Metacognition: Helping Students Plan, Monitor, and Evaluate Study Skills and Strategies

Dr. Muhammad Dawood, New Mexico State University

Dr. Muhammad Dawood received his BE degree from the NED University of Engineering and Technology, Karachi, Pakistan, 1985, and his MS and Ph.D. degrees, the University of Nebraska-Lincoln, in 1998 and 2001, respectively, both in electrical engineering. Dr. Dawood is involved in teaching both nationally and internationally since 1995. At present, Dr. Dawood is an Associate Professor at the Klipsch School of Electrical and Computer Engineering, New Mexico State University (NMSU), Las Cruces, New Mexico. Dr. Dawood's research interests lie in the area of Engineering Education, EM Propagation through Dispersive media; radar; and Antennas; He is a member of IEEE.

Dr. Karen Trujillo, New Mexico State University

Dr. Karen Trujillo has been an educator for over 20 years. She started as a teacher, became an administrator and has been a research faculty member at NMSU for six years. She has been a PI and Co-PI of multiple NSF grants focused on STEM Education. She is the director of The Alliance for the Advancement of Teaching and Learning and recently started the STEM Outreach Alliance Research Lab (SOAR) to study the impact of STEM Outreach efforts at NMSU. She also serves as the State Director for Educators Rising NM and the Co-Chair of the New Mexico Math and Science Partnership.

Dr. Patti Wojahn, New Mexico State University

As past Writing Program Administrator, I worked closely with many academic departments interested in supporting the writing and communication abilities of their students. For many years, I worked with Integrated Learning Communities for at-risk entry-level engineering majors, overseeing development and use of a curriculum adapted specifically for this group. I continue to analyze data from research studies exploring challenges and identifying at-risk characteristics among students in first-year writing courses. Presently, I work on an initiative focused on writing in the disciplines as part of our university's Higher Learning Commission 10-year re-accreditation cycle. As Borderlands Writing Project Director, I also work with K-16 teachers to strengthen quality in using writing in their courses to help students learn, regardless of discipline.

Dr. Melissa J. Guynn, New Mexico State University

I am a cognitive psychologist with a primary interest in human memory.

Mr. Luis Manuel Rangel Jr.
S. M. Yahea Mahbub, New Mexico State University

Metacognition: Helping Students Plan, Monitor, & Evaluate Study Skills & Strategies

Abstract: In STEM education, numerous studies have explored how instructors, pedagogy, and curriculum affect student learning, with less attention paid to the impact of student characteristics on academic performance. Yet students' own beliefs, choices, practices, and behaviors can and do affect their academic outcomes. Applying research on learning from the fields of education and the social and behavioral sciences is only now impacting research in undergraduate engineering education, one of five major shifts in this field during the past 100 years. Still, engineering education research has not drawn widely on the existing research on metacognition— monitoring, understanding, and controlling thoughts that may lead to more productive behavior and practices. In 2016, a multi-disciplinary team of researchers at a Hispanic Serving Land Grant University in the Southwest embarked on a study of how the introduction of metacognition and strategies on "learning how to learn" to engineering students could impact their performance in class. Our preliminary data indicates that 75% of freshmen, 50% of sophomores, and 35% of juniors do not routinely adopt effective study strategies. Our NSF-funded research project focuses on freshman students enrolled in Engineering 100, Introduction to Engineering, which is part of the innovative First-year "Engineering Experience" program. Along with improving instruments to assess metacognitive thinking, we are developing minimally-intrusive interventions including a workshop, handouts, and reflective writing designed to improve students' metacognitive awareness (their ability to monitor and control their own learning) and knowledge of effective study strategies. This paper presents preliminary findings on this intervention. Pre-post results are discussed for students who received the metacognitive awareness and study strategy intervention versus those who did not.

Introduction

Retention and graduation are prominent concerns in engineering education. In 2007, the average retention rate at U.S. engineering schools was just 56% [1]. Using 2016 data from 150 engineering schools, Veenstra et al. [2] states that the 5-year graduation rates vary widely among colleges of engineering and is related to the first year retention rate. The research implies that colleges with a 90% first year retention rate have a 72% 5-year graduation rate and colleges with a 66% first year retention rate only have a 33% 5-year graduation rate. In the College of Engineering (CoE) at our university, the two-year retention rate is only 47% and the graduation rates are 16% and 29.3% over 4 and 6 years, respectively. These statistics prompted the CoE at this university to launch a first-year engineering learning-community program in Fall 2014, adding a new course: ENGR 100: Introduction to Engineering. This course helps launch a holistic student-centered environment, as advocated by American Society for Engineering Education (ASEE) [3-4] and others [5-7].

While examining 50 attrition studies spanning 6 decades from engineering programs, Geisinger et al. [8] identified five factors that contribute to poor retention rates in engineering nationwide. These factors include classroom and academic climate; grades and conceptual understanding; self-efficacy and self-confidence; interest and career goals; and race and gender. Of primary concern are both discipline-specific skills and knowledge (e.g., mathematics), as well as more general, non-discipline-specific self-efficacy and metacognitive knowledge and skills. *Metacognition*, often defined as “thinking about thinking,” is primarily about knowing, understanding, monitoring, and controlling one’s cognitive processes, leading to altered and ideally more productive behaviors [9] – [13]. The study of *metacognition* is not new, having gained traction in the late 1980s; however, attention to it is sparse in engineering education.

Further, students are often deficient in understanding and implementing metacognition skills [14], [12], [13], and how to utilize available resources for improved learning [15]. In fact, preliminary data from our earlier research indicated that 75% of freshmen, 50% of sophomores, and 35% of juniors do not routinely use effective study strategies, with a letter-grade difference between those who do versus who do not [16] - [17]. Fortunately, students' levels of self-efficacy and their ability to monitor their own learning are factors that can be changed and improved through appropriate interventions [18], [19]. *Metacognitive awareness* can strengthen their ability to recognize the limits of their current learning practices, and then take steps to remedy the situation; such awareness is valuable for learners at all ages [20]. Further, metacognitive strategies and practices can enhance learning and impact student achievement [21] – [26].

Motivation

Although recent studies [12] - [15], [21] - [27] indicate the effectiveness of metacognition in promoting student success in college science learning, in the STEM literature, much attention has been paid to the roles of instructors, pedagogy, and curriculum, with comparatively less attention on how student characteristics and habits impact student learning. Yet research in other disciplines shows that students' own beliefs, choices, practices, and behaviors does impact student academic outcomes [28]. Self-efficacious students have been found to persist, engage more, and set and achieve higher goals in academic tasks [18] – [19], [29] – [32].

Following a workshop on metacognitive awareness and study skills by McGuire [33] in Fall 2013, we developed a self-evaluation survey, now called the “Self-Evaluation Study Strategy Instrument” (SESSI) to identify student study practices. Since Fall 2013, this survey has been administered to students in electrical engineering classes and iteratively improved. Details of this survey and the interventions used in this course can be found in [16], [17]. The SESSI allows classification of students into one of two groups, namely Type 1 (Poor study habits) and Type 2 (Good study habits). Averaged over eight semesters for one junior-level electrical engineering class, the students whose responses placed them in study practices Type 2 (Good) had an average exam 1 score of 78% as compared to Type 1 (Poor) students, with an average score of 66%. This data highlighted concerns mentioned above that many students are not aware of how to optimize their own learning. From Fall 13 through Fall 17, these SESSI results were shared with the classes along with a 50-min workshop on metacognition and related strategies for learning [33]. Students were also provided with one-page study strategy handout and were asked to implement at least two strategies from this handout as they prepared for their next exam. After the third exam, the SESSI was re-administered, resulting in almost all students indicating efforts to move to Type 2 (Good). The result was that most of the students were able to improve their performance on the subsequent tests and in the course. After observing these promising findings, the research team embarked on a multi-year study at NMSU to try to improve the metacognitive knowledge and skills of the students enrolled at the very beginning of their engineering education, in ENGR100, in order to improve their grades, ideally improving retention and graduation rates.

Although our study takes up several different aims, in this paper, we are interested in whether students in a Fall 2017 experimental group (attending a workshop about metacognition and taking part in reflective assignments) relative to a control group showed improvement in their metacognitive awareness or self-reported study strategies from the beginning of the semester (pre-test survey) to the end of the semester (post-test survey). In addition, we were interested in whether or not the results on these survey instruments were related to overall student performance.

Methods

A. Participants

The participants in the study reported here were all Fall 2017 freshmen enrolled in ENGR 100, Introduction to Engineering. The course is designed to acquaint students with various engineering majors; introduce them to the engineering-relevant aspects of various systems and devices; highlight relationships among engineering, mathematics, science, and society; and help students develop skills that will be needed later in the major and in the field.

There were 12 sections of ENGR 100 during the Fall 2017 semester (8 experimental and 4 control), with approximately 30 students per section. Due to the fact that some instructors taught more than one section per semester and were involved in the project in prior semesters, it was not possible to randomly assign sections to the experimental and control conditions. Data were collected from all students, but only students who completed both a pre-test survey and a post-test survey were included in the study, a total of 252 students, 79 in control and 173 in experimental groups.

B. Data Collection

In the Fall of 2016 and the Spring of 2017, the research team administered the Metacognition Awareness Inventory (MAI) and the Self Evaluation Study Skills Instrument (SESSI) to all ENGR 100 sections. The MAI is a 52-item self-report inventory developed to measure metacognitive awareness in adults [34]. Cited at least 215 times since its publication in 1994, this inventory was developed to measure major components of metacognition identified in the literature: cognitive knowledge and cognitive regulation. It is a reliable and valid way to identify metacognitively-aware versus metacognitively-unaware learners. SESSI as reported in [16-17] is an instrument developed at NMSU and refined over 8 semesters (since Fall 2013) with students in an electrical engineering course. SESSI has shown promise in the preliminary studies [16-17] and is a much shorter version (compared to the MAI or LASSI [35]) with strong potential to be adopted in the future by engineering faculty.

After these two semesters (Fall 2016, Spring 2017) of data collection, we first focused on identifying which, if any, of the MAI questions showed a relationship with student achievement and which did not. After conducting an item analysis of the MAI survey data, and comparing the results of the survey to test scores, it became apparent that the MAI had some problems: 1) there were too many survey items for students to remain focused until completion, and 2) some survey items were ambiguous. This resulted in our creation of a modified Metacognitive Awareness Inventory (MMAI) consisting of 20 prompts. These 20 items were also reworded to make them more clear. Similarly, one survey item (#9) in the SESSI was reworded. During the Fall 2017 semester, the MMAI and the revised SESSI instrument were administered to all students in ENGR 100 during time-point 1, one week after Exam 1 and during time-point 2, one week before the Exam 4, final exam.

C. Interventions

In addition to evaluating the survey instrument itself, we set out to compare survey results between the treatment and control conditions. The students in the experimental group engaged in a workshop, received an informational handout on metacognitive strategies, and were asked to answer periodic online reflective writing prompts related to metacognition and their study practices; the students in the control group received none of these.

*Intervention 1***:** *50-min Lecture and Materials on Metacognition, Self-efficacy, and Bloom's Taxonomy*: Shortly after the pre-test survey had been administered, one class period was devoted to our workshop intervention. This workshop included literature about effective learning strategies and our longitudinal data on connections study strategies and grades. Bloom's Taxonomy, metacognition, and self-efficacy were also discussed, emphasizing how and why strategies that were effective in high school are not necessarily adequate to succeed in college. A copy of recommended strategies was given to participants, who were asked to complete brief assignments inviting them to apply metacognitive awareness to plan future approaches to studying. They were advised to target 2-3 strategies as they prepared for subsequent exams.

Intervention 2: Journaling/Reflective Writing: Reflective journals are powerful tools that encourage students to think about their study behaviors and the outcomes of those behaviors. These prompts were administered online via the online learning management system at four points in the semester, calling on students to reflect on their learning strategies and outcomes, with such prompts as the following: *"To what extent were the learning/studying practices you used to prepare for Exam 1 typical of how you study for classes?" "Which of the study strategies provided in the workshop have you used in the past?" "Which look like useful options for you to adopt as you prepare for future exams?"*

D. Data Analysis

The revised instruments, MMAI and SESSI, were used during the Fall 2017 semester, in 8 experimental sections and 4 control sections. Students' scores from the four ENGR 100 exams were also collected.

This study uses multilevel modeling, common in the social sciences for naturally nested data [36]. Here, Model 1, the student-level model, assesses the growth or change in student exam and MMAI scores over time. Model 2, the teacher- or intervention-level model, assesses the effects unique to the assigned treatment conditions and the MMAI scores.

Instead of two treatment conditions (control and experimental), the data are grouped into three treatment conditions, namely, control, experimental, and modified. The modified condition was so characterized when we realized that two of our experimental sections had also been administered additional Self-Efficacy instruction by other researchers also studying student learning. Thus, our experimental group consisted of 6 sections (n=6), our control group consisted of 4 sections (n=4), and our modified group consisted of 2 sections (n=2). Further, only preliminary results related to MMAI are reported in Section IV below.

Preliminary Findings and Discussion

A. Student Performance on Exams by Treatment Condition

The four exams in ENGR 100 varied in content and difficulty, and student performance on one exam therefore did not necessarily predict performance on other exams. In considering what instructors might want to see as "growth" in performance, we (not surprisingly) found that exam performance overall did not rise in a linear manner as shown in Fig. 1, below. We set out to track exam performance by condition (Experimental, Control, and Modified). (We must note that we are still gathering information about the self-efficacy interventions that we discovered took place in the two Modified sections, conducted by researchers of whom we were not aware at the time of our study. It is therefore difficult for us to explain the performance of those in the Modified condition, who had originally been assigned to our Experimental condition.)

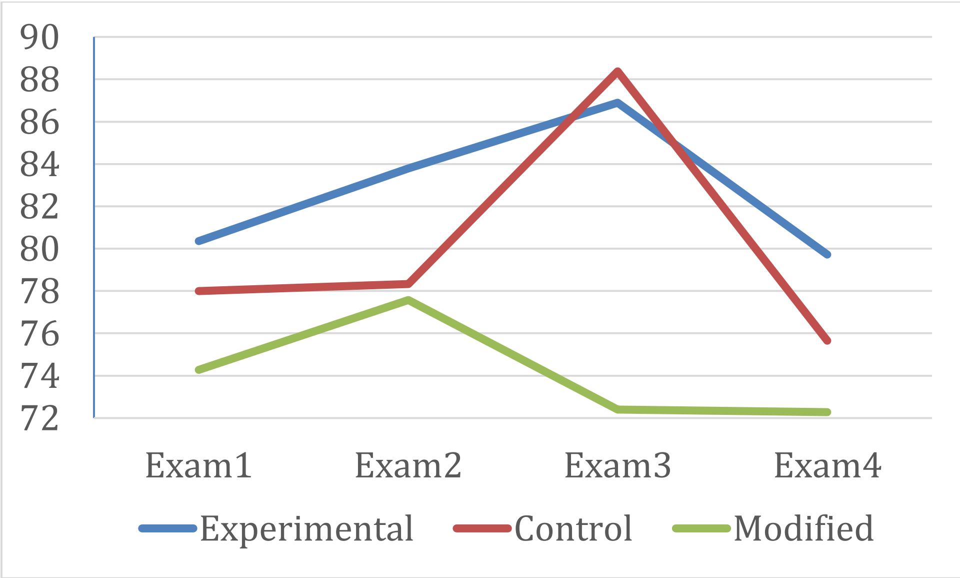

Figure 1: ENGR100 Mean Exams Scores by Condition, Exp = experimental, Ctl = control, Mod = modified.

To test whether students in the three conditions were similar at the onset, we explored mean scores on the first exam, which took place before any intervention. Analyses indicate that on this first exam, mean scores for students in the two conditions (experimental and control) did not vary significantly (80% vs. 78%), as depicted above in Figure 1, which shows pretreatment equivalence between these two groups. However, the Exam 1 score for the modified group is 74%, relatively lower than that for the other two groups.

On Exam 2, students in the experimental group performed significantly better than did their control group counterparts (84% vs. 78%, $p = 0.0097$). Between Exam 1 and Exam 2, the experimental group received the first part of our intervention. Specifically, these students took part in a workshop that included a lecture and assignments asking students to review, discuss, and apply new metacognitive and study skills knowledge. These students (in the experimental group) had also completed two of four journal prompts asking them to reflect on their own learning and study practices.

There was no significant difference in scores between the experimental and control groups (87% vs. 88%, respectively) on Exam 3. One possible explanation is that the control students worked to gain momentum in the course after not performing as well as they had wanted on Exams 1 and 2. That said, it is the case that the experimental students were showing a linear growth in exam score performance up until the final exam (Exam 4).

When it came to the final exam (Exam 4), however, students in the experimental condition once again performed better than did those in the control condition, although the difference was not quite statistically significant ($p = 0.0537$). In future analyses, we will explore the qualitative data that were captured in experimental students' reflections at four points during the semester, typically before each exam. These four prompts, eliciting reflective writing from the experimental students, were structured to reinforce the information (lecture, handouts, assignments) introduced in the workshop. We hope these reflective responses will help explain the better exam score performance of students in the experimental group than the control group on two of the three exams following the initial Exam 1.

We note that it is clear in Figure 1 that students in the modified condition tended to differ on exam performance from students in the experimental and control conditions after Exam 1. For instance, although there was a moderate advantage for those in the experimental as opposed to the modified group on Exam 2 (84% vs. 78%, p = 0.098), experimental group performance showed an advantage over modified group performance for both Exams 3 and 4 (87% vs. 72%, p = 0.0001, and 80% vs. 72%, p = 0.048, for Exam 3 and 4 respectively). We also noted a difference in average scores between the modified and the control groups for Exam 3 (72% vs. 88%, p = 0.0001). We wonder whether the two modified sections (i.e., students who were unintentionally included in two separate but somewhat related studies) added confusion, over-stimulation, or overload of information, interfering with learning the course material itself in those two sections. Due to the "noise" in these two modified groups, we do not want to dwell further on the exam results from the two modified sections at this point.

B. Effects of Metacognitive Teaching Strategies on Students' Metacognitive Thinking

The second analysis was carried out to investigate the effect of our interventions on students' metacognitive thinking, as measured by MMAI scores, pre and post. As with the first exam scores, students' initial MMAI scores did not vary by condition. In other words, regardless of condition, students began the semester with similar MMAI scores.

Given our interventions emphasizing metacognitive thinking, we anticipated students' MMAI scores to change more in a positive direction in the experimental than in the control sections. There was, however, no significant difference between the experimental and control groups in scores on the post-MMAI survey.

Although we had assumed we would do so, we did not find an association between an increase in grades and an increase from the pre-MMAI scores to the post-MMAI scores; students who had improved grades on exams did not correspondingly improve in MMAI scores. This was somewhat surprising given that we had initially seen that pre-survey MMAI scores significantly interacted from Exam 1 to Exam 2 ($p = 0.0412$). In other words, we could predict students' Exam 2 score direction based on their MMAI scores. We learned from a model assessing variability that a student's initial MMAI score, although predictive of Exam 2 score, is not a good predictor of how students perform overall in a course. The model shows that growth in student scores between Exam 1 and Exam 2 can be explained by initial MMAI scores, and that scores on Exams 3 and 4 were more reliant on which condition students were in (e.g., experimental, modified, or control).

Still, we looked further into possible connections between grades and MMAI scores by establishing a definition of "good" students as those who either increased by 10 points or more between Exam 1 and Exam 3 or maintained a "B" or above across the semester. This category of "good" students accounted for about 39% of the total population in Fall 2017 (98 of the 252 total in Fall 2017). Within this 39% of "good" students, three-quarters were more likely than were students *not* categorized as "good" to maintain their MMAI scores throughout the course, with an average variation of just one unit (out of 60) increase or decrease between pre- and post-surveys. This suggests that "good" students might come in with an established awareness of metacognitive practices for learning.

As we move forward, we will continue to examine our results more deeply, assessing results from the reflective journals on self-reported study practices and attempting to use these to better understand the exam scores, particularly among those students in the experimental group. We will also connect our Fall 2017 data to data collected in our initial semesters of this project. For now, we are satisfied that the interventions are showing some promise. Moreover, to date, we have achieved our aim to keep the interventions as minimal as possible with an eye to offering ready materials - and instruments to assess the materials - to the broader field.

Conclusions and Future Work

The initial focus of our effort reported on here was to develop and evaluate our streamlined MMAI survey, and to deliver what we prepared as an informative workshop on effective study habits and learning strategies, encouraging students to improve their metacognitive awareness and, in turn, study strategies. This paper presents some preliminary findings from the Fall 2017 data.

Compared to those in the control group, students receiving our interventions performed significantly better on two of the four exams: Exam 2, which occurred just after the metacognitive and study skills workshop, and the final, Exam 4. They carried the momentum until Exam 3, falling slightly at Exam 4 (the final exam).

Moreover, MMAI scores significantly predicted test score changes between Exam 1 and Exam 2. Although overall exam score averages did not differ between the conditions as much as we had anticipated, students in the experimental condition had higher exam score averages (83%) than did students in both the control (80%) and the modified (74%) sections. The effect of the metacognition intervention on students' self-reported metacognitive strategies was modest and the relationship between students' MMAI scores and exam scores overall was weak.

We have learned a number of lessons through this research. Particularly, we see that despite our aim to intervene minimally in an engineering class, a single 50-min metacognition workshop may not be enough to produce a sustained change in student behavior across the entire semester. At the same time, our future analysis of written reflections may reveal that students were taking in lessons that they can build from in future semesters, even though the immediate effect was not great. Thus, we intend to increase the frequency of journal prompts to try to keep students reflecting on their behaviors and how these relate to their performance, along with reporting our findings on students' own take on their learning and performances. Future analyses will also allow us to connect results from the SESSI survey to those from the MMAI reported here. Ultimately, we will be offering not just data-informed interventions to improve students' metacognitive awareness and study strategies but also streamlined instruments to measure students' growth in these areas as well as potentials for growth in learning, performing, and procuring degrees in engineering. After completing our fuller analyses, we will report our findings to make further contributions to the field in these areas.

Acknowledgements

This work was supported by two NSF grants, Award # 1612445 and Award # 1564931

References

[1] Thomas K. Grose, (2012). "The 10,000 Challenge," PRISM-American Society for Engineering Education (ASEE), See <http://www.prism-magazine.org/feb12/feature_02.cfm>
[2] Thoughts on Variability in Graduation Rates at Engineering Colleges, May 25, 2016 <https://www.veenstraconsulting.com/blog/2016/5/24/thoughts-on-variability-in-graduation-rates-at-engineering-colleges>, accessed on 2/4/2018.
[3] American Society for Engineering Education (ASEE). Best Practices and Strategies for Retaining Engineering, Engineering Technology and Computing Students: Going the distance. See <http://www.asee.org/retention-project>

[4] American Society for Engineering Education. Creating a Culture for Scholarly and Systematic Innovation in Engineering Education. (2009). See http://www.asee.org/about-us/the-organization/advisory-committees/CCSSIE/CCSSIEE_Phase1Report_June2009.pdf

[5] George Kuh, (2008) "High-Impact Educational Practices – what they are, who has access to them, and why they matter." See http://www.neasc.org/downloads/aacu_high_impact_2008_final.pdf

[6] David L. Kirp, (2014). "How to Help College Students Graduate," The New York Times-Opinion Pages. See. http://www.nytimes.com/2014/01/09/opinion/how-to-help-college-studentsgraduate.html?action=click&contentCollection=Arts&module=MostEmailed&version=Full&regi

[7] Henry M. Levin and Emma Garcia, (2013). "Benefit-cost analysis of accelerated study in associate programs (asap) of the City University of New York (CUNY)," Center For Benefit-Cost Studies In Education, Teachers College, Columbia University, May 2013. < http://www.cuny.edu/academics/programs/notable/asap/Levin_ASAP_Benefit_Cost_Report_FINAL_05222013.pdf>

[8] Brandi N. Geisinger and D. Raj Raman, "Why They Leave: Understanding Student Attrition from Engineering Majors," International Journal of Engineering Education Vol. 29, No. 4, pp. 914–925, 2013

[9] Falwell, J. H., (1979), "Metacognition and cognitive monitoring: A new area of cognitive developmental inquiry," American Psychologist, 34, pp. 906-911, 1979.

[10] Martinez, M. E., (2006), "What is Metacognition," Phi Delta Kappan, pp. 696-699, May 2006.

[11] Livingston, J. A., (1997), "Metacognition: An Overview," 1997. Accessed at <http://gse.buffalo.edu/fas/shuell/cep564/metacog.htm>

[12] Cunningham Patrick, Matusovich M. Holly, Hunter N. Deirdre-Annaliese, Williams A. Sarah, and Bhaduri Sreyoshi, "Beginning to Understand Student Indicators of Metacognition," American Society for Engineering Education, 2017.

[13] Cunningham Patrick, Matusovich M. Holly, and McCord E. Rachel, "Teaching Metacognition: Helping Engineering Students Take Ownership of Their Own Learning," Frontiers in Education, IEEE Proceedings, October 21-24, 2015, Texas.

[14] Taner D. Kimberly, "Promoting Student Metacognition," CBE—Life Sciences Education, Vol. 11, 113–120, Summer 2012.

[15] Chen Patricia, Omar Chavez, Desmond C. Ong, and Brenda Gunderson, "Strategic Resource Use for Learning: A Self-Administered Intervention That Guides Self-Reflection on Effective Resource Use Enhances Academic Performance," Psychological Science 2017, Vol. 28(6) 774–785.

[16] Dawood M., "Metacognition, Study Habits, Learning, and Grades," 2016 Frontiers of Engineering Education Symposium, September 25-28, 2016. https://www.naefoee.org/symposia/currentsymposium.aspx?tabid=17137

[17] Muhammad Dawood, John Tapia, Karen Trujillo, Mellisa Guynn, Patti Wojahn, "Preliminary results on students' study habits and their grades in STEM courses," IEEE APS/URSI Int'l Symposium, in EM Educational Methods and Tools, July 9-14, 2017.
[18] Bandura, A. (1993), "Perceived Self-efficacy in Cognitive Development and Functioning," Educational Psychologist, 28(2), 117-148, 1993.
[19] Bandura, A. (1997), "Self-efficacy: the exercise of control," New Your, Freeman.
[20] Bransford, J. D., Brown, A. L. and Cocking, R. R. (Eds) (2000). "How People Learn: Brain, Mind, Experience, and School," National Academy Press, Washington, D.C. 2000. http://www.nap.edu/catalog/9853.html
[21] E. Cook, E. Kennedy, and S.Y. McGuire, *2013), "Effect of Teaching Metacognitive Learning Strategies on Performance in General Chemistry Courses," *Journal of Chemical Education*, 2013, 90, 961-7.
[22] *Zhao,N., Wardeska, G. J., McGuire,Y. S., and Cook, E.(2014) "* Metacognition: An Effective Tool to Promote Success in College Science Learning," Journal of College Science Teaching, March/April 2014. See: http://digital.nsta.org/article/Metacognition%3A_An_Effective_Tool_to_Promote_Success_in_College_Science_Learning/1630723/196227/article.html
[23] Elliott, Timothy R.; Godshall, Frank; Shrout, John R.; Witty, Thomas E. (1990), "Problem-solving appraisal, self-reported study habits, and performance of academically at-risk college students." Journal of Counseling Psychology, Vol 37(2), Apr 1990, 203-207
[24] Credé, M., and Kuncel, N. R., (2008), "Study Habits, Skills, and Attitudes The Third Pillar Supporting Collegiate Academic Performance," Perspectives on Psychology Science, Vol. 3, n. 6, pp. 425-453.
[25] Wernersbach, Brenna M. (2011), "The Impact of Study Skills Courses on Academic Self-Efficacy". Graduate Theses, Utah State University, Logan, Utah.
[26] N. Ogden, S. Evans, G. Thurlow, (2012), "Student Self-Efficacy and Attitudes Following Integration of Study Strategy Information into Course Content." Paper 12, SoTL Commons Conference, March 7, 2012, available at < http://digitalcommons.georgiasouthern.edu/cgi/viewcontent.cgi?article=1534&context=sotlcommons >
[27] Williams A. Sarah, John Morelock, Holly M. Matusovich, and Patrick Cunningham, "Lessons in Transfer: Better understanding of engineering students' metacognitive development," Frontiers in Education, IEEE Proceedings, October 12-15, 2016.
[28] Pajares, F., (1996). "Self-efficacy beliefs in Academic Settings," Review of Educational Research, Vol. 66, n. 4, pp. 543-578, 1996.
[29] Zimmerman, B. J., (2000), "Self-efficacy: an essential motive to learn," Contemporary Educational Psychology 25, pp. 82-91, 2000.
[30] Hackett, G., and Betz, N. E., (1989), "An exploration of the mathematics self-efficacy/mathematics performance correspondence," Journal for Research in Mathematics Education, 20, pp. 263-271, 1989.

[31] Collins, J. L., (1982), “Self-efficacy and ability in achievement behavior.” Paper presented at the Annual Meeting of the American Educational Research Association, 1982, New York.
[32] K. D. Multon, Brown, S.D., and Lent, R. W., (1991), “Relations of self-efficacy beliefs to academic outcomes: A meta-analytic investigation,” Journal of counselling Psychology, 18, 30-38, 1991.
[33] S. McGuire, “Get Students to Focus on Learning Instead of Grades: Metacognition is the Key!” Metacognition Workshop Presented at Teaching Academy, NMSU, Fall 2013.
[34] Schraw, G., and Dennison, R. S., (1994), “ Assessing Metacognitive Awareness,” Contemporary Educational Psychology 19, pp. 460-475, 1994.
[35] LASSI-Learning and Study Strategies Inventory: <http://www.hhpublishing.com/_assessments/lassi/>
[36] Raudenbush, S. W. & Bryk, A. S. (2001). Hierarchical Linear Models: Applications and Data Analysis Methods (Advance Quantitative Techniques in the Social Sciences) 2nd ed. SAGE Publications.