The Effect of 5E Learning Model Instruction on Seventh Grade Students’ Metacognitive Process

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SYNOPSIS

INTRODUCTION

Since 1970s, researches have been suggesting new perspectives about explaining how learning takes place, while examining what are the causes of students’ success or failure. According to these researches not having a specific strategy (Feitler & Hellekson, 1993), having difficulty in using appropriate strategy for a given task, when they come across with new and complicated tasks using ineffective strategy and plans affect students’ success (Kirby & Ashman, 1984). Therefore, Brown (1974) claimed that different mechanisms from students' cognitive processes have effects on their success (Cited in Victor, 2004). Thus, it has been started to be said that in addition to cognitive processes, awareness and regulation of these processes, that is, their metacognition can be effective in students' learning.

According to John Flavell (1987:21), who is a scientist and mostly mentioned in studies where metacognition is mentioned, metacognition is the knowledge of a person about his cognitive processes. New definitions after Flavell defined metacognition as knowledge of cognition and regulation of cognition (Pintrich, 2002; Nietfeld, Cao & Osborne, 2005). Knowledge of cognition is about an individual's awareness about his own cognition (Schraw & Moshman, 1995; Pintrich, 2002). Knowledge of cognition is divided into three in itself as declarative knowledge, procedural knowledge and conditional knowledge (Jacobs & Paris, 1987). Procedural knowledge is the knowledge of what strategy to use for a cognitive task and how to use this strategy (Schraw, Crippen & Hartley, 2006; Thomas & Mee, 2005). Conditional knowledge which is the third part of knowledge of cognition is the knowledge about why, when and where to use declarative and procedural knowledge (Jacobs & Paris, 1987; Schraw, 1998). This characteristic of conditional knowledge indicated that three

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components of metacognition are not different from each other and there is an interaction among them (Thomas & McRobbie, 2001).

Regulation of cognition is composed of planning, self-monitoring and self-evaluation skills (Schraw, 1998). Planning is to choose appropriate strategies and sources for the task. In addition to that, planning includes defining aims, activating prior knowledge about the task and time management (Schraw & Moshman, 1995). Self-monitoring is to be aware of your performance while dealing with a specific task (Nietfeld, Cao & Osborne, 2005) and checking the process in a regular interval to see whether the task is understood or not (Candan, 2005). Self-evaluation is estimation of an individual for his own learning products and regulation processes (Schraw & Moshman, 1995).

**Metacognition in Science Education**

Definitions about metacognition have caused the question about how individuals' metacognition is effective in their learning. According to Gauld (1986) metacognition enables students to aware their cognitive structure in building the knowledge. Hennesey (1993) claimed that it was not enough teacher explain the correct scientific idea so a learning environment in which both teachers and students can aware their cognitive structures about science concepts was necessary. For this purpose, group and class discussions help to form a language that is based on metacognition while they enable them to aware both their own and their friends' cognitive structures (Beeth, 1998; Hennesey, 1993). Students who use this language in learning environment can look for answers to “why” in research-inquisition process, “how” in problem solving process, “what to do” in decision process (Milli Eğitim Bakanlığı, MEB, 2005).

In science education studies where metacognition took place, there was an idea that when students' metacognition improved, their learning products would improve too. Baird (1990) used a check list which included questions like “what is the aim of this lesson?, what do I know about this subject?, why am I learning this lesson?” to make students use their metacognition. At the end of the study, it was found that students were able to identify the learning aims more easily while they were learning the subject. Another study in which check list was used and in this way students revealed their opinions about the concepts was conducted by Blank (1997). At the end of the study, it was indicated that metacognitive guidance provided to the students helped them to internalize their comprehension about ecology in their long-term memory. This result was congruent with Gauld's (1986) findings claiming that it was necessary for students to use their metacognition that enables them to make reflections about their comprehension while building knowledge. About current electricity, Georghiades (2004) made his students to use their metacognition by asking them “what is the aim of this activity?”, “what did you learn from this activity?”, “What information helped you to reach this finding?” and “explain how you solved the problem to your friend”. According to the written test results used in the study, experimental group students' knowledge about current electricity is more permanent than control groups' knowledge.

In some studies about metacognition, it was seen that metaconceptual term was used (Mason & Boscolo, 2000; Mikkilä-Erdmann, 2001; Wiser & Amin, 2001). Yürük (2005) used metaconceptual process in his study and studied the efficacy and permanency of metaconceptual teaching. While laboratory activities and activities based on problem solving were being carried out for both experimental and control group students, in addition to these activities in experimental group, journal keeping, concept mapping, poster studies, group and whole class discussions were used too, so students’ metacognitive functions were developed. According to their scores from Force Motion and Concept Test, there is a significant
difference between experimental group and control group students’ scores from both post and retention tests. Briefly, according to these studies these students checked their prior knowledge using their metacognition, made comparisons between the concepts in teaching and in their comprehension, discovered the relationship between the concepts they were taught and they could learn this knowledge permanently.

5E Learning Model
One of the learning models used to improve students’ metacognition is 5E learning model. In teaching force and motion there are strikingly few studies examining the metacognition. A number of study findings examining the efficacy of this model in teaching force and motion showed that the model had positive effects on students learning (Campbell 2006; Ergin, 2006; Ergin, Kanlı & Ünsal, 2008; Hırça, Çalış & Seven, 2011; Özsevgeç, 2006). The phases of the model are engage, explore, explain, elaborate and evaluate (Çepni, 2005:44; King, 2005; Nelson & Nelson, 2006). According to these studies, the phases of the model are briefly presented below:

1. Engage Phase: This is the phase in which the teacher gets the interest and attention of the students. Moreover, students are helped to realize what they previously knew about the subject in order to aware their previous ideas. The lesson starts with an amusing and intriguing introduction and students are asked about the reasons of the problem. The aim is not finding the correct answer but make them ask questions and come up with different ideas.

2. Explore Phase: In this phase students produce some ideas to solve the problem by doing group work in an environment where teacher can lead them like a computer, video or in a library. Teacher functions like a guide in this phase but let his students to find the answers of the problems, have first-hand experiences, and explore.

3. Explain Phase: First, groups make a class discussion to discuss their findings. The teacher tries to make a connection between what students are learning and what they previously knew. Furthermore, the teacher asks some questions to help students to structure scientific concepts and share his knowledge about the concept with the students. This is the most teacher-centered phase of this model and in necessary situations teacher makes some explanation in basic knowledge level.

4. Elaborate Phase: Students apply knowledge and problem solving approaches to the new cases and problems. In this way, they learn new concepts that were not in their minds. Students are encouraged to use newly learned knowledge, skills, terms and concepts and in new situations to present what they have learnt.

5. Evaluate Phase: At the end of the cycle, this phase enables the student to reflect what he learnt. At the same time, while learning new concepts and skills students evaluate their development at this phase. At this phase, teacher can observe the students while they are solving problems and ask them open-ended questions.

In the light of above studies, how metacognition would take place in 5E learning model in terms of classroom activities looks like a subject that needs to be investigated. When the Science and Technology program is examined, it is seen that metacognition is not directly used but there are statements like “students would be aware of their own ideas” and “identifying students weaknesses and strengths” (MEB, 2005). Although they are implicit, these statements emphasize that in Science and Technology program, metacognition should be considered in teaching. On the other hand, metacognition should be examined in a more comprehensive way in order to identify how metacognition changes according to individual differences.
PURPOSE OF THE STUDY

The aim of this study is to examine the effects of 5E learning model on students’ metacognitive processes in a class where 5E learning model is used.

METHODOLOGY

a) Research Design

The survey is presented as a part of a doctorate thesis study. In quantitative part of the study, a pre-test post-test control group quasi-experimental design was used (Karasar, 2002). While in experimental group an instruction based on 5E learning model was administered, in control group an instruction recommended by MEB program was given. In qualitative part of the study, with some students chosen from experimental group semi-structured interviews were done before, during and at the end of the model was administered. Furthermore, the groups were observed and recorded, and these recordings students’ journals were also used as data sources.

b) Participants

Three target students were chosen from experimental group students using purposive sampling. Purposive sampling method is nonprobability-sampling method and researcher designs the sampling according to his criteria (Cohen, Manion & Morrison 2000:103). In this study, criterion sampling which is one of purposive sampling method is chosen. The researcher can form criterion or criteria mentioned here or a criterion list prepared in advance can be formed (Yıldırım & Şimşek, 2000:73). While choosing target students from experimental group, primarily their scores from pre-tests were taken as criteria. Students’ scores from each test were calculated and then these scores were grouped as high, medium and low. Then, three students from each group were chosen.

c) Semi-structured Interview Form

White (1998) states that metacognition is a mental activity which cannot be observed directly. Therefore the measurement of metacognition raises some problems. Furthermore the students’ difficulty in monitoring their understanding to any other person is another problem which makes difficult to measure metacognition. In this study it is aimed the students to gain the habit of thinking aloud. The thinking aloud protocol which adopted from Kayacan (2005) was used for students to practice and enhance their habit. Literature review is also done and metacognitive guidance used by Yürük (2005) in his study was turned into interview questions and new questions were added and formed a semi-structured interview form. There are 8 questions in the form.

e) Implementation

Teaching Materials Prepared for Experimental Group

A lesson’s implementation order in which a worksheet used that is prepared according to 5E learning model is given below.

1. Engage Phase: Prepared worksheets were delivered to the groups and in the first phase of the model above open-ended questions that caused cognitive conflict, and reveal their previous knowledge were asked or situations were given. These questions were answered individually in some activities and as a group work in other activities.

2. Explore Phase: Groups dealt with the tasks they were supposed to complete and in this phase they clarified the guesses and ideas they were supposed to make. Moreover, students did some tests with their material, and explained their reasons.

3. Explain Phase: Spokesperson of each group stated the opinion of the group about the situation. While the groups were explaining their opinions researcher guided them to use what they learnt. Similarly, during the lesson while questions were asked and answered, examples about the concepts were given, and in each situation when students or teachers
expressed their opinions, researcher made similar guidance by this way it was aimed that whether students find teachers’, their own answers or his classmates’ opinions, guesses and examples clear and understandable or not was checked. When the clarity could not be achieved, students were asked about what they could do and to achieve intelligible some guidance were given by the researcher. After intelligible was implemented groups were asked whether they find the stated opinions reasonable or not and when their answers were yes or no, they were asked to explain their answers with justifications. In this phase, finally teacher introduced the new concept and presented the explanations and terms about the concept.

4. Elaborate Phase: The teacher presented students one or more than one new problematic situations and students were asked to use newly learned knowledge to solve this problem. At this phase, students’ comprehension level was considered to move onto a new concept and decision was given accordingly. In some situations, this phase took a large proportion in order to be sure that students understood the subject. In worksheets, this phase was placed under “Could we learn?” heading.

5. Evaluate Phase: Students were asked to give examples where the concept was used in real life, so the knowledge, concept or skills students learned were tried to be linked with daily life as much as possible. This phase also justified the condition of the concept’s fruitfulness.

In addition to the worksheets, experiments, refutation texts, poster studies were other teaching materials used with experimental group. Like in the worksheets, students were guided to use intelligibility and plausibility while using these teaching materials.

Forming Intelligibility and Plausibility Concepts

In this study, instruction order developed by Hennesey (1993) was taken as a basis and made some additions to it and formed a new order. First step of instructional order is intelligibility which is also first condition of the conceptual change. At the end of two hours instruction about intelligibility, the basis of clarity term was formed in students. Guidance was repeated in fixed intervals to strengthen this basis and to be used by the students in the future.

Second step of instructional order is second condition of conceptual change that is plausibility. In order to form a mutual understanding in the classroom about the plausibility term, a different route from Hennesey’s implementation of instructional order was followed. In this section, two imaginary students named Ahmet and Ceren read a newspaper article claiming that mobile phone usage is dangerous and their conversation about this news was used. Researcher asked the students what was meant by the term “plausibility” in the text. When students’ responses were completed, the researcher explained plausibility based on student responses. Like in teaching intelligibility, it was explained to the students that they need to use plausibility in the following lessons. Therefore, students were asked to identify whether the ideas claimed in the lessons were intelligible and then plausible or not.

f) Data Analysis

Collected raw data were analyzed with content analysis. For this purpose, without defining any categories, data were revised. Later on, student statements belong to the same category were grouped and named as a category. While categories were named, conceptual frame and definitions defined in literature about metacognition were considered. Categories in literature about metacognition and categories found in this study and their definitions were compared (Yürük, 2005; Young, 1997). As results of comparison show that categories found in this study were oriented to measure metacognition so its content validity was achieved (Bilgin, 2006).
After achieving the validity, second step is the reliability of category coding (Bilgin, 2006). At this phase researcher took help from a specialist researcher about metacognition. Three written interview data was given to the second researcher to identify metacognitive categories. For existing categories consistence percentage was calculated as following; for awareness it was 92 %, for monitoring oneself and others it was 89%, for evaluating oneself and others it was 94% and for self-controlling it was 85%. For all categories, average consistence percentage was 90%.

FINDINGS

At the end of interviews done with three students, mutual metacognitive categories emerged. These categories are:

- Awareness about oneself and others
- Monitoring oneself and others
- Evaluating oneself and others
- Self-controlling

But these categories differentiate in terms of quality. Also, categories’ change process is different in each student. Derya’s adaptation was more remarkable than others, who is one of the target students. She had no difficulty in reflecting her metacognition both during the one to one interviews and in the classroom. Moreover, from the beginning until the end of the interviews while reflecting metacognitive categories she was able to present rich contextual data. On the other hand, it is seen that her self-controlling skill about what she learnt was weak. It can be said that except self-controlling skill generally Derya reflected metacognitive categories at the same level from the beginning until the end of implementation. Canan’s (the second target student) metacognitive change is different from Derya’s. In the first two interviews, Canan had difficulty to reflect her metacognition, but beginning from the third interview, she showed a positive change. Therefore, Canan’s metacognitive change was not at the same level from the beginning until the end of interviews like Derya. The third interview was a breaking point for Canan. On the other hand, her self-controlling skill was lower than Derya. She displayed this skill only in the last interview.

Similar to Canan, Sinan (the third target student) had difficulty in reflecting his metacognition until the second interview. After the second interview an improvement in self-monitoring skill was observed. However, there was a continuous weakness in his evaluating and self-controlling skills which are metacognitive categories. Therefore, Sinan’s metacognitive development was not consistent in itself. Different changes in different directions observed in three students caused differentiation of the students’ metacognitive changes in the same class.

DISCUSSION and RESULTS

Metacognitive categories existed in this study with target students were also observed in the study conducted by Yürük (2005). In Yürük’s study, metacognitive categories existed at the end of one to one interviews done with two students chosen from experimental group, are awareness, monitoring and evaluation. Yürük stated that existed metacognitive categories in students do not go with all or nothing rule. In the study, all students were engaged in activities based on metacognition but in frictional force subject, while one student reflected
metacognitive awareness the other one reflected evaluation skill. In a similar way, Case, Gunstone & Lewis (2001) stated that metacognitive development was unique to the individual and related with the personal characteristics of the students. Taking this as a starting point, it can be claimed that in spite of the instruction given in the same class, students’ individual differences caused different metacognitive developments.

In this study through 5E learning model students’ metacognition was tried to be improved. According to Saka (2006) because of the discussions made among the groups especially at the engage phase, students who stated their ideas could aware the difference in ideas and reach a consensus from these differences. In this study, in the worksheets the situations given in order to create cognitive conflicts, or refutation texts enabled students to use their self-monitoring skills. For instance, as a group spokesperson waiting for her turn Derya, revised what she did at that time and made a change about the dependent variable she used in the experiment (Spiral never changes it is fixed. However, spiral’s stretching changes. At that time, I understood this.). Therefore, it can be said that implementation of educational strategies in which students realize their own ideas and their friends’ ideas will help to improve their metacognition.

According to Hennessey (1993) the language in the classroom during the discussions both the teacher and students use is quite important. When the language based on metacognition is used effectively in the classroom, Hennesey (1993) stated that students can realize their own ideas. A teacher who is teaching based on 5E learning model should do in class or out of class activities that will contribute to raise students who can think creatively, critically and multi-dimensionally, learn how to learn, who are responsible from their own learning and make clear judgments (Ayvacı & Bakırcı, 2012). When this is considered, it can be said that teaching done in the experimental group, which was based on 5E learning model, had an effect on existence of metacognitive categories and their progress.

SUGGESTIONS

While measuring metacognition, techniques like interview, observation, and document analysis were used. The technique that is the most suitable for the students is a topic that should be studied in further studies. In this study, the interviews done with one of the target students, Derya, and analysis of voice recording show that she can easily reflect metacognitive awareness and skills but this is not the case for Canan. Although Canan was able to have metacognitive awareness and used metacognitive skills as the study progresses, one to one interviews needed to be done with her to reveal all these processes. This situation shows that observing metacognition is a difficult task and for some students it might be necessary to choose special techniques. It is understood that for students who could not use their verbal skills very often in-group discussions like Canan, while measuring metacognition direct observation is not a suitable technique. With such students, interviews based on stimulated recall make it possible to observe the metacognitive processes.

In 5E learning model engaging in group activities may affect their metacognition. Students can discover consistent and inconsistent structures in both their and others’ cognitive structures with the help of group work provided by teachers. Therefore, in classroom a learning environment where students with different cognitive learning levels come together and share their ideas should be provided. Moreover, it should be considered that there are students with different cognitive, metacognitive and affective characteristics and those characteristics should be considered while preparing instructional materials and using them in the classroom.
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