Fostering Self-Regulated learning in Introductory Computer Programming Course

Saleh Alhazbi  
Computer Science and Engineering Dept.  
Qatar University  
salhazbi@qu.edu.qa

Mahmood Hassan  
Institutional Research Dept.  
Qatar University  
mhassan@qu.edu.qa

ABSTRACT
In this paper, we describe strategies we have used to foster self-regulated learning (SRL) in computer programming course in order to enhance the learning process. Strategies include direct instructions, guided practice and feedback, they were implemented using different tools to train student on SRL skills. Students in this course were enrolled in two sections randomly, one section was considered the treatment group where we implemented these strategies, while the other section represented the control group. In order to investigate the effectiveness of these strategies, we used indirect and direct assessments. Motivated Strategies for Learning Questionnaire (MSLQ) was used as indirect assessment to assess students’ awareness of SRL skills in the treatment group comparing to others in the control group. Students performance in both groups was used as direct assessment. The results show that these strategies improve students’ Self-regulation in learning computer programming, consequently students who were trained on using SRL skills outperformed those who were not.

Categories and Subject Descriptors
K.3.2 [Computer and Information Science Education]: Computer science education

General Terms
Human Factors, Performance

Keywords
Self-regulated learning, Computer Programming Course, Student’s Journal, Affirmative assessment

1. INTRODUCTION
Self-regulated learning (SRL) is a learning process where responsibility of learning is placed more on learners themselves to control and evaluate their own learning. Zimmerman [23] defines self-regulated learners as the learners who are able to “metacognitively, motivationally, and behaviourally active participants in their own learning process.” Metacognitive refers to learner awareness and control of the cognition processes, this includes: planning, monitoring, and self-evaluation [16]. Self-regulation is not an indicator of mental intelligence or a personal characteristic that cannot be changed, it is a learning model that can be acquired through experience and self-reflection [15]. Training students on SRL skills aims to enhance their performance by helping them create better habits of studying [22], apply learning strategies that fit better with each one’s learning style [7], and be able to monitor and evaluate their progress [6].

Research has showed that high achievers usually use more self-regulated learning strategies than lower achievers [4], [21]. Additionally, studies like [11], [17] have found a significant correlation between students’ performance and self-regulated learning. There is limited research [2], [3] investigated the importance of using self-regulated learning in computer science education. The study in [2] has concluded that there is a need to infuse self-regulated learning in computer science teaching because students are not aware of important SRL strategies, and they are less familiar of metacognitive strategies. On the other hand, Bergin, Reilly and Traynor [3] found that SRL is important in learning computer programming, their study has indicated that students who perform well in programming use more Self-regulated learning strategies like metacognitive than lower performing students. However no much research discusses how to encourage SRL in computer programming course in order to enhance students’ learning.

1.1 Why SRL in Computer Programming Course?
Generally, computer programming is considered a difficult subject. Students need not only to understand the knowledge of programming language like syntax and data types, but also to master skills of problem analyzing, program design and implementation [5]. This requires students to work outside the classroom independently on developing these skills using different strategies like: reading subject materials, developing algorithms to solve problems, writing code, fixing program errors, seeking help from others, etc. Training students to be self-regulated learners will help them to work on these skills by their own which eventually will enhance their learning. By using SRL skills, students can adapt themselves to the most appropriate style of learning that fits with their preference.

Moreover, SRL model addresses some reasons behind the difficulties of learning programming. Novice programmers usually lack the skill of planning ahead before starting program implementation [18], thus training students on planning as one of SRL skills, will enhance students metacognitive skills of planning their learning process in general. Consequently that makes students think of problem solving and solution design before starting to code. Another problem when learning programming is
that novice students usually are not aware of their own deficiencies [1], [9]. By training students to be self-evaluating learners, they will be able to identify their weaknesses, and accordingly seek help from the instructor or other peer students, seeking help is also one of SRL skills.

In this paper, we describe our experience of fostering self-regulated learning in computer programming course. The students enrolled in two different sections. We implemented our strategies in one section and used the other one as a control group in order to assess the effectiveness of these strategies. The reminder of this paper is organized as follows: section 2 discusses the strategies used to infuse SRL in computer programming course. Section 3 describes how we assess the effectiveness of these strategies. Section 4 shows the result of the study. Discussion and conclusion are presented in section 5.

2. Strategies to Promote SRL in Computer Programming Course

In this section, we explain the strategies used to promote self-regulated learning skills in computer programming course taught in Fall 2012 at Qatar University. Specifically, our objective was to enhance students SRL skills in term of metacognitive and help seeking. Generally, creating self-regulated learning environment can be achieved using different instructional strategies include: direct instruction, guided practice, feedback [20]. We have used different tools to implement these strategies, Table 1 shows the strategies and the tools used to implement each one of these strategies.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct instruction</td>
<td>Booklets, discussion</td>
</tr>
<tr>
<td>Guided practice</td>
<td>Student’s Journal</td>
</tr>
<tr>
<td>Feedback</td>
<td>Student’s Journal, formative assessment, forum</td>
</tr>
</tbody>
</table>

2.1 Direct Instruction

In order to improve students awareness of self-regulated learning, a small booklet was prepared and given to the students, it describes SRL skills including setting goals, planning, progress monitoring, seeking help, self-evaluation and reflection. This booklet encourages students to practice these habits of study, it directs students to set specific goals each time before they start studying the subject, then monitor their study trying to fulfill these goals. When facing difficulties, they are supposed to seek help either from the instructor, other students, or any other source of help. When they finish, they should be able to evaluate themselves against their goal, according to that evaluation, they should have reflection.

The booklet guides students on how to apply these skills when studying computer programming with emphasize on subject nature and the need to spend more time practicing programming rather than just reading the materials, it describes the appropriate practice of problem solving and program implementation.

In addition to the booklet, classroom discussions have been held many times about SRL skills and how to practice these skills when studying. This discussion includes sharing some of students experiences.

2.2 Guided practice

Direct instructions help students understand SRL model and its importance, however, students need to practice SRL strategies independently under instructor’s guidance [8]. To guide students individually, they were asked to write a weekly journal reporting their experience of their own learning outside the classroom. Reflective journaling has been used as a pedagogical method to engage students in learning process in different disciplines [12]. We utilized the electronic journal feature of Blackboard to implement this strategy, it is a private tool that is only accessible by the instructor and the student.

In their weekly journals, students specify the lessons they have studied, their goals before starting study, difficulties they have faced, how they have overcome them, how they evaluate themselves and what were their reflections. Each week, these journal entries are reviewed by the instructor who gives comments when needed to help students improve their habits of study. These comments include guidance to implement SRL strategies correctly, directions to the correct method to study the subject, and instructions to overcome the difficulties like referring students to external resources, or setting appointment. Moreover, the journal was used as an archived channel of communication between the instructor and students, which increases student-instructor communication.

In order to encourage students to write weekly journal, this was considered an assignment that was required to submit weekly. Also, it was noticed that some students have difficulties writing on their activities, therefore, a journal template was developed to be filled in by the students to report about their study goals, difficulties, sources of help, evaluation and their reflection.

2.3 Feedback

Feedback plays an important role to train students on SRL skills [20], it gives a learner an indication about his current state (of learning and performance) related to the goals and standards. Besides external feedback provided by instructor and peers, self-regulated learners should be able to generate internal feedback as they monitor their learning engagement and assess their progress towards the goals [10]. We have used different tools to implement this strategy. While the journal is used by students to log their learning activities, it is used by the instructor to provide students with feedback about their habits of learning, and to help them overcome technical programming problems. Another important tool that was used to help students get weekly feedback is formative assessment, it is an assessment that aims to generate feedback on performance to improve students learning [19]. Weekly exams were posted to Blackboard to assess students understanding of the materials covered during the week. Although these exams are not part of the course grades, and solving them is optional, student answers were graded in order to help students monitor their progress. On the other hand, formative assessment helps the instructor to realize the problems faced by students. Besides giving students feedback, formative assessments push students to seek help when needed through discussions with the instructor or with peers. In order to support this, an online forum was set and students were encouraged to participate in this forum to seek or offer help. This helps create an active learning environment and improves the level of interaction.
3. Evaluation
At the end of the semester, we investigated effectiveness of using the strategies above in improving SRL skills of the students (indirect assessment), as well as examined their impact on students’ performance (direct assessment). The subjects of the study were 48 students who enrolled in programming concepts course at Qatar University (QU) in Fall 2012, this is a CS1 course which is offered to both computer science and computer engineering majors. Students study C++ language in this course. This study was conducted on QU female campus so all students are female and new students. The subject students enrolled randomly in two different sections. The strategies above was implemented in one of these sections (treatment group) which has 22 students, the other section was considered the control group which has 26 students.

To measure students’ self-regulatory skills, we used Motivated Strategies for Learning Questionnaire(MSLQ), a widely used self-report instrument developed by Pintrich, Smith, Garcia, and McKeachie in 1991 [14]. This questionnaire uses a seven-point scale ranging from 1 (not at all true for me) to 7 (very true of me) to measure motivational scales and learning strategies, items are evaluated determined by calculating the average. Modular design of the questionnaire makes it flexible for researchers to use only the modules that fit their needs. In this study, we employed the scales that measure metacognitive strategies, and help seeking. Metacognitive component assesses skills of planning, monitoring and evaluation. Help seeking component aims to assess students awareness of pursuing help from instructor or other peer students. The questionnaire was given to the students in both groups at the end of the semester but before the final exams.

To investigate the eventual impact of these strategies on students learning, we compare students’ performance in treatment group to performance of those in the control group. The performance is based on the overall score which is determined by different assessment methods including quizzes, homework, exams, and lab works.

4. Results
Table 2 shows the results of analyzing students responses in term of metacognitive scale, it indicates that there is a significant difference between the treatment and the control group in favor of the treatment group (students in the section who received SRL training).

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>t</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>26</td>
<td>53.9</td>
<td>7.1</td>
<td>-2.63</td>
<td>45.7</td>
<td>0.04</td>
</tr>
<tr>
<td>Treatment</td>
<td>22</td>
<td>57.9</td>
<td>6.5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p<0.05

On the other hand, by analyzing students responses on help seeking scale, it was found that there is no significant difference between treatment group and control group, as it is described in Table 3.

Table 3. Independent t-test, difference between means of help seeking scale in control group and treatment group

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>t</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>26</td>
<td>19.0</td>
<td>3.9</td>
<td>-.59</td>
<td>46</td>
<td>0.56</td>
</tr>
<tr>
<td>Treatment</td>
<td>22</td>
<td>19.6</td>
<td>4.1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p<0.05

To assess the ultimate effect of mastering SRL on students’ performance, we use t-test to compare overall performance of students in control group and treatment group. As it is shown in Table 4, it is found that there is a significant difference (t=-2.33, p=0.025), students in treatment group (who received SRL training) outperform those in control group (77.8 vs. 68.0).

Table 4. Independent t-test, difference between students’ performance in control group and treatment group

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>t</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>26</td>
<td>68.0</td>
<td>14.6</td>
<td>-2.33</td>
<td>40</td>
<td>0.025</td>
</tr>
<tr>
<td>Treatment</td>
<td>22</td>
<td>77.8</td>
<td>12.3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p<0.05

Generally, by investigating the relationship between students’ performance and SRL, results show there is a significant correlation between students’ performance and SRL for control group and treatment group as well as for all students regardless of the group, this relationship is described in Table 5.

Table 5. Correlation between students’ performance and SRL skills

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Pearson Correlation</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>26</td>
<td>0.46</td>
<td>0.03</td>
</tr>
<tr>
<td>Treatment</td>
<td>22</td>
<td>0.43</td>
<td>0.04</td>
</tr>
<tr>
<td>All students</td>
<td>48</td>
<td>0.50</td>
<td>0.001</td>
</tr>
</tbody>
</table>

5. Discussion and conclusion
The results of this study show that self-regulated learning skills are teachable and can be trained, it can be infused into learning environment using some direct and indirect strategies. The results revealed that students who received SRL training were more aware of using these strategies when studying computer programming. Our study supports finding of the study in [3] that SRL is an important in learning computer programming, therefore improving students’ SRL skills in this course will eventually enhance their performance. The importance of SRL in learning computer programming is due to the nature of the subject which requires learner to master different levels of learning objectives include: understanding syntax of the language, understanding written programs, fixing errors, and the highest level which is gaining skills of problem analyzing and program developing to solve the problem. These variety of skills requires more independent work from learner at his own time, therefore regulated learners will be more able to master these skills better than others.
6. REFERENCES


