Published in final edited form as:
Adv Health Sci Educ Theory Pract. 2011 March ; 16(1): . doi:10.1007/s10459-010-9248-1.

Assessing Medical Students' Self-regulation as Aptitude in Computer-based Learning

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Abstract

We developed a Self-Regulation Measure for Computer-based learning (SRMC) tailored toward medical students, by modifying Zimmerman's Self-Regulated Learning Interview Schedule (SRLIS) for K-12 learners. The SRMC's reliability and validity were examined in 2 studies. In Study 1, 109 first-year medical students were asked to complete the SRMC. Bivariate correlation analysis results indicated that the SRMC scores had a moderate degree of correlation with student achievement in a teacher-developed test. In Study 2, 58 third-year clerkship students completed the SRMC. Regression analysis results indicated that the frequency of medical students' usage of self-regulation strategies was associated with their general clinical knowledge measured by a nationally standardized licensing exam. These two studies provided evidence for the reliability and concurrent validity of the SRMC to assess medical students' self-regulation as aptitude. Future work should provide evidence to guide and improve instructional design as well as inform educational policy.

Keywords

computer-based learning environments; instrument development; inter-rater reliability; learning achievement; medical students; concurrent validity; self-regulated learning

Computer-based instructional modules are being rapidly implemented into medical education to solve current problems in medical curriculum (Ward et al., 2001). These include students' limited and disrupted opportunities for clinical exposure, a rapidly growing knowledge base, and an attempt to address a lack of consensus on the core content of medical curriculum (Kalet et al., 2007; Harden & Hart, 2002).

However, there has been little empirical evidence for the educational effectiveness of such multimedia modules (Greenhalgh, 2001). In addition, the researchers in medical education have not paid adequate attention to the moderating effects of learner variables on instructional design and educational effectiveness (Cook et al., 2007; Regehr, 2004).

Among the learner characteristics that should be considered, self-regulation, which refers to "self-generated thoughts, feelings, and actions for attaining academic goals" (Zimmerman, 1998, p.73), is a primary variable since successful learners are capable of managing their own learning process cognitively, metacognitively, and motivationally (Zimmerman, 1986, 1989). In particular, a learner in a computer-based learning environment, which is usually more open-ended than structured, is required to have more self-regulation because this learner must exercise more independence and self-control than in traditional learning

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environments (Azevedo et al., 2004; Greene and Land, 2000; Hadwin and Winne, 2001; Hill and Hannafin, 1997; Moos and Azevedo, 2008).

According to social cognitive theory, self-regulation is affected by the context in which the learning material is situated (Bandura, 1991; Zimmerman, 1998, 2000). Therefore it is likely that a learner who may be able to successfully self-regulate learning in traditional learning environments may not be able to have the same level of success in self-regulated learning in computer-based environments (Moos and Azevedo, 2008; Whipp and Chiarelli, 2004). A reliable and valid measure of learners' self-regulation in a computer-based learning environment would allow us to study the reciprocal relation of this rapidly emerging environment. Furthermore, measured self-regulation skills would in turn inform instructional design and tailoring.

Self-regulation has been viewed both as an aptitude (trait) and an event (state) (Snow, 1996; Winne and Perry, 2000). Self-regulation viewed as an aptitude is a dispositional learner variable, a trait which is "a relatively enduring attribute of a person that predicts future behavior" (Winne and Perry, p. 534). In contrast, self-regulation as an event is "a transient state embedded in a larger, longer series of states unfolding over time" (Winne and Perry, p. 534). Individual learners will bring different levels of self-regulatory skills to any learning task (Kanfer et al., 1996), and although self-regulatory skills can be taught (Boekaerts, 1997; Zimmerman et al., 1994), in the absence of such self-regulation training, baseline individual differences (treated as an aptitude) in self-regulatory skills are important modifiers of learning achievement. Therefore, in this study we treated self-regulation as an aptitude.

Many studies on computer-based learning have adopted self-regulation measures developed for traditional learning environments. However, these existing measures have come under criticism since they cannot reflect the unique characteristics of self-regulated learning behavior in computer-based learning environments (Cho and Jonassen, 2009). In response to this need, we developed the Self-Regulation Measure for Computer-based learning (SRMC) and assessed its reliability and concurrent validity by comparing it with other cognitive measures in two studies.

Methods

In the first study, we assessed whether first-year medical students' self-regulation behavior measured by the SRMC was associated with their academic achievement in *Human Anatomy*, a notoriously challenging course requiring students to memorize a large amount of declarative knowledge. The second study investigated whether third-year medical students' self-regulation learning behavior measured by the SRMC were associated with their general clinical knowledge measured by a nationally standardized licensing exam, which assesses comprehension and application of a broad range of relevant knowledge.

Instrument Development

As one of existing self-regulation measures, the Self-Regulated Learning Interview Schedule (SRLIS) (Zimmerman and Martinez-Pons, 1986, 1990) is a structured interview protocol in which students verbally describe their self-regulated learning behaviors in each of six hypothetical learning contexts. Since the SRLIS does not cue subjects about socially accepted and desired behaviors, it has the strength of being less subject to bias and therefore more valid (Zimmerman, 2008). However, the SRLIS was originally developed for secondary school students in traditional didactic learning contexts, and therefore may have limited application to learners in post-graduate education in computer-based learning environments.

In order to address the limitations of current self-regulation measures for our work, we developed the Self-Regulation Measure for Computer-based learning (SRMC) by modifying the SRLIS to be appropriate for medical students.

Preliminary Interview—The first author conducted pilot interviews with 6 Dentistry students and 4 Medical students enrolled in a large private medical school in the northeastern United States. He asked the following open ended questions: "Have you experienced any computer-based learning since you enrolled the Dental/Medical school?", "What type of computer-based learning material (e.g., learning management system, online module, and simulation/game) have you used?", "How often did you use computer-based learning material?", "When do you think computer-based learning material is effective?", and "When do you think computer-based learning material is ineffective?" We recorded the interviews and analyzed them for common themes as well as unique responses. We identified four common computer-based learning contexts in health science: taking an online lecture, studying individually, preparing for a test, and response to being interrupted (Table 1) and modified the instruction and description of SRLIS to be appropriate to medical education.

The Self-Regulation Measure for Computer-based learning (SRMC)—In the SRMC, a learner is asked to describe the methods he or she used in each of these four learning contexts. For example, the following learning context is provided to a learner.

> "Assume that you are using online courseware. Do you have a method that you would use to help you learn and remember the information being given?"

The learner can answer the question as yes or no. If he or she answers yes, the following prompt asking to list the methods is provided.

> "List as many of your methods (i.e., taking notes) as you can"

On the other hand, if the learner reports that there is no method, another protocol is used to ask the same question but with different words.

> "If you were having trouble understanding or remembering the information delivered through the online courseware, what method might you use?"

SRMC scoring—Based on research and theory (Zimmerman and Martinez-Pons, 1986), learners' responses to the SRMC are categorized into 10 classes of self-regulation behavior (self-evaluation, organizing and transforming, goal setting and planning, seeking information, keeping records and monitoring, environmental structuring, self-consequences, rehearsing and memorizing, seeking social assistance, and reviewing records) and 2 classes of non-self-regulation behavior (will power and non-applicable statements). The definitions and examples of the categories are presented in Table 2.

This data is then summarized in two separate scores. The first score is the strategy use (SU), which is a dichotomous score indicating whether a particular strategy is mentioned, and the second score is the strategy frequency (SF), which is the number of times that a particular strategy is mentioned. The SU score indicates how many types of self-regulated learning strategy a student can use. The SF score shows how frequently a student uses the strategies in learning contexts.

Participants

Study 1—All 160 first-year medical students from a U.S. medical school enrolled in a Human Anatomy course were approached to voluntarily participate in this study. The Human Anatomy course uses a computer-based learning management system (i.e., Advanced Learning Exchange; ALEX - a local version of SAKAI, http://alex.med.nyu.edu) as a primary instructional platform, along with a series of large group lectures and laboratory sessions in which students conduct cadaver dissections.

Study 2—The participants for Study 2 were 69 third-year medical students rotating through surgical clerkship at the same medical school as in Study 1. In addition to using the ALEX learning management system, these students were asked to use web-based learning modules for surgical education (i.e., WISE-MD; http://wise-md.med.nyu.edu) as part of their clerkship curriculum. The modules consist of a series of Multimedia Learning Objects and present comprehensive information (i.e., core knowledge, technical skills, and professional skills) on their respective specific clinical topic.

Procedure

Study 1—This study was approved by the institutional review board (IRB). After obtaining the approval of the director for the Human Anatomy course, a recruiting email was sent to students and posted in the course specific announcement board in ALEX. Students who agreed to participate in the study went to an online SRMC survey website, completed the consent procedure, and then anonymously filled out the SRMC. Students then provided us with their most recent score on the Anatomy examination in the class.

Study 2—With the surgical clerkship director's approval, we emailed clerkship students and posted in ALEX to ask for participation in the study. As in Study 1, a student who was willing to participate in the study went to the online survey website to complete the SRMC and reported their United States Medical Licensing Examination (USMLE) Step 1 score which assesses whether they understand and can apply important scientific concepts to the practice of medicine (United States Medical Licensing Examination, 2008). We also collected their Medical College Admission Test (MCAT) scores and their undergraduate GPA, because these are known predictors of the USMLE scores (Swanson et al., 1996; Wiley and Koenig, 1996).

Data Analysis

In order to report the reliability of the SRMC, we calculated Cronbach's alphas and interclass correlation coefficients (ICC) in both studies. In addition, we used a bivariate correlation (Study 1) and a hierarchical regression analysis (Study 2) to show the concurrent validity evidence of the SRMC.

Results

Reliability of the SRMC

Internal Consistency—Internal consistency for the SRMC was evaluated using Cronbach's alpha coefficient in both studies, which was quite high overall, $\alpha = .961$ (SU); $\alpha = .985$ (SF) in Study 1 and $\alpha = .990$ (SU); $\alpha = .969$ (SF) in Study 2. The Cronbach's alpha coefficients for the SRMC scores and 10 categories of self-regulated learning strategies in both studies are presented in Table 3.

Inter-rater Reliability—Two graders scored the responses of SRMC with a predetermined rubric. The first author was the first rater. The second rater who had substantial knowledge of self-regulation was trained in the grading procedure. To assess inter-rater reliability, we calculated interclass correlations (ICC) in both studies.

In Study 1, the ICC calculations showed generally acceptable levels of inter-rater reliability, ICC of the SU = .925 (95% Confidence Interval: .890–.949) and ICC of the SF = .960 (95%

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CI: .905–.980). All ICCs for the categories of self-regulated learning strategies were greater than .800 except for self-consequence, ICC = .753 (95% CI: .652 – .828).

In Study 2, we also found high inter-rater reliability, ICC of the SU = .981 (95% Cl: .969–.989) and ICC of the SF = .960 (95% CI: .941–.970). All ICCs for the 10 categories of self-regulated learning strategies were greater than .850.

The ICCs for 10 categories of self-regulated learning strategies in both studies are presented in Table 4.

Validity of the SRMC

In Study 1, we investigated the relation of student achievement in a teacher-developed test and self-regulation. We collected complete analyzable SRMC data from 89% (97/109) of subjects who responded to the survey 68% (109/160) of all available students. Table 5 summarizes strategies reported by the first-year medical students over the four different learning contexts. Overall, the most frequently used self-regulated learning strategy was seeking information ($M = 2.34$, $SD = 1.71$) and the least frequently used strategy was self-consequence ($M = .15$, $SD = .39$) over four different learning contexts.

Bivariate correlation analysis showed a moderate degree of correlation between the SF scores in the SRMC and the Anatomy test scores, $\gamma = .477$, and between the SU scores in the SRMC and the test scores, $\gamma = .296$.

In Study 2, we examined the relation of student achievement in a standardized test and self-regulation. We hypothesized that self-regulated learning behaviors measured by the SRMC would be related to third-year medical students' high achievement in the USMLE step 1 test.

After excluding subjects with incomplete data, 58 out of 69 third-year clerkship students' data (84%) were included in the analyses. Table 5 summarizes strategies reported by the third-year clerkship students over the four different learning contexts. The most frequently used strategy was seeking information as with the first-year medical students. The least frequently used strategy was organizing and transforming.

We conducted a hierarchical regression analysis to investigate if addition of the frequency of self-regulation strategies (SF) improved the prediction of a student's national licensing exam score beyond traditional measures such as MCAT scores and undergraduate GPA. We entered only the SF score in the regression equation to avoid multicollinearity. The predictive utility of the SF score was compared to that of the students' MCAT scores and undergraduate GPA. Table 6 shows the descriptive information and zero-order correlations for SRMC scores, undergraduate GPA, MCAT score, and USMLE step 1 score.

The results indicated that all variables including the SRMC (SF) score, the MCAT score, and undergraduate GPA entered in a regression analysis accounted for 41 % of the variance $F(3, 41) = 9.58$, $p < .001$, cohen's $f^2 = .70$. The MCAT score was a significant predictor of the USMLE score, $t = 2.51$, $p < .05$. When the SF score was added to the regression analysis in step 2 results indicated an R^2 change of .27, F change $(1, 41) = 18.50$, $p < .001$, with the SF score being the overall strongest predictor of the USMLE score, $t = 4.30$, $p < .001$. The results of regression analysis are shown in Table 7.

Discussion

The two studies reported in this paper provide evidence for the reliability of SRMC scores and for the concurrent validity of the SRMC to assess and study medical students. The results of Study 1 indicated that first-year medical students' self-regulated learning behaviors measured by the SRMC was positively moderately associated with their level of academic achievement in the Human Anatomy class in which they were engaged at the time of the research. Study 2 indicated that third-year medical students' self-regulated learning behavior was associated with their score on the national licensing examination, a more general measure of clinical knowledge. These results are consistent with the findings of Zimmerman's original studies (1986, 1990) with secondary school students and provide support for the concurrent validity of the SRMC for the comprehension and application of a broad range of relevant knowledge. Furthermore, Zimmerman's studies on the SRLIS already showed the evidence of construct validity of the SRMC based on comprehensive review of self-regulated learning.

In summary, the present research underlines the importance of considering individual difference such as self-regulated learning. Considering that educational multimedia material may impede effective learning when the characteristics of learners and tasks are not considered thoroughly in instructional design (Paas and Kester, 2006), it is important to measure relevant learner characteristics. Among these learner characteristics, learners' self-regulation is a critical skill for academic success (Pintrich and De Groot, 1990; Quirk, 2006; Zimmerman and Schunk, 2001). The SRMC provides a feasible measure of this important construct in advanced learners, such as medical students, in computer-based learning environment. Future work should provide evidence to guide and improve future instructional design as well as inform educational policy.

There are limitations to our studies. First, although medical students usually have a high level of verbal ability, which allows them to write about their behaviors in the open-ended protocol of the SRMC, students' responses might be biased by their individual verbal ability or style. In order to avoid the potential limitation from either verbal ability or style, we focused on scoring whether students mentioned key concepts regardless of a verbose style, and reported acceptable inter-rater reliability in both studies. Second, we did not examine other types of reliability such as test-retest reliability in this study. This will be done in future studies.

Third, it is not known how the findings generalize to other types of computer-based learning environments. Considering that students in Study 1 mainly used computers as a learning management system, and students in Study 2 used multimedia-based learning contents with limited interactivity, future research should confirm that SRMC scores predict achievement in different computer-based learning environments such as synchronous and asynchronous online learning environments.

Finally, it is suggested that further research be conducted in exploring the relative impact of self-regulation compared to that of prior knowledge, self-efficacy, motivation and other demographics on such learning. More work needs to be done to determine if tailoring the instructional design, such as adding scaffolding features for low SRMC scoring students leads to more effective learning.

Overall, our results indicate that the SRMC provides a promising tool for educators and researchers to assess students' perception of their self-regulation strategies of medical students in computer-based learning environments.

Acknowledgments

This study was supported by grants from the National Science Foundation Advanced Learning Technologies (ALT) program (NSF#IIS-0537252) and the National Library of Medicine (1R01LM009538-01). We thank Victoria H. Ort, Ph.D. Department of Cell biology at New York University and Mark Hochberg, MD, Department of Surgery at New York University for their support of this research.

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Table 1

Learning contexts in self-regulation measure for computer-based learning (SRMC)

Learning Contexts in SRMC	
1	Assume that you are using online courseware. Do you have a method that you would use to help you learn and remember the information being given?
2	Assume that you are studying for your course. Is there any particular method that you would use when you do not understand the concepts?
3	When taking a test in online courseware, do you have a particular method to prepare for these tests?
4	Many times, learners have difficulty focusing on learning tasks in online learning environment because there are other interesting things that they would rather do, such as surfing websites, checking emails, and chatting with friends. Do you have any particular method to motivate yourself to focus on online learning materials under these circumstances?

Table 2

Categories of self-regulated learning strategies (Adapted from Zimmerman & Martinez-Pons, 1986, p. 618)

Categories of Strategies	Definitions	Examples
1. Self-evaluation (SE)	Students-initiated evaluations of the quality or progress of their work	Making sure I have understood all of key concepts…
2. Organizing & transforming (OT)	Students-initiated overt or covert rearrangement of instructional materials to improve learning	Draw a picture…
3. Goal setting & planning (GP)	Students-initiated educational goal setting and planning related to the goals	Listen the first time, take note the second time…
4. Seeking information (SI)	Students-initiated efforts to secure further task information from non-social sources	Using Wikipedia, Googling…
5. Keeping records & monitoring (KM)	Students-initiated efforts to record events and results	Taking notes…
6. Environmental structuring (ES)	Students-initiated efforts to select or arrange the physical setting to make learning easier	Using computers outside of my room…
7. Self-consequence (SC)	Students' imagination of rewards or punishment	Reward myself with online games…
8. Rehearsing & memorizing (RM)	Students-initiated efforts to memorize materials by overt and covert practice	Repeat the information trying to memorize it…
9. Seeking social assistance (SS)	Students-initiated efforts to solicit help from peers or teachers	Ask my friends to explain…
10. Reviewing records (RR)	Students-initiated efforts to reread notes or materials to prepare for class or further testing	Re-read online materials…
11. Will power statement (WP)	Students' statements to mobilize unspecified psychic forces	Just study a lot…
12. Not applicable (NA)	Students' statements not related to self-regulated learning strategies	Get used to looking at monitors for long times…

Table 3

Cronbach's alpha coefficient for self-regulated learning strategies and SRMC scores

Strategies/SRMC scores	Cronbach's alpha	
	Study 1	Study 2
Self-evaluation (SE)	.967	.961
Organizing & transforming (OT)	.939	.921
Goal setting & planning (GP)	.981	.980
Seeking information (SI)	.974	.982
Keeping records & monitoring (KM)	.950	.967
Environmental structuring (ES)	.961	.958
Self-consequence (SC)	.860	.935
Rehearsing & memorizing (RM)	.896	.929
Seeking social assistance (SS)	.974	.979
Reviewing records (RR)	.911	.947
Strategies Use (SU)	.961	.990
Strategies Frequency (SF)	.985	.969

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Table 4

Interclass correlation (ICC) and 95% confidence interval for self-regulated learning strategies and SRMC scores

Strategies/SRMC scores	ICC (95% CI)	
	Study 1	Study 2
Self-evaluation (SE)	.936 (.906 – .957)	.926 (.877 – .955)
Organizing & transforming (OT)	.887 (.835 – .923)	.855 (.767 – .912)
Goal setting & planning (GP)	.962 (.944 – .975)	.960 (.933 – .976)
Seeking information (SI)	.940 (.893 – .964)	.958 (.917 – .977)
Keeping records & monitoring (KM)	.904 (.860 – .935)	.937 (.895 – .962)
Environmental structuring (ES)	.924 (.888 – .949)	.920 (.869 – .952)
Self-consequence (SC)	.753 (.652 – .828)	.876 (.800 – .925)
Rehearsing & memorizing (RM)	.805 (.720 – .866)	.859 (.766 – .916)
Seeking social assistance (SS)	.948 (.922 – .965)	.958 (.930 – .975)
Reviewing records (RR)	.831 (.754 – .884)	.900 (.837 – .940)
Strategies Use (SU)	.925 (.890 – .949)	.981 (.969 – .989)
Strategies Frequency (SF)	.960 (.905 – .980)	.941 (.903 – .965)

Table 5

Means and standard deviations of 1st-year and 3rd-year students' self-regulation strategies

Strategies/SRMC scores	Study 1 (*n* = 97) First-Year Students		Study 2 (*n* = 58) Third-Year Students	
	M	***SD***	***M***	***SD***
Self-evaluation (SE)	.59	.85	.53	.71
Organizing & transforming (OT)	.47	.86	.16	.49
Goal setting & planning (GP)	.60	.87	.48	.63
Seeking information (SI)	2.34	1.71	2.60	1.74
Keeping records & monitoring (KM)	.95	.85	.69	.71
Environmental structuring (ES)	.74	.86	.66	.83
Self-consequence (SC)	.15	39	.22	.50
Rehearsing & memorizing (RM)	.37	.73	.22	.46
Seeking social assistance (SS)	.97	.93	.45	.68
Reviewing records (RR)	.80	.96	.62	.70

Table 6

Means, standard deviations, and zero-order correlations among USMLE step 1 scores, MCAT scores, undergraduate GPA, and SRMC scores

	M	***SD***	**1**	**2**	**3**	**4**	**5**
1. USMLE step 1 score	233.62	13.50	-				
2. MCAT score	33.13	2.48	.318*	-			
3. Undergraduate GPA	3.76	.19	.141	.031	-		
4. SRMC-SU	4.28	1.50	.402**	−.029	−.080	-	
5. SRMC-SF	6.64	2.67	.561**	.073	.073	.657**	-

Note.

* $p < .05$,

** $p < .01$

Table 7

Regression coefficients for predicting medical students' licensing examination score (USMLE) based on their MCAT score, undergraduate GPA, and the SRMC scores (SRMC-SF)

Step	Variables	B	SE	Beta (β)
1	Constant	136.80	44.97	
	MCAT score	1.90	.74	.36 *
	Undergraduate GPA	9.17	10.04	.13
2	Constant	139.87	37.79	
	MCAT score	1.58	.63	.30 *
	Undergraduate GPA	6.21	8.46	.09
	SRMC-SF score	2.71	.63	.52 ***

Note. R^2 = .15 for Step 1: ΔR^2 = .27 for Step 2 (ps < .001).

* $p < .05$,

*** $p < .001$.