AC 2010-1265: USE OF METACOGNITION STRATEGY TO IMPROVE STUDENT LEARNING

Quamrul Mazumder, University of Michigan - Flint

Anita Ainsworth, University of Michigan-Flint

Use of Metacognition Strategies to Improve Student Learning

Abstract

It is conceivable that over the next decade all students will have access to some form of internet-based device while attending classes. A preliminary study to assess students' understanding of the course materials and assessment of their behavior towards outcome is presented in this paper. This study investigates how meta-cognition influences student capacity to self-assess their understanding (learning), student regulation of their learning (confidence level), class dynamics (reaction) and instruction methods. Student self-assessment associated with the content knowledge and effort required to become successful in the examination will be evaluated. Students were asked to self-assess their confidence level in their answers. The correlation of expected results to predicted results on examination is expected to reflect on what the student thought they understood versus the outcome of their exam scores. The study evaluates how students regulate their own learning through self evaluation and improve their ability to self-assess their understanding more critically.

Introduction

The objective of this two-phase, sequential mixed method study is to explore participant views toward learning to develop and test a meta-cognition instrument. The first phase is an investigation of meta-cognitive strategies currently utilized by engineering students, determined by comparing pre- and post-survey results to test scores in an introductory engineering course. Results from this investigation will be used to determine whether meta-cognitive tools improve learning, confidence levels, reactions and instruction methods in the engineering courses offered at the University of Michigan-Flint. The study results will also be used to determine how a computer-based interactive meta-cognition tool can be used to improve student learning during the second phase of this study.

This study focuses on four areas of students self-assessment or evaluation: (1) learning (which meta-cognitive strategies are employed by students while learning), (2) confidence level (measures the relationship between students' meta-cognitive strategies and their performance), (3) reaction (differences in meta-cognitive strategies between the more accomplished students verses less competent students), (4) instructional methods (how students engage meta-cognitive strategies when the methods and materials being presented are already familiar to the students). A preliminary analysis of the level of understanding of the course material along with a comparison of pre-test and post-test survey results with academic performance may provide an understanding into how the effects of meta-cognition on academic performance is presented.

Background

Examining the works of the late Dr. Pausch show he believed the best way to help students learn was to teach them how to judge themselves [1] to become more self-reflective learners. He would ask: "Do they recognize their true abilities? Do they have a sense of their own flaws? Were they realistic about how others viewed them?" Educators need to equip their students with

the ability to judge for themselves how they were progressing. [1] This technique is referred to as meta-cognition strategies for higher learning. The purpose of this study is to determine if students who use meta-cognition strategies are more likely to improve their ability to acquire knowledge compared to those who do not use these strategies. Further, are students aware of these strategies or do they need to be taught the techniques to recognize their true potential? Are they able to facilitate this process on their own or should they be aided through the use of technology? This study explores the learning process, meta-cognition and whether an interactive meta-cognition tool can facilitate self-reflective learning.

Overview of Learning

Operant learning involves a mechanical process, such as rote learning, whereby the learner uses memorization through repetition, without a thorough understanding of the material being learned. Higher order of thinking is reflected through meaningful learning, which takes the newly learned material and applies it to a concept or theory that has been previously learned by forming a relationship between the two so that the mechanics of the new information make sense.[2] Higher order thinking is based on three main criterions: the first is the utilization of abstract structures for thinking; [3] the second involves organization of information into an integrated system; [4] the third criterion requires the application of sound rules of logic and judgment. [5] The original question remains unanswered: are students aware that these strategies exist or do they need to be taught these techniques in order to recognize their true leaning potential?

The concept of higher learning had always been a challenge for educators until David Ausubel introduced his systematic approach to teaching it. He proclaims that ideas are linked together in a regular sequence, where all of our thoughts and ideas are in smaller receptacles, which are then inserted into larger ones to be stored. The larger receptacles subsume the smaller ones creating a classification system for our thoughts, whereby the subsumers become the main categories. [6] Basically, subsumers lay the foundation for information to be categorized. Ausubel contends that "subsumption may be described as facilitation of both learning and retention" [7], and these subsumers act as anchoring devices for newly acquired information.

Ausubel stresses "existing cognitive structure, that is an individual's organization, stability, and clarity of knowledge in a particular subject matter field at any given time, is the principal factor influencing the learning and retention of meaningful new material" .[8] "If this ideational scaffolding is clear, stable, and well organized," Ausubel and Fitzgerald point out, "it is reasonable to suppose that it provides better anchorage for new learning and retention than if it is unclear, unstable, and poorly organized". [9] This demonstrates why meaningful learning is fixed in the mind longer than rote learning. In addition, he claims that "having a clear and well organized structure is also in its own right the most significant independent variable influencing the learner's capacity for acquiring more new knowledge in the same field". [10]

Ausubel goes on to explain that "the learning and retention of unfamiliar but meaningful verbal material can be facilitated by the advance introduction of relevant subsuming concepts" [11]

which are referred to as organizers. Organizers are abstract concepts that are introduced prior to the lesson, which assist in connecting the dots between what has already been learned and what has yet to be learned. "Organizers are particularly useful when learners do not already possess the relevant concepts needed in order to integrate new information into their cognitive systems". [12] Ausubel also pointed out these organizers "facilitate the learning of factual material more than they do the learning of abstract material, since abstractions in a sense contain their own built-in organizers". [11] Meaningful learning is the higher order thinking that occurs when we embrace the connection between the old and the new ideas.

Ausubel and Robinson maintain the following prerequisites for meaningful learning to occur: (1) the material presented to the learner be capable of being related in some 'sensible' fashion, (2) the learner must possess relevant ideas to which the new ideas can be related or anchored, (3) the learner must actually attempt to relate, in some sensible way, the new ideas to those which he presently possesses. If all of the above conditions are not present, this will become rote learning instead of meaningful learning. [13]

Overview of Meta-cognitive Strategies

Meta-cognitive strategies are beyond the cognitive strategies which help learners regulate their own cognition and focus, plan, and evaluate their progress as they move toward communicative competence. [14] They are management techniques by which learners control their learning process via planning, monitoring, evaluating and modifying their learning approaches. It has been found that cognitive approaches to achievement motivation suggest that low self-perceived ability inhibits achievement and that high ability estimates foster and encourage achievement .

Methodology

Experimental Design. The study was based on a 3 x 2 (number of hours spent preparing for test; 1=less than 1 hour, 3=1-3 hours, 5= 4+hours) x (perceived ability; high or low) subjects factorial design.

Participants. Participants were 21 male students and 2 female students from the University of Michigan-Flint campus, ranging in age from 18-24 years. They were recruited for this study by being enrolled in Intro to Engineering 102. Each student received five extra credit points for participating in this study although participation was voluntary.

Experimental design and procedure. Prior to taking their midterm exam, participants were asked to complete a pre-test survey which was designed to measure their level of perceived ability and confidence in the subject matter. Next, they took the mid-term exam after which they were asked to complete a post test survey to assess the level of accuracy of their knowledge about the subject matter. In this study, there were 2 dependent variables, one with 3 levels (hours spent preparing; 1, 3, or 5) and one with 2 levels (perceived ability; high or low). Therefore, that data was analyzed using a 3 (hours preparing) x 2 (perceived ability) between subjects ANOVA using SPSS software. The results of the pre-test were compared to mid-term exam scores and later the mid-term exam scores were compared to the post test survey to

determine how accurate they determined their assessment of understanding the subject matter. The next phase of this study will involve a true experiment with a control group using an online meta-cognition tool "LECTURETOOLS" to determine if meta-cognitive strategies improve learning amongst students at the University of Michigan-Flint.

Results

To test our model's assumption that low perceived ability impedes performance and that high level absorption advances achievement to areas of their strengths, a 3 x 2 between subjects ANOVA was conducted to evaluate whether time spent studying for exam and confidence levels had an impact on academic performance on exams.

It was assumed that students may regulate their own learning and improve their ability to self-assess their understanding more critically. Number of hours spent studying is a between subject variable with 3 levels (1=less than 1 hour, 3= 1-3 hours, 5= 4+ hours); perceived grade was the other between subjects variable with 2 levels (high and low). The main effect of the between subjects variable perceived grade was not significant using a critical alpha of .05, $F(1,6) = .139$, $p = .722$, $\eta^2 = 27.37$. This indicates that students with a high grade expectation did not necessarily do better than students with a low expectation. Table 1 shows the descriptive statistics of perceived grade of students reported different amount of time preparing for the final examination.

Table 1: Descriptive statistics for hours spent studying and perceived grade.

Hours spent studying	Perceived Grade Low=Below 75% M (SD)	Perceived Grade High=75% above M (SD)
Less than 1	2.869 (.194)	2.820 (.198)
1 – 3 hours	3.089 (.080)	2.772 (.138)
4 or more		**3.235 (.203)**

The main effect of the between subjects hours spent preparing variable is not significant using a critical alpha of .05, $F(2,6) = .261$, $p = .778$, $\eta^2 = 51.357$, thus it showed not significant effect related to hours spent preparing for the exam. The interaction between perceived grades and hours spent studying was not significant using a critical alpha of .05, $F(1,6) = .130$, $p = .731$, $\eta^2 = 25.565$ indicates that there were no combination of factors contributing to the results, such as the number of hours preparing or higher level of confidence being linked to a higher actual academic outcome.

In addition a 2x2 between-subjects ANOVA was conducted with actual exam scores as the dependent variable and grade expected and hours per week spent studying as the independent

variables. The results indicated that there were no significant results and no main effects on any of the above mentioned variables.

A study known as Cronbach's alpha was also conducted to estimate the internal consistency of the items used to determine the confidence assessment scale of the students. Coefficient alpha for the scale was .644, indicating a medium degree of internal consistency among the items on the scale. The means of the individual items ranged from 1.54 to 3.04, with a mean on the total scale of 12.36 (SD = 3.76). Overall, the participants' responses on the scale indicated that they possesses a mid range level of confidence with regard to their understanding of the subject matter.

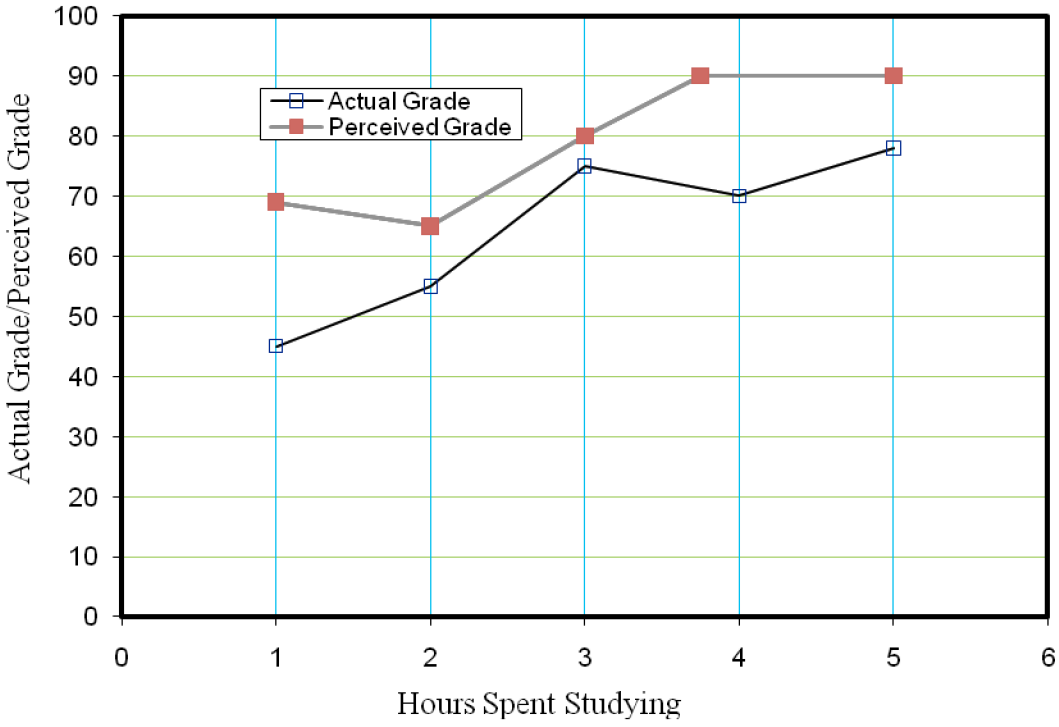

Figure 1: Comparison of mean perceived grade with actual grades.

Figure 1 shows a comparison of students' perceived grade to their actual grades as relates to number of hours spent in preparing for the examination. The data reflects overestimation of students perception of their performance in the examination due to lack of meta-cognition skills indicating that students are not able assess their level of understanding and prediction of outcomes. With improved meta-cognition skills, the gap between their perception and actual performance may become smaller.

Discussion

Introduced in the first phase was an experimental paradigm evaluating the study of meta-cognitive behavior. Overall performance was based on each participant's assessment of their knowledge of the subject matter. It was hypothesized that the students' confidence level would affect the actual score they received on their exams. This level was compared to their actual

performance, based on exam scores. No significant effect was revealed to link the number of hours spent studying for an exam and the confidence level of the ability of the student to predict the grade expected to achieve on the exam. Our hypothesis that low perceived ability impedes performance and high level absorption advances achievement was not supported. However, it is important to note the very small sample size, thus the result of the early phase of this study has very low statistical power. It is also important to emphasize that students were chosen to participate from the Engineering 102 class; this is not representative of the entire population at the University of Michigan-Flint. Further studies in this area will be conducted with more random assignments when selecting samples for these studies.

Phase 2 of this study will investigate if students are even aware of meta-cognitive strategies to empower them, and how these strategies will enhance their abilities if they were to use them to facilitate the learning process. Since many of the meta-cognitive strategies can be taught to students, it would be plausible for educators to incorporate new methods and tools to facilitate the use of meta-cognitive strategies which can improve student achievement.

There are several implications for teaching meta-cognitive strategy. First, students may not be aware of the importance of utilizing meta-cognitive strategies because, unless reinforced by a teacher, they do not realize the importance of the process. Secondly, in order to properly incorporate these strategies into the classroom, teachers must first teach a subject in-depth, to form the requisite firm foundation of factual knowledge. [15] The teacher must bring a wealth of experience of in-depth study of the subject matter. They must be familiar with the "process of inquiry between information and the concepts that help to organize that information in the discipline". [15] Thirdly, teachers must acknowledge that all students bring different experiences and backgrounds into the classroom, thereby making students' understanding and ability to process these concepts different from one another. Teachers must embrace the growth and development of the students' thinking and understanding of ideas. Future studies should be done on tracking the age at which students are taught to implement meta-cognitive strategies and compare this to their academic achievement. The study will also compare students' organizational skills to see if there is any correlation between the way they organize their thoughts and their level of academic achievement.

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