the assigned task during laboratory work. Moreover, students with a high level of coregulation reached higher levels of task interpretation; similarly, students with a low level of coregulation reached lower levels of task interpretation. A $t$ test analysis revealed a statistical difference in coregulation for students with a high level of task interpretation compared to those with a low level. Therefore, students’ task interpretation of the assigned task during laboratory work differs between high- and low-coregulated students. That is, students that are more responsive to their own and team members’ engagement in the assigned task had a better understanding of what they had to do in the laboratory.

The findings confirmed a previous study by Hadwin and Oshige (2011), which described CRL as a process in a learner’s acquisition of SRL, in which SRL is gradually appropriated by the individual learner’s interactions during the assigned task activities. In
this study, SRL is represented by task interpretation defined as a critical feature and the heart in the SRL process (Butler & Cartier, 2004; Butler & Winnie, 1995).

To conclude, during collaborative learning, the regulation of activities can take place at individual or group levels of social interactions. This study measured CRL at the individual level when students were in the process of completing an assigned task during laboratory work. According to the findings, students with a higher level of coregulation showed higher levels of task interpretation. The findings suggested that students with high levels of CRL were more engaged during laboratory activities, and were guided, supported, shaped, and constrained by the activities of the other group members. These findings merit additional investigation of behaviors at the group level from which researchers could make further inferences related to CRL.

**Research question #3: How is students’ task interpretation related to conceptual understanding?**

The Pearson correlation tests revealed that a significant positive relationship existed between students’ task interpretation and conceptual understanding. Several studies have associated students’ task interpretation with task performance. (Miller, 2009) found that students’ task interpretation significantly predicted task performance. Hadwin et al. (2009) stated that students who better communicated with the professor regarding task perceptions tended to perform better in the course. Studies by Helm (2011) indicated that students’ task interpretation was related to successful learning. Also, Venkatesh and Shaikh (2011) found a positive relationship between students’ task interpretation and
learning outcomes. Shulman and Tamir (1973) maintained that laboratory activities develop creative thinking and conceptual understanding. Kolloffel and de Jong (2013) stated that a better conceptual understanding of the problem in a lab will increase the likelihood that the learners will select the appropriate procedure to solve the problem and succeed during lab activities. Based on the above-referenced findings and the fact that students’ task interpretation and conceptual understanding have never before been related in the context of laboratory work, the researcher anticipated a positive relationship between the issues of task interpretation and conceptual understanding, and that is what the Pearson correlation tests revealed in this study. Similarly, the researcher also anticipated a strong value of correlation between task interpretation and conceptual understanding. As a consequence, the researcher analyzed the strengths of the relationship with the values of correlation. Although there are no hard-and-fast rules for describing the strength of the correlation, the researcher considered the descriptive guidelines of Cohen (1988) indicating correlations above .5 to be large/strong, correlations between .3 and .5 as medium/moderate, and those below .3 as small. The researcher considered the Pearson correlation scores of participants from medium to small. That is, when students had an understanding of what they were to do in the laboratory, they showed a comprehension of concepts, purpose, and relationships involved in the laboratory activities. Furthermore, the researcher decomposed the task interpretation in the explicit and implicit aspects to determine the correlation with conceptual understanding, but no relevant differences were found in the strength of the correlation of conceptual understanding considering the explicit and implicit aspects of
the students’ task interpretation. However, when the explicit and implicit aspects were divided into specific topics, interesting results were found to explain the strength of the correlations. The explicit aspect measured the understanding of the objectives, formulas, materials, and steps to follow during the lab activity. All of them were related to conceptual understanding except the objectives. The implicit aspect measured the main purpose, concepts involved in the laboratory activity, and the resources needed to complete the laboratory activity. The main purpose and concepts were correlated with conceptual understanding but not the resources needed to complete the laboratory activity. The researcher inferred that one reason for the medium to small correlation was the inclusion of the topics that were not correlated with conceptual understanding, such as objectives and resources in the analysis of the correlation. A second reason for the medium to small correlation might be related to another factors involved in the development of the laboratory activity, such as the involvement of procedural knowledge and the ability to complete the laboratory activity.

Finally, an additional analysis identified that students improved in the conceptual quiz by an average score of 18.4%. Although the improvement is statistically significant, the average final score of the students was 69.4%. In their study, Davidowitz & Rollnick (2003) stated that students were aware of the importance to link theory and practice during a laboratory activity, but its comprehension did not necessarily indicate adoption. Perhaps this is the reason why students did not go beyond 90 or 100% of average in the conceptual quiz and confirmed previous research which found that students struggle to
establish a connection between laboratory activities and the material covered in the classroom (Davidowitz & Rollnick, 2003; Domin, 1999; White, 1996).

To conclude, the findings of this study suggested that there is a relationship between students’ task interpretation and conceptual understanding which has not been reported in the most recent published reports. The low level of students’ conceptual understanding after the lab activities could be interpreted as evidence that students do not fully engage mentally during laboratory activities. Students simply follow directions without thinking of how the experiment relates to other information they have learned. That is, students do not reflect on the value of their observations during laboratory work.

**Implications and Recommendations for Future Studies**

Results support the model of Hadwin (2006) which measured the explicit and implicit aspects of students’ task interpretation. The findings of this study are also consistent with the model of SRL by Butler and Cartier (2004) which described task interpretation as the first step and a key determinant in the SRL process. Because the context of the studies of task interpretation described in the review of literature was in engineering design, the findings of this study revealed that those theoretical models can be translated in the context of a laboratory where students conduct hands-on activities. Therefore, the results can serve as preliminary information for future studies relating aspects of the SRL process in the context of laboratory activities.

This study contributes to research by directly investigating the relationship
between task interpretation and conceptual understanding in the context of laboratory work. While research indicates that task interpretation and conceptual understanding are key aspects of academic performance, no recent research has investigated the relationship between the two constructs in laboratory activities. Thus, this study relates the research of the SRL process in the context of laboratory activities. It adds to the emergent literature by investigating empirically the understanding of the explicit and implicit aspects of the students’ task interpretation within a framework of SRL in the context of laboratory activities.

The research methods used in the study apply a new approach for measuring task interpretation in laboratory activities. Specifically, the study of task interpretation extends previous research by employing open-ended question tests as external devices to elicit responses from participants on questions related to an assigned task during laboratory work. Thus, a more varied list of resources is made available to investigators to study how to best measure task interpretation.

Students evidenced an inaccurate or incomplete understanding of the assigned tasks during laboratory work. Students’ task interpretation should be aligned with the instructors’ perception of the tasks described in the procedures of lab experiments. Therefore, facilitators need periodically to review the experiments of laboratory to identify if students are correctly interpreting the task described in the lab guides.

Implicit aspect of task interpretation is challenging for students because the difficulty trying to extrapolate the assigned tasks. Facilitators must encourage students to put forth more effort in interpreting the implicit aspects of the task by identifying key
concepts, formulas, purpose of the laboratory activity, and understanding of the procedures regardless of the student’s ability to perform the assigned task.

Facilitators are perhaps familiar working with instructional methods emphasizing in team-work, which requires substantial time, effort, and resources. But facilitators can add an additional strategy developing a regulatory approach and employing collaborative learning with the students helping them to recognize, refine, and monitor their strategies in laboratory activities.

The implicit aspect of task interpretation is a strong predictor of academic success (Oshige, 2009). Further investigation is required to examine the influence of the implicit aspect of task interpretation in order to understand its role during laboratory activities.

Measuring coregulation during laboratory work may be challenging for research because it consists of observing, capturing, and summarizing individual and group behaviors. However, further investigation is required to measure coregulation in real time (videotaping) during laboratory work in order to make inferences related to SRL process when students are working on assigned tasks in a laboratory. Also, further investigation is required to measure coregulation during a period of time where students have to work together in lab activities (i.e. regular semester of classes). By increasing the interactions of the students during the time spending together might be a potential in working more collaboratively developing new strategies or modifying existing strategies as they use to work with their peers.

Future research is needed to examine the influence of the socio-contextual aspect of task interpretation in the task process, coregulation and conceptual understanding. The
socio-contextual is related to beliefs about learning, ability and the expectations of the students. Perhaps, the influence of this aspect might conduct to infer in another factors involving in the understanding of the assigned task in laboratory work.

The instrument to measure the conceptual understanding (conceptual survey) might be improved including multiple choice questions to add more consistency to the survey with a better level of reliability (Grosse & Wright, 1985). Even better, and it there is no time constrain, the changing of True-False to a multiple choice might be considered to measure the students’ conceptual understanding.

Future research is essential to examine the relationships between task interpretation and conceptual understanding in laboratory work in order to explore other factors that might influence the engagement of the students in the assigned tasks.
REFERENCES


the annual conference of the Canadian Society for the Study of Education, Saskatoon, Saskatchewan, Canada.


Proceedings of the 7th annual meeting of the South African Association of Research for Mathematics and Science Education, Grahamstown, South Africa: Rhodes University.


APPENDICES
Appendix A. Informed Consent Form
INFORMED CONSENT

Students’ Task Interpretation and Conceptual Understanding in Electronics Laboratory Work

Purpose Dr. Oemardi Lawanto and a student researcher, Presentacion Rivera-Reyes, in the Department of Engineering Education at Utah State University are conducting a research study to describe the how students interpret the assigned task during laboratory activities and it’s relation with conceptual understanding. Also, this study is trying to describe the process of collaboration at metacognitive level during laboratory activities. We are asking students enrolled ENGR 2210 – Fundamental Electronics for Engineering, Fall 2014 to provide consent for us to analyze data from questionnaires and surveys. There will be approximately 100 total participants in this research.

Procedures If you provide consent, you will complete a questionnaire for three specific lab activities in three selected sessions. For every lab activity, you will be asked to complete the following procedure:

1. Complete Conceptual Survey Version A.
2. Read the lab activity.
3. Complete Task Analyzer Questionnaire Version A.
4. Complete the lab activity.
5. Complete Task Analyzer Questionnaire Version B.
6. Complete Conceptual Survey Version B.
7. Complete Co-regulated Learning Questionnaire.

We expect it will take you approximately 30 minutes to complete this activity (10 minutes responding every Task Analyzer, 4 minutes responding every Conceptual Survey, and 2 minutes responding the Co-regulated learning questionnaire). Data analysis will not begin until after final grades for the semester have been assigned. If you do not provide consent, you will still be required to complete the lab activity, as part of the laboratory session that you have registered for the semester.

Risks There is a small risk that the information on homework, exams, or other course materials could be accidentally disclosed. Several measures will be used to minimize this risk; see “Confidentiality” below.

Benefits Consent to have your data included in this study may not lead to any direct immediate benefits. However, the results may provide evidence and important information regarding the nature of effective instruction in laboratory work. This study may fill an important gap in many literature bases related to task interpretation during laboratory activities. Thus, the implications might generalize to laboratory instructional practice as well as other instruction such as employee training.
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Explanation & offer to answer questions: Dr. Oenardi Lawanto or Presentacion Rivera-Reyes has explained this research study to you and answered your questions. If you have other questions or research-related problems, you may reach Dr. Oenardi Lawanto at (435) 797-8699 or by e-mail at olawanto@usu.edu and Presentacion Rivera-Reyes at (435) 881-0801 or by email at p.rivera@usu.edu.

Compensation: You will receive 8 extra credit points of the total points of examination (exams), and 8 extra credit points of the total points of laboratory. If you choose not to participate in this research project, other opportunities to earn equivalent extra credit points will be offered.

Voluntary nature of participation and right to withdraw without consequence: Participation in this research is entirely voluntary. You may withdraw your consent at any time without consequence. If you choose to do so, your data will still be protected according to federal, state, and university guidelines, but will not be copied or included with other data as part of this research study.

Confidentiality: Research records will be kept confidential, consistent with federal and state regulations. Only the investigator and research staff listed on the bottom of this form will have access to the data which will be kept in a locked file cabinet in a locked room to maintain confidentiality. Before records are used for research, they will be irreversibly anonymized—all personally identifiable information will be removed and replaced with an anonymous identifier. Records linking your name to your data will be destroyed as soon as data collection is complete. All consent forms will be stored separately from the data in a locked drawer in a locked office for three years following completion of the study. Electronic information will be kept in password protected computer files. All printed documents for this survey will be shredded to avoid disclosure of information. All data will be coded to remove any identifying information from the participants.

IRB Approval Statement: The Institutional Review Board for the protection of human participants at USU has approved this research study. If you have any pertinent questions or concerns about your rights or a research-related injury, you may contact the IRB Administrator at (435) 797-0567 or email irb@usu.edu. If you have a concern or complaint about the research and you would like to contact someone other than the research team, you may contact the IRB Administrator to obtain information or to offer input.

Copy of consent: You have been given two copies of this Informed Consent. Please sign both copies and retain one copy for your files.
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Investigator Statement “I certify that the research study has been explained to the individual, by me or my research staff, and that the individual understands the nature and purpose, the possible risks and benefits associated with taking part in this research study. Any questions that have been raised have been answered.”

Dr. Oenardi Lawanto
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olawanto@usu.edu

Presentacion Rivera-Reyes
Student Researcher
(435) 881-0801
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Signature of Participant By signing below, I agree to participate.

Participant's signature _______________________________ Date _______________________________
Appendix B. Lab Activity #3.1
Lab Activity #3.1

ENGR 2210 – Lab Session #3

Application of Network Theorems

Name:

A number:

Lab section:

Objectives

Terminal Objective: Verify Network Theorems

Performance Objective: Given necessary equipment, verify network theorems in electric circuits to satisfy criteria

Enabling Objectives:
1. Identify Thevenin equivalent voltage.
2. Identify Thevenin equivalent resistance.
3. Identify the maximum power transfer.
4. Demonstrate Superposition theorem.
5. Use a Wheatstone Bridge to measure an unknown resistance.

Laboratory Hardware:
1. Protoboard
2. DC power supply
3. DMM
4. Appropriate connecting leads
5. Resistors (100 Ω, 220 Ω, 330 Ω, 460 Ω, 560 Ω, 680 Ω, 1KΩ, 1.1KΩ, 2.2KΩ, 3.3KΩ)
6. Unmarked fixed resistor in the range of 47Ω to 220Ω
7. Potentiometer Trimmer 1KΩ, 5KΩ, 10KΩ.
8. Trimmer adjustment tool

Learning Activities:
1. Read Summary: Network Theorems
2. Complete lab activity 3.1 Measuring Thevenin Equivalent Circuit
3. Complete lab activity 3.2 Measuring Voltage using Superposition Theorem
4. Complete lab activity 3.3 *Wheatstone Bridge measurements*

**Summative Evaluation:**
The following activities will be used to assess the students’ ability to perform the lab objectives:
1. Lab activity 3.1 *Measuring Thevenin Equivalent Circuit*
2. Lab activity 3.2 *Measuring Voltage using Superposition Theorem*
3. Lab activity 3.3 *Wheatstone Bridge measurements*

**Lab activity 3.1 Measuring Thevenin Equivalent Circuit**

Procedure:
1. Construct the circuit shown in Figure 5.

![Figure 5](image)

2. Accurately measure the voltage $V_L$ across the load resistance $R_L$ with the DMM. (1 point)

$$V_L(1\,\text{k}\Omega)$$

3. Find $E_{TH}$: remove the load resistance $R_L$ and measure the open circuit voltage between the terminals “a” and “b.” This is equal to $E_{TH}$. (2 points)

$$E_{TH} =$$

4. Find $R_{TH}$: turn off the source voltage (10V), remove the cables of the source voltage, and replace it with a short circuit. Remove the resistance $R_L$ and measure the resistance between the terminals “a” and “b.” This is equal to $R_{TH}$. (2 points)

$$R_{TH} =$$
5. Using a potentiometer (variable resistor), set the potentiometer to $R_{TH}$ measured in #4: connect the terminal strips of the DMM in position 2 and 3 of the potentiometer, rotate the screw of the potentiometer with an adjustment tool, and measuring accurately the value of $R_{TH}$. See Figure 6.

6. Construct the Thevenin Equivalent Circuit with $E_{TH}$ and $R_{TH}$ measured in #3 and #5. See Figure 7.

7. Accurately measure the voltage $V_L$ across the load resistance $R_L$ with the DMM. Compare it to the $V_L (1 \Omega)$ obtained in #2. Explain. (2 points)

$$V_L (1 \Omega) = \text{(Value measured with Thevenin Circuit Equivalent)}$$
8. Using the Voltage Divider Rule for circuit of Figure 11, calculate \( V_L \) for \( R_L = 1\,\text{K}\Omega \). Compare it to the measured values. Explain any differences. (2 points)

*Maximum Power Transfer (Validating the condition \( R_L = R_{TH} \))*

9. Construct a Thevenin Equivalent Circuit as shown in Figure 8.

![Figure 8](image)

10. For each value of \( R_L \) given in the table below, measure \( V_L \), and record in the spaces provided in Table 1. Calculate the corresponding value of power \( P_L \) dissipated in \( R_L \), and record. (5 points)

11. Plot the power delivered \( P_L \) to the resistance \( R_L \) as a function of \( R_L \) collected in Table 1. (5 points)
12. From the plot, determine the value of resistance which corresponds to maximum power transfer, and compare this with the theoretical value. (2 points)

\[ R_L = \text{__________________________} \]

13. Compare the value of maximum power transferred to the load resistor with the theoretical value of Figure 8. Explain any difference. (2 points)
CURRICULUM VITAE

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EDUCATION

2010-2015 PhD in Engineering Education
Utah State University, Logan, UT, USA.
Dissertation:
“Task Interpretation and Conceptual Understanding in Electronics Laboratory Work”
Advisor: Dr. Oenardi Lawanto

1994-1996 Master in Business Administration
National University of Honduras, Honduras.

1988-1993 BS in Electrical Engineering
National University of Honduras, Honduras.

SUMMARY OF TEACHING QUALIFICATIONS

- Evidence-based teaching and tutoring
- Motivating students through one-to-one mentoring
- Laboratory instruction
- Curriculum design and innovation
- Classroom management
- Multicultural oriented instruction
- Problem-based learning

RESEARCH INTEREST / TECHNIQUES

- Troubleshooting problem-based learning using metacognition and self-regulated learning
- Metacognition
- Self, Collaborative, and Shared Regulated Learning
- Operate telecommunication measure and diagnostic instruments such as multimeter, oscilloscope, spectrum analyzer, Bit-Error Rate analyzer, and fiber optic splicer
- Talk-Aloud, MSLQ (English and Spanish)
- Use of enhanced guided notes
SUMMARY OF INDUSTRIAL / PROFESSIONAL QUALIFICATIONS

- Management
- Teamwork
- Ability to work in interdisciplinary teams
- Expertise developing telecommunication projects
- Project Coordination
- Design
- Planning
- Evaluation
- Troubleshooting
- Solid ethic values
- Multicultural oriented

TEACHING EXPERIENCE

2012-Present  Teaching Assistant, Utah State University, Logan, Utah, USA.

Teaching Assistant for ENGR-2210, Fundamental Electronics for Engineers in the Department of Engineering Education, College of Engineering. This course is offered during spring, summer, and fall sessions with an approximate enrollment of 90, 20, and 160 students respectively. Duties and responsibilities include:
- Co-developed and modified curriculum content in course.
- Management of Canvas Learning Page for course.
- ABET accreditation portfolio, assembly and assessment.
- Led innovative software and real-life experiments for practical applications of electronic concepts.
- Proctored exams, graded, tutored students, led help sessions, led lab sessions, and updated canvas platform of the course.

2007-2009  Lecturer/Instructor, Technological University of Honduras, Honduras.

Lecturer for TEL 301, Transmission System I to 15 senior students from rural and urban areas of the telecommunication engineering major in the Department of Mechatronic, College of Engineering. Duties and responsibilities include:
- Design and teach TEL 301, an introduction to systems of high data transmission through microwave and fiber optics, point-to-point and point-to-multipoint systems, techniques of multiplex, and techniques to design paths in microwave links.
- Supervised students during their off-campus internship experiences which were tied in with the course.

Lab instructor of Physics in the Department of Physics of the Faculty of General Studies. Duties and responsibilities:
- Teaching lab sessions for Physics I to 150 freshman students of different engineering majors.
- Teaching lab session for Physics II to 90 sophomore students of different engineering majors.
- Teaching lab sessions for Medical Physics I to 120 students of different science majors.

WORK EXPERIENCE


Responsible for the design of the transmission backbone of the entire network, including:
- Managing the rollout stage of coordinating the installation of microwave links for 1,200 cell base stations in 9 months.
- Evaluating new proposal of expansion of the transmission network. The transmission backbone was built of approximately 850 links with capacity from 10 to 9,600 megabits per second.
- Coordinating the design of microwave links and fiber optic rings in accordance to the policies of service level of the company.

1999-2008  Access System Manager, Columbus Networks -Telecom Carrier, Honduras.

Responsible for the design, installation, operation, and maintenance of wireless systems in the frequencies of 3 and 10 Gigahertz, including:
- Coordinating the installation, commissioning, and put in service of Local Multipoint Distribution Service System (LMDS), a broadband wireless access system.
- Coordinating the installation, operation, and later maintenance of the microwave links and fiber optic rings of medium and high capacity of the network (8 to 9,600 megabits per second).
- Coordinating the maintenance of ancillary equipment for 45 sites for telecommunications: air conditioner, power, and grounding equipment.
Planning & Cell Field Engineer, Millicom International Cellular - Wireless Provider, Honduras.

Responsible for installation, commissioning, and put in service analog cellular systems and medium capacity microwave links, including:

- Installing DC power, batteries, and grounding systems.
- Installing radio base stations for cellular network coverage.
- Installing microwave links up to 34 Megabits per second of capacity.
- Designing new sites for analog cellular coverage.
- Compiling and analyzing traffic information to design growth plans for trunk interconnections with PSTN.
- Designing microwave network to support cellular network.
- Elaborating technical specifications for the Government's telecommunications institution.
- Collaborating in maintenance and planning budgets.
- Supporting installation department with "put in service" radio base stations and microwave links.
- Supporting Operation & Maintenance department with preventive and corrective maintenance on radio base stations and microwave links.
- Evaluating performance, managing, and effectively training technicians in microwave systems.

PUBLICATIONS


PROFESSIONAL CERTIFICATIONS AND COURSES

- Residential and Industrial Electrical Installations (50 hours)
  
  *Educational Institute S. de R.L., Tegucigalpa, Honduras, Jan-May, 1991.*

- Basic Transmission Technologies for Telecommunication Engineers (5 weeks)
  
  *Central American Institute of Telecommunications, Tegucigalpa, Honduras, Sep 1993.*

- Fiber Optic theory course for Telecommunication Engineers (5 weeks)
  
  *Central American Institute of Telecommunications, Tegucigalpa, Honduras, Aug 1994.*

- Operation and Maintenance Digital Cross-Connector DACS-II (1 week)
  

- HD-II Cell Site, course of instruction, operation and maintenance for radio base station (1 week)
  
  *Motorola Cellular Infrastructure Group, Mundelein, IL, USA, June 1997.*

- Cell Site installation and grounding systems (1 week)
  
  *Motorola Cellular Infrastructure Group, Mundelein, IL, USA, July 1997.*

- Ericsson Microwave Minilink-E, course of installation, operation, and maintenance (1 week)
  
  *Ericsson Telecom of Mexico, Tegucigalpa, Honduras, Aug 1997.*

- Frequency Planning for cellular systems AMPS/NAMPS (2 days)
  
  *Motorola Cellular Infrastructure Group, Mundelein, IL, USA, July 1997.*

- WalkAir Wireless Local Loop, course of instruction, commission, and maintenance (7 days)
  
  *Siemens International Center, Lisbon, Portugal, Dec 1999.*

- Passport, ATM-Frame Relay switch, course of operation and maintenance (1 week)
  
  *Nortel Networks Educational Services, Milpitas, CA, USA, Jan 2000.*

- RAD equipment certification: Multiplex Access, Compressed Voice, and Last Mile (1 week)
  
  *RAD Data Communications, Panama, Panama, Aug 2000.*

- Certified Alvarion System Specialist –CASS- (2 weeks)
  
  *Alvarion Professional Educational Center, Miami, FL, USA, May 2002.*

- Certified Alvarion Network Administrator –CANA- (1 weeks)
  
  *Alvarion Professional Educational Center, Miami, FL, USA, July 2003.*

- USY-9600 Urban High Data Transmission Microwave, operation and maintenance (1 week)
  
  *Alcatel Industry of Telecommunications, Mexico D.F., Mexico, July 2003.*

- ADD-DROP SDH Multiplexer 1651/1661, operation and maintenance (1 week)
  
  *Alcatel Industry of Telecommunications, Mexico D.F., Mexico, July 2003.*

- ADD-DROP SDH Multiplexer NR2500, operation and maintenance (1 week)
UTStarcom Inc, Tegucigalpa, Honduras, June 2005.
- LSY-9600 Long Range High Data Transmission Microwave, operation and maintenance (1 week)

ADDITIONAL
- Proficient in Spanish and English (read/write/speak).
- Ample experience in managing interdisciplinary teams.
- Excellent classroom management and interpersonal skills.

LEADERSHIP AND SERVICE
- Graduate Student Teacher of the Year 2014 Award, Department of Engineering Education, College of Engineering, Utah State University.
- Member of the American Society of Engineering Education (ID#70934).
- President and founder member of the chapter USU of the American Society of Engineering Education, April 2014-present.
- Reviewer of conference papers for American Society of Engineering Education (ASEE) and Frontiers in Education (FIE), 2012-2014.
- Supervisor and counselor of senior students of Telecommunication Engineering during off-campus internships (400 hours of duration).
- Member of the Association of Mechanical, Electrical, and Chemistry Engineers of Honduras (C-680).

Updated on September 2015