Teaching Community Approach to Prompting Effective Active Learning through Implementing Self-Regulated Learning Assessment in Multiple STEM Courses

Prof. Wei Zheng, Jackson State University

Dr. Wei Zheng is an associate professor of Civil Engineering at Jackson State University. He received his Ph.D. in Civil Engineering from University of Wisconsin-Madison in 2001 and has over ten years of industrial experience. Since becoming a faculty member at JSU in 2005, he has made continuous efforts to integrate emerging technologies and cognitive skill development into engineering curriculum.

Dr. Gordon W Skelton, Jackson State University

Gordon W. Skelton Professor Department of Electrical and Computer Engineering Jackson State University Jackson MS

Dr. Skelton has been involved mentoring and education of student in engineering and computer science for over 25 years. His focus centers on the development of self-regulated learning, problem solving and confidence building.

Dr. Jianjun Yin

Teaching Community Approach to Prompting Self-Regulated Learning Skill Development in Multiple STEM Courses

Abstract

Learners not only have to manage the motivation to sustain their learning efforts, but also need to strategically regulate their cognitive activities in order to effectively acquire knowledge. Educational research has provided understanding of effective Self-Regulated Learning (SRL) and revealed that optimal learning is strongly correlated to the extent to which the learner uses SRL. However, those findings have not been well known and utilized by the STEM faculty members to facilitate learning of their students, particularly those African American students who had poor preparation in their early schooling. These students may mostly need the SRL skills for comprehending complex STEM subjects. This paper is intended to communicate a novel perspective for prompting STEM faculty to acquire SRL and other learning theories and prompting students to develop higher-order learning skills, which is the main implementation framework of a NSF-funded Target Infusion Project. The novelty of the presented framework lies in building a broad teaching community among STEM instructors and learning scientists, whose members can provide the peer support to acquire learning theories and design, implement, and evaluate effective teaching practice in implementing SRL Assessment. This novelty approach enables STEM instructors to adapt or develop learning strategies that are particularly suitable for a specific STEM subject. The process also enables students to be simultaneously prompted for learning, adopting, and evaluating various regulating strategies in context of learning subjects from multiple STEM courses. The paper reports findings from the work-in-progress of implementation of a proposed framework on faculty's preparation and perception for integrating skill development instructions for their students. Current status of students' learning strategy use and learning disposition is discussed.

1. Introduction

According to findings on How People Learn, learners not only have to set the motivation to sustain their learning efforts, but also need to strategically regulate their cognitive activities in order to effectively acquire knowledge and solve problems. The latter activity refers to metacognition. Self-regulated learning is defined as "the active learning guided by learning motivation, metacognition (thinking about one's thinking, and knowing one's learning beliefs and strategies), and strategic action (planning, monitoring, evaluating progress, and taking proper action)" [1,2,3].

Most educational researchers agree that the self-regulation process is a cyclical process and includes three major phases: (1) planning, during which learners set goals, make strategic plans, and judge their self-efficacy; (2) execution, which involves learner's performance and control of their learning efforts, and use of learning management strategies and self-monitoring; and (3) self-reflection, which involves the self-evaluation of mastery, causal attributions, and reactions to the learning task and performance after learning efforts, leading back to the planning phase that precedes the efforts in the next learning cycle [1,4,5]. Boekaerts[6] had identified different learner's competencies that foster self-regulated learning, including the cognitive, metacognitive, and motivational aspects of self-regulation.

To promote students to develop SRL skills, Somuncuoglu et al[7] suggested that metacognitive strategies in SRL can be taught by integrating self-regulated activities that increase the students' awareness of planning (set learning goals), monitoring (self-testing), and regulating (determine the best way to learn) into students' learning processes. Butler[8] emphasized students should be supported to construct their SRL skills rather than taught with predefined strategies, and recommended that SRL skills can be constructed by promoting self-regulation in the context of meaningful work, requesting students to articulate strategies in their own words, and asking students to reflect on when and why certain strategies promote success.

Paris et al.[9] also concurred on the fact that SRL skills could be developed with various tactics, including activities that provoke the self-assessment or reflection of learning. They reviewed the self-assessment as opportunities for students to monitor, reflect on, and understand their own learning. Drawing from nearly 200 sources, Clark[10] found that the theory of formative assessment is a unifying theory of instruction that directs practice and improves the learning process by developing SRL strategies. The author recognized that feedback from formative assessment actualizes and reinforces self-regulated learning (SRL) strategies among students.

However, students with less SRL skills may not spontaneously assess their learning or may not know how to effectively assess their learning. Thus, a scaffold should be provided to students to provoke or guide their self-assessment. A common scaffold method for indirectly guiding the assessment and regulation of learners' learning processes is prompts[11]. The goals of prompts are to increase students' awareness for mostly unconsidered learning activities, activate learners to think about the efficiency of their strategies, and guide learners' reflection at a level that they do not generally consider [12, 13]. Well-designed and embedded prompts direct learners to perform a specific desired activity which is contextualized within a particular learning and problem-solving situation[12,13].

Educational researchers had consistently demonstrated success in using self-assessment and prompts for improving students' learning. White et al.[14] adopted the reflective assessment in their mechanics curriculum for junior high school students, and showed that students who routinely answered the reflective assessment prompts developed a better understanding of both the subject matter and the inquiry process. Tien et al[15] demonstrated students who engaged in articulating their current understanding and reflecting on the implications of their observations appeared to develop a greater conceptual understanding than students in a traditional college chemistry course. Alonso-Tapia et al[16] provided self-assessment prompts to higher school students for landscape analysis, and illustrated that students using these prompts had showed better knowledge than students working without them.

Nonetheless, SRL has just started to draw attention among the technology and engineering education community. Based on the SRL theories, Blank et al[17] implemented the SRL assessment through the self-assessment-for-learning approach in a two-year technology course. In their program, a series of self-assessment questionnaires, integrated into class tests, were adopted to help students learn more effectively through tracking and assessing their academic learning and to develop self-regulated skills. These questionnaires simulated a three-phase SRL in a series of self-directed feedback cycles, including planning, practice, and evaluation. Students became more skillful in using both metacognitive and cognitive skills to constantly adjust and improve their learning efforts through intentional practice with the SRL assessment.

The first author and his colleagues had adopted the SRL assessment developed by Blank et al.[17] with some modification, which emphasizes the stage of identification of priorities and resources and adds the prompts for learning strategies, and implemented it in engineering courses. They demonstrated positive impacts on students' perceptions and use of SRL strategies. Their accumulated data indicated students' learning performance had improved in comparison with those who did not receive the SRL assessment. Additionally, junior students seemed to have more academic performance improvement than did senior students[18].

However, those findings from educational research and practice have not been well known and utilized by the STEM education community to facilitate learning by their students. Most STEM faculty members had not been formally trained in teaching and lack expertise in adopting and developing effective pedagogies for addressing their students' learning needs. Although many STEM faculty members may have recognized that SRL skills are important for their students' learning successes, most of them may not be aware of or utilize the cognitive science research findings that could effectively guide higher-order skill development. Thus, their efforts for helping their students may not as effective as they desire.

This paper presents a new initiative for prompting STEM faculty to acquire SRL and other learning theories and prompting students to develop higher-order learning skills. This initiative is the main implementation framework of a NSF-funded Target Infusion Project. Reported findings and outcomes of the work-in-progress of implementation of this proposed framework is discussed. The objectives of implementing the presented initiative are: to expand faculty's expertise in fostering students' active learning through their participation in a teaching community and interaction with learning scientists; and to facilitate students' SRL skill development by implementing the SRL Assessment in diverse STEM courses.

The SRL assessment is composed of various questions that prompt students to make plans, adopt learning strategies, reflect on their learning efforts, and make adjustments on their learning efforts. It is implemented through integration with a series of course quizzes in a repeated cyclic manner to foster students' SRL skills. Through such guided learning processes, students can have the opportunity to learn, adopt, and practice different learning strategies, and track and assess more effectively their academic learning thus making adjustments for their improvement. This process should lead to enhancement of their academic performance, as well as their self-confidence and self-regulation skill.

The novelty of the presented framework lies in building a broad teaching community among STEM instructors and learning scientists. Those members can provide the peer support to acquire learning theories and design, implement, evaluate, and publish their effective teaching practices in implementing SRL Assessment. Implementation includes intellectual exchange based on their common interest and pursuit. This novelty enables STEM instructors to adapt or develop learning strategies that are particularly suitable for a specific STEM subject, and enables students to be prompted for learning, adopting, and evaluating various regulating strategies in context of simultaneously learning subjects from multiple STEM courses. The mixed-methods with quasi-experimental design are also developed to collect and analyze data used to reveal the impact of SRL assessment on African American students' learning in STEM.

2. Framework of presented initiative

The objectives of the initiative are to promote the adoption of the evidence-based pedagogy in STEM teaching and the institution-wide implementation of the Self-Regulated Learning (SRL) Assessment in STEM courses and to expand faculty's expertise in fostering active learning in their STEM teaching. The overarching goal is improving students' learning skills, academic performance, and retention in STEM fields. The initiative is implemented through extending the prior NSF-supported efforts through implementing SRL assessment in more STEM courses, and augmenting the ongoing faculty professional development activities by establishing a broad teaching community for providing peer support for STEM instructors in order to develop their expertise in fostering and assessing active learning through teaching practices.

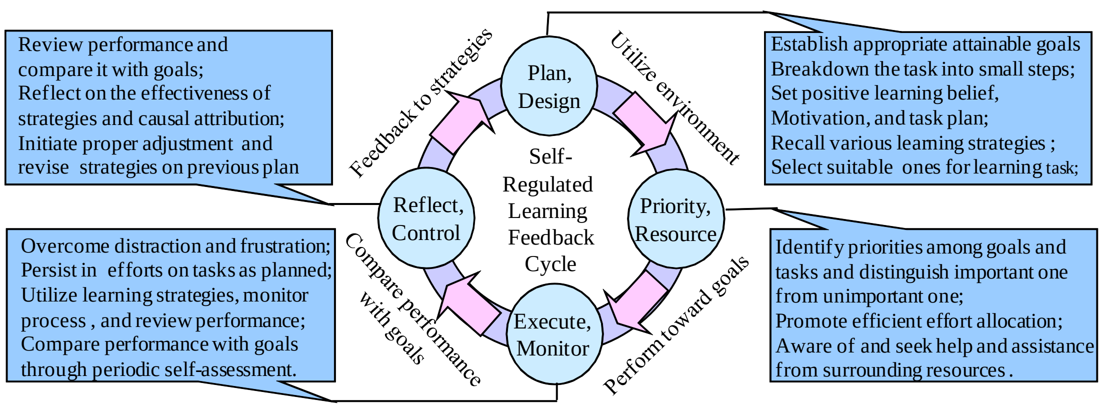

Fig. 1 SRL four-phase cyclical process model

2.1 SRL Assessment and its implementation procedures

One major activity of this initiative is to implement the SRL assessment to foster students' SRL skills from multiple STEM courses. The proposed SRL assessment framework is based on the model presented by Blank et al.[17] Zheng et al[18] modified the assessment for use in civil engineering courses. The SRL assessment framework integrates SRL skill development with traditional course quizzes to facilitate students to use their quiz grades as feedback. This feedback is then used to assess and reflect their learning through monitoring and evaluating their learning progress and making future adjustments.

Before the SRL assessment is implemented in the class, the SRL conceptual model and selected SRL strategies are presented to the students as stand-along learning modules integrated into lecture and course handouts. The presented SRL model partitions SRL into four phases in repeated cycles towards learning goals: (1) planning and designing, (2) identifying priorities and allocating resources, (3) self-monitoring, and (4) evaluating and controlling with particular SRL components for each phases as shown in Fig.1. In this model, identification of priority and resource is emphasized and separated from the planning phase as presented in the typical SRL three-phase model[17]. This separation is made to meet the need of the African American students based on the authors' observations and the importance of students' organizing information and knowledge based on their priority and seeking help from their environment as suggested by Paris and Winograd[19]. The presented SRL strategies include the metacognitive strategies categorized by Chamot[20] and cognitive strategies summarized by Beattie at al[21], as well as problem solving strategies synthesized by Yashin-Shaw[22]. Detailed implementation procedures of the SRL assessment can be found in a previously published ASEE paper by Zheng et al.[18].

2.1 Community for developing and sharing teaching expertise and strategies

The other major activity of the imitative is to establish a broad teaching community through collaboration among diverse STEM faculty members and learning scientists. This teaching community is designed to provide peer support for the implementation of the SRL assessment in multiple STEM courses, and to help STEM instructors develop expertise in fostering active learning thus developing effective pedagogy in STEM education. This teaching community is environed as a voluntary group of faculty members from the College of Science, Engineering, and Technology and the College of Education and Human Development, who share common interests in pursuing the effective pedagogy for enhancing students' learning engagement and outcomes. The project strategy for maintaining and expanding this broad teaching community is to initiate the community, to demonstrate the benefits of community activities in terms of students' learning outcomes and faculty's professional development in teaching, and eventually to make the community the core for promoting teaching innovation. The community will act as the resources for supporting faculty members seeking effective pedagogy in STEM education.

The faculty professional development, through the teaching community, lies in the peer support mechanism. In this model, STEM instructors will team with the learning scientists and project team members to adopt, develop, implement, and evaluate the SRL assessment or other active learning pedagogues for their STEM courses. The STEM instructors will be assisted in collecting students' learning data to record their pedagogy and to document their observations and experiences. The STEM instructors will share their experience and implementation issues with their peers. This peer interaction allows them to receive feedback on the instructional activity in a desire to improve their pedagogical innovations. This continuous improvement process will be achieved through regular exchange among community members. The regular exchanges among members will be conducted through regular communication and meetings. Here members can intellectually share experience, exchange knowledge, and provide feedback in supporting their peers in improving teaching and pursuing innovations.

2.3 Evaluation of Impacts of SRL Assessment

To reveal the impacts of SRL Assessment on students' learning in STEM subjects, mixed methods with quasi-experimental design were adopted to collect and analyze data of students' learning process and outcomes. The project evaluation will be guided by evaluation questions listed in Table 1.

Table 1 Project Evaluation Design

Types	Evaluation Questions	Measurement	Evaluation Method	Indicators/ evidence
Implementation Evaluation	1. Is the project implemented as scheduled? (outcomes 1-5)	Work log, products, reports, and regular discussion	Check with project schedule and milestones	Developed instructional materials; implementation progress; and data collection and analysis.
Formative Evaluation	2. Is there any significant different in domain knowledge between control group and invention group? (outcome 1)	Pre- and Post- tests, concept inventory, concept map, quiz and exam scores	Compare Means and SDs between two groups with T-test	Results from the statistics comparison between control and experimental groups in terms of domain knowledge.
	3. Is there any significant difference in SRL, self-efficacy, and engagement between control group and invention group? (outcome 2)	Pre- and Post- tests with all well-accepted instruments	Compare Means and SDs between two groups with T-test	Results from the statistics comparison between control and experimental groups in terms of SRL, self-efficacy, and engagement.
	4. Has participating instructors selected learning topics and relevant strategies for SRL assessment? (outcome 3)	Faculty presentation of their SRL assessment materials, and students' learning outcomes.	Peer review and comments, Compare Means of learning between two groups	Results from the statistics comparison between control and intervention groups in terms of SRL and domain knowledge.
	5. To what extent can faculty develop their expertise in promoting students' SRL and teaching innovation and research? (outcome 4)	Pre- and Post- test survey questionnaires on faculty; Comments and suggestions from Faculty	Compare Means and SDs between pre- and post- tests with T-test; and qualitative analysis.	Students' learning outcomes; faculty comments and suggestions; qualities of instructional materials; and numbers of publications, proposals, and funding.
	6. What is the correlation among the learning process variables and learning outcome variable (outcome 5)	post-tests on learning outcomes, and SRL assessment questionnaires; faculty survey and suggestions, interview	Correlation analysis between the process & outcome variables; qualitative analysis.	correlation analysis results; qualitative analysis results; faculty comments and suggestions;
Summative Evaluation	7. Does the project achieve the goals and objectives? (outcomes 1-5)	Data analysis results and Faculty's comments and suggestions	Exam above analysis results & check with expected outcomes	Results from statistics analysis; improved instructional materials and strategies; faculty suggestions

The student participants will come from multiple STEM courses instructed by participating instructors. The students' learning process variables are be divided into two categories: cognitive process and metacognitive process. The students will be selected from the students' SRL assessment questionnaires embedded in selected class quizzes, as described in the proceeding section. Based on the construct by Beattie et al.[21], cognitive process variables will be further divided into 10 dimensions. Based on the construct by Chamot[20], metacognitive process variables will be divided into 4 dimensions: Plan/Organize, Monitor/Identify problems, Evaluate, Manage. The variables will be further divided into 15 sub-dimensions. Those process variables will be estimated and quantified by using a students' self-reported Likert scale based on the time lengths and frequencies of each dimension in which students perform.

The students' learning outcome variables will be divided into two main categories: (1) learning performance in terms of deeper understanding of domain knowledge measured by using a concept inventory, concept map construction, and course quizzes and exams; and (2) learning disposition in terms of SRL skills, perceived value of SRL assessment, self-efficacy, identity, engagement measured by using different questionnaires developed based on an accepted instrument.

In each implementation year, the evaluation procedures and instrument will remain the same, but the intervention will be different. The students in year one will make up the control group to provide the baseline data for the subsequent intervention in the same courses. Thus, the SRL assessment is implemented, but the pre- and post- tests are conducted. It is intended to provide the baseline data and have participating STEM instructors adopt the SRL assessment for their courses in the subsequent years. The students in year two and year three will makeup the intervention groups. In year two, the SRL assessment adopted by the individual STEM instructor will be implemented as the intervention. In year three, the SRL assessment revised by the individual STEM instructor based on the year two implementation will also be implemented as the intervention. The evaluation data collection and procedures, as well as corresponding instruments, are shown in the Table 10 below.

Table 10 Overview of the Evaluation Procedures for Each Year

Phases	Contents	Duration
(1) Pre-tests	Demographics and GPA	Two weeks
	Prior knowledge test (content specific knowledge, metacognitive knowledge)	
	Self-efficacy, engagement, identity, SRL skills	
(2) Implementation of SRL assessment (year 2 and year 3)	learning assignment and requirement, introduction of SRL assessment	Ten weeks
	Acquisition of knowledge and problem solving	
	Implementing the SRL assessment, responding to inquiring, reflecting	
(3) Post-tests and debriefing	Post knowledge test (content specific knowledge , metacognitive knowledge, problem solving skills)	Two weeks
	Self-efficacy, engagement, and identity	
	Interview of selected participants	

*Note: In the first year, there is no intervention.

3. Teaching Community activities

Last fall, year one implementation started with baseline data collected by participating instructors. Those instructors were asked to adopt or to develop the Concept Inventory before the fall semester began for measuring students' basic understanding of important course subjects. The project team provided those instructors with instruments for measuring the status of students' learning strategy use and learning dispositions. One challenge faced by the project team members and participating instructors was to facilitate a commonly suitable time for the teaching community meetings. The project leader eventually had to have the first meeting at two different times for two groups of participating instructors, the one with 12 STEM instructor participants, and the other with 4 STEM instructor participants. During the meetings, the project core team members provided the handouts of the proposed SRL assessment and its implementation procedures, and explained them to participating participants. Besides clarifying several questions on the detailed implementation raised by the participating instructors, participating instructors also shared their teaching experience and discussed students' learning issues. Discussion among participants recommended use of technology to share learning theory and to maintain communication among the community members. This communication process includes the use of e-mails, blogs, and the learning management system used at the university (Blackboard Learn).

After the community meetings, the theoretical framework of the proposed SRL assessment, obtained from extensive literature review, was delivered to instructors to provide the background information on the proposed SRL assessment. All participating instructors engaged in developing three course tests or quizzes that will be used to embed the SRL assessment and will be implemented in year two and year three. Instructors are expected to prepare additional learning and problem solving strategies that are related to their specific courses.

4. Status of STEM instructors' teaching strategy use and assessment on students' learning

The status of STEM instructors' teaching strategy use and assessment on students' learning is revealed through a faculty survey. During and after the meeting, participating instructors provided their perception and reflection on the proposed SRL assessment and their students' learning in the form of a faculty survey. This survey focused on faculty's knowledge in learning theories, skills in implementing and assessing teaching pedagogy, and experience in documenting teaching innovations and findings, as well as their perception on their students learning.

There are total of 11 survey items designed to measure the STEM faculty's understanding of Self-Regulated Learning strategy from different aspects. The first 9 items were used to ask the basic concepts of Self-Regulated Strategy (SRL). Their descriptions are tabulated in Table 5. The last two survey items are yes-no questions to measure whether the faculty knows and applies SRL in the process of teaching. The item descriptions are provided in Table 6. There were 13 STEM faculty members who submitted the survey. All submitted surveys were valid for analysis.

The means of the first 9 survey items in Table 5 can be categorized into three groups: high group (mean ≥ 4.4), medium (4≤ mean<4.4), and low (mean<4). As results, there are 2 items in high group, 5 items in medium group, and 2 in low. The data showed that STEM faculty members have sufficient knowledge of various learning theories and strategies and try to apply these learning strategies in their class whenever possible. They are also willing to learn and apply innovative teaching strategies in their teaching, and willing to assess student's reactions to adjust and refine their teaching approach. The noticeable findings are that STEM faculty members rarely interact with each other in their own field (mean=3.92), or discuss learning strategies with colleagues from the field of education (mean=3.38), which illustrates that the association and interaction among faculty members need improvement. This is why this program proposed to establish a teaching community to share their knowledge and experience in prompting active learning and in implementing and assessing teaching pedagogy. Table 6 revealed that although 84.6% of the faculty members know self-regulated learning strategies, only 69.2% of the faculty members actually integrated these strategies into their teaching process to foster students' learning. This indicates that there is a need for integrating Self-Regulated Learning strategies in the STEM courses.

Table 5 Faculty survey of basic understanding of SRL

Questions	Mean	Std. Deviation
Apply learning strategy	4.77	0.44
Apply innovative approach	4.46	0.78
Apply learning strategy to improve student's learning	4.38	0.77
Willing to learn innovative strategies	4.38	1.04
Assess and refine teaching approach	4.31	0.75
Sufficient Knowledge on strategies	4.08	1.04
Assess student's reaction	4.08	1.04
Discuss strategy with colleague in my field	3.92	0.95
Discuss strategy with colleagues in education	3.38	1.50

N=13

Table 6 Faculty survey of using of SRL

	Do you know SRL strategies?		Have you integrated SRL strategies in your instruction?	
	Frequency	Percent	Frequency	Percent
Yes	11	84.6	9	69.2
No	2	15.4	4	30.8
Total	13	100.0	13	100.0

N=13

The other set of faculty survey questions asked the participating STEM instructors their assessment or perception of their students' learning disposition. The two top factors ranked by the 13 participating STEM instructors for each surveyed category are presented below. Those results are similar to those obtained by using the same survey conducted by Zheng et al[18] in the previous year, and are summarized as follows:

- The most determining factors contributing to their students' low performance in learning outcomes are lack of learning time and motivation.
- The major factors that can promote faculty members to integrate teaching innovation in their courses are professional recognition and student appreciation.
- The major factors that can hinder students to appreciate and adopt the assignment intended to improve their learning, besides the course disciplinary content, are lack of motivation and not related to course grade.
- The possible improvement for students after integrating SRL assessment in their class is learning motivation, strategies and skills.
- Effective ways that can help instructors to adopt, develop, and implement teaching innovation in their courses are to share and discuss learning and teaching with peers and to know the findings from learning science and effective practices.
- Most of the instructors believe that implementing the current SRL is the effective way to improve students' learning.

- Most instructors believe that the current SRL assessment approach is suitable and easy for implementation in their courses.

- Most instructors believe that their students appreciate the fact that SRL is integrated into their courses. Most instructors know some learning and teaching theory from learning science and have integrated them into their courses before the implementation of current SRL.

- Most instructors believe that the implementation of SRL promotes them to know more about effective learning and teaching methodology developed in learning science.

Status of Students' learning strategy use and their learning dispositions

The Status of Students' learning strategy use and their learning dispositions is assessed by using questionnaires based on an accepted instrument to determine the students' use of meta-cognitive strategy and cognitive strategy. Two open-end questions were used for students to report their own descriptions on their application of strategies. During the fall semester of 2014, those questionnaires were collected from students in courses instructed by participating STEM instructors. Altogether, there were about 240 freshmen from STEM majors involved. 224 of these students returned valid answers.

Table 1 General use of meta-cognitive strategy and cognitive strategy

Strategies	Mean	Std. Deviation
Meta-cognitive strategy	1.30	1.28
Cognitive Strategy	2.04	1.30

n=224

Two raters were invited to determine the frequency of all strategies from the answers to the two open-end questions according to the categorization of cognitive strategies and metacogntive strategies made by Beattie at al[21]and by Chamot[20] respectively. Their ratings were later averaged to obtain the final frequency of application of each strategy among those students. Under this rubric, there are four items for meta-cognitive strategy namely Plan/Organize, Identify priority, Monitor and Evaluate and fifteen items for cognitive strategy.

The rating results from the two open-ended questions are illustrated in Table 1. It showed that the frequencies of application of these strategies among students are not optimistic, no matter in meta-cognitive strategy or in cognitive strategy. The mean of frequencies of application of meta-cognitive strategy is 1.30, the mean of frequencies of application cognitive strategy is 2.04. This result is equivalent to each student on average only used 1.3 of 15 meta-cognitive strategies and adopted 2.04 of 15 cognitive strategies.

Table 2 below is the detailed presentation of meta-cognitive strategy, from which it can be revealed that "Plan/Organize" was the most frequently used strategy, followed by "Identify priority" as the second, "Monitor and identify problems" as the third, and "Evaluation" as the last one. These findings indicate that students are poor in Evaluation, which includes analysis, assessment, verification, criteria fulfillment, elimination, and selection of ideas. In fact, evaluation is not only an essential component of Meta-cognitive but also a strong indicator of self-regulated Learning. This deficiency requires further effort be devoted to cultivating students' meta-cognitive awareness and appropriate ways to apply them in their STEM study through scaffolding of self-regulated learning.

Table 2 Frequency of application of meta-cognitive strategy

Meta-Cognitive Strategies		**Frequency**	**Percentage**
Plan/organize	Goal setting Content planning Orienting strategies	128	38.0%
Identify priorities	Priority identification Resources allocation	82	24.0%
Monitor and identify problems	Goal monitoring Cognitive awareness Comprehension check Problem identification	70	21.0%
Evaluation	Analysis Assessment Verification Criteria fulfillment Elimination Selection of ideas	57	17.0%

n=224

Table 3 Frequency of application of cognitive strategy

Cognitive	**Frequency**	**Percentage**
Rehearsal	127	25.4%
Association	119	23.8%
Transformation	78	15.6%
Aids for problem solving	44	8.9%
Seeking help	39	7.8%
Retrieval	29	5.8%
Search	25	5.0%
Contrast	11	2.2%
Aids for attention	9	1.8%
Elaboration	6	1.2%
Organization	6	1.2%
Synthesis	3	0.6%
Context shifting	2	0.4%
Attribute finding	1	0.2%
Acknowledging limitations	1	0.2%

n=224

Table 3 provides a full account of cognitive strategy. Among these fifteen sub-items in cognitive strategy, the five most frequently used strategies are: rehearsal (25.4%), association (23.8%), transformation (15.6%), aids for problems solving (8.9%) and seeking help (7.8%). These five cognitive strategies occupied 81.5%, which states that students are more likely to practice target information via verbalizing and visualizing, forming the mental connection of either related or unrelated ideas, converting difficult or unfamiliar information into more manageable ones, connecting to a concrete object or other cue to the problem, and turning to instructors or peers for help. The least frequently used cognitive strategies are organization (1.2%), context shifting (0.6%), synthesis (0.4%), attribute finding (0.2%) and acknowledging limitations (0.2), shown in Table 1-3, having a 2.0 % share of the total frequencies. Previous researches claim that these strategies are also important elements in preparing students for self-regulated learning.

Student learning disposition revealed results are tabulated in Table 4. There are 33 items designed to measure students' learning habits and behaviors from different aspects. 240 students from different classes of STEM were surveyed. Of the questionnaires received 202 were considered valid for analysis. The description of the surveyed items is presented in Table 2-1. The means of 33 items can be categorized into three: high group (mean ≥ 4), medium (3≤ mean<4), and low (mean<3). Therefore, there are 16 items in the high group, 14 in the medium group, and 3 in the low. These data illustrate that STEM students are strong in explaining a subject in their own way, associating questions with previous knowledge, comprehending, defining main points, summarizing, studying regularly, keeping notes, success depend on attempts, memorizing test-concerning parts, repeating the knowledge, and enjoying learning new things. They also prefer not to study in a noisy place. The noticeable findings are that STEM students are poor in arranging information (mean=2.66), and distinguishing ideas (mean=2.73). Also revealed is a lack of confidence (mean=2.99), which poses a threat to their self-regulated learning. As a result, in later teaching arrangements, more attention should be paid to the 14 medium items and the 3 low items to promote self-regulated learning among STEM students.

Table 4 Description of learning disposition

Questions	Mean	Std. Deviation
Explain subject in one’s own way	4.29	0.77
Ask and answer questions	3.99	0.88
Associate with previous knowledge	4.29	0.77
Comprehension	4.11	0.88
Define main points	4.01	0.98
Summarize	4.01	0.91
Note down important points	4.32	0.81
Find main idea	4.08	0.94
Fixed study hours	3.00	1.28
Time-managing	3.63	1.20
Study regularly	4.26	0.86
Make plan before study	3.60	1.16
Make daily, weekly and monthly plan	3.13	1.28
Focus on study	3.97	1.05
Keep notes	4.08	0.99
Study everyday	3.00	1.14
Prepare information	3.06	1.20
Trouble in arranging information	2.66	1.35
Draw concepts	3.01	1.25
Categorizing features	3.77	0.98
List ideas and concepts	3.46	1.16
Difficulty in distinguishing ideas	2.73	1.30
Learn in class	4.31	0.83
Success depend on attempts	4.54	0.64
Enjoy learning new things	4.42	0.74
Regular study	4.38	0.73
Lack confidence	2.99	1.36
Distraction	3.62	1.10
Not study in noisy place	4.14	1.02
Memorize test-concerning parts	4.06	0.87
Determine important information	3.97	0.93
Repeating the knowledge	4.01	1.01
Memorize	3.92	1.10

Note: N=202

Summary and Conclusion

Self-regulated learning is universally acknowledged as an important skill in promoting students’ learning, but how it can be nurtured among African American STEM students in an effort to impact their learning remains unclear. This project aims to form a teaching community of STEM instructors and learning scientists to foster SRL skills from multiple courses through implementing the SRL assessment in authentic STEM educational setting, and to reveal the impacts of the SRL assessment on students' learning disposition and learning outcomes. This paper presented a framework of a working plan and the first outcomes from the work in progress.

In available outcomes of the work in progress, surveys of students revealed that students have poor use of learning strategies, especially in meta-cognitive strategy, which is considered as a pivotal mediator and facilitator to cognitive learning. At the same time, these strategies are core components of SRL learning. It can be tentatively concluded that currently African American STEM students have not practiced SRL in their daily study. From the perspective of instructors, it is discovered that instructors have a certain degree of knowledge of SRL, they believe that SRL is a suitable approach, and they have clear ideas about students needing motivation and guidance in practicing SRL. However, instructors do not share and exchange with each other which may prevent the application and exploration of effective instruction for promoting SRL skill development among students. Though most of them know about SRL, only some of them have tried to integrate SRL into their teaching. All of the analyses confirmed that the current status of knowledge and application of SRL among African American students at our institution is lacking.

Future research in this project will be devoted to two main topics: 1) to identify how to cultivate students' awareness and habits of using self-regulated learning strategies, and determine the effectiveness; and, from the perspective of instructors, 2) how to keep themselves informed of SRL. This last topic requires the teaching community to communicate, discuss compare, and even challenge each other to deepen and expand their theoretical and practical knowledge of SRL. It is expected that all these measurements and findings will contribute to enhancing African American STEM students' academic achievement.

Acknowledgements

The authors gratefully acknowledge the support of the National Science Foundation under the grant NSF/HRD # 1436343. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation. The authors thank the participating STEM course instructors for their contribution of implementing presented instructional framework, including Dr. Mohammed Ali, Dr. Ibrahim Farah, Dr. Fengxiang Han, Dr. Tzusheng Pei, Dr. Huiru Shih, Dr. Francis Tuluri, Dr. Robert Whalin, Dr. Zhenbu Zhang, Dr. Justin Allison, Dr. Daning Chen, Dr. Ming-ju Huang, John Watts, Dr. Himangshu Das, and Xing Yang. The authors thank Dr. Yu-chun Kuo for her contribution as the project evaluator. Authors also thank graduate students Ms. Haiyan Zhou,Ms. Yun Huang, Mr. Yanhua Cao, and Mr. Yujing Nie for their assistance in collecting and analyzing students' learning data and input them in an organized format.

Reference

1. Zimmerman, B. J. (2000). “Attaining self-regulation, A social cognitive perspective.” In M. Boekaerts, P. R. Pintrich, and M. Zeidner (Eds.), *Handbook of self-regulation*, San Diego, CA, Academic Press, 13-39.

2. Winne, P.H., and Perry, N.E. (2000). “Measuring self-regulated learning.” In P. Pintrich, M. Boekaerts, and M. Seidner (Eds.), *Handbook of self-regulation*, Orlando, FL, Academic Press, 531-566.

3. Perry, N.E., Phillips, L., and Hutchinson, L.R. (2006). “Preparing student teachers to support for self-regulated learning.” *Elementary School Journal*, 106, 237-254.

4. Zimmerman, B. J., and Campillo, M. (2003). “Motivating self-regulated problem solvers.” In J. E. Davidson, and R. J. Sternberg (Eds.), “The nature of problem solving”, New York, Cambridge, 233-262.

5. Greene, J., and Azevedo, R. (2007). “A theoretical review of Winne and Hadwin’s model of self-regulated learning: New perspectives and directions.” *Review of Educational Research*, 77 (3), 334-372.

6. Boekaerts, M. (1997). “Self-regulated learning: A new concept embraced by researchers, policy makers, educators, teachers, and students.” *Learning and Instruction*, 7, 161-186.

7. Somuncuoglu, Y., and Yildirim, A., (1999). “Relationship between achievement goal orientations and use of learning strategies.” *Journal of Educational Research* 92 (5), 267-77.

8. Butler, D. (2002). “Individualizing instruction in self-regulated learning.” *Theory Into Practice*, 41(2), 81-92.

9. Paris, S., Paris, A. (2001). “Classroom Applications of Research on Self-Regulated Learning.” *Educational Psychologist*, 36 (2), 89-101.

10. Clark, I. (2012). “Formative Assessment: Assessment Is for Self-regulated Learning.” *Educational Psychology Review*, 24, (2), 205-249.

11. Wirth, J. (2009). “Prompting self-regulated learning through prompts.” *Zeitschrift für Pädagogische Psychologie*, 23(2), 91-94.

12. Davis, E.A., and Linn, M.C. (2000). “Scaffolding students’ knowledge integration: Prompts for reflection in KIE.” *International Journal of Science Education*, 22 (8), 819–837.

13. Ifenthaler, D., (2012). “Determining the effectiveness of prompts for self-regulated learning in problem-solving scenarios.” *Journal of Educational Technology and Society*, 15 (1), 38–52.

14. White, B., and Frederiksen, J. (1998). “Inquiry, modeling, and metacognition: making science accessible to all students.” Cognition and Instruction, 16(1), 3-118.

15. Tien (1999)

16. Alonso-Tapia, J., and Panadero, E. (2010). “Effects of self-assessment scripts on self-regulation and learning.” *Infanciay Aprendizaje*, 33 (3), 385-397

17. Blank, S., Hudesman, J., Morton, E.D., Armstrong, R., Moylan, A., White, N., and Zimmerman, B. (2006). “A Self-regulated Learning Assessment System for Electromechanical Engineering Technology Students.” Proceedings of the National STEM Assessment Conference, Washington, D.C.

18. Zheng ,W., Wang, L.S. and Yin, J.J., (2013) “Correlation Analysis of Scaffolding Creative Problem Solving Through Question Prompts with Process and Outcomes of Project-Based Service Learning.” Proceedings of 2013ASEE Annual Conference & Exposition, Paper number: AC 2013-6169, Atlanta, Georgia, June 23 - 26, 2013

19. Paris, S. G., and Winograd, P., (2003). "The Role of Self-Regulated Learning in Contextual Teaching: Principles and Practices for Teacher Preparation," *Preparing Teachers to Use Contextual Teaching and Learning Strategies: To Improve Student Success In and Beyond School*. Retrieved from http://www.ciera.org/library/archive/2001-04/0104prwn.pdf.

20. Chamot, A. U. (2006). “Preparing language teachers to teach learning strategies.” In W. M. Chan, K. N. Chin, and T. Suthiwan (Eds.), *Foreign language teaching in Asia and beyond*, Singapore, Centre for Language Studies, National University of Singapore, 29-44.

21. Beattie, J., Jordan, L., and Algozzine, R. (2006). *Making Inclusion Work: Effective Practices for All Teachers*, Corwin Press, 154.

22. Yashin-Shaw, I. (2006). “Thinking Creatively About Strengths-Based Strategies”, in Strength Based Strategies –2006. Retrieved from http://www.strengthbasedstrategies.com/PAPERS/22%20%20Irena%20ShawFormatted.pdf