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Understanding Student Coregulation in Task Interpretation during Electronics Laboratory Activities

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Abstract

Coregulation (CRL) is a transitional process in which students share problem-solving techniques and utilize self-regulated learning (SRL) when interacting with peers. Coregulation may help students to define and modify inconsistencies in their SRL strategy. Task interpretation is described as the critical first step in the SRL process, and it is a key determinant in setting the goals and strategies to accomplish those goals. Limited information exists regarding coregulation and task interpretation in the context of laboratory work. Laboratory activities help students to move from abstract ideas to a practical understanding. However, it is generally agreed among educators that students involve little mental engagement in the laboratory activities. The purpose of this study was to investigate how students' level of coregulation was associated with their task interpretation and how the level changed over time. One-hundred and forty-three sophomore students enrolled in an electronics course participated in this study. A paper-and-pencil questionnaire was used to measure students' coregulation. Similarly, a questionnaire developed and piloted by the researcher measured students' task interpretation. High-coregulated students showed high levels of SRL, while low-coregulated students showed low levels of SRL. The findings confirmed a previous study by Hadwin and Oshige, which described coregulation as a process in a learner's acquisition of SRL, in which SRL is gradually appropriated by the individual learner's interactions when they are working in the assigned task activities. Further investigation is necessary to unveil other factors related to these constructs in order to engage students in laboratory work.

Keywords: coregulation, laboratory activity, self-regulated learning, task interpretation

1. Introduction

The general purpose of this study was to provide new insight into how coregulation (CRL) is associated with Self-regulated Learning (SRL) in the context of laboratory work. Several researchers (e.g., Corno & Mandinach, 2004; Hadwin & Oshige, 2007; Jarvela & Jarvenoja, 2007; McCaslin & Hickey, 2001; Schunk, 2001) have considered the social processes involved in how learners acquire and use the SRL process by interacting with a group on a joint task. Interactions occur when learners *coregulate* their cognition, motivation, and behavior (Hadwin & Oshige, 2007). Coregulation occurs in a specific context when students acquire the SRL process by injecting their own ideas into the assigned tasks (DiDonato, 2013). Coregulated students may improve their SRL by understanding how to interpret laboratory-related tasks. Self-regulated learning (SRL) is defined as a form of interactive, goal-directed activity that involves interpreting tasks, setting goals, selecting, adapting or inventing strategies that are effective for achieving those goals, monitoring process, and adjusting approaches as needed (Lawanto, Goodridge, & Santoso, 2011; Zimmerman, 2006). 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 & Cartier, 2004). Task interpretation refers to students' construction of an internal representation of the externally assigned task (Hadwin, Oshige, Miller, & Wild, 2009). It is considered by Buttler and Cartier (2004) the heart of the SRL process because it is determinant of the goals and strategies that students bring in a specific context in the learning process. Coregulation and task interpretation have been under-researched, particularly in the context of complex and ill-structured tasks (Hadwin, 2006), and in engineering design and project management (Lawanto, Butler, Cartier, Santoso, & Goodridge, 2013). In the laboratory context, students must integrate their experiences with the concepts of the classroom, establish a context for the purpose of the laboratory activity, and determine the activity's relevance to them (Novak & Gowin, 1984). The similarity of skills required for successful engagement in complex and ill-structured task contexts, engineering design, project management, and laboratory activities suggests that a study in the laboratory context is an area of unique research.

1.1 Coregulation

Coregulation or coregulated learning (CRL) refers to a transitional process in a learner's acquisition of the self-regulated learning (SRL) process, within which learners and their peers share a common problem-solving plane, and SRL is progressively taken by the individual learner through interactions with others (Hadwin & Oshige, 2011). In the context of CRL, students bring their own ideas, concepts, and self-regulation skills to the group, all of which play an important role in the personal and team engagement in the activity (Chan, 2012). McCaslin (2009) emphasized that coregulation occurs through activity, engagement, and mutual relationships in which individuals share their expertise to novel learning. Some individuals are more capable or advanced students, with a higher awareness of the SRL process. They are also high-coregulated learners in which CRL may help them to identify, monitor, and change discrepancies in their own regulatory strategy, which they can use to advance their SRL process. For their low-coregulated peers, working with more regulated partners could help them to develop strategies for future use (DiDonato, 2013).

Grau and Whitebread (2012) agreed that in the context of coregulated learning, students bring their own ideas, concepts, and self-regulatory abilities to the group-work. All of these personal characteristics impact their engagement during the activities of the group. But when the group works effectively and productively cannot be predicted by the accumulation of their personal characteristics. Therefore, it is necessary to integrate the contributions of individual SRL for enriching the regulation of the group activity. Although collaboration in small groups is expected to enhance learning, just setting students together not necessarily result in collaboration and productive learning. For that reason, students need to know how to regulate their learning and collaboration (Chan, 2012; DiDonato, 2013; Jarvela & Hadwin, 2013). Coregulation may occurs in the context of laboratory work when students improve their understanding in interpreting laboratory-related tasks. But there is limited information about coregulation in the laboratory context.

1.2 Self-Regulated Learning and Task Interpretation

Self-regulated learning (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, 2006). In SRL, students must consider what they are being asked to do, activate concepts and perceptions resulting from previous learning experiences that are relevant to the assignment, and construct a personal plan to complete the assigned task (Hadwin et al., 2009; Lawanto, 2011). Task interpretation is the critical first step in the SRL process. 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 et al., 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 processes to assess and interpret task information provided by an instructor in a particular context (Hadwin et al., 2009). Researchers have related task interpretation to engineering design, project management, and engineering projects in general, but not in the specific context of laboratory work. Similar to coregulation, there is limited information regarding students' task interpretation as a part of the SRL in a laboratory setting.

1.3 The Context for Coregulation: Laboratory Activities

Laboratory activities help students move from abstract ideas to actual illustrations at a time when the mind needs concrete representations of understanding (Gage & Berliner, 1984; Lawson, 1995; Piaget, 1973). In a laboratory setting, students must consider facts, principles conceptual models, theories, and laws of science in order to engage with the material and achieve a sense of academic success (Hart, Mulhall, Berry, Loughram, & Gunstone, 2000; Ruby, 2001). Moreover, laboratory activities often require good teamwork skills and management of constrained resources such as time, and encourage social skills such as cooperation (Hart et al., 2000). Laboratory activities help students to focus on the importance of communicating, publicizing, and verifying the results of the experiments (Hart et al., 2000). 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 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 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). 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.

2. Method

There is limited research regarding coregulation and task interpretation 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 coregulation and task interpretation in the context in the context of laboratory work. The purpose of this study was to investigate how students' level of coregulation was associated with task interpretation during the self-regulation process and how the students' coregulation changes over time in laboratory work. Two research questions were examined: Is there any difference in students' task interpretation between high- and low-coregulated students?, and how do the students' coregulation change over time? Coregulation was measured at the individual level as students completed an assigned task in three different laboratory activities during the semester. The level of task interpretation, as a critical first step in the SRL process of understanding the assigned tasks during laboratory work (Butler & Cartier, 2004; Lawanto et al., 2011) was measured at the end of each laboratory activity.

2.1 Participants

A total of 143 students enrolled in an electronics course, Fundamental Electronics for Engineers, participated in this study. The course is designed for sophomore engineering students registered in nonelectrical engineering majors. In it, students learn how to analyze electrical circuits of direct (DC) and alternating current (AC) applying theorems, principles, and laws. Students are required to enroll in the laboratory portion of the course in which they build circuits and use measurement instruments such as multi-meter, power supplies, and signal generators. The laboratory part of the course includes seven laboratory sessions and is designed to include activities that give students hands-on exposure to concepts. Three laboratory activities of different laboratory sessions (i.e., Labs 3, 4, and 6) were selected by the researcher to conduct this study: (1) Measuring Thevenin Equivalent Circuit (i.e., Lab 3), (2) Charging Phase of Resistive-Capacitive Circuits (i.e., Lab 4), and (3) Capacitive Reactance and Frequency (i.e., Lab 6).

2.2 Instruments

2.2.1 The Coregulated Learning Questionnaire (CLQ)

The instrument designed by the researcher to measure coregulation was named the Coregulated Learning Questionnaire (CLQ), a modified version of the instrument by the same name developed and tested by DiDonato (2013) to measure coregulation. It consisted of 19 statements with a *good* value of Cronbach's alpha indicating a score of .83 (DiDonato, 2013; George & Mallery, 2003; Kline, 1999). The CLQ for this study 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 remained unchanged. Statement 14, added at the end of the questionnaire, asked the participants if they had planned first, or merely started working on the laboratory activity. Six statements were removed from the original because their work was related to activities after hours. Students responded to statements based on a 4-point Likert scale in which the number indicated the degree to which the student believed she or he did what the statement described. The options included always (4), most of the time (3), some of the time (2), or never (1). Because of the modifications of the instrument, reliability was calculated after the application of this instrument as follows: average values were calculated for each of the 14 items from all three laboratory activities, and then calculated the 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).

2.2.2 The Task Analyzer Questionnaire (TAQ)

The Task Analyzer Questionnaire (TAQ) was designed to measure the level of task interpretation as representative of the SRL of the participants in three selected laboratory activities. Three different versions of the TAQ were developed for these laboratory activities. Each of the TAQ consisted of eight open-ended questions to measure the students' task interpretation of the assigned tasks in the activity. Questions were related to the objectives, formulas, materials needed, steps to follow during the activity, main purpose, concepts involved in the activity, and resources needed to complete the laboratory activity (Hadwin, 2006; Helm, 2011). Table 1 shows examples of questions from the TAQ questionnaire.

Table 1. Examples of questions from the Task Analyzer Questionnaire (TAQ)

Questions
1. What are the learning objectives of this lab activity?
2. What formulas will (were) you use during this lab activity?
3. Describe the process in this lab activity to measure/calculate/build [*depending of specific lab activity*].
4. What is the main purpose of this lab activity?
5. List the main concepts from the class that will be (were) used in this lab activity.
6. List external reading/audio/video resources that are relevant for this lab activity.

Previously in a pilot study, internal reliability was conducted for the TAQ. The Cronbach's alpha scores for the TAQ were *acceptable,* ranging from .663 to .855 (George & Mallery, 2003; Kline, 1999). Students' responses to the TAQ questions ranged from 0 to 3 points. 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 of the researcher, a laboratory instructor also graded the answers of this instrument. They both separately graded the quizzes and then met to conciliate the differences in grades on the quizzes. 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 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. An additional analysis to calculate the Kendall's coefficient of concordance (W) was made to support the validity of the grading of the TAQ. 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. This coefficient ranked from .691 to .929 for all three laboratory activities. 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.

2.3 Data Collection

A paper-and-pencil version of the CLQ and TAQ were administered to participants in the seventh (i.e., Lab 3), ninth (i.e., Lab 4), and thirteenth (i.e., Lab 6) weeks after the completion of the three laboratory activities during 15-week semester. 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® examining the scores of the CLQ to identify the group of participants with low level of coregulation (scores above quartile 3) and the group of participants with high level of coregulation (scores below quartile 1). This analysis was possible because the TAQ scores were considered normally distributed. Third, a t test analysis in SPSS was conducted to answer the research questions. A value of .05 for the Type I error was used to determine any significance between high- and low- coregulated students following the laboratory activity. After that, a descriptive statistical analysis in SPSS was conducted again to compare the average scores of the 14 items of the CLQ responses of the seventh week (*time 1*), the ninth week (*time 2*), and the thirteen week (*time 3*). Finally, a t test analysis was conducted to identify any significance between *time 1* and *time 3* during the semester.

3. Results

Preliminary analyses were conducted to identify whether the use of parametric or nonparametric analysis to answer the research questions. 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" (Jamieson-Noel, 2004; Norman, 2010). The researcher evaluated the normality of the data collected of the TAQ instrument applying the Shapiro-Wilk test (Royston, 1982) which is typically tested at a significant value of .001. Results of Shapiro-Wilk test ($S\text{-}W$ = .983, df = 143, p =.072) suggested that normality was a reasonable assumption for the TAQ data collected. Based on the previous arguments, the researcher conducted a parametric analysis to answer the research questions.

3.1 First Research Question: Is There Any Difference in Students' Task Interpretation Between High- and Low-Coregulated Students?

To answer this question, a statistical analysis of the CLQ (student's coregulation) data 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 TAQ (student's task interpretation). 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 2 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 ([a]). Items10, 13, and 14 were negative worded and reverse coded using the formula [5 – score] ([b]).

Table 2. Descriptive Statistics of the Coregulated (CLQ) scores

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

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

[b] Negative-worded items were reversed coded using the formula [5–score].

Second, groups with high and low levels of coregulation were identified after the laboratory 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 were considered normally distributed. Table 3 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 3. High- and Low-Coregulated (CLQ) participants

Participants	*N*	*M*
High CLQ	34	1.19[a]
Low CLQ	36	2.03[a]

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

Next, a *t* test analysis was conducted to identify any statistical difference between the scores of the TAQ for high- and low-coregulated participants. Table 4 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 4. Independent-Sample *t* Test of Task Analyzer (TAQ) scores for High- and Low-Coregulated (CLQ) participants

Participants	*N*	*M*	*SD*	*t*	df	Sig. (2-tailed)
TAQ for High CLQ	34	14.46[a]	1.79	2.66	68	.01*
TAQ for Low CLQ	36	13.09[a]	2.44			

Note. [a] Maximum score is 24 points; * $p < .05$.

3.2 Second Research Question: How Do the Students' Coregulation Change Over Time?

A descriptive statistical analysis was conducted for the CLQ scores in *time 1* (i.e., Lab 3), *time 2* (i.e., Lab 4), and *time 3* (i.e., Lab 6). These times represent the data collected in the seventh, ninth, and thirteenth weeks of the semester respectively. Table 5 shows the average and standard deviations values of CLQ for these times. For all the average values of *time 1*, *time 2*, and *time 3* the closer the value was to 1, the higher the coregulation of participants ([a]). Participants showed improvement in the level of coregulation from *time 1* to *time 3*.

Table 5. Descriptive statistics of the CLQ in Time 1, Time 2, and Time 3

Item	*N*	*M*	*SD*
Time 1	14	1.94[a]	0.83
Time 2	14	1.90[a]	0.81
Time 3	14	1.87[a]	0.83

Note. [a] Four-point Likert scale scores, (1) = All of the time, (2) = Most of the time, (3) = Sometimes, (4) = Never.

Table 6 also shows the results of a paired-sample *t* test indicating that scores were significantly different for the CLQ *time 1* scores as compared to the CLQ *time 3* scores. Participants showed a better level of coregulation at *time 3* matching with *time 1*. No significant differences were found when comparing the scores of *times 1* and *2*. Perhaps, the reason of this is the difference of only two weeks between *time 1* and *time 2*.

Table 6. Paired-sample *t* Test of the CLQ for Time 1 and Time 3

Participants	*N*	*M*	*SD*	*t*	df	Sig. (2-tailed)
CLQ *time 1*	14	1.94[a]	.83	2.480	13	.028*
CLQ *time 3*	14	1.87[a]	.76			

Note. [a] Four-points Likert scale scores, (1) = All of the time, (2) = Most of the time, (3) = Sometimes, (4) = Never; * $p < .05$.

4. Discussion

The regulation of activities in the process of regulation can take place at individual or group levels of social interactions. This study measured CRL at the individual level when students completed an assigned task during laboratory work. The descriptive statistical analysis of CLQ scores showed a good level of coregulation of the participants. That is, students were aware of their engagement while working on the assigned laboratory task. Moreover, students with a high level of coregulation reached higher levels of task interpretation and 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 differed between high- and low-coregulated students. Students who were 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).

There was no specific rule in the laboratory that participants had to work with the same peer during the laboratory activities in the semester; however, most of the participants chose to work with the same peer. Descriptive statistics showed that participants had a better level of coregulation over time with a statistical significance between the seventh and thirteenth weeks. This finding was consistent with DiDonato (2013) who stated that by increasing the students' time spent working collaboratively might encourage the development of new strategies or the modification of existing ones. As a result, an enhanced link could result between material covered in lectures and laboratory activities.

The curriculum developers and laboratory instructors are perhaps familiar with instructional methods that emphasize teamwork. But they can add an additional strategy that develops a self-regulatory approach and employs coregulated learning with the students helping them to recognize, refine, and monitor their strategies in laboratory activities (DiDonato, 2013). In other engineering careers that include laboratory activities as part of the curriculum, instructors may also consider the coregulated learning as part of the instruction to help students in the process of interpreting the assigned tasks and consequently engage them with the material covered in the classroom.

This study contributes to research by investigating coregulated learning in task interpretation in the context of laboratory work. Thus, this study relates the research of the SRL process in the context of 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, researchers may use the results of this study to extend the research of coregulated learning process by measuring coregulation in real time such as video recording the activity during laboratory work in order to make inferences related to SRL process when students are working on assigned tasks. In addition, this study attempts to apply a new approach for measuring task interpretation by employing open-ended questions. This may be beneficial to researchers adding a more varied list of resources to study how to best measure task interpretation during laboratory work.

References

Butler, D., & Cartier, S. (2004). Promoting students' active and productive interpretation of academic work: A key to successful teaching and learning. *Teachers College Record, 106*, 1729-1758. http://dx.doi.org/10.1111/j.1467-9620.2004.00403.x

Butler, D., & Winne, P. (1995). Feedback and self-regulated learning: A theoretical synthesis. *Review of Educational Research, 65*, 245-281. http://dx.doi.org/10.3102/00346543065003245

Chan, C. (2012). Co-regulation of learning in computer-supported collaborative learning environments: A discussion. *Metacognition Learning, 7,* 63-73. http://dx.doi.org/10.1007/s11409-012-9086-z

Corno, L., & Mandinach, E. B. (2004). What we have learned about student engagement in the past twenty years. In D. M. Mcinerney, & S. Van Etten (Eds.), Big theories revised (pp. 299-328). Greenwich, CT: Information Age.

Davidowitz, B., & Rollnick, M. (2003). Enabling metacognition in the laboratory: A case study for four second year university chemistry students. *Research in Science Education 33*, 43-69. http://dx.doi.org/10.1023/A:1023673122220

DiDonato, N. C. (2013). Effective self- and co-regulation in collaborative learning groups: An analysis of how students regulate problem solving of authentic tasks. *Instructional Science, 41*, 25-47. http://dx.doi.org/10.1007/s11251-012-9206-9

Domin, D. (1999). A Review of Laboratory Instruction Styles. *Journal of Chemical Education, 76*(4), 543-547. http://dx.doi.org/10.1021/ed076p543

Gage, N., & Berliner, D. (1984). *Educational psychology*. Boston: Houghton Mifflin.

George, D., & Mallery, P. (2003). *SPSS for Windows step by step: A simple guide and reference. 11.0 update* (4th ed.). Boston: Allyn & Bacon.

Grau, V., & Whitebread, D. (2012). Self and social regulation of learning during collaborative activities in the classroom: The interplay of individual and group cognition, learning and instruction. *Learning and Instruction, 22*, 401-412. http://dx.doi.org/10.1016/j.learninstruc.2012.03.003

Hadwin, A. (2006, May). *Student task understanding*. Paper presented at the Learning and Teaching Conference, University of Victoria, Victoria, British Columbia, Canada.

Hadwin, A., & Oshige, M. (2007). *Self-regulation, co-regulation and socially shared regulation: Examining many faces of social in models of SRL*. Paper presented at the EARLI.

Hadwin, A., & Oshige, M. (2011). Self-regulation, co-regulation, and socially-shared regulation: Exploring perspectives of social in self-regulated learning theory. *Teachers College Record, 113*(2), 240-264.

Hadwin, A., Oshige, M., Miller, M., & Wild, P. (2009, July). *Examining student and instructor task perceptions in a complex engineering design task*. Paper presented at the proceedings of the Sixth International Conference on Innovation and Practices in Engineering Design and Engineering Education (CDEN/C^2E^2), McMaster University, Hamilton, ON, Canada.

Hart, C., Mulhall, P., Berry, A., Loughran, J., & Gunstone, R. (2000). What is the purpose of this experiment? Or can students learn something from doing experiments? *Journal of Research in Science Teaching, 37*(7), 655-675. http://dx.doi.org/10.1002/1098-2736(200009)37:7<655::AID-TEA3>3.0.CO;2-E

Helm, S. (2011). *An exploration of elementary students' task understanding*: *How do young students understand the school activities they are assigned?* (Master's Thesis, University of Victoria, Canada). Retrieved from https://dspace.library.uvic.ca//handle/1828/3822

Jamieson-Noel, D. (2004). *Exploring task definition as a facet of self-regulated learning* (Doctoral Dissertation, Simon Fraser University, Canada). Retrieved from http://summit.sfu.ca/item/8716

Jarvela, S., & Hadwin, A. (2013). New frontiers: Regulating learning in CSCL. *Educational Psychologist, 48*(1), 25-39. http://dx.doi.org/10.1080/00461520.2012.748006

Jarvela, S., & Jarvenoja, H. (2007). *Socially constructed self-regulated learning in collaborative learning groups*. Teachers College Records.

Kline, P. (1999). *The handbook of psychological testing* (2nd ed.). London: Routledge.

Lawanto, O. (2011, June). *Work in progress: Student task interpretation, design planning, and cognitive strategies in engineering design project: An exploratory study for grades 9-12*. Paper presented at the ASEE/IEEE Frontiers in Education Conference annual conference, Rapid City, SD. http://dx.doi.org/10.1109/fie.2011.6142765

Lawanto, O., Butler, D., Cartier, S., Santoso, H., & Goodridge, W. (2013). Self-regulated learning strategies between high and low performing in an engineering design project: An exploratory study on college freshmen. *International Journal of Engineering Education. 29*(2), 459-475.

Lawanto, O., Goodridge, W., & Santoso, H. B. (2011, June). *Task interpretation and self-regulating strategies in engineering design project: An exploratory study*. Paper presented at the annual conference of the American Society of Engineering Education (ASEE), Vancouver, Canada.

Lawson, A. (1995). *Science teaching and the development of thinking*. Belmont, CA: Wadsworth Publishing.

McCaslin, M. (2009). Co-regulation of students' motivation and emergent identity. *Educational Psychologist, 44*(2), 137-146. http://dx.doi.org/10.1080/00461520902832384

McCaslin, M., & Hickey, D. T. (2001). Self-regulated learning and academic achievement: A Vygotskian view. In B. J. Zimmerman, & D. H. Schunk (Eds.), *Self-regulated learning and academic achievement: Theoretical perspectives* (pp. 227-252). New York: Lawrence Erlbaum.

Norman, G. (2010). Likert scales, levels of measurement and the laws. *Advanced in Health Scientific Education, 15*, 625-632. http://dx.doi.org/10.1007/s10459-010-9222-y

Novak, J. D., & Gowin, D. B. (1984). *Learning how to learn*. New York and Cambridge, UK: Cambridge University Press. http://dx.doi.org/10.1017/CBO9781139173469

Piaget, J. (1973). *To understand is to invent: The future of education*. New York: Grossman.

Royston, J. P. (1982). Expected normal order statistics (exact and approximate). *Applied Statistics, 31*(2),161-165. http://dx.doi.org/10.2307/2347982

Ruby, A. (2001). *Hands-on science and student achievement* (Doctoral Dissertation, RAND, Santa Monica, CA). Retrieved from http://www.rand.org/publications/RGSD/RGSD159/

Schunk, D. H. (2001). Social cognitive theory and self-regulated learning. In B. J. Zimmerman, & D. H. Schunk

(Eds.), *Self-regulated learning and academic achievement: Theoretical perspectives* (2nd ed., pp. 125-151).

White, R. (1996). The link between the laboratory and learning. *International Journal of Science Education, 18*(7), 761-774. http://dx.doi.org/10.1080/0950069960180703

Zimmerman, B. J. (2006). Development and adaptation of expertise: The role of self-regulatory processes and beliefs. In K. A. Ericsson, N. Charness, P. J. Feltovich, & R. R. Hoffman (Eds.), *The Cambridge handbook of expertise and expert performance.* (pp. 705-722). Cambridge, UK: Cambridge University Press. http://dx.doi.org/10.1017/CBO9780511816796.039