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Implementing Self-Regulated Learning Process Model and Assessment for Facilitating Civil Engineering Students to Master Engineering Concepts

Abstract

Learning and problem-solving involve iterative cyclic processes that require both cognitive strategies and regulation of efforts. Students who fail in their engineering studies may attribute the failures to their lack of ability to learn engineering rather than to use cognitive strategies effectively. These students may eventually decide to quit from engineering programs due to their frustrations from setbacks. Thus, there is a need for engineering faculty to adopt an integrative instruction that can help students to develop cognitive skills and effectively regulate their learning efforts during the learning and problem-solving processes. This paper presents a novel instructional framework that integrates Self-Regulated Learning (SRL) process model into course instruction for facilitating students to learn engineering concepts, as well as its implementation outcomes from a mainstream civil engineering courses, Concrete Structures Design. Relevant cognitive science development and educational practice on SRL is first introduced. A new integrative pedagogical framework is presented with three learning topics in reinforced concrete structures design. The instruction is implemented through integrating self-assessment questionnaires with course quizzes and tests on the above-mentioned concepts. The evaluation of the students learning indicated that the presented instruction could benefit student’s learning, and the majority of students perceive the importance of self-regulated learning skills and are interested in learning self-regulated learning skills.

Introduction

Self-regulated learning (SRL) Self-Regulated Learning (SRL) has become a research subject and educational practice in the context of Educational Psychology. It refers to active learning that is guided by motivation to learn, metacognition (awareness of one’s knowledge and beliefs), and strategic action (planning, monitoring, and evaluating personal progress, and taking proper action). A wealth of research has supported that optimal academic performance is strongly tied to the extent to which the learner uses SRL. Equipping students with SRL abilities not only contributes to success in formal education, but also prepares them for lifelong learning. Despite the extensive research in the literature, SRL is still not well known and utilized by the engineering education community for facilitating student learning in Science, Technology, Engineering, and Mathematics (STEM).

On the other hand, the attitudes and skills that embrace self-regulated learning and lifelong learning are specified explicitly or implicitly in the “Vision for Civil Engineering in 2025” (Vision 2025) and the “Civil Engineering Body of Knowledge for the 21st Century” (BOK2) by American Society of Civil Engineers (ASCE) for future civil engineers. The 24 outcomes specified by BOK2 include those that emphasize higher order executive skills of problem-solving, innovative design, and lifelong learning by possessing self-directed learning ability. For example, outcome 23 states: Lifelong learning – “Plan and execute the acquisition of required expertise appropriate for professional practice”. Civil engineering graduates must “demonstrate the ability for self-directed learning, and develop their own learning plan”. “Self-directed
learning is a mode of lifelong learning because it is the ability to learn on one’s own with the aid of formal education”.

In the literatures on civil engineering education, however, few research efforts have been found to deliberately cultivate students’ self-directed learning or SRL skill development by using explicit integrative instructions based on effective theoretical frameworks from cognitive science and educational psychology. It remains up to individual students to make their SRL development as by-products of their engineering education. Although many engineering faculty members have recognized that self-directed learning skill are important for students, most of them may not be aware of and utilize the research development from cognitive science that provide the guidance for such higher-order skill development. More efforts need to be put on helping their students to develop these skills.

Based on previous experience working with students who have difficulty mastering engineering or those who plan to leave the engineering programs, faculty members in the school of engineering at the authors’ institution have come to a conclusion that most of these students possess the ability for achieving the required performance to succeed in engineering. The reasons resulting their failing or dropping out of engineering may include: (1) lack of motivation and interest in learning engineering; (2) lack of good learning habits, strategies and efforts in their studies; and (3) lack of connection with other students and faculty members for seeking support.

This paper presents a new instructional framework that integrates SRL process model into course instruction. The integrative instruction is to simulate four phases of SRL in series of self-directed feedback cycles, and to prompt application of learning strategies and self-reflection at the different phases of learning and problem-solving process. This is implemented through integrating self-assessment questionnaires with course quizzes and tests on the specified topics. Several types of instrument are adapted to evaluate the effectiveness of the proposed instruction, including the pre- and post-test questionnaire for measuring change of students’ academic dispositions and the quality of students’ quizzes and exams. Through these deliberately designed processes, students have the opportunity to learn how to use different learning strategies, track and assess more effectively their academic learning, make adjustment for improvement, and eventually enhance their self-confidence and self-regulation skills.

In this paper, literature across cognitive science and education is first briefly reviewed. Relevant cognitive science development and educational practice on SRL are introduced. A new instructional framework and its implementation outcomes from a mainstream civil engineering course are presented, as well as the perceptions of faculty members who implement SRL assessment on students’ self-regulated learning. The general integrative pedagogical framework and three learning topics in Reinforced Concrete Structures Design are also presented, in which self-regulated learning assessment are included in the course quizzes and exams. The implementation of the instruction and its outcomes are revealed, and their further improvements are also discussed.

**Literature Review**

To turn self-regulated learning theory into practice and promote students to develop their self-
regulated learning skill, Paris & Winograd\(^3\) suggested that self-regulated learning can be taught with various tactics, including indirect modeling and activities that entail reflective analyses of learning. Somuncuoglu and Yildirim\(^4\) recommended that metacognitive strategies in self-regulated learning can be specifically emphasized by incorporating self-regulated course activities that raise the students’ awareness of planning (set learning goals), monitoring (self-testing), and regulating (determine the best way to learn). Celuch and Slama\(^5\) gave students assignments based on the above recommendations to stimulate students’ self-regulated learning in marketing education. The learning benefits of these assignments have been favorably assessed with student surveys and feedback. Young\(^6\) evaluated motivational effects of classroom environment in facilitating self-regulated learning in his marketing education. His findings suggested that active application-oriented experiences delivered by enthusiastic faculty, who provide high interaction, supportive feedback, and clear goals that emphasize learning over grades, can increase students’ motivation and their use of self-regulated learning.

Nonetheless, self-regulated learning has just started to draw attentions among engineering and technology education community. Blank et al.\(^7\) developed a self-regulated learning assessment system through the self-assessment-for-learning approach in their two-year technology program. Within this framework, students learned to track and assess more effectively their academic learning and self-regulation skills through a series of self-assessment questionnaires associated with class quizzes. These questionnaires simulated a three-phase SRL model in series of self-directed feedback cycles. Each cycle included planning, practice and evaluation. Through deliberate practice with self-regulated learning assessment, students became more skilled at using both metacognitive and external feedback to continuously adjust and improve their learning efforts.

**Instruction Materials**

The learning materials that cover a set of self-regulated learning concepts, models, and related strategies were developed based on the literature, and had been presented to students in class as stand-alone learning contents for one- or two-class period. The self-regulated learning strategies were focused on three aspects as outlined below:

- **Personal**: these strategies usually involve how one organizes and interprets information, goal setting and planning, keeping records and monitoring, and rehearsing and memorizing
- **Behavioral**: these strategies involve actions that the student takes, e.g. self-evaluating or regulating (checking quality or progress), self-motivation, and self-reinforcement
- **Environmental**: these strategies involve seeking assistance and structuring of the physical study environment, e.g. seeking information (library, internet), environmental structuring (selecting or arranging the physical setting, minimizing distractions, breaking up study periods and spreading them over time), emulating exemplary models, and seeking social assistance (from peers or instructors)

The self-regulated learning conceptual model and selected learning strategies were presented to the students through course handouts. The presented SRL conceptual model was partitioned into four phases: (1) planning and designing, (2) identifying priorities and allocating resources, (3) self-monitoring, and (4) evaluating and controlling. This model was proposed based on the
three-phase model by Blank et al.\textsuperscript{7}, with the modification that the identification of priority and allocation of resource were particularly separated from learning strategies. This separation was due to the importance of students to organize information and knowledge based on their priority, and seek help from their environment, as suggested by Paris and Winograd\textsuperscript{3}. The proposed self-regulated learning model is actually repeated cycles of the four phases towards learning goals as shown in Fig. 1. The selected learning strategies included in the model are listed in Table 1.

![Fig. 1 SRL four-phase implementing feedback cycle model](image)

### Table 1 Selected learning strategies

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Brief Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orienting Strategies</td>
<td>Draw attention to a task through instructor’s input, highlighted material, and/or students’ self-regulation.</td>
</tr>
<tr>
<td>Specific Aids for Attention</td>
<td>Maintain attention by connecting a concrete object or other cue to the task.</td>
</tr>
<tr>
<td>Specific Aids for Problem-Solving or Memorization</td>
<td>Enhance problem-solving by connecting a concrete object or other cue to the task.</td>
</tr>
<tr>
<td>Rehearsal</td>
<td>Practice (rehearsal) target information through verbalization, visual study, solving similar problems, or other means.</td>
</tr>
<tr>
<td>Elaboration</td>
<td>Expand target information by relating other information (e.g. creating a phrase, making an analogy).</td>
</tr>
<tr>
<td>Transformation</td>
<td>Simplify target information by converting difficult or unfamiliar information into more manageable one.</td>
</tr>
<tr>
<td>Imagery</td>
<td>Student transforms target information by creating meaningful visual, auditory, or kinesthetic images of the information.</td>
</tr>
<tr>
<td>Mnemonics</td>
<td>Transform target information by relating a cue word, phrase, or sentence to the target information.</td>
</tr>
<tr>
<td>Organization</td>
<td>Categorize sequences or organizes information for more efficient recall and use.</td>
</tr>
</tbody>
</table>
Instruction Framework for Integrating SRL into Engineering Curriculum

The instruction strategy is to integrate SRL skill development with traditional course assignment and facilitate students to use their grades as feedback to self-reflect their learning through monitoring and evaluating the learning progress and making future adjustments. It is adapted with some alternations based on SRL assessment system\(^7\). Within this strategic framework, the instructors assign a classroom quiz or homework in students’ learning domain and integrate self-assessment questionnaires with the assignment. Students are asked to make a self-efficacy assessment on how confident they are in correctly doing the assignment before they do it. After finishing the assignment, students then are asked to make self-evaluative assessment on their confidence in correctly doing the assignment again. When the corrected quiz or homework are returned in the following class session, students have the opportunity to learn from their errors by completing self-reflection forms, which is divided into four sections that correspond to the four phases of the SRL model as shown in Fig. 1.

In the first two sections on the form (i.e. planning phase, and identifying property and recourse), students compare their confidence ratings from the quiz or homework with their graded performances, and describe which academic strategies or processes are not working, and then revise or establish new strategies. In addition, students are required to identify the priority in the learning topic or the learning recourse (e.g. peer and instructor help, or reference) for improvement. Then, students rate their confidence about the new approach that they think would work. Instead of giving students a new quiz or homework immediately, alternation from Blank’s model is made to give students more time to apply these strategies for preparing new assignment. The new quiz or homework in the initial content domain is given to students in the next class section. Meanwhile, students are asked to complete the third section on the form, in which each step of the problem solving process has to be explained in the students’ own words. Lastly, in the final section (i.e. evaluation phase) on the reflection form, students rate the extent to which they are satisfied with their performance. Through these deliberately designed processes, students are expected to learn how to track and assess more effectively their academic learning, make adjustment for improvement, and foster self-regulation skills. Detailed instructions are list below:

Integrating Instruction on SRL with Three Learning Topics

1. Instructors select learning topics for a class quiz or homework;

2. Students are asked to think and answer questions in the pre-test instrument before doing the quiz or homework;

3. Students work on the quiz or homework;

4. Students are asked to think and answer questions in the post-test instrument after the quiz or homework;

5. Instructors grade the quiz and homework and give students hints to the right answers on the students’ work sheet or in class;
6. Students are asked to think and answer questions in the instrument after they see their grade;

7. Students are given a chance to correct their quiz or homework;

8. Students are asked to think and answer questions in the post-test instrument after doing the quiz or homework;

9. Instructors grade the quiz and homework and return it to students;

10. Students are asked to think and answer questions in the instrument after they see their grade;

11. Instructors give another similar topics to students and procedures 1 to 10 are repeated;

12. Instructors give second learning topics and procedures 1 to 10 are repeated;

13. Instructors give third learning topics and procedures 1 to 10 are repeated.

### Table 2 (a) Self-evaluation form 1- Plan It

<table>
<thead>
<tr>
<th>Question</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Think and answer following question before solving the quiz problem, and circle the number that presents how confident you are that you can solve the above problem correctly.</td>
<td>1, 2, 3, 4, 5; 1=not confident, ….., 3=partly confident, ….., 5=very confident</td>
</tr>
<tr>
<td>You have made a plan for preparing the quiz or exam, after you were informed about this quiz or exam?</td>
<td>1, 2, 3, 4, 5; 1=not true at all, ….., 3=partly true, ….., 5=very true</td>
</tr>
<tr>
<td>You have identified the priority in preparing the learning subject that the quiz or test would cover, such as reading note, textbook, and sample problems.</td>
<td>1, 2, 3, 4, 5; 1=not true at all, ….., 3=partly true, ….., 5=very true</td>
</tr>
<tr>
<td>You have sought or would be willing to seek the help from instructor or peers if you have problem in understanding the subject.</td>
<td>1, 2, 3, 4, 5; 1=not at all, ….., 3=partially true, ….., 5=very true</td>
</tr>
<tr>
<td>You have read textbook and class note on the above problem in the quiz or exam subject.</td>
<td>1, 2, 3, 4, 5; 1=not at all, ….., 3=partially, ….., 5= completely</td>
</tr>
</tbody>
</table>

How much time have you sent for preparing the quiz, since you were informed about this quiz?

What strategies (as shown in Table 1 above) have you used when you prepared the quiz?

### Table 2 (b) Self-evaluation form 2- Evaluate It

1. After getting your quiz back, what do you learn by comparing your grade with your confidence estimates before doing test and after getting the test grade?
Table 2 (c) Self-evaluation form 3- Reflect It

2. Explain what strategies or processes make you correctly solve the quiz problem, if you are successful.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have searched my memories for the topic content I have read or learn.</td>
<td>1, 2, 3, 4, 5</td>
</tr>
<tr>
<td>I have recalled the solution procedures to similar problems.</td>
<td>1, 2, 3, 4, 5</td>
</tr>
<tr>
<td>I find answer from understanding the concept of problem subject.</td>
<td>1, 2, 3, 4, 5</td>
</tr>
<tr>
<td>I transfer the solution of the similar problems to the quiz problem.</td>
<td>1, 2, 3, 4, 5</td>
</tr>
<tr>
<td>Other method</td>
<td>1, 2, 3, 4, 5</td>
</tr>
</tbody>
</table>

3. You think or image how to transfer the successful strategies or processes into other setting, if you are successful.

4. Explain what strategies or processes went wrong on the quiz problem, if you are not successful.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>I cannot remember an important concept or principle I learn on the quiz subject.</td>
<td>1, 2, 3, 4, 5</td>
</tr>
<tr>
<td>I cannot remember an important concept or principle on the prerequisite subject, such as math.</td>
<td>1, 2, 3, 4, 5</td>
</tr>
<tr>
<td>I did not read the quiz problem carefully and misunderstand the problem.</td>
<td>1, 2, 3, 4, 5</td>
</tr>
<tr>
<td>I cannot understand the content I learn in the quiz subject.</td>
<td>1, 2, 3, 4, 5</td>
</tr>
<tr>
<td>I cannot connect and apply what I learn to the quiz problems.</td>
<td>1, 2, 3, 4, 5</td>
</tr>
<tr>
<td>I cannot break the problem into sub-problems and come up with solution procedure.</td>
<td>1, 2, 3, 4, 5</td>
</tr>
<tr>
<td>I cannot connect what I have learnt together and put them together to find the solution.</td>
<td>1, 2, 3, 4, 5</td>
</tr>
<tr>
<td>I cannot check and examine if my solution is right one and find errors to correct them.</td>
<td>1, 2, 3, 4, 5</td>
</tr>
<tr>
<td>Other</td>
<td>1, 2, 3, 4, 5</td>
</tr>
</tbody>
</table>

5. Please make comments and reflection on the above learning strategies that make you successful:

6. Please make comments and reflection on the above learning strategies that make you successful

Table 2 (d) Self-evaluation form 4- Plan for next circle

**Adjust and Plan It**

5. What strategies will you use to prepare and correctly solve the new problem in the same subject?

6. How confident are you now that you can correctly solve this similar item?

<table>
<thead>
<tr>
<th>Confidence Level</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not confident</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Very confident</td>
<td>5</td>
</tr>
</tbody>
</table>

**Priority and Resource**

7. What is the priority of your preparation for the next problem?

8. What resource will you use for your preparation?

**Practice It**
Assessment Framework for Integrating SRL into Engineering Curriculum

To assess students’ perception and understanding of self-regulated learning, a pre-test (questionnaires) was first conducted. After the test, direct instructions on SRL and motivation materials were then given. These instructions were integrated in class quiz or homework about three learning topics or problems. After class quiz, post-test (questionnaires) on students’ satisfaction on SRL instructions and the related cognitive strategies were conducted. Students’ grades on the designated course were also selected. The self-evaluation form derived from the above mentioned assessment framework is listed in Table 2.

Example of Embedded SRL Assessment Integrated with Content-Specific Quizzes

The presented instruction framework was implemented in CIV 320 - Structural Analysis and CIV 420 - Introduction of Reinforced Concrete Design from 2009 to 2010 at the Department of Civil and Environmental Engineering at JSU. It was implemented in the form of lectures on technical content and instructions on self-regulated learning strategies through integrating self-assessment with quizzes and tests on three selected relevant topics for each different course during the semester. As an example, the general self-regulated learning assessment questionnaires that were integrated with three quizzes and implemented in CIV 420 are given in the following.

Reinforced concrete design is a required upper-division course in civil engineering departments throughout the United States. The theory behind designing reinforced concrete structures involves the basic concepts and principles of engineering mechanics and mechanics of materials. The sequential quizzes are intended to have students fully understand the strain, stress, and force in reinforced concrete sections, and their relations and applications in determining the capacity or resistance of reinforced concrete members in the context of singly-reinforced beams, doubly-reinforced beams, and doubly-reinforced columns. They provide students with opportunities through the repeated learning process and the associated quizzes to master those principles and concepts.

The objectives of the quizzes are: (1) provide a platform to familiarize students the important concepts of course materials, (2) provide an opportunity for students to practice periodically the essential design concepts of reinforced concrete, and (3) improve students’ confidence and familiarities in solving assigned problems. Through the courses and the associated quizzes,
students are expected to be guided by self-regulated learning processes. The three quizzes are shown in Fig. 2(a)-(c) for readers’ interests.

**Problem:** For a singly-reinforced beam section and its strain diagram shown below, please answer the following questions (f'c = 4000 psi, fy = 60 ksi.)

(a) section  (b) strain  (c) stress  (d) force

**Question 1:** When reinforced concrete beam starts failure, what is the maximum strain in the concrete compression zone, and what is the compression zone depth? What is the real maximum stress in the concrete beam compression zone? Draw real concrete compression stress distribution in Fig. (c) (20 points).

**Question 2:** Draw Whitney stress of concrete compression in Fig. (d). What is the Whitney stress distribution depth, a, and what is the assumed uniform stress value? (20 points).

**Question 3:** Determine the strain and stress of the bottom reinforcement steel in tension when the beam starts failure. And indicate the stress in Fig (b) (20 points).

**Question 4:** Determine the total compression force of concrete Cc (20 points)

**Question 5:** Determine the total tension force Ts in the bottom reinforcement steel (20 points)

**Question 6:** What is the failure model of this concrete member, i.e. tension-controlled failure or compression-controlled failure (20 bonus points)

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**Problem:** For a doubly-reinforced beam section and its strain diagram shown below, please answer the following questions (f'c = 4000 psi, fy = 60,000 psi.)

(a) section  (b) strain  (c) stress  (d) force

**Question 1:** When reinforced concrete beam starts failure, what is the maximum strain in the concrete compression zone, and what is the real maximum stress in the concrete beam compression zone (10 points).

**Question 2:** What is the Whitney stress distribution depth, a, and what is the assumed uniform stress value? And also sketch the Whitney stress block in (d) (15 points).

**Question 3:** What is the compression zone depth, c, when the beam starts failure? And indicate c in the above figure. (10 points)

**Question 4:** What is the strain of tensile reinforcement steel when the beam starts failure? And indicate the stress in the above figure. (15 points)

**Question 5:** What is the strain of compressive reinforcement steel when the beam starts failure? And indicate the stress in the above figure. (15 points)

**Question 6:** What is the strength reduction factor for the flexural strength of the beam (15 points)?

**Question 7:** What is the ultimate moment design strength of the reinforced concrete beam (15 points)?

---

Fig. 2 (a) Quiz 1- Singly-reinforced beam section

Fig. 2 (b) Quiz 2 – Doubly-reinforced beam section
**Problem:** For a doubly-reinforced column section and its strain diagram shown below, please answer the following questions (fc' = 4000 psi, fy = 60,000 psi.)

**Question 1:** When reinforced concrete beam starts failure, what is the maximum strain in the concrete compression zone, and what is the compression zone depth? What is the real maximum stress in the concrete beam compression zone? Draw real concrete compression stress distribution in (c) (20 points).

**Question 2:** Draw Whitney stress of concrete compression in (d). What is the Whitney stress distribution depth, \(a\), and what is the assumed uniform stress value? (15 points).

**Question 3:** Determine strain and stress of the top reinforcement steel in compression when the beam starts failure (15 points).

**Question 4:** Determine the strain and stress of the bottom reinforcement steel in tension when the beam starts failure. And indicate the stain in (b) (15 points).

**Question 5:** Determine the total compression force \(C_s\) in top reinforcement steel in compression; and total compression force of concrete \(C_c\) (15 points)

**Question 6:** Determine the total tension force \(T_s\) in the bottom reinforcement steel in tension (15 points)

**Question 7:** What is the nominal axial load capacity \(P_n\) and what is the nominal moment capacity \(M_n\) (20 points)

**Question 8:** What this failure model of this concrete member, i.e. tension-controlled failure or compression-controlled failure (20 bonus points)

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**Fig. 2 (c) Quiz 3 – Doubly-reinforced column section**

**Students’ Learning Outcomes Based on Two-year Implementation**

The impacts of implementation of SRL instruction on students’ learning outcomes were assessed based on students’ academic performance that is indicated by the students’ course grade. The students from the course equipped with SRL instruction (years 2009-2010) were made of intervention group. The students from the same course without implementation of SRL in years 2005-2008 were regarded as empirical control group. The courses were junior level CIV 320 - Structural Analysis and senior level CIV 420 - Introduction of Design of Reinforced Concrete Structures. Those two courses have been instructed by the first author in the past five (Fall) semesters. The course examination and course work assignment were the same for each year, which provided comparable basis for empirical assessment of the impact of SRL assessment on students’ learning. The average scores of students form the course CIV 320 and CIV 420 in years 2009 and 2010, in which the presented self-regulated learning assessment was implemented, were compared with those from the same courses from years 2005 through 2008, in which the presented self-regulated learning assessment was not implemented. Comparisons of scores are listed in Table 3. It can be seen from Table 3 that students’ learning performance increased after implementing SRL framework. More specifically, the junior students benefited more than the senior students. The overall average score of the surveyed junior students increased significantly (>15% on average) after implementing the proposed framework.
Table 3 Students’ grade comparison

(a) Junior-level course CIV 320

<table>
<thead>
<tr>
<th>Year</th>
<th>A (4)</th>
<th>B (3)</th>
<th>C (2)</th>
<th>D (1)</th>
<th>F (0)</th>
<th>Withdraw</th>
<th>Total # of student</th>
<th>Avg. score</th>
<th>Average score in past four years</th>
<th>Grade increase (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>3</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>2.80</td>
<td>Relative to 2005-2008</td>
<td>2.39</td>
</tr>
<tr>
<td>2009</td>
<td>4</td>
<td>5</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>17</td>
<td>2.76</td>
<td>Relative to 2008</td>
<td>17.15 (2010) 15.48 (2009)</td>
</tr>
</tbody>
</table>

2008  5  3  4  6  0  0  18  2.39
2007  1  1  3  4  0  0  9   1.89
2006  1  1  4  0  0  1  7   2.50
2005  2  3  4  0  1  0  10  2.78

(b) Senior-level course CIV 420

<table>
<thead>
<tr>
<th>Year</th>
<th>A (4)</th>
<th>B (3)</th>
<th>C (2)</th>
<th>D (1)</th>
<th>F (0)</th>
<th>Withdraw</th>
<th>Total # of student</th>
<th>Avg. score</th>
<th>Average score in past four years</th>
<th>Grade increase (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>11</td>
<td>2.82</td>
<td>Relative to 2005-2008</td>
<td>2.82</td>
</tr>
<tr>
<td>2009</td>
<td>8</td>
<td>4</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>18</td>
<td>3.11</td>
<td>Relative to 2008</td>
<td>0.00 (2010) 10.28 (2009)</td>
</tr>
</tbody>
</table>

2008  2  2  4  0  0  1  9   2.75
2007  1  1  3  1  0  0  6   2.33
2006  3  6  1  0  0  0  10  3.20
2005  0  4  0  0  0  0  4   3.00

Note: In 2005-2008, the SRL was not implemented in the courses.

Students’ perception and comments on the presented instruction framework

For each course implemented with the proposed self-regulated learning instruction, post-test survey was conducted anonymously after the implementation. In this survey, the self-regulated learning skills, as well as the clarity, delivery, and organization of the module, were asked. Students were asked to give the score to five questions based on 1 to 5 scales: 5 = always true for me; 4 = frequently true for me; 3 = somewhat true for me; 2 = not very true for me; 1 = not at all true for me. Higher scores indicated better students’ perception of these activities. They were also asked to provide their comments to reveal their related learning experience and make suggestions. The five questions in the survey are tabulated in Table 4. Results from the survey were used to determine students’ perception on the importance and their interest of self-regulated learning.

Table 4 Questions in students’ satisfaction survey

1. I think that the self-regulated learning assessment and promoted reflection on the problem-solving process is very important topics and I am interested at learning and using them.

2. I think that self-regulated learning assessment and promoted reflection on the problem-solving process is practical and useful for my study.

3. I think that the instruction materials for self-regulated learning assessment and promoted reflection on the problem-solving process are organized effectively.

4. I think that the basic concept and application of self-regulated learning assessment and promoted reflection on the problem-solving process are presented clearly.

5. I think that if I master certain learning content, such as doing the homework or exam correctly, it is mainly because I pay attention during lectures and understand them in the class.
Based on valid surveys been collected, the results form the surveys on two courses in civil engineering, i.e. CIV 320 and CIV 420, are tabulated in Tables 5(a) and 5(b).

Table 5 Results from the survey of two civil engineering courses

(a) Junior-level course CIV 320

<table>
<thead>
<tr>
<th>Question</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Average score per question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>2</td>
<td>6</td>
<td>6</td>
<td>1</td>
<td>3.40</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>3</td>
<td>5</td>
<td>6</td>
<td>1</td>
<td>3.33</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>0</td>
<td>2.87</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>0</td>
<td>2.80</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>3.27</td>
</tr>
<tr>
<td>Overall average scores</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.15</td>
</tr>
</tbody>
</table>

(b) Senior-level course CIV 420

<table>
<thead>
<tr>
<th>Question</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Average score per question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>9</td>
<td>1</td>
<td>3.71</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>7</td>
<td>2</td>
<td>3.71</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>9</td>
<td>1</td>
<td>3.64</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>7</td>
<td>0</td>
<td>3.36</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>8</td>
<td>3</td>
<td>3.93</td>
</tr>
<tr>
<td>Overall average scores</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.67</td>
</tr>
</tbody>
</table>

Most of the students who participated in this survey had made positive and suggestive comments on the integration of self-regulated learning assessment into their courses for facilitating the learning of engineering concepts and approaching to solve engineering problems. These positive comments included:

- The self regulated learning process must be stressed and emphasized more.
- I need to improve my study habits. The self-regulated learning assessment allowed me to see that.
- The process is good and I do not have any comments on improving.
- I know that I must pay attention in class as well as study outside of class. It is important to ensure the material is understood.
- I think that I really understand concrete design better than before in this process. I think the major problem or misconception were the relations when it comes to stress and strain.
- My major misconception about reinforced concrete design has been corrected through doing self-regulated learning assessment, and reflection is finite intelligence in my idea.
- When I first start solving problems of reinforced concrete design I use to be confused by the units but now I think I'm getting use to it.
I think that I learned step by step method. I learned how to approach a problem that I know how to solve in the proper way.

I have confession on the real max stress. Through this process, I now understand that the max stress (in concrete when the beam starts failure) is the concrete's compression strength.

Taking strengths and using them to work on my weakness. Doing more planning on how to get work and study done.

I learned how to explain more clearly and how I get my answers.

Three students, who may not perceive the importance of self-regulated learning, have made the following comments:

- I do not like self-regulated learning; I prefer the classroom setting.
- Self-regulated learning doesn’t work at all. If we could learn by our self, there is no need to go to school.
- I think that the assessment shouldn’t be apart of the regular test. It really makes it longer and causes me to loose focus. I suggest giving after tests are collected for better results. Surveys are always something extra and cause students to loose focus.

Instructors’ Perceptions on Students’ Learning and implementation of novel instructions

The discussion and survey were also carried out among instructors who have implemented SRL in other engineering course at JSU. Those revealed perspective of engineering instructors in implementing SRL and improving students’ learning skills and outcomes, and are summarized as follows:

- The most deterministic factors contributing to our students’ lower performance in their learning outcomes are lack of motivation and time for studying.
- The major factor that can promote faculty members to implement teaching innovation, such as integrative SRL framework, in their courses is self-enjoyment and fulfillment.
- The possible improvement for students after implementing current SRL assessment is their learning motivation.
- An effective way to help instructors to adopt, develop, and implement teaching innovation in their courses is to reflect and publish the practice of their teaching.
- Over half of the instructors believe that current SRL assessment approach is suitable and easy for implementation.
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 recognize that the implementation of SRL promote them to know more about effective learning and teaching methodology developed in learning science.

Summary of findings from the implementation outcomes

Findings from the preliminary study revealed that the majority of students perceived the importance of self-regulated learning skills, and they were interested in learning self-regulated learning skills. They also perceived the benefits from self-regulated learning assessment through planning and using learning strategies in facilitating them to understand the basic engineering concepts and problem solving. It is notable that the senior students have higher perception on the importance of self-regulated learning and benefited from implementation of self-regulated learning assessment than the junior students. This may be attributed to the fact that senior students are more mature in developing higher-order skill through their engineering education.

Comparing the academic performance of intervention group with empirical control group, junior students seemed to have more academic performance improvement than those of senior students. This may imply that the implementation of self-regulated learning assessment has more positive impacts on the learning outcomes of younger students than those of senior students, even though younger students may have relatively lower perception on SRL than senior students. On the other hand, although all students showed relatively higher perception on the importance of self-regulated learning assessment and higher interests in learning self-regulated learning skills, they had lower perception on the organization, effectiveness, and delivery clarity of the self-regulated learning instruction. Based on the students’ perception and comments, it would be necessary for the instructors to conduct SRL assessment after the in-class quizzes or exams. It’s worth noting that a few students had misconception on the significance of implementing self-regulated learning assessment. They thought that self-regulated learning referred to self-directed learning and did not realize the importance of making plan, using strategies, and reflecting and adjusting learning activities. In the next implementation, attentions should be paid on avoiding this misconception.

Conclusion

In this paper, literature across cognitive science and education was first briefly reviewed. The general integrative pedagogical framework and three learning topics in reinforced concrete structures design were presented to integrate self-regulated learning assessment with course quizzes and exams. The implementation of the instruction and its outcomes from two civil engineering course of CIV 320 Structural Analysis and CIV 420 Introduction of Reinforced Concrete Design at JSU were revealed, and their further improvements were also discussed. Results from students’ outcome showed that the majority of students could perceive the importance of self-regulated learning skills, and they were interested at learning self-regulated learning skills. Students’ learning outcomes were also benefited from self-regulated learning assessment through planning and using learning strategies in facilitating them to understand the basic engineering concepts and problem solving.
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Reference: