AC 2010-1294: INTEGRATING SELF-REGULATING LEARNING WITH AN OBJECT-ORIENTED PROGRAMMING COURSE

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Integrating Self-regulated Learning with an Object-Oriented Programming Course

Abstract

This paper presents a self-regulated learning strategy integrated into a freshman-level object-oriented programming course at one of HBCU (Historically Black Colleges and Universities). A set of surveys was conducted in this course to support the self-regulated learning process. Analysis of the surveys shows positive effects on students' learning and performance in this course. This learning experience may be transferred to learning in other courses.

Introduction

This paper presents the self-regulated learning (SRL) strategy integrated into a freshman-level object-oriented programming course at one of HBCU (Historically Black Colleges and Universities). Usually object-oriented analysis and design (OOAD) is covered in a senior software engineering course in computer science. It is practiced widely in the software industry. In our institution, OOAD is introduced at the freshman level.

The course title is Object Oriented Programming (3 semester hours). Before taking this course, the students have taken a Java programming course (3 semester hours) as the prerequisite. This Object Oriented Programming course is a continuation of the Java programming course. It teaches further topics in Java and OOAD. In general, OOAD is considered challenging[1], because in the OOAD process practitioners have to make many judgments along the way.

For the most crucial phase of class identification, a verbs/verb phases driven identification procedure is followed[2] in this course. After class identification, Java/C++ classes emerge from the domain description. Basically, OOAD is a process of converting the description of the activities in a software domain in English into an outline (structure) of an object-oriented program in Java or C++. The description is about how the people run their business in a domain, e.g. a furniture store, in English. The resulting computer program is a modeling of the activities in the domain. This conversion from description in English to a description in an object-oriented programming language is almost mysterious for a computer science freshman. In order to become mature in practicing OOAD, usually this requires extensive experience working on different kinds of software projects. Introducing OOAD at the freshman level in a computer science curriculum gives students early exposure to OOAD, and the students can practice the same process on other software projects throughout the rest of the curriculum[1]. A graduate from this curriculum will have good exposure and practice in OOAD. This topic is particularly suitable for practicing self-regulated learning. The mastering of OOAD can be checked at different points in a semester. The survey questions help students' learning.

Teaching OOAD at the freshman level poses great challenges to the instructor. In addition to the challenges of teaching a complex topic, particularly in an HBCU (Historically Black Colleges and Universities), many students are from families of financial disadvantage and/or are not well prepared for college academically. It is not uncommon that many students at an HBCU work long hours (over 30 hours a week) and at the same time full time students. Effective teaching and

learning strategies become important, as some students may not have enough time and energy for off-class study.

When a student comes to our computer science program, the student is interested in this discipline. In order to maintain a good retention rate of the program, efforts have to be put in nurturing students' motivation, confidence, and strategies in learning. The emphases are on reflection, motivation, and confidence. Constructive behaviors are built up that will affect a student's learning in general. There is a need for a minority institution to adopt new instructional strategies that will help students to effectively regulate their learning motivation, strategies, and efforts. Students who have followed through this course may be able to transfer this practice to other courses.

The purpose of this study is understanding how self-regulated learning improves effectiveness of learning OOAD. The outcomes of this study are insights gained about the process of self-regulated learning in the context of learning object-oriented analysis and design. In this course that was offered in Fall 2009, surveys to support self-regulated learning were conducted and analyzed. Results are reported in this paper.

Self-regulated Learning

Self-regulated learning (SRL) means consciously monitoring and regulating the learning process to make learning effective. In the learning process, a learner is involved in two roles: a person who learns and a person who monitors/regulates the learning. Self-regulated learning is guided by meta-cognition (awareness of thinking), strategic action, and motivation to learn[3,4]. It has been developed as an effective cognitive model in educational psychology. Self-regulated learning involves self-monitoring and self-correction in the three aspects of learning: motivation, behavior, and cognition. An important aspect of SRL is that the learner believes a person's intelligence is expandable[5]. That means the intelligence level of a person can increase through learning. This self-belief of expandable intelligence (EI) is crucial that learners will attribute their successes or failures to factors within their control, i.e. effective use of strategies or efforts on the work, rather than the lack of ability.

During the course, SRL practice was explained to students along with problem solving. This course integrated SRL skills development with traditional course assignments and facilitated students to use their grades as feedback to self-reflect their learning through monitoring and evaluating the learning progress and making future adjustments. Surveys were conducted along with assignments and exams in the course to support the self-regulated learning process. The ultimate goal is for students to transfer this self-regulated learning practice to other courses. A class time was allocated for presenting and discussing self-regulated learning.

Course Layout

In this course, the main evaluation instruments were the 1st exam, the 2nd exam, the final exam, and a term project in object-oriented analysis and design. There were also some small in-class exercises. The 1st exam covered general concepts about classes (objects, inheritance, polymorphism, etc.). The take-home 2nd exam contained an individual project for a software

domain starting from a given use case and a given scenario. The students did the rest of the object-oriented analysis and design phases divided into the 2nd and the final exams. The final exam was a continuation of the 2nd exam for this project. There were also some questions from other topics in Java, such as exception handling, file I/O, graphical user interfaces, on these two exams. Answers to the first half of the project on the 2nd exam were given on the final exam, and the students followed through the rest. For the Fall semester of 2009, the project was course registration system.

A group term project on the domain of a furniture store was also given, and this project ran ahead of the individual exam project. The term project was divided into a few phases. When a phase was done, it was reviewed and corrected before moving on to the next phase. The purpose of assigning two projects was giving students more opportunities to practice OOAD. The due date for the term project was set to the final week. That gave students plenty of time to review and modify. The practice of object-oriented analysis and design is the most important component in this course. The object-oriented analysis and design process is described in the two surveys (see Appendices A & B).

The practice of self-regulated learning was mostly concentrated on object-oriented analysis and design for this course. Surveys were given to support this self-regulated learning process.

Surveys and Results

The two main surveys (see Appendices A and B) for the whole detailed OOAD process to support self-regulated learning for students played an important role in students' learning in this class. Each survey had student's identity on it. The instructor reiterated the fact that the answers to survey questions had nothing to do with a student's grade. Some survey questions were closed-ended, and students were asked to give a rating of understanding level for a topic. These ratings are shown in the tables to follow. An analysis follows each table. The other survey questions were open-ended. The students had to think carefully before writing out an answer. Diverse and descriptive answers were expected. The answers to the open-ended questions helped giving the instructor impressions about the class in practicing self-regulated learning.

The students followed the OOAD process to complete a group OOAD term project and an individual OOAD project on the 2nd and final exams. The first survey was given when the term project was about completed. The students were given the second survey at the same time the take-home final exam was given one week before the due date. These surveys evaluated the students' levels of mastering OOAD at two important check points.

The key point was that these surveys modified the students' behaviors about learning. They wanted to do better than the first time when answering the second survey questions. In the final week, students frequently came to the instructor for discussions about the project and exam questions. In the two-hours session with students in a class, the students were very actively involved in discussing questions/problems related to the term project and final exam questions. The survey questions stimulated the motivation for learning. Compared with the students in previous classes (every semester since Spring 2003), the performance in OOAD of the class in

Fall 2009 was much better. The motivation and activities for learning OOAD in this class was impressive.

In addition to the the two surveys for the contents of OOAD, a number of surveys were conducted for gathering background information about the students, for students' understanding of self-regulated learning, and for understanding students' learning skills/strategies and motivation.

These OOAD survey questions simulated an adapted self-regulated learning process in series of self-directed feedback cycles at two different times.

a. Survey about student profile for the class

The following table shows the work hours per week of the students and their grades in the course. These include on-campus and off-campus jobs.

Number of hours worked per week	>=50 hours	40~50 hours	30~40 hours	20~30 hours	12 hours or less	Total number of students responded
Number of students	1	2	4	2	10	18
Grades	1 C	2 C's	1 A, 3 B's	2 A's	4 A's, 2 B's, 2 C's, 1 F	

The students who worked over 40 hours a week did not do well and barely passed the class (a grade of C). Working that many hours a week does not leave enough time to do well in school. The result is mixed for the students who worked between 30 and 40 hours a week. Generally they received grades from medium to good. As what a student described in one of the surveys reflected this fact well: "My major misconception is not having enough study time due to work." This student worked 40 hours a week, and this statement probably meant that this student could have managed time better and did better in this class. This student received a C. For the students who worked less than 12 hours, the grades are mixed. Quite some were good, but still there was a failure (an F). In addition to working for long hours, some distractions among the students were taking care of a baby and family, too many extracurricular activities, as responded in a survey. In the future, this survey can be improved by looking into more detailed information, such as ranking the activities that affect their performances, asking students if time management is very important and rating their time management.

Note that reading an important question could trigger self-regulated learning. The student will become aware of the problem and may monitor and improve in the problem area next time. As a student stated, "I need to use my time to study more." This is a self-regulated reflection on what needs to be done to improve course performance. This student did very well in the first

half of the semester (a top student), but skipped classes in the second half. This statement may be a self-regulated result for improvement.

b. Survey about the importance of self-regulated learning

Self-regulated learning and the belief on expanding intelligence were mentioned throughout the semester, and a lecture in self-regulated learning was given for the students. All students who responded to the survey about self-regulated learning expressed that self-regulated learning was positive in their learning and most said they would try to practice it in other courses. As a student stated, "I never thought I could learn something from doing a self-regulated assignment (a survey), but after I have done this, I understand I need to make use of my time to prepare myself better and study my lessons more regularly." This student is in the college tennis team and has to play tennis 3 hours a day. She competes in international tournaments. She expressed that playing tennis did interfere with her studies. Still she had a very good performance in this class. The survey questions did trigger her awareness of the problem and the self-regulated learning process for improvement.

A survey question asked what a student's major misconception was and had been corrected in the self-regulated assessment. Some of the responses in corrected form included "Time is a key asset." "I should study more, and I have to read over the material constantly." "I found more ways to understand different materials," "Most times to really grasp new information, I must study 1 or 2 hours every other day, and I can't only rely on lectures." "I have been doing too many extracurricular activities outside of classes, and these prohibit a student from doing well." "Notes will help me understand what was going to be on the test."

In the future, the surveys will be phrased in a way that when a student reads a question, this trigger self-regulated thinking for awareness of the problems and finding solutions for improving.

Asking students to write in sentences or a short paragraph instead of giving ratings (check boxes) only for survey questions may provide more information. This kind of surveys will give more insights about the questions for the instructor and the students.

c. Surveys about the object-oriented analysis and design (OOAD) process

The following tables show the results of the two OOAD surveys. Each column of the table is for a student. Each entry is a number (from 1 to 10) to indicate the understanding level given by a student.

There are 3 check points, which are (Check 1) before taking the course, (Check 2) after having mostly done the term project, and (Check 3) after having taken the final exam. A blank indicates that the student did not respond to the question(s). The row *Grade* shows the student's grade for the course.

1). Class and object

Student	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15
Check 1	1	7	5		5	5	8.5	4	4	6	4	4		5	1
Check 2	9	9	5		5	7.5	9	8	7	9	6	5		6	6
Check 3	9		5	7	7		9.5		8		6	6	5	7	8
Grade	A	C	B	B	A	A	A	B	B	A	C	C	C	A	A

2). Use case diagram, use cases, and scenarios

Student	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15
Check 1	7.5	10	3		0	7	7	2	2	1	1	0		2	0
Check 2	10	10	4		5	9	10	5	6	10	8	0		10	9
Grade	A	C	B	B	A	A	A	B	B	A	C	C	C	A	A

3). Class identification and class diagram

Student	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15
Check 1	5	6	2		1	7	8	1	5	1	1	0		5	0
Check 2	10	8	2		10	9	10	5	8	9	6	5		10	8
Grade	A	C	B	B	A	A	A	B	B	A	C	C	C	A	A

4). Sequence diagrams, attributes, method assignment, detailed class diagram, and code outline

Student	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15
Check 1	1	5	2		5	4	7.5	3	0	2	1	0		1	0
Check 2	9	8	2		7	8.5	10	8	4	9	5	0		7	7
Grade	A	C	B	B	A	A	A	B	B	A	C	C	C	A	A

5). OOAD overall after having taken this course

Student	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15
Check 3	9		3		7		10		8		6	7	7.5	8	10
Grade	A	C	B	B	A	A	A	B	B	A	C	C	C	A	A

Note that comparing the data of two students does not give much insight. One student with excellent performance expressed in the class that she had low self-esteem. This student tends to give low numbers for proficiency in topic areas. Comparing data from the same student does make sense. The trend for understanding level for a student from check points 1, 2, to 3 is going higher. That means students thought their proficiency in each area increased over time in the

course. Partly the survey questions drove those proficiency levels higher. Some numbers for specific students stayed low and/or the same, moving from one check point to the next. Usually they expressed that they did not do the specific parts of the project. The corresponding survey question itself raised a warning flag for the student and triggered a self-regulated learning process (awareness and improvement). In the second (final) survey, we usually saw improvement in the same area.

The OOAD overall performance data (students' perception) are more consistent with the grades (actual performances), though there are two irregularities.

For those students who gave high proficiency rating for a certain area, later on this student would see the graded exams back. It they were consistent, then it was fine. If not, this would trigger self-awareness and possibly future improvement. For those students with low self-esteem, good grades would help to raise toward the reality and build confidence level. For those students who skipped classes, questions about proficiency served as warning. Some students wrote in the surveys that they should have come to the classes regularly, because they found that they could not do certain problems. Usually students who skip classes tend to ignore the activities that are missing. The questions on surveys serve as reminders for what they have missed. This brings up self-awareness and possible positive reaction.

After having done all the surveys, a student wrote "My attendance could be better. Take more extensive notes and practice more." responding to the question that if we had to start it all over, what would a student do differently. Going over survey questions helped finding weaknesses, stimulated reactions, and modified behaviors for solving problems.

The surveys for OOAD used indirect assessments of student performance and growth moving from one check point to the next, though at the end the student's semester grade was included. The assessments were done by the students, not by objective measures, such as tests. Object oriented analysis and design involves substantial work and more of an art. In this course, objective measures were not given along the way going through check points 1, 2 to 3. In the future when the instructor is assigned to teach the same course again, tests may be given for students to work out simpler questions/problems to get the proficiency levels of students in OOAD at these 3 check points. These tests to go with the 3 check points will be similar and will provide a benchmark for comparison. Assessments with objective measures will be good improvement for next course with integrated self-regulated learning.

Transferring self-regulated learning experience to other courses

Though most students in this course expressed that they would practice self-regulated learning in other courses. Still they are some points to be asked and clarified. The surveys did help students' performances. What if no surveys are given and students are on their own? Can students do the same process of self-regulated learning? Practicing self-regulated learning process in another course involves automatically making up questions in learning in general and questions for the topics covered in the course in specific. Students have to be aware of the proficiency level for each topic covered and learning in general over time in the course.

After enough courses done in this manner, the students could be instilled this self-regulated learning practice. The ultimate goal is that students themselves will make up questions consciously and automatically in another course. What the instructor can do is giving a survey about what questions, topic specific and learning in general, a student will ask himself/herself, and the instructor will evaluate how good those questions are for self-regulated learning. This may give insights into transferability of the self-regulated experience from supervised to unsupervised contexts. This may be a good improvement for another course with integrated self-regulated learning.

Discussions

Designing questions for surveys that helps self-regulating learning is most important. When a question is written down, thoughts must be put on what consequences students will react to the question. *Letting students answer well-thought questions itself will trigger self-regulated learning that is beneficial to students' learning.* Fall 2009 was the first time self-regulating learning was integrated into the course. For the future, the survey questions will be revised to become more focused. For example, there were too many questions about students' background. Some will be dropped and some will be investigated further, such as the health levels of students and how they cope with stress.

Other fundamental issues, such as health, stress, are important. These issues may have great effects on students' motivation. Though the solutions are out of the scope of this study, being aware of these issues is very important toward solutions.

The surveys did help students' performances. What if no surveys are given and students are on their own? Can students do the same (self-regulated learning)? After enough courses done in this manner, the students could be instilled this self-regulated learning practice. Hopefully students themselves will come up with questions to ask themselves automatically in another course. In the coming semester, inviting other instructors to integrate self-regulated learning in their classes will be helpful.

Conclusion

Self-regulated learning did help the performances of students in this freshman level object oriented programming course. Along the course, surveys that match topics being covered were given, along with the surveys for gathering students' background information. Answering the questions in the surveys is a very important part of self-regulated learning process that helps students' learning. The survey questions triggered the self-regulated learning process. Practicing this learning experience in other courses is the next great step. Eventually students may be able to learn and at the same time monitor effectively the learning process.

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Bibliography

1. Yevtushenko Pei and Loretta Moore, "Implementing an Object-Oriented Analysis, Design, and Programming Course at the Freshman Level," in Proceedings of ADMI-2005 Symposium on Computing at Minority Institution, Rincon, Puerto Rico, Oct. 13-15, 2005.
2. Tzusheng Pei and Hyunju Kim, "Verbs/Verb Phrases Driven Class Identification," in the Proceedings of the 22nd International Conference on Computers and Their Applications, Honolulu, Hawaii, March 28-30, 2007, pp.349-354.
3. N.E. Perry, L. Phillips, and L.R. Hutchinson, "Preparing Students Teachers to Support for Self-regulated Learning," Elementary School Journal, 106, 2006, pp. 237-254.
4. B.J. Zimmerman, "Self-regulated Learning and Academic Achievement: An Overview," Educational Psychologist, 25, 1990, pp.3-17.
5. L.S.Blackwell, K.H. Trzesniewski, and C.S. Dweck, "Implicit Theories of Intelligence Predict Achievement across Adolescent Transition: A Longitudinal Study," Journal of Child Development, 78 (1), 2007, pp. 246-263.

Appendix A

Class related concepts and the Object Oriented Analysis and Design (OOAD) initial survey

Answers are not relevant to a student's grade.

1. For the concepts of class and object (attributes, methods, constructors, creating objects out of classes, implementing a software system by interacting objects):
a).Describe the understanding level (from 1 to 10) you had before taking this class. Do use a few words, a phrase or a paraphrase to describe. They are m

ore expressive than a number.

b). Describe the understanding level (from 1 to 10) after having mostly done the term project in this course. Do use a few words, a phrase or a paraphrase to describe. They are more expressive than a number. Describe concepts you have difficulty understanding and what improvements you need to have from your part and from the instructor of this course.

2. For the object oriented analysis and design process: use case diagrams, use cases, scenarios under each use case, class identification (identifying Java classes to create for this project), class diagram, sequence diagrams and method assignment, detailed class diagram, Java code outline (a program where each method has an empty body.

Phase 1.1 Draw a use case diagram that shows a number of use cases for summarizing activities in the domain and a number of actors that are involved in the use cases. Draw an arrow from an actor to a use case if the actor is involved in the use case. A use

summarizes related activities. For example, *borrow book* is a use case for a library system.

Draw the diagram on MS Word or other drawing software, such as SmartDraw. (There are good professional software for this purpose.) Each phase will be included in the next phase.

Phase 1.2 Continue from Phase 1.1. List a number of scenarios for each use case you have identified in Phase 1.1. A scenario is a sequence of steps. There will be no loops and no branches in a scenario. Students may put a title for each scenario. They must type the use cases and scenarios into computer. Use *Copy and Paste* for common steps in scenarios.

a).For phase 1 (1.1 and 1.2), describe the understanding level (from 1 to 10) you had before taking this class. Do use a few words, a phrase or a paraphrase to describe. They are more expressive than a number.

b). For phase 1 (1.1 and 1.2), describe the understanding level (from 1 to 10) after having mostly done the term project. Do use a few words, a phrase or a paraphrase to describe. They are more expressive than a number. Describe concepts you have difficulty understanding and what improvements you need to have from your part and from the instructor of this course.

Phase 2.1 Now we have a use case diagram, a set of use cases, and a number of scenarios under each use case. Follow the class identification process covered in our class or the class identification Power Point slides. The result will be a collection of Java classes to create.
Phase 2.2 Take the collection of classes and draw a class diagram. This diagram must show relationships between classes.

a).For phase 2 (2.1 and 2.2), describe the understanding level (from 1 to 10) you had before taking this class. Do use a few words, a phrase or a paraphrase to describe. They are more expressive than a number.

b). For phase 2 (2.1 and 2.2), describe the understanding level (from 1 to 10) after after having mostly done the term project. Do use a few words, a phrase or a paraphrase to describe. They are more expressive than a number. Describe concepts you have difficulty understanding and what improvements you need to have from your part and from the instructor of this course.

Phase 3.1: Now we have a use case diagram, a set of use cases, and a number of scenarios under each use case, and a class diagram (with all the classes and some essential/important attributes in classes). Draw sequence diagrams for most common/complex scenarios. While drawing a sequence diagram, decisions are made for method assignment (what class a method should belong to).

Phase 3.2: Fill in attributes and methods in classes in the class diagram. The result is a detailed class diagram, which is the design for the software system to be built for a furniture store. To work on this part, we need the results of 3.1 (sequence diagrams) and 2.1 (class identification)

Phase 3.3: Mechanically translate the detailed class diagram into the code outline, which has the whole program except that the body of each method is empty. Programming these empty bodies is called object oriented programming, which is out of the scope of our project.

a).For phase 3 (3.1 and 3.2), describe the understanding level (from 1 to 10) you had before taking this class. Do use a few words, a phrase or a paraphrase to describe. They are more expressive than a number.

b). For phase 3 (3.1 and 3.2), describe the understanding level (from 1 to 10) after after having mostly done the term project. Do use a few words, a phrase or a paraphrase to describe. They are more expressive than a number. Describe concepts you have difficulty understanding and what improvements you need to have from your part and from the instructor of this course.

3.Overall for this class, what do you think about it? What are most difficult for you to understand? What improvements can you think of from your part and from the instructors part? What would you do differently if we started all over the same class? Please write more.

Appendix B

Class related concepts and the Object Oriented Analysis and Design (OOAD) final survey

Answers are not relevant to a student's grade.

1. For the concepts of class and object (attributes, methods, constructors, creating objects out of classes, implementing a software system by interacting objects):

a. Describe the understanding level (from 1 to 10) after you have taken the final exam. Do use a few words, a phrase or a paraphrase to describe. They are more expressive than a number.

b. Describe concepts (among attributes, methods, constructors, creating objects out of classes, implementing a software system by interacting objects) you have difficulty understanding and what improvements you need to have from your part and from the instructor of this course.

1).Attributes:
2).Methods:
3).Constructors:
4).Creating objects out of classes:
5).Implementing a software system by interacting objects:

2. For the object oriented analysis and design (OOAD) process:
This OOAD process includes use case diagrams, use cases, scenarios under each use case, class identification (identifying Java classes to create for this project), class diagram, sequence diagrams and method assignment, detailed class diagram, Java code outline (a program where each method has an empty body).

a). Describe the understanding level (from 1 to 10) after you have taken the final exam. Do use a few words, a phrase or a paraphrase to describe. They are more expressive than a number.

b). Describe concepts you have difficulty understanding and what improvements you need to have from your part and from the instructor of this course.

1).Use case diagrams:
2).Use cases:
3).Scenarios under each use case:
4).Class identification (identifying Java classes to create for this project):
5).Drawing a rough class diagram after class identification:
6).Sequence diagrams and method assignment (what class each method belongs to):

7).Detailed class diagram with attributes and methods filled in:

8). Java code outline (a program where each method has an empty body, a direct translation from a class diagram).

3.Overall for this class,

1).What do you think about this class?

2).What are most difficult for you to understand?

3).Are you comfortable building software using OOAD? If not, what else do you need to learn/to have?

4).What improvements can you think of from your part and from the instructors part?

5).What would you do differently if we started all over the same class? Please write more.

6). What are good about Self-Regulated Learning (SRL)? Do you think the SRL knowledge is transferable to other courses (so that you will have improved performance in other courses)? Do you think you will apply SRL to other courses?