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Investigating Students' Self-Regulated Learning While Learning Electric Circuit Concepts with Enhanced Guided Notes

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Abstract

Measuring self-regulated learning (SRL) skills of engineering college students while using enhanced guided notes (EGN) promotes a better understanding of how students deal with note-taking activities. This study focused on students' task interpretation, cognitive strategies, and SRL processes including planning, monitoring, and regulating strategies while using EGN in an electric circuits course. The main objectives of this study were to (1) understand how students' SRL skills changed after using EGN; and (2) evaluate how students' conceptual understanding on electric circuits improved after using EGN.

Ninety-seven students enrolled in the Fundamental Electronics for Engineers course at a land grant university participated in the study. A self-regulated learning survey instrument developed using Butler and Cartier's SRL model was used to capture students' task interpretation, cognitive strategies, and SRL processes. In addition, Holton's DC/AC Circuits Concept Inventory was used to measure students' conceptual understanding of DC/AC concepts. Participants were asked to complete both surveys twice online, at the beginning and end of the semester. Descriptive statistics, independent and paired t-tests, and a cluster analysis technique were used to analyze data.

Data analysis of the SRL survey revealed that students had different SRL profiles. Students in the improved group reported a significant improvement in planning, monitoring, and regulating strategies. On the other hand, those in the declined group showed a lower awareness of all SRL skills at the end of semester. Furthermore, the findings revealed an improvement in students' conceptual understanding. This article will also discuss the potential implications for electric circuit concepts instruction.

***Keywords*:** Electric circuit concepts, enhanced guided notes (EGN), self-regulated learning (SRL)

1. Introduction

A growing body of literature suggests that classroom activity generally does not stimulate students to actively engage in learning[1, 2]. Specifically in engineering education, many instructors focus on writing engineering formulas and solving problems on the chalkboard, often asking the students to check their understanding. Elshorbagy & Schonwetter described the teaching practice as "deductive instruction, where the instructor is viewed as `the sage on the stage'" [3, p. 297]. During traditional lectures, students are generally passive[2, 4, 5]; consequently, information received passively with no attendant action is not readily retained in long-term memory[6]. Research also suggests that students learn best when they take an active role in learning through discussion, practicing, games, and applying concepts and ideas[7-9]; however, these activities are often impractical to conduct, particularly in large classes. A recent study involving engineering students found that active participants achieved greater learning and were more motivated than their passive peers[10].

A major concern that most instructors have involves the effectiveness of lectures in facilitating students' learning. Studies have shown that students' attention during lectures declines after 10-15 minutes[11, 12]. According to Hartley and Davis[13], the amount of notes written declined over the course of a lecture. Unless the students' attention is focused on what the instructor is saying, there is little chance that meaningful processing and note-taking will follow. Konrad, Joseph, and Itoi[14] suggested that a note-taking activity can improve an individual's concentration. Guided notes are prepared by instructors and contain incomplete text, diagrams, and graphs, and students must listen to the instructor and think critically to answer the prompted questions and fill in missing parts of the information.

Although previous studies have been conducted to develop and evaluate guided notes, a limited study has been conducted by involving a variation of self-regulated learning prompts used to learn electric-circuit concepts. This study focused on students' task interpretation, cognitive strategies, and SRL processes including planning, monitoring, and regulating strategies while using EGN in an electric-circuits course. A better understanding of these issues will specifically benefit engineering educators who encourage their students to take systematic notes during lecture. The objectives of this study were *to understand how students' SRL skills changed after using EGN; and to evaluate how students' conceptual understanding of electric circuits improved after using EGN.*

2. What are Enhanced Guided Notes?

Guided notes contain incomplete information with blank spaces consisting of essential concepts, ideas, diagrams, graphs, problems, and conclusions. Standard guided notes, also called semi- or skeleton-notes, have been used in undergraduate teaching for quite some time. Unlike the guided notes introduced in many studies[15-17], the enhanced guided notes (EGN) developed by this study include questions that prompt students to assess their metacognitive self-regulated learning (SRL) strategies. This component is not present in the standard guided notes. The questions appear throughout the guided notes, including the introduction of each topic, elaboration of the theoretical concepts, along with issues that arise during problem solving.

The format of EGN used in this study focused on the improvement of EGN implemented in the previous study[18]. The improvement efforts included the addition of relevant prompts to exercise students' SRL skills and a new graphic design of the EGN to improve convenience of writing notes. Evaluation of the previous EGN[18] found that the three aspects that students liked the most about the use of EGN in the classroom included: the ability to focus more on learning and less on writing, less writing/drawing, and identification of specific points important for the class. Findings from the study also suggested that the guided notes helped the students to understand the concepts discussed in the class; improved their problem solving skills, and actively engaged them in learning during the class lectures.

Through EGN, students engage in the learning process along with their instructor during lectures. Besides conceptual theories, formulas, and problems to solve, the EGN include questions that prompt students to assess their understanding about theories, problem-solving strategies, and the principle concepts related to the topic of discussion. Compared to the traditional lecturing method in most colleges, these new learning materials and strategies may offer students an enhanced learning experience that more effectively utilizes lecture time.

Table 1. *Examples of prompt questions in the enhanced guided notes of electric-circuits concept*

Questions	Condition where questions were asked
• What would you expect of the relationship between *v* and *i* for a resistive circuit? Why?	• Conceptual information
• Predict the formula to calculate the total impedance for a parallel circuit.	• Conceptual information
• What theoretical principles or laws do you need to use to solve this problem?	• Problem solving
• How do you use your theoretical principles or laws?	• Problem solving
• Should you expect to get these answers?	• Problem solving
• How can you check your answers?	• Quick reflections
• Based on your self-evaluation, what are your weak areas?	• Quick reflections

3. Insight into Self-Regulated Learning

Zimmerman argued that self-regulated learners are "metacognitively, motivationally, and behaviorally active participants in their own learning process"[19, p. 239]. It is clear that metacognition is a major component of one's self-regulated learning (SRL) strategies. In this article we used SRL processes to represent the link between metacognition and SRL. Butler and Cartier's SRL model described the dynamic and iterative interplay between metacognitive and cognitive activities[20-22] which characterize SRL as a complex, dynamic, and situated learning process[23]. The model consists of eight SRL features that interact with each other: layers of context, what individuals bring, mediating variables, task interpretation, personal objectives, SRL processes, cognitive strategies, and performance criteria.

The *first feature*, layers of context, may include learning environments such as school, classroom, 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. The *second feature*, what individuals bring to the context, includes factors such as student strengths, challenges, interests, and preferences. Over time, students accumulate a learning history that shapes their development of knowledge and skills, self-perceptions, attitudes toward school, and concepts about academic work. The *third feature*, mediating variables, involves knowledge, perceptions about their competence and control over learning, and perceptions about activities and tasks. These variables also include emotions experienced before, during, and after completing a task. The *fourth feature* is student task interpretation. Task interpretation (or task demand) is the heart of the SRL model insofar as it shapes key dynamic and recursive self-regulating processes. Students' interpretation of task demands is a key determinant of the goals set while learning, the strategies selected to achieve those goals, and the criteria used to self-assess and evaluate outcomes.

Students set personal objectives, the *fifth feature*, such as achieving task expectations that impact their direction for engaging or not engaging in learning. Students manage their engagement in academic work by using a variety of SRL processes, the *sixth feature* in the Butler and Cartier model: planning, monitoring, evaluating, adjusting approaches to learning. Students prepare their learning activity, select strategies for task completion, self-monitor progress, and adjust goals, plans, or strategies based upon self-perceptions of progress or feedback and performance. These strategies are iterative and dynamic endeavors. The *seventh feature*, cognitive strategies, refers to students' cognitive activities employed as they engage in learning, as planned, monitored, and adjusted through self-regulating strategies. Last, performance criteria, as the *eighth feature*, are the standards against which students judge their progress during learning. Our focus in this study was more specifically the fourth feature of the Butler and Cartier model, task interpretation, and its relationship to students' use of cognitive and self-regulated learning strategies (i.e., planning, monitoring, and regulating).

In general, the use of SRL processes benefits students in improving their learning performance. According to Zimmerman, SRL refers to students' "self-generated thoughts, feelings, and actions which are systematically oriented toward attainment of their goals"[24]. Applying learning strategies is important; Borkowski and Thorpe suggested that low-performing students may not understand how to relate learning strategic behavior with learning efforts[25].

4. Method

Our goal of this study was to evaluate students' self-regulated learning skills and their learning performance while learning electric circuit concepts using the enhanced guided notes. Butler and Cartier's SRL model was used to evaluate students' task interpretation, cognitive strategies, and their SRL strategy use including planning, monitoring, and regulating strategies. In addition, students' DC/AC conceptual understanding was assessed to measure their learning performance.

4.1 The Participants and Context of the Course

Ninety-seven students enrolled in the Fundamental Electronics for Engineers course during the fall 2011 at a land grant university participated in the study. While the majority of the participants had a cumulative GPA of 3.00 or higher, fourteen percent had a cumulative GPA range from 1.00 to 2.99. Sixty-one percent were sophomores, followed by juniors (34%), seniors (4%), and freshmen (1%).

The course is a fundamental electric-circuit course required for engineering students who are not enrolled in electrical engineering. Similar circuit courses are offered at universities across the country. At this university, the students are from the mechanical and aerospace engineering, civil and environmental engineering, biological and irrigation engineering, and engineering education. In one class meeting, the instructor distributed several pages of guided notes to the students. The notes were used to replace the one-way communication that was typical of class meetings. Students were asked to fill in the blank spaces found on the pages. The guided notes prompted students with 'what,' 'why,' and 'how' questions regarding the material covered to exercise their SRL skills. Examples of these prompts were: "What theoretical principles or laws do you need to use to solve this problem", "How do you use your theoretical principles or laws," and "Are you sure that is correct?" Furthermore, at the end of the class meeting, students were asked to evaluate their learning process through a 'self-reflection' section to evaluate their understanding upon particular topics.

4.2 Instrumentation

A self-regulated learning survey instrument developed using Butler and Cartier's SRL model was used to capture students' task interpretation, cognitive, and SRL processes. The SRL survey was adapted from the Inquiry Learning Questionnaire (ILQ) by Butler and Cartier based on their theoretical model[20-23]. Students were asked to rate themselves on a 4-point Likert scale (1 = *almost never*, 2 = *sometimes*, 3 = *often*, 4 = *almost always*). Five subscales were developed to capture students' SRL skills at the beginning and end of the semester. The subscales were task interpretation, planning, cognitive, monitoring, and regulating strategies. Subscales of the questionnaire had Cronbach's Alpha scores ranging from .637 to .870 (see Table 2 for samples of the SRL questionnaire items). Furthermore, to compare the impact of EGN usage to learning performance, scores from DC/AC concepts inventory tests were evaluated. The 20 multiple-choice questionnaire was designed by Holton[26] to identify students' misconceptions and what fundamental conceptual knowledge they lack.

4.3 Data Collection and Analysis

One hundred and fifteen engineering students participated in this study, but only 97 valid data sets were analyzed. There were 18 suspiciously completed surveys that required us to further investigate the validity of the responses. We found those students responded to each survey item with the same answers (e.g., marked "3" for all items or block of items). Participants were asked to complete both SRL and DC/AC concepts inventory surveys twice online, at the beginning and end of the semester. While descriptive statistics were used to evaluate how many students had improved their SRL skills after using EGN, a cluster analysis was also used to identify different SRL profiles among students. A series of paired samples t-tests was conducted to measure students' conceptual understanding.

Table 2. *SRL features and examples in the context of learning electric circuit*

Features	**Examples**
Task Interpretation (*TI*)	• When I have to learn and solve math, science, or engineering problems involving new concepts, I find important details or facts (e.g., symbols, units).
Planning Strategies (*PS*)	• Before I begin the activity of learning and solving math, science, or engineering problems involving new concepts, I start by just reading the learning resources.
Cognitive Strategies (*CS*)	• While I am learning and solving math, science, or engineering problems involving new concepts, I pay attention to underlined or bolded words in learning resources, if there are any.
Monitoring Strategies (*Mon*)	• When learning and solving math, science, or engineering problems involving new concepts, I check whether I can describe the main topic of the subject.
Regulating Strategies (*Reg*)	• When I have difficulties learning and solving math, science, or engineering problems involving new concepts, I check to make sure I have completed everything required for the activity.

5. Findings

5.1 Students' Self-Regulated Learning Skills after Using the Enhanced Guided Notes

Data from SRL questionnaires were analyzed to investigate students' SRL skills during the semester. From descriptive statistics ($n = 97$), we found SRL skills, before and after using EGN were relatively similar on *task interpretation*, *planning*, *cognitive*, *monitoring*, and *regulating strategies*. Although overall there was no significant SRL difference found between before and after using the EGN, our findings suggested a trend of improvement in the questionnaire-item level specifically on monitoring and regulating strategies (see Tables 4a-e).

Table 3. Descriptive statistics of ***SRL features*** *before and after using EGN*

No.	Features	Before	After
		M (*SD*)	*M* (*SD*)
1.	Task interpretation	3.21 (.47)	3.17 (.49)
2.	Planning strategies	2.80 (.43)	2.81 (.56)
3.	Cognitive strategies	3.13 (.39)	3.08 (.41)
4.	Monitoring strategies	3.17 (.42)	3.19 (.43)
5.	Regulating strategies	3.18 (.43)	3.16 (.46)

Table 4a. Descriptive statistics of ***Task Interpretation*** *before and after using EGN*

No.	When I have to learn and solve math, science, or engineering problems involving new concepts, I…	Before	After
		M (*SD*)	*M* (*SD*)
1.	find important details or facts (e.g. symbol, unit).	3.44 (.60)	3.45 (.68)
2.	find the main concepts in the learning resources.	3.29 (.66)	3.35 (.66)
3.	understand or explain the concepts that I learned.	3.10 (.71)	2.99 (.74)
4.	see how concepts about the subject go together.	3.23 (.69)	3.07 (.73)
5.	apply concepts of what I learned to different situations or problems.	3.01 (.77)	3.00 (.74)

Table 4b. Descriptive statistics of ***Planning Strategies*** *before and after using EGN*

No.	Before I begin the activity of learning and solving math, science, or engineering problems involving new concepts, I start by…	Before	After
		M (*SD*)	*M* (*SD*)
1.	planning my time.	2.53 (.83)	2.60 (.92)
2.	choosing a method for completing the problems.	3.18 (.74)	3.08 (.85)
3.	creating a strategy.	3.03 (.84)	3.01 (.81)
4.	checking the scope of the activity.	2.71 (.74)	2.82 (.85)

Table 4c. Descriptive statistics of ***Cognitive Strategies*** *before and after using EGN*

No.	While I am learning and solving math, science, or engineering problems involving new concepts, I…	Before	After
		M (*SD*)	*M* (*SD*)
1.	pay attention to underlined or bolded words in learning resources, if there are any.	3.57 (.63)	3.43 (.66)
2.	pay attention to important concepts.	3.56 (.56)	3.56 (.54)
3.	take notes on the important concepts.	3.27 (.78)	3.11 (.88)
4.	think about what I already know about the subject.	3.41 (.64)	3.40 (.67)
5.	draw conclusions from what I have learned.	3.31 (.70)	3.18 (.71)
6.	think of related examples.	3.10 (.70)	3.00 (.79)
7.	think of how I can apply the new learned concepts to solve a problem or respond to questions.	2.97 (.77)	2.99 (.69)
8.	find links between concepts.	3.03 (.67)	3.01 (.74)

Findings revealed important differences between before and after using EGN on monitoring strategies. We found that significant improvements occurred particularly in items such as "check whether I can describe the main topic of the subject" (t = -2.032, p =.023), "check that I have found all the important concepts" (t = -2.179, p =.016), and "ask myself whether my methods for solving problems are good" (t = -2.208, p =.015). We also found a significant decline in "judge the quality of my work" (t = 2.802, p = .003) and "keep track how much time I have to finish my work" (t = 2.076, p = .021; see Table 4d).

Table 4d. Descriptive statistics of ***Monitoring Strategies*** *before and after using EGN*

No.	When learning and solving math, science, or engineering problems involving new concepts, I…	Before	After
		M (*SD*)	*M* (*SD*)
1.	judge the quality of my work ** (↓).	3.20 (.75)	2.97 (.71)
2.	check now and then to see if my work is going well.	3.35 (.68)	3.23 (.74)
3.	check to make sure I have completed everything required for the activity.	3.61 (.55)	3.61 (.57)
4.	identify what I do and don't understand.	3.32 (.65)	3.29 (.63)
5.	check whether I can describe the main topic of the subject** (↑).	2.72 (.79)	2.93 (.79)
6.	check that I have found all the important concepts** (↑).	2.92 (.75)	3.11 (.75)
7.	check what I can remember from what I learned.	2.94 (.77)	3.08 (.76)
8.	keep track of how much time I have to finish my work** (↓).	3.19 (.88)	2.98 (.96)
9.	ask myself whether my methods for solving problems are good* (↑)	2.82 (.78)	3.02 (.78)
10.	ask myself whether I will get a good grade.	3.44 (.69)	3.42 (.79)
11.	check to make sure I come up with an answer that makes sense to me.	3.57 (.58)	3.60 (.57)

Note: * $p < .01$; ** $p < .05$; (↑): significantly improved; (↓): significantly declined.

Table 4e. Descriptive statistics of ***Regulating Strategies*** *mean before and after using EGN*

No.	When I have difficulties learning and solving math, science, or engineering problems involving new concepts, I…	Before	After
		M (*SD*)	*M* (*SD*)
1.	check to make sure I have completed everything required for the activity.	3.54 (.58)	3.43 (.64)
2.	review the difficult concepts again.	3.24 (.75)	3.26 (.74)
3.	try to make links between concepts.	3.08 (.66)	3.13 (.70)
4.	make links between concepts I am learning and problem I solved.	3.20 (.69)	3.26 (.67)
5.	try to memorize concepts.	2.94 (.88)	2.95 (.83)
6.	try to use better methods for working.	3.13 (.66)	3.08 (.73)

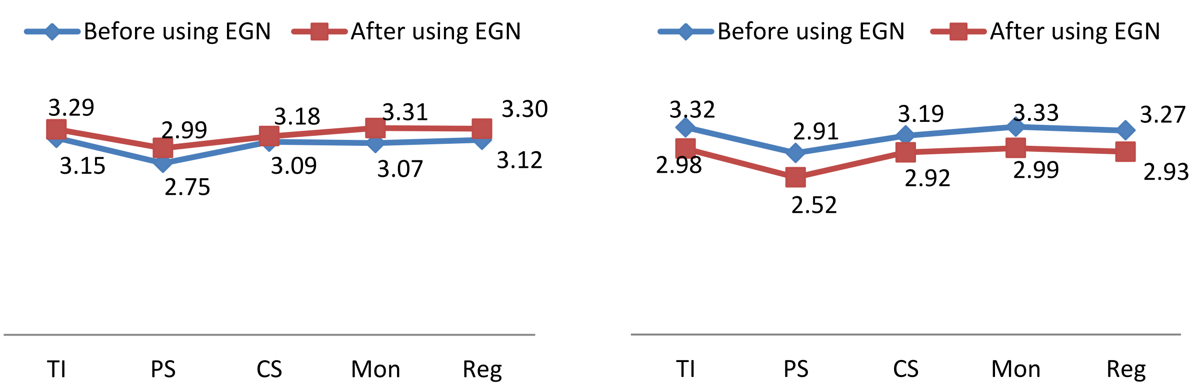
We investigated further to evaluate if students' SRL profiles in our sample population were diverse. The use of the cluster analysis technique enabled the researcher to achieve a detailed profile of students' SRL. We found two categories of students based upon different SRL levels before and after using the EGN: *improved or declined.* It was found that 61 (62.89%) and 36 (37.11%) students were clustered in improved and declined groups, respectively. Seventy-nine percent of the improved group students had GPA greater than 3.25 and sixty-two percent of them were in freshman and sophomore level. On the other hand, seventy-five percent of the declined group students had GPA higher than 3.25. This number is a little bit lower than the improved group. The number of sophomore students in declined group is a little bit higher than the improved group (64%); no freshman student in declined group.

After calculating the number of students from the improved and declined groups, we then evaluated the SRL profiles of each group. The mean value of each self-regulated learning (SRL) strategy was used to describe students' SRL profiles that belonged to the two groups (see Figures1a-b). Furthermore, paired samples *t*-tests were carried out to investigate whether SRL changes as depicted in the figures were statistically significant for each group. Five independent paired t-tests were conducted by considering Bonferroni adjusted alpha levels of .01 per test (.05/5). Statistical tests showed students in the improved group were significantly improved on planning, monitoring, and regulating strategies. On the other hand, students in the declined group were significantly worse off on all SRL processes at the end of semester (see Table 5).

Table 5. *SRL skills differences in each group before and after using enhanced guided notes*

Groups	Task interpretation		Planning strategies		Cognitive strategies		Monitoring strategies		Regulating strategies	
	t	*p*	*t*	*p*	*t*	*p*	*t*	*p*	*t*	*p*
Improved (n = 61)	-2.066	(.022)	-4.52	(.00)↑*	-2.066	(.058)	-6.62	(.00) ↑*	-4.28	(.00)↑**
Declined (n = 36)	3.463	(.001) ↓*	4.35	(.00)↓*	4.431	(.000)↓*	7.75	(.00) ↓*	6.35	(.00) ↓*

Note: * $p < .01$ (1-tailed); ** $p < .05$ (1-tailed); (↑) significant increased; (↓) significant decreased.



(1a) *Improved group (n = 61)* (1b) *Declined group (n = 36)*

Figure 1(a-b). *Students' SRL profiles: improved and declined groups*

5.2 Students' Conceptual Understanding of Electric Circuits Improved after Using the Enhanced Guided Notes

We evaluated students' learning performance to see how well students had performed on the DC/AC conceptual inventory. Paired samples t-tests (1-tailed) were conducted to determine whether significant improvement in student conceptual understanding occurred. We found significant improvement in student DC/AC conceptual understanding after using EGN (M_{before} = 9.58, SD_{before} = 2.61; M_{after} = 11.53, SD_{after} = 3.28; t = -6.072, df = 96, p = .000). The mean scores reflect improvement in the number of students' correct answers on the 20 multiple-choice concept inventory.

When we evaluated the DC/AC conceptual understanding in the improved and declined groups, the improved group showed significant improvement in achieving correct answers after using the EGN (M_{before} = 9.61, SD_{before} = 2.46; M_{after} = 11.70, SD_{after} = 3.21; t = -5.446, df = 60, p = .000). Similar to these findings, the declined group reported improvement in their DC/AC conceptual understanding (M_{before} = 9.53, SD_{before} = 2.88; M_{after} = 11.22, SD_{after} = -3.42; t = -2.965, df = 35, p = .003). Furthermore, independent t-tests suggested that the improved outperformed the declined group on all exams and the DC/AC conceptual understanding (no statistical significant was found). We also evaluated the comparisons of students' learning performance using Mann-Whitney mean ranks tests. The results revealed similar findings with the independent *t*-tests (see Table 6). More specifically, the improved group reported significantly higher scores on the final exam compared to the declined group (U = 855.000, $p < .05$).

Table 6. *Mann-Whitney mean ranks between improved and declined groups on performance*

	Improved group (n = 61)	Declined group (n = 36)
Performance assessment	Mean rank (Sum of ranks)	Mean rank (Sum of ranks)
DC/AC Concepts test before using EGN	**50.24** (3064.50)	46.90 (1688.50)
DC/AC Concepts test after using EGN	**50.52** (3081.50)	46.43 (1671.50)

6. Conclusions

The current research successfully developed new types of instructional materials and strategies for use in an electric circuit course. The enhanced guided notes (EGN) were designed to replace traditional note-taking practiced in most engineering courses. The first important contribution of this study was to describe profiles of students' self-regulated learning (SRL). When looking across the SRL skills, overall mean comparisons between before and after using the EGN on the SRL survey revealed no statistically reliable differences. However, our findings suggested a trend of improvement in monitoring and regulating strategies in the questionnaires. Significant improvement and decline were found in monitoring strategies.

As our early data analysis found that SRL skills of all participants were relatively similar before and after using the EGN, we decided to run cluster analyses. Cluster analyses were conducted to see whether different SRL profiles existed among students. From the analyses, we identified two groups of students: improved (i.e., students with SRL improvements) and declined (i.e., students with SRL decline). The analysis of the SRL survey data revealed intriguing findings about changes in students' awareness of their SRL skills. While the improved group significantly improved their SRL on planning, monitoring, and regulating strategies, the declined group significantly declined in all SRL skills after using the EGN.

The second important contribution of this study was to describe students' learning performance on DC/AC conceptual understanding. As we expected before, our findings showed that note-taking activity using the EGN benefits the students in improving their performance on DC/AC conceptual understanding. Results of the cluster analysis also triggered us to investigate differences in the conceptual understanding of the two groups. Our findings suggested that the improved group outperformed the declined group on the DC/AC conceptual tests.

7. Discussion

The findings of this study are important in terms of advancing the understanding of the use of note-taking in engineering classrooms. Previous studies reported that students benefitted from the use of guided notes. Research also has shown that note-taking skills need to be improved further[27, 28]. In the main author's prior work[18], we found that the use of EGN improved students' understanding of the course content. However, it was not clear how prompted questions on the

EGN improved the way students think or their learning strategies. This study extends that work by examining students' self-regulated learning profiles while learning electric circuit concepts using the EGN.

Our data analysis on DC/AC concepts inventory found that students' conceptual understanding of DC/AC concepts improved at the end of the semester. The results suggested that it may be valuable to identify high and low performers according to conceptual understanding test scores, evaluate the content of their notes, and encourage the students to share their notes with peers. This strategy may trigger the students to learn in a collaborative learning environment. When we evaluated the learning performance between the two groups, our findings suggested that the improved group outperformed the declined group on the DC/AC conceptual tests. The findings suggested that a higher percentage of students in the class (63%) had the advantage of exercising their SRL while using the EGN than did those students who reported a lower awareness of their SRL. The demographic composition of each group might provide some insight into this phenomenon. Our data analysis of student demographic information showed that the improved group had a higher percentage of students with a good GPA, and fewer freshmen and sophomores than did the declined group. Moreover, the declined group might have been more apt to misjudge their self-regulated learning before using the EGN. Hadwin & Webster suggested that there are correlations between overconfidence in judgment and GPA[29]. The overconfidence also found between judgment accuracy of metacognition and levels of retention[30].

The current study built from prior research to advance the understanding of the strengths and challenges inherent in learning electric circuit concepts using EGN. To build further on these efforts, we offer three recommendations. *First*, an increase in sample size is essential to improve the generalizability of the findings. *Second*, a longitudinal study is needed to investigate whether the use of enhanced guided notes benefits the students in other classes. *Third*, further study is needed to continue to nuance the SRL prompts on the enhanced guided notes as suggested by the students. Moreover, we suggested that the prompts should be contextual according to the topic presented.

8. References

1. Lord, T., "Using constructivism to enhance student learning in college biology," *Journal of College Science Teaching*, vol. 23, 1994, pp. 346-348.
2. Stewart-Wingfield, S., & Black, G. S., "Active versus passive course designs: The impact on student outcomes," *Journal of Education for Business*, vol. 81, no. 2, 2005, pp. 119-125.
3. Elshorbagy, A., & Schonwetter, D. J., "Engineer morphing: Bridging the gap between classroom teaching and the engineering profession," *International Journal of Engineering Education*, vol. 18, no. 3, 2002, pp. 295-300.
4. Dorestanni, A., "Is interactive learning superior to traditional lecturing in economics courses?" *Humanomics*, vol. 21, no. 1/2, 2005, pp. 1-20.
5. Felder, R. M., & Brent, R, "The ABC's of engineering education: ABET, Bloom's taxonomy, cooperative learning, and so on," Paper presented at the 2004 American Society for Engineering Education Annual Conference & Exposition, Salt Lake City, UT, 2004.
6. Van Eynde, D. F., & Spencer, R. W., "Lecture versus experiential learning: Their different effects on long-term memory," *Organizational Behavior Teaching Review*, vol. 12, no. 4, 1988, pp. 52-58.
7. Cortright, R. N., Collins, H. L., & DiCarlo, S. E., "Peer instruction enhanced meaningful learning: ability to solve novel problems," *Adv Physiol Educ*, vol. 29, 2005, pp. 107–111.

8. Mierson, S., “Skits and games to enhance students' learning of physiology,” *Adv Physiol Educ*, vol. 22, 1999, pp. 283–284.
9. Sarason, Y., & Banbury, C., “Active learning facilitated by using a game-show format or who doesn’t want to be a millionaire?” *Journal of Management Education*, vol. 28, no. 4, 2004, pp. 509-519.
10. Gonzalez, A. B., Rodriguez, M. J., Olmos, S., Borham, M., & Garcia, F., “Experimental evaluation of the impact of b-learning methodologies on engineering students in Spain,” *Computers in Human Behavior*. (2012, in press).
11. Anderson, T. H., & Armbruster, B. B., “The value of taking notes during lectures,” In R. Flippo & D. Caverly (Eds.), *Teaching reading & study strategies at the college level*. Newark, DE: International Reading Association, 1991, pp. 166-194.
12. Davis, B. G. *Tools for teaching*. San Francisco: Jossey-Bass, 1993.
13. Hartley, J., & Davies, I. K., “Notetaking: A critical review,” *Programmed Learning and Educational Technology*, vol. 15, 1978, pp. 207-224.
14. Konrad, M., Joseph, L. M., & Itoi, M., “Using guided notes to enhance instruction for all students,” *Intervention in School and Clinic*, vol. 46, no. 3, 2011, pp. 131-140.
15. Hohn, R. L., Gallagher, T., & Byrne, M., “Instructor-supplied notes and higher-order thinking,” *Journal of Instructional Psychology,* vol. 17, no. 2, 1990, pp. 71-74.
16. Hosain, M. U., “Effective teaching using seminotes,” *Journal of Professional Issues in Engineering Education and Practice*, vol. 120, no. 2, 1994, pp. 193-197.
17. Narjaikaew, P., Emarat, N., & Cowie, B., “The effect of guided note taking during lectures on Thai university students' understanding of electromagnetism,” *Research in Science & Technological Education*, vol. 27, no. 1, 2009, pp. 75-94.
18. Lawanto, O., “The use of enhanced guided notes in an electric circuit class: An exploratory study,” *IEEE Transactions on Education*, vol. 55, no. 1, 2012, pp. 16-21.
19. Zimmerman, B. J., “A social cognitive view of self-regulated learning,” *Journal of Educational Psychology*, vol. 81, 1989, pp. 329-339.
20. Butler, D. L., & Cartier, S. C., “Learning in varying activities: An explanatory framework and a new evaluation tool founded on a model of self-regulated learning*,”* Paper presented at the annual conference of the Canadian Society for the Study of Education, Toronto, ON, 2004.
21. Butler, D. L., & Cartier, S. C., “Multiple complementary methods for understanding self-regulated learning as situated in context,” Paper presented at the annual meetings of the American Educational Research Association, Montreal, QC, 2005.
22. Cartier, S. C., & Butler, D. L., “Elaboration and validation of the questionnaires and plan for analysis,” Paper presented at the annual conference of the Canadian Society for the Study of Education, Toronto, ON, 2004.
23. Butler, D., & Winne, P., “Feedback and self-regulated learning: A theoretical synthesis,” *Review of Educational Research*, vol. 65, no. 3, 1995, pp. 245-281.
24. Zimmerman, B. J., “Dimensions of academic self-regulation: A conceptual framework for education,” In D. H. Schunk & B. J. Zimmerman (Eds.), *Self-regulation of learning and performance: Issues and educational applications*. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc, 1994, pp. 3-21.
25. Borkowski, J.G. & Thorpe, P.K., “Self-regulation and motivation: a life-span perspective on underachievement,” In D.H. Schunk & B.J. Zimmerman (Eds.), *Self-regulation of learning and performance*. Hillsdale, NJ, Lawrence Erlbaum Associates, 1994, pp. 45-73.
26. Holton, D. L., “Enactive modeling as a catalyst for conceptual understanding: An example with a circuit simulation,” Published Dissertation, Vanderbilt University, 2006.
27. Ferris, D., & Tagg, T., “Academic listening/speaking tasks for ESL students: Problems, suggestions, and implications,” *TESOL Quarterly,* vol. 30, 1996, pp. 297-320.
28. Tsai, T. F., “EFL college freshman note-taking training for reading comprehension,” *The Journal of Human Resource and Adult Learning, vol.* 5, no. 2, 2009, pp. 12-18.
29. Hadwin, A. F., & Webster, E. A., “Calibration in goal setting: Examining the nature of judgments of confidence,” *Learning and Instruction*, vol. 24, 2013, pp. 37-47.
30. Dunlosky, J., & Rawson, K., “Overconfidence produces underachievement: Inaccurate self evaluations undermine students' learning and retention,” *Learning and Instruction*, vol. 22, 2012, pp. 271–280.