Metacognitive support of learning activities in an EAIH

The impact of metacognitive incentives on self-regulated learning behaviors

Adel DERAOUI; Hakim ALLALI; Abedelmajid HAJAMI;
Monitoring Laboratory for Emerging Technologies (MLET)
Faculty of Science and Technology - Settat
Deraouiadel@yahoo.fr

Abstract: *This article relies on ongoing doctoral research whose goal is to measure the effect of metacognitive support on the success of online learning in terms of metacognitive self-regulation behaviors and in terms of quality of learning observable at the level of the higher skills of Analysis, Creation and Evaluation of the cognitive processes model of Krathwohl and Anderson (2001).In this article we will try to present our first results of the impact of metacognitive incentives on self-regulated learning behaviors in learners in Online Distance Learning (FAD).*

Key words: *metacognitive prompt, EIAH, metacognition, metacognitive support; self- regulated learning.*

1. Introduction

The metacognitive support is provided by metacognitive assistance via a pedagogical agent system that we have integrated into the structure of an LMS.

The independent variable is, the integration of metacognitive incentives in a pedagogical scenario according to the model of mediated learning activity, proposed by our Laboratory: LAVETTE (Mohtadi et al., 2014) illustrated in (figure N ° 1).

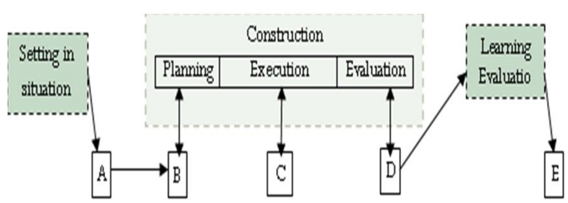


Figure 1: The articulation of scaffolding techniques with phases of learning activity

The dependent variables are:

- *The self-regulation behavior induced in learner learning as measured by the scales of cognition regulation presented by Schraw and Dennison's Inventory of Metacognitive Activities (MAI: Metacognitive Awareness Inventory) (1994);*
- *The overall performance of learners measured by the final marks obtained by the assessment of prior learning in the higher skills of analysis, creation and evaluation of the cognitive processes model of Krathwohl and Anderson (2001).*

2. Research questions

The current study investigated the following two research questions:

a. *To what extent does the integration of metacognitive incentives into online Distance Learning (FAD) sessions induce self-regulated learning behaviors in learners?*
b. *Does metacognitive support implemented by metacognitive prompts embedded in Online Distance Learning (FAD) sessions have an effect on learners' learning success?*

3. Methodology

The support, considered in the context of this study, consists of a system of metacognitive prompts provided to learners with the aim of stimulating, at home, self-regulation in their learning behaviors in a situation of Distance Learning. line by an LMS.

The study took place under authentic conditions. Part of the electrical engineering module, intended for student trainees in EST electrical systems and technologies at the Regional Center of Education and Training (RCET) Settat, delivered remotely via LMS Moodle and Ganesha.

The independent variable, therefore, was the integration of metacognitive support into the learning environment to support the learner along his or her online Distance Learning courses for one week with a scheduled access.

Two dependent variables are evaluated and analyzed:

- *The metacognitive behavior of self- regulation of students learning;*
- *Student grades, as obtained in the written assessment administered at the end of the experience*

Our methodological approach is hypothetico-deductive insofar as we have sought to predict the validity or otherwise of our hypotheses.

Quantitative and qualitative data were collected to assess the effectiveness of metacognitive support integrated into the learning environment, both for self-regulated learning behavior and for learners' academic performance.

The study implements a pretest-posttest design with control groups and experimental groups consisting of 40 EST student trainees at the Settat RCET. Quantitative and qualitative data were used to compare self-regulation behaviors in learning between learners with metacognitive support and those in the group who did not have metacognitive support during the online Distance Learning ( ) course. In addition, the scores obtained in the post- intervention evaluation were compared between the two groups.

Since learners' metacognitive skills, and their pre- acquired knowledge in the field of electrical engineering, are decisive in the development of our experience, we have previously measured these trait variables characterizing the participants (pre-test measurements). The objective was to form groups whose participants did not differ significantly on one of these two variables.

In this article we present the experimental results related to our first research question: To what extent does the integration of metacognitive incentives into online Distance Learning (FAD) sessions induce self-regulated learning behaviors in learners?

4. Experimental protocol

a. Choice of Ganesha platform

After a comparative study of pedagogical aspects between the most widespread open source platforms (Claroline, Ganesha, Moodle) according to the following criteria:

- Be operational and have been used by learners as part of teaching;
- Enable the operation of self-assessment activities;
- Manage several types of activities;

- Integrate the SCORM / AICC standard;
- Integrate IMS Content Package;
- Have a mapping close to the IMS-LD standard;
- Do not require the installation of any particular software on the learning station.

The choice is focused on the GANESHA platform.

b. The educational scenarios to implement in Ganesha

To design our educational scenario we used the script editor G-MOT[1]. In fact, all scenarios produced by this publisher can be exported to IMSLD. What is interesting in this software is that the user does not need to know the IMSLD specification for the construction of his scenarios since, by a specific export command, the parser interprets and automatically transforms into an imsmanifest file .xml any valid scenario produced in the editor including conditions and notifications. This file complies with the IMS-LD standard. It contains all the essential elements of levels A, B and C of the standard and can be opened in another editor compatible with the IMS-LD standard such as ReloadLDEditor.

The graphic aspect facilitates the design of the scenarios by making it possible to visualize the path of the actors with their activities and the necessary resources. However the automation of the export in IMS-LD at a price. It involves some compromise of simplification. For example: paths in "loops" are not taken into account; the "Environments" of the specification are created artificially by including input or output resources; Objects of type "Operations" are transformed into activities.

To be possibly executable in a compatible IMSLD "Player" (in particular on the Ganesha platform), we called on the editor ReloadLDEditor [Bolton 2004], to finalize our scenario and to add (instantiate) the actors and concrete resources concerned and to produce the final package. The map of IMS LD with Ganesha passes through the resource: "IMS Content Package" in its "specialized packages" version which contains a folder including the manifest integrating our Learning Design generated by ReloadLDEditor.

After the design of our training design and its implementation in the Ganesha platform, a training schedule in face-to-face and distance learning is set up for a class of 60 trainee students in EST to the electrical engineering module.

c. Implementation of the experimental study

The study was conducted in three phases:

<u>First phase in class:</u>

It was intended for a diagnostic pre-test in electrical engineering and a psychometric pretest, to evaluate their metacognitive skills. A two-hour session was scheduled to upgrade the students of both groups with some conceptual gaps in electrical engineering that we have cleared from the diagnostic pretest and mastery of the subject platform of the experiment. At the end of this first phase; we formed the two groups of experience:

- ***Control group (GC, n = 30 students),*** in this condition, learners undergo online training through the Ganesha platform in courses containing learning scenarios without any metacognitive support.
- ***Experimental group (GE, n = 30 students)*** benefited from a course containing educational scenarios with selective and contextual programming of incentives to metacognitive self-regulation behaviors.

The prerequisites and prerequisites of the electrical engineering part of the module, subject of the experiment, were

[1] The software developed at the center of research LICEF of the Distance university under the direction of Gilbert Paquette, allows to represent knowledge according to the technique of "modeling by typed objects" (MOT), (Paquette, 2002).

measured using a multiple- choice questionnaire presenting a set of key questions which relate to the different basic concepts of electrical engineering related electric machines; the goal is to ensure that the examination of online learning success in terms of disciplinary achievement is not due to anything other than the effect of our independent variable.

Metacognitive knowledge was measured using the Meta-Cognitive Awareness Inventory (MAI) of Schraw and Dennison (1994).

Before the week of the experiment, the Ganesha platform is presented to the two groups participating in our survey by explaining to them the different technical and pedagogical functionalities available according to the category of the group to which they are assigned while informing them about the tasks they must perform accomplish during the week of the remote phase.

A	Planning invitation: • What's the problem? • What are we trying to do? • What do we know about the problem? • What are the data? • How can this data help us? • What is our plan? • Are there other ways to do this? • What would happen if .... ? What will we have to do in the next step?	**Preparation**	▪ Analysis of the task ▪ Planning ▪ Selection of strategies ▪ Define the objectives
B	Invite of Monitoring: • Is the chosen strategy used? • Is the proposed plan followed? • Do we need to change the plan? • What is our goal now? • Are we on the right track? • Are we getting closer to our goal?	**Performance**	▪ Implementation of the strategies chosen in the preparation phase ▪ Monitor the progress of strategies implemented and assess their effectiveness ▪ Regulate strategies or replace them when needed
C	Evaluation invitation: • What works? • What does not work? • Should we do otherwise the next time?	**Evaluation**	▪ Evaluate the result of the performance ▪ feedback

Second phase remote:

It was intended for the execution of learning scenarios, designed for our experience, without any guidance from the tutor. The total duration of this phase is one week with scheduled access to the Ganesha platform, divided into two-hour sessions each day. The participants belonging to the experimental group supported have benefited, in a programmed way, from the four categories of metacognitive incentive

Table 5: The three categories of metacognitive incentives

- **Planification prompt:**

Beginning of construction, planning incentives are undertaken to help the learner analyze the task, plan its learning, select strategies and set goals.

Figure 4: examples of invite meta cognitive during the phase of planning

- **Monitoring prompt:**

During construction, other metacognitive prompts are presented each time the learner activates a new resource, solicits metacognitive help, or exhibits abnormal behavior at the time level allocated to a resource (Too short or too long).

The incentives offered to the learner are then monitoring incentives based on the self-assessment of the quality of his learning, the relevance of the resources in relation to the objectives and the, strategic plans, and the adequacy of his prerequisites for educational material presented.

Figure 5: examples of invite meta-cognitive during the construction phase

- **Evaluation prompt:**

At the end of each training sequence; evaluation prompts are selected and displayed to students. By doing so, the student was invited to verbalize the relevance of his strategic choices by pushing him to practice a reflective analysis of his practices throughout his learning.

Figure 6: examples of metacognitive prompt during the evaluation phase

Third phase in class:

It was reserved for post-secondary students and the degree of development of metacognitive skills in both groups of our survey. Instructions concerning the use of questionnaires based on table forms were also communicated to the participants, in particular explanations of the different items are provided.

5. Preparation of measuring instruments

Several evaluations are used to collect the data for this research. On the one hand, we collected data before and after the experimental treatment applied to the participants by the administration of pretests and psychometric posttest; we also collected data on learner performance using two self-developed assessments: Pre-test evaluation prior to experimental treatment and prior learning assessment after experimental treatment.

a. Measures of metacognitive skills of pre-test

In the literature, metacognitive skills are measured in terms of metacognitive regulations, metacognitive knowledge, or both. In all cases, these components are measured by different means. Some researchers use self-reported inventories to assess metacognitive skills (Schraw and Dennison, 1994, Sperling et al, 2004). Other researchers examine the metacognitive judgments of metacognitive measures as metacognitive measures by repetitive tests (Everson and Tobias, 1998, Nietfeld et al., 2005, Schraw, 1994). Everson and Tobias (1998) are interested in the capacity of knowledge monitoring ability (KMA). This ability is considered to be involved in metacognitive regulation. They have developed a means to evaluate it by examining the difference between students' estimates of their knowledge in the verbal domain and their actual knowledge as determined by their performance in standardized tests.

They found a very strong relationship between the KMA and the final grade in an English class and in their overall averages. They also found that this capacity for metacognitive regulation, KMA, is linked to academic success in college and is a good predictor of college success.

Schraw (1994) was interested in the relationship between metacognitive knowledge and metacognitive regulation. He measured metacognitive knowledge by asking students to rate how they thought they could control their accuracy on a series of multiple choice questions in reading.

He measured metacognitive regulation at both the local and global levels by evaluating students' accuracy for each question and then assessing their accuracy after performing the tests. Based on the results of his study, Schraw suggested that students may differ not in their metacognitive knowledge and skills but in their metacognitive regulatory skills. He further suggests that metacognitive knowledge can develop independently of metacognitive regulation. Finally, Schraw found that the actual test performance was significantly correlated with the stopping of the pre-test test performance, a measure of metacognitive knowledge. Test performance was also correlated with metacognitive regulation as it found correlations between performance and global and local judgments. As part of this research, the metacognitive skills of learners participating in the experiment were measured by the Schraw & Dennison (1994) Meta-Cognitive Awareness Inventory (MAI). It is a tool for evaluating metacognitive knowledge, whether it concerns self- knowledge, strategies or tasks, or metacognitive skills of planning, monitoring, self-regulation, self- evaluation., resource evaluation or strategy implementation.

The prerequisites and computer skills were assessed by an evaluation in 20 multiple-choice questions designed by ourselves that contains general elements of computer use, operating system and web browsing.

b. Measures of school performance

Evaluating the potential effects of a metacognitive support on student performance is one of the goals of our work. Learner performance vis-à- vis the educational objectives of the content administered through our WASH then form a primary dependent variable; therefore, we developed a benchmarked assessment (Appendix C) to test learner performance just at the end of the mediated training and administered to all participants in all three groups.

This performance test contains a complex problem situation whose resolution requires mastery the different electrical engineering disciplinary skills developed during the online FAD course and the Bloom Taxonomy skills reviewed by Lori Anderson and David R. Krathwohl in 2001: analyze, evaluate and create.

To ensure the objectivity of the evaluation, we chose, in the design of this evaluation, multiple- choice questions based on the following criteria:

Criterion 1 (Cognitive Ability Analysis on 6 points):

A multidisciplinary system is proposed to the participants which they must analyze for:

- *Deduce its global function;*
- *Predict behaviors based on the values assigned to certain state parameters;*
- *Determine the values to assign to certain variables to achieve a desired behavior.*

Criterion 2 (Cognitive assessment skills on 6 points):

The instruction proposed to the participants is to evaluate the choice of an asynchronous motor in a multidisciplinary system, aimed at a specific function; learners must then decide on the appropriateness of this choice to perform the function indicated.

Criterion 3 (Cognitive creation skill on 8 points):

Participants are invited to modify in a multidisciplinary system a converter to meet a given specification.

c. Psychometric posttest

The psychometric posttest is made up of several questionnaires measuring the participants' reports to their own metacognitive processes that they had deployed during the online Distance learning (FAD).

We have translated and reformulated in a more specific way the items in the MAI questionnaire of Schraw & Dennison (1994) to evaluate learning via an LMS. On a five-level Appendix ...... scale, learners were asked if they had done a metacognitive process.

d. Dynamic measurement of the metacognitive process

Zimmerman and Martinez-Pons (1986) have shown that questionnaire measures are good predictors of performance scores in standard test learners and correlate well with their performance levels. However, Hadwin and others (Hadwin et al, 2001; Perry and Winne, 2006) suggest that although the questionnaires provide relevant information about learner perceptions, they fail to capture the dynamic and adaptive nature of the questionnaires. self-regulated learning in which learners are involved during learning, building knowledge, and problem solving.

Therefore, to reinforce both pretest and posttest questionnaires of the metacognitive abilities of our experimental group, we collected and analyzed data from learner traces through the occurrence of dynamic and adaptive events (Zimmerman, 2008, Azevedo and Witherspoon, 2009). This measurement is characterized by a collection of data via a trace system during the actual performance of one or more tasks. All trace parameters are stored in the database of the distance learning platform. The traces we have selected are:

- *the list of resources (forum, chat, messaging, tutor instructions, video supports, pdf supports, reinforcement exercises, help) visited by the learner,*
- *the visit duration allocated to each resource,*
- *the number of visits made to each resource,*
- *the order of the visits of the resources,*
- *the resources visited in relation to the objective being*
- *the overall time of finalization or validation of a resource.*

In an LMS, its trace parameters are stored in MySQL databases.

We used his tracks for a qualitative analysis related to how the students performed metacognitive activities. In particular, we examined the nature of the pathways favored by students, the resources visited and the time devoted to each type of cognitive regulation activity.

e. Results and discussions of data from experimentation

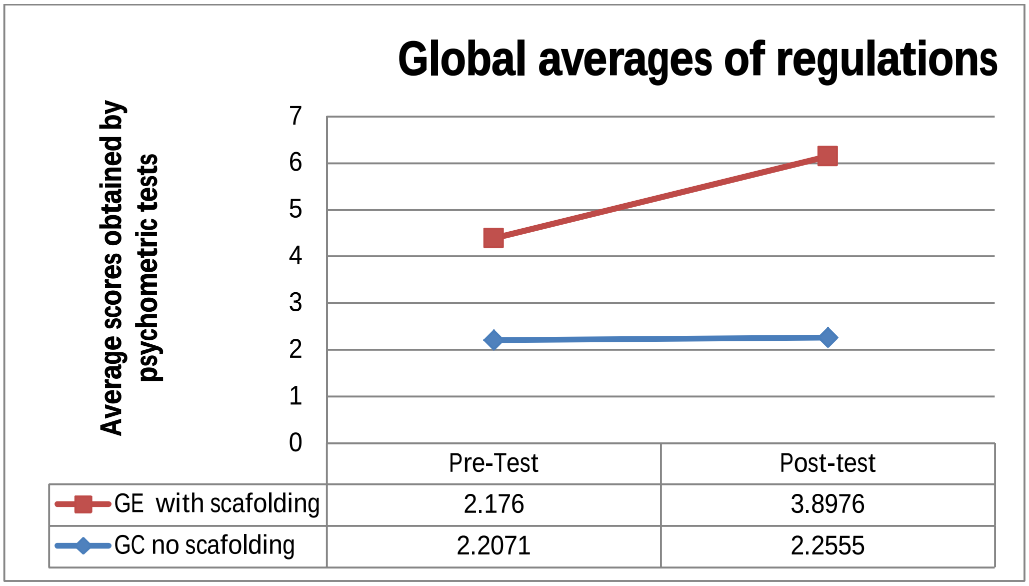
1. Effect on metacognitive behaviors

Our first research question is to examine whether integrating metacognitive assistance into an LMS would have beneficial effects on the e-learning process. And so, if the students, who participated in this experiment and received a metacognitive support, can implement a more elaborate learning process than learners who did not have this opportunity shoring.

a. *Analysis of data from psychometric test instruments*

A very significant difference was found between the two groups in the overall effect of shoring on their self-regulation behavior in learning. Both GE experimental groups reported that they have deployed many more processes metacognitive regulation that the control group.

Global averages	Pre-Test Meta-cognitive regulation	Post-test Meta-cognitive regulation
GC	2,2071	2,2555
GE	2,1760	3,8976



From this graph it can be deduced that the effect of metacognitive shoring, on the general average of the scores obtained in the psychometric posttest, relative to the metacognitive regulation induced by the metacognitive incentives integrated into our test LMS, is clearly significant in the programmed shoring mode.

b. *Comparison of metacognitive regulations by scale between pre-test and post-test*

Planning

Paired samples test for the GE-supported group

Planning		paired differences					t	ddl	Sig. (bilateral)
		Average	standard deviation	Average standard error	Confidence interval 95% of the difference				
					Inferior	Superior			
Pair 1	Pretest - Posttest	1,32082	1,1775	,05918	0,97761	1,66402	8,302	29	,000

Themonitoring

Paired samples test

Monitoring		paired differences					t	ddl	Sig. (bilateral)
		Average	standard deviation	Average standard error	Confidence interval 95% of the difference				
					Inferior	Superior			
Pair 2	Pretest - Posttest	1,73091	1,06913	,06691	1,17112	2,08870	10,236	29	,000

Information management

Paired samples test

Information management		paired differences					t	ddl	Sig. (bilateral)
		Average	standard deviation	Average standard error	Confidence interval 95% of the difference				
					Inferior	Superior			
Pair 3	Pretest - Posttest	3,139	1,272	,097	2,718	3,560	15,476	29	,000

Debugging

Paired samples test

Questionnaire		paired differences					t	ddl	Sig. (bilateral)
		Average	standard deviation	Average standard error	Confidence interval 95% of the difference				
					Inferior	Superior			
Pair 4	Pretest - Posttest	,45718	,51397	,08322	,27617	,64719	5,919	29	,000

The evaluation

Paired samples test

Questionnaire		paired differences					t	ddl	Sig. (bilateral)
		Average	standard deviation	Average standard error	Confidence interval 95% of the difference				
					Inferior	Superior			
Paire 5	Débogage Prétest - Débogage Posttest	,45718	,51397	,08322	,26717	,64719	5,919	29	,000

We deduce from the statistical point of view that the effect of programmed support on all the metacognitive behaviors tested is very significant. Indeed, the bilateral meaning between the abilities of planning, debugging, monitoring; information management, and evaluation is almost nil.

c. Qualitative analysis of trace data

To reinforce the verification of our baseline hypothesis, which states that the integration of metacognitive assistance into online FAD pathways develops self- regulatory learning skills in learners, we used numerical traces of participants' activities recorded by the system to assess, qualitatively, the way they performed metacognitive activities namely the nature of the courses preferred by the students, the resources visited.

- **The nature of the privileged courses**

The courses taken by the participants are another index of metacognitive regulation competence. We have identified several possible paths to browse the resources proposed by our educational designation. Two different types of pathways can be observed:

➢ ***Courses guided by the navigation links***

The graphical interface of our pedagogical design is rich by navigation links. Systematically tracking these links can disorient the learner from his or her main purpose and make him feel like he is going around in circles without making any progress in learning. This type of course is an indication of a weakness in the self- regulation of the learner. Indeed, the borrowing of this course since shows that it is not the learner who controls his learning but, rather, his learning environment.

This index is found among learners in both groups with very different proportions: 56.5% among participants in the GC group and 18.5% among learners in the GE group.

➢ ***The routes guided by the plan***

We have equipped the interface of our educational designation with a menu of the training plan grouping in a sequential way all the resources useful to the training courses. We consider that a course is guided by the plan when the learner accesses resources, at least three, in the order in which they are indicated in the plan of our designates. This index reflects that the learner masters the internal logic of the concepts treated by the designer of the content.

This index is found at least once in 79% of participants in GE-supported group and 66% of the unsupported learners.

➢ ***The courses guided by the objectives***

In each session of our teaching assignment, we have given the learner the choice of their goal list, and the choice of adequate resources for this list of objectives.
The identification of this type of course and carried out when the learner consults the list of objectives and its resources at least three per session.

This is the index that testifies more to self- regulation. It is actually spotted in 56% of the supported group. The control group, unsupported, 4% of learners who made this choice of course.

- **The resources visited**

A significant average difference could be found for the overall number of use of the resources consulted. Indeed, GE had visited far fewer educational resources than GC (sig = 0.017). Something we can explain by the non-disorientation of the GC during the execution of his training courses.

Conclusion:

All of these behaviors that are dynamically identified confirm the contribution of our metacognitive assistance with metacognitive prompts embedded in our online (Distance Learning (FAD)) pathways. In fact, supported participants demonstrate self-regulatory behaviors when they control their activities and choices according to a set goal. They are less exposed to the risks of giving up their training halfway. These data come to reinforce the quantitative results presented above that favor a positive effect of metacognitive incentives on self- regulatory behavior in online FAD via computer platforms.

Bibliography

FLAVELL John, MILLER Patricia, MILLER Scott. 1993. Cognitive development, London : Prentice Hall international, 3ème éd. p. 255.

Flavell, J.H. (1979). Metacognition and cognitive monitoring: A new area of cognitivedevelopmental inquiry. American Psychologist, 34, 906-911.

Flavell, J. H. (1987) Speculation about the nature and development of metacognition.

F. Weinert & R. Kluwe (Eds.), Metacognition, motivation, and understanding (pp. 21- 29). Hillsdale, NJ: Lawrence Erlbaum.

Flavell, J.H. & Wellman, H.M. (1977). Metamemory. In R.V. Kail & J.W. Hagen (Eds.), Perspectives on the development of memory and cognition. Hillsdale, NJ: Erlbaum.

Flavell, J.H. (1976). Metacognitive aspects of problem-solving. In L.B., Resnick (Ed.). The nature of intelligence (pp. 231-236). Hillsdale, N.J.: Lawrence Erlbaum Associates.

Forum Français pour la Formation Ouverte et à Distance (FFFOD). Financement et mise en œuvre de la FOAD – Vade-mecum des bonnes pratiques. In : FFFOD, Le Vade-Mecum [en ligne], Octobre 2015, Vanves : FFFOD. [http://www.fffod.fr/media/vademecum.pdf] (consulté le 23 avril 2013).

Brown, A. L., & Campione, J. C. (in press). Three faces of transfer: Implications for early competence, individual differences, and instruction. To appear in M. Lamb, A. L. Brown, & B. Rogoff (Eds.) Advances in developmental psychology (Vol. 3). Hillsdale, NJ: Erlbaum.

Brown, A. L., Armbruster, B. B. & Baker, L. (1986). The role of metacognition in reading and studying. In Orasanu, J. (Ed.), Reading Comprehension: From Research to Practice (pp. 49-75). Hillsdale, NJ: Lawrence Erlbaum

Brown, A. L., Bransford, J. D., Ferrara, R. A., & Campione, J. C. (1983). Learning, remembering, and understanding. In J. H.

Flavell & E. M. Markman (Eds.), Handbook of child psychology (Vol. 1): Cognitive development (pp. 77- 166). New York: Wiley.

Brown, A. L., Campione, J. C., & Barclay, C. R. (1979). Training self-checking routines for estimating test readiness: Generalization from list-learning to prose recall. Child Development, 50, 501-512.

Brown, A., Knowing when, where and how to remember : a problem of metacognition, in Advances in instructional psychology, R. Glaser, Editor. 1978, Lawrence Erlbaum Associates: Hillsdale, New Jersey. p. 225-253. 30.

Brown, A.L. and J.S. DeLoache, Metacognitive skills, in Cognitive development to adolescence : A reader. , K. Richardson and S. Sheldon, Editors. 1988, Lawrence Erlbaum Associates Hillsdale. p. 139-150.

Brown, A.L., The development of memory: Knowing, knowing about knowing, and knowing how to know. Advances in child development and behavior 1975. 10: p. 103- 152. 29.

Zimmerman, B. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P.R. Pintrich, &

M. Zeidner (Eds.), Handbook of self–regulation: Theory, research, and applications (pp. 13-29). San Diego: Academic Press.

Zimmerman, B. J. & Martinez-Pons, M. (1986). Development of a structured interview for assessing student use of self-regulated learning strategies. American Educational Research Journal, 23, 614-628.

Zimmerman, B. J. & Schunk, D. H. (2011). Motivational sources and outcomes of selfregulated learning and performance. In B.

Zimmerman & D. Schunk (Eds.), Handbook of self-regulation of learning and performance (pp. 49– 64). New York, NY: Routledge.

Zimmerman, B. J. (1998). Developing self-fulfilling cycles of academic regulation: An analysis of exemplary instructional models.

In D. H. Schunk & B. J. Zimmerman (Eds.), Self- regulated learning: From teaching to self- reflective practice (pp. 1-19). New York: Guilford Press.