Metacognition Strategies to Improve Confidence and Academic Performance of Engineering Students

Quamrul Mazumder and Anita Ainsworth
University of Michigan-Flint
Flint, MI 48502
Email: qmazumde@umflint.edu

Abstract

Integration of metacognition strategies can increase the students’ knowledge about their own learning and empower them to self-regulate their learning process. To evaluate the students’ metacognitive abilities and how it contributes to their learning process as well as overall academic performance, a study was conducted in an introductory first-year, engineering classroom. Due to limited interaction between the professor and students in a large classroom, use of metacognition strategies may enhance the overall learning in the class. During the first two weeks of the class, students were taught about different metacognition strategies, tools, and techniques that they can use to become a better learner. Questions related to specific learning objectives were asked in the form of pre-tests and post tests before and after each lecture. Then, they were asked to discuss their answers in small groups and respond to the questions again. Students’ response to answers as well as their confidence levels on their answers were recorded.

The results of pre-test, post-test, post group discussion scores, and confidence levels were compared with their academic performance that was measured by quizzes, tests, and the final examination. It was observed that confidence levels of students as well as their exam scores increased as the class progressed. Higher correlation was observed between participation and final exam scores for students who asked questions using online metacognition tools compared to other students.

Introduction and Method

The study was conducted in a first-year engineering class, EGR102 in winter 2010 semester with 32 students where online metacognition software, LectureTools, was used. The objective of this study was to evaluate the effect of the students’ academic performance when using the metacognition software. LectureTools allows students to review lecture slides using their own laptop during the class as well as participate by asking online questions to the instructor. Students can also provide real-time feedback on their level of understanding of a particular lecture slide by using a scale of 0 to 10.

During first two weeks of the class instructions were provided about different metacognition strategies that students can use to monitor and improve upon their knowledge. Students were taught how to make study plans and use different learning techniques such as using mnemonic devices, sketches, concept maps, diagrams, analogies, etc. Instructions were provided about how to monitor their level of understanding using self-regulation strategies such as predicting outcomes using practice tests, reciprocal teaching and problem solving, comparing
their performance against a set of stated objectives, and how to improve their performance. Instructional strategies used in the classroom includes making students aware that they are responsible for their own learning, state objectives and learning outcomes, informal assessment focused on conceptual knowledge, encouraging reflection and revision, encouraging deep learning instead of surface learning, and development of high confidence level in their knowledge, etc. It was emphasized that higher confidence on their knowledge is equally important to the topic learned by the student.

![Diagram of Weekly Pre and Post-Test Data Collection Procedure]

**Figure 1: Weekly Pre and Post-Test Data Collection Procedure**

Before each class, students were given a pre-test questionnaire, with ten multiple choice questions that are relevant to the learning objective of that day. Students were asked to answer each question and at the end provide an overall confidence level measure using a scale of 0 to 10. After the lecture, students answered the same set of questions as post-lecture test and provided their confidence level. Students then met as a group and answered the same set of questions after discussing with their peers. Data was collected once a week throughout the semester using the procedure shown in Figure 1.

**Research Question:**

The work presented in this paper attempts to address how metacognitive strategies improve confidence levels which in turn can also improve academic performance. Another research question is to evaluate the changes in metacognitive ability of students throughout the semester, as well as any correlation between student participation and academic performance.
Literature Review

One of the greatest barriers to learning is the lack of the student’s ability to apply their knowledge in problem-solving due to their inability to achieve abstract thinking at a higher cognitive level. In order to demonstrate higher levels of cognitive strategies, confidence in their knowledge must be achieved through deep learning rather than surface learning, which is practiced by many of their peers. An important characteristic of successful students is that they are capable of assessing and regulating their learning behavior while striving for deeper understanding of how well they know and understand the material. An important aspect of learning is to possess a clear understanding of metacognition. To employ metacognitive strategies, the learner must be aware of how one learns and possess the ability to control his own learning process.

In order to embrace learning at a higher level, it is important for educators to consider adjustments in their methods of teaching. One such method to consider is brain-based learning. Brain-based classrooms are referred to as “brain-friendly places” such as those that foster the learning environments compared to traditional lecture only class with minimum or no discussion. In these locations, the brain’s function and the students’ role in learning is regarded in terms of the teaching and learning process. This brings an emotionally enriched environment, where learners are immersed in challenging experiences. In brain-based classrooms, it is presumed that learners are unique and that prior knowledge serves as a baseline for new learning.

One of the skills that brain-based learning focuses on is not just how to use thinking in the learning process, but about the thinking process itself. According to Caine & Caine, there are three phases to the learning and teaching process. These phases are not separate from one another, but instead, feed off of each other forming a symbiotic relationship. The phases are: (1) orchestrated immersion, (2) relaxed alertness, and (3) active processing. The aim of orchestrated immersion is to make the context of the subject matter meaningful and alive in the learners’ minds. Evoking emotion through various sensory organs will aide in the retention and recall process of the new information. It also assists in establishing patterns and associations in the brain, while at the same time providing learners with rich and complex experiences to make learning more permanent.

Relaxed alertness refers to challenging learners in a proper way, but with a very low level of threat. This establishes a sense of security which allows for more risk taking by the learner. The learners need to have a sense of security while being challenged in a relaxed and alert manner in order for them to establish association between the old and new knowledge.

Both of these methods play a significant role in the ongoing process of establishing a higher level of cognitive strategies, one that is necessary to employ metacognitive strategies required in the changing college curriculum and workplace. Active processing is the theoretical organization and internalization of the meaningful information by learners. This is important because it leads to the recognition of the metacognitive strategies relating to this study. One of the components of the active processing phase is evaluation. The five components of a reliable evaluation in brain-based learning are: (1) context, (2) emotions, (3) physical environment, (4) process, and (5) organization. The areas of evaluation involve the past, present, and future.
learning process - as well as the mental, physical, and emotional state of learning\textsuperscript{11}. In contrast to past procedures where summative evaluation was used, this evaluation procedure is both formative as well as summative. The objective is to understand the interests and understand the strengths and weaknesses of the students’ learning styles. To accomplish this goal within the evaluation process, the procedure cannot be threatening and should be motivating for the learners\textsuperscript{12}. It should be regarded as a focus on meaningful learning, rather than memorization. Nuan\textsuperscript{13} defined learning strategies as:

Strategies are the mental and communicative procedures learners use in order to learn and use language. Underlying every learning task is at least one strategy. However, in most classrooms, learners are unaware of the strategies underlying the learner tasks in which they are engaged.

It is also important to have knowledge of strategies employed, for the simple reason that the greater the awareness of what you are doing, the more conscious you are of the learning processes in which you are involved.

Results and Discussion

The weekly pre-lecture, post-lecture, and post group discussion scores and their corresponding confidence levels were plotted for one week as shown in Figure 2. As students become more familiar with the materials covered during the class, their confidence level and score both increases between pre-test and post-test as expected.

![Figure 2: Comparison of Weekly Pre and Post Test Scores with Confidence Levels](image)

Statistical analysis was conducted using SPSS 17 software by first aggregating the data using descriptive statistics such as mean and standard deviation. The dependent t-test was determined to be the most appropriate for this experiment. Comparable analysis was conducted using a one-way within subject’s analysis of variance (ANOVA) of confidence levels. A second
analysis of class participation was compared by calculating the actual performance in given conditions such as Quiz1 (Wks 1-4), Quiz2 (Wks 5-7), Final Exam (Wks 1-14). In other words, comparisons were made between actual exam scores and confidence estimates within a condition. This was done by comparing the percentage of questions answered correctly on a quiz or exam to the average percentage of the student’s confidence level for each condition. In addition, comparisons were made to the number of questions asked by students compared to the final exam scores.

**Table 1. Comparison of Examination score and Confidence Level (n =32)**

<table>
<thead>
<tr>
<th>Time</th>
<th>Quiz/Exam</th>
<th>Mean Score (%)</th>
<th>Standard Deviation (Score)</th>
<th>Mean Confidence (%)</th>
<th>Standard Deviation (Confidence)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wk 1-5</td>
<td>Quiz 1</td>
<td>67.78</td>
<td>2.090</td>
<td>88.2</td>
<td>11.317</td>
</tr>
<tr>
<td>Wk5-8</td>
<td>Quiz 2</td>
<td>73.94</td>
<td>6.618</td>
<td>81.7</td>
<td>12.246</td>
</tr>
<tr>
<td>Wk1-14</td>
<td>Final Exam</td>
<td>79.41</td>
<td>8.913</td>
<td>85.1</td>
<td>7.583</td>
</tr>
</tbody>
</table>

Two quizzes and one final examination were conducted during the semester. The confidence level of students during the previous week’s pre-test and post-test data were compared to determine any correlation with the exam score of students. The mean scores were lowest for the first five weeks and then began to improve, which means that the confidence level and academic performance has improved as the class progressed. This class was using the software LectureTools. It is difficult to determine whether this improvement was due to LectureTools or to the student’s normal increase in confidence as the class progressed. A second observation can be made because there was a large difference between mean score and mean confidence in quiz one as students were overconfident in their ability to assess themselves. The difference between their confidence and final exam score is lower, which demonstrates the improved ability of students to self-assess their own knowledge and predict outcomes. This improvement may be due to the metacognitive abilities developed during 14 weeks of class.

**Table 2: ANOVA between Online and In-Class Participation to Final Exam Score (n = 32)**

<table>
<thead>
<tr>
<th>Method of Participation</th>
<th>Level of Participation</th>
<th>F value</th>
<th>Level of Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Questions asked by hand (in-class)</td>
<td>50</td>
<td>0.484</td>
<td>P = 0.814</td>
</tr>
<tr>
<td>Questions asked on-line</td>
<td>54</td>
<td>2.908</td>
<td>P = 0.027</td>
</tr>
<tr>
<td>Total number of questions asked</td>
<td>104</td>
<td>2.047</td>
<td>P = 0.086</td>
</tr>
</tbody>
</table>
A one-way between subjects ANOVA was conducted. Total number of questions asked through in-class participation was fifty - slightly less than online questions. The total number of questions asked was used as a measure of participation which shows that the level of participation increased by 108% as a result of online metacognition tools. Another observation was that the online participants were primarily international, female, and minority students who did not feel comfortable asking questions during class. This observation can imply that the impact of online metacognition tools on international, female, and minority students were higher than other students.

The result p=.086 shows no significance; however, the value was approaching significance. This prompted the next tests, that involved separating the data and analyzing the variables individually (i.e. questions asked by hand and questions asked on line). First, an analysis of the number of questions asked by hand compared to final exam scores was conducted. The results of this analysis also showed no significant correlation (p=.814). Another comparison of the number of questions asked on-line (with the technology) to the final exam scores showed a significant correlation between variables (p=.027).

Summary and Conclusion

Integration of metacognition strategies can improve students’ abilities to self-assess and self-regulate their own learning which can also increase their confidence level on the subject. Improved confidence level showed better academic performance, as observed in this study. It is important to provide instruction about how to assess, evaluate, and monitor the students’ progress as well as their confidence level on the material learned.

The first research question was answered with data presented in Table 1, which shows an improved alignment between students’ confidence level and their academic performance. The difference between confidence level and score has decreased from quiz one to the final exam score. This may be due to students’ improved abilities to predict their outcome with a realistic confidence level. Comparison between students’ participation and their final examination score reveals a significant correlation between online participation and final exam scores. This demonstrates that the online metacognition software, LectureTools, was able to improve academic performance.

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References