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## **The Contributions of the Comprehension Tests to the Cognitive and Affective Development of Prospective Teachers: A Case Study**

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Abstract: The aim of this study was to investigate the role of comprehension tests while teaching algebra and its effects on students' success. This study was carried out with 108 third year undergraduate students enrolled in math education in faculty of education. Several data collection instruments were used for gathering data from the participants such as; comprehension test, written documents, semi-structured interviews schedule, and participant and nonparticipant observations sheets. Collected data were subjected to content analysis and triangulation among the data was ensured. Results indicated that three different major categories emerged from the content analysis of the data: (1) measure of comprehension test(s), (2) positive and (3) negative impacts of the test on learning (the development of cognitive and affective skills). Further recommendations and implications about the use of comprehension tests is given at the end of the study based on the findings.

Key words: Algebra teaching, comprehension tests, undergraduate mathematics students.

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## **Introduction**

Assessment is a complicated process which may influence the beliefs on the nature and knowledge of mathematics, and educational process, on instruction and the connection among individual, school and society. This viewpoint regarding assessment is crucially important for reform attempts to be realized in educational process (Ridgway&Passey, 1993). Today, the tests are usually used for assessing outcomes and give more emphasis to products and rote learning rather than students' progress. They have only interested in the products of the learning. These tests do not provide adequate evidences for teacher to design their one lesson plans based on the needs. They seem to be limited while determining students' thinking process, strategies and learning potentials (Ginsburg, Jacobs&Lopez, 1993). For this reason, these tests need to be supported with several other assessment methods to assess students as a whole and needs to be re-designed according to new educational approaches and development in the world (Romberg, 1993). Essentially, NCTM (1989) see that standardized achievement tests do not reflect and measure students' general success, readiness or measure any program you want to measure. In traditional way of assessment in maths, quotations of "... explain the theory and prove it" or "... prove the theory" include these kinds of questions and help try to understand and to assess the students' knowledge about the theories. However, there are some deficiencies of these types of assessment and they are as follows; (Conradie&Frith, 2000):

a) Whichever the students have ability, students should need to memorize some facts in order to respond the types of questions given above.

b) The students can only concentrate on the concepts stressed in the lessons as a result of studying and memorizing the results and theorems taught by the instructor/teacher.

c) The answers of the questions mentioned above cannot be easily assessed.

d) The feedback to be gathered from the students with low success will be quite limited when they are testes in this way and it would be hard to diagnose their deficiencies of understanding or learning.

The insufficient results of the assessments activities performed by use of the traditional methods direct the educators to seek for alternatives. In this sense, the comprehension tests are proposed as alternative tests to the traditional ones. These tests were first used at the beginning of 1990s. It has been believed with the use of these tests that the traditional methods does not seem to adequately measure the students who have low math success, but have potential to learn maths (Frith, Frith & Conradie, 2006). The comprehension tests are dynamic tests that provide chances the instructors/teacher to add several things to the questions in order to help students find the correct answers. The test also includes instruction regarding the concepts to which the students are not familiar. The concept of dynamic test assesses the learning potential of the learners and concentrates how the students learn rather than what they learn (Feuerstein, 1979; cited in Frith, Frith&Conradie, 2006). For example, in these tests, students' ability is directed from teaching to learning; students generalize the results, make interpretations and practice the definitions. In the construction of the comprehension tests, the basic points to be paid more attention are that the test should include the basic maths concepts and the language used in the test should be simple and clear (Frith, Frith&Conradie, 2006).

### **Purpose of the Study**

It is known that the traditional teaching methods don't affect the students' maths learning, not develop their attitudes towards maths and also not improve the students' academic success (Alanis, 2004). Moreover, traditional measurements and assessment instruments do not show the students' knowledge level and also how they apply their knowledge (Hiebert&Carpenter, 1992). Due to the limitations of traditional assessment

methods, researchers have been tried to find out the alternative methods for assessing students' performance. Furthermore, the researchers who are dealing with maths teaching are trying to design alternative methods to the traditional teaching methods. The comprehension tests are observed to be one of these methods. However, the learning and teaching environment should be re-designed in order to implement the comprehension test effectively.

The purpose of the present action research study was to investigate the 3 year undergraduate math students' perceptions of the usage of comprehension tests and their effectiveness in math teaching. Following research question guided the overall study.

What are the perceptions of undergraduate math education students' regarding comprehension tests and their effectiveness?

## **2. METHOD**

### **2.1. Research Design**

This action research was carried out by making use of both qualitative and quantitative research techniques. The action research is a type of investigation of real world functions and their effects, and is used such areas as for up-dating instructional methods and evaluation procedures and for increasing instructional effectiveness of teachers (Cohen, Manion & Morrison, 2000). According to McKernan (2000) the action research is a systematic self-reflective scientific investigation used by either researcher or teacher for developing personal understanding and application regarding an emerged problem. This action research was realized in the fall semester of 2007-2008 academic year in the class of "Introduction to Algebra".

### **2.2. Participants**

This sample of the study comprised 3<sup>rd</sup> year undergraduate students who took the course titled as Introduction to Algebra from Department of Math Education in Faculty of Education. The participants will become a math teacher one year later and will be appointed

to second level of primary education. Until this semester, the participants have taken the following math related-classes; Abstract Mathematics, Calculus I, Calculus II, Geometry, Calculus III, Linear Algebra I, Calculus IV, Linear Algebra II. This semester, they took Analytic Geometry in addition to Introduction to Algebra.

It is believed that since a comprehension test mainly includes basic mathematical knowledge due to its nature (Frith, Frith & Conradie, 2006), the classes that the participants took up to know are prerequisite for using comprehensive tests. In the research, Introduction to Algebra was preferred because this lesson includes basic mathematics knowledge and also is sufficient for the comprehension tests because the course is based on the theory. The course of Introduction to Algebra is offered in one semester (14 week) in 3 hours. The participants of the study were selected among the students taking this class. 108 volunteered to participate in the study.

### **2.3. Data Collection Instruments**

Several data collection instrument were used for gathering data from the participants. These instruments are as follows; (1) the comprehension test, (2) written documents, (3) semi-structured interviews, (4) participant and non-participant observation.

#### **2.3.1. Development of the Comprehension Test and its Administration**

The maths comprehension tests aim at assessing the university students' math knowledge as well as revealing undergraduate students' potential of success (Frith, Frith & Conradie, 2006). In other words, they entail process rather than product. Introduction to Algebra lesson was considered in this manner and re-designed for effective administration of these tests. Instead of asking "... prove the theory?" or "show...?" which are traditional teaching methods questions, the questions and theorems were given to the students with solutions and proofs and sometimes with their solutions and proofs together but without theory and problem explanations. In this way, the students' ideas about the theory and

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problems were aimed to be investigated. The theory proofs and the solutions of the problems and the critical points, and transition points were numbered as 1, 2,...etc, the students were asked to consider these numbers while answering the questions. During the implementation of the course, a discussion among the students was created with the questions of “where does it come?”, “why do we write it?” “if it was like that, what would happen?”. Students’ were randomly selected for the asked questions. This way enables the students to be awake all the time during the instruction and raise their attention to the discussion. Through the instruction, informal feedbacks were regularly gathered from the students. Also, the students who don’t answer the question correctly were protected by the researcher, (the researcher and the students both in the lessons and without the lesson activities, they know each other) and the researcher create a safe and convincing environment to have a confidence. After a 2,5 months teaching and learning period, a first comprehension test with four questions were given to the students and they were asked to answer the questions. These four questions were all regarded as group theory and proofs. Two of these questions’ proof were already shown in the instruction, the rest were given as an assignment. However, some parts of the proved theories were not stated in the comprehension test. Moreover, students were not informed about the test day, they only knew that test will be administered at any time within three weeks. This situation enabled the students to get high motivation toward the class..

### **Comprehension Test Examples**

Two of the questions of comprehension test are given below. Whereas 3<sup>rd</sup> theorem was not proved in the class and given to the students as an assignment, 4<sup>th</sup> theorem proved in the class. Simple and clear language was used while writing test items. Below example was designed to reveal the strengths and weaknesses of the students while proving the theorem. Conradie and Frith’s (2000) study was taken as a base, 3(a), 3(d), 3(e), 4(d), 4(e), and 4(h) were concepts used for the proof, 3(b), 3(c), 4 (b), and 4(c) are important steps in proof, 3(f),

3(h), 3(i), 4(f), and 4(g) are regarded as the structure of proof, 3(g) and 4(e) are regarded as sensitive points, and 4(i) is for investigating students' knowledge of proof methods.

*Item 3. Read the theorem below and prove it.*

Every group is isomorphic to a permutation group (Cayley's Theorem).

*Proof:* Let  $g$  be a fixed element of  $G$  and consider the mapping  $\lambda_g : G \rightarrow G$  defined by  $\lambda_g(x) = gx$  for all  $x$  in  $G$  **(1)**.  $\lambda_g(x) = \lambda_g(y) \Rightarrow gx = gy \Rightarrow g^{-1}(gx) = g^{-1}(gy) \Rightarrow x = y$  for all  $x$  and  $y$  in  $G$  **(2)**. For  $z \in G$ ,  $\lambda_g(g^{-1}z) = g(g^{-1}z) = z$  **(3)**. Let  $S_G$  be the set consisting of the mappings  $\lambda_g$ . Now consider the mapping  $\lambda : G \rightarrow S_G$  defined by  $g \rightarrow \lambda_g$  **(4)**.  $\lambda_{(g_1g_2)}(x) = (g_1g_2)x = g_1(g_2x) = \lambda_{g_1}(\lambda_{g_2}(x)) = (\lambda_{g_1}\lambda_{g_2})(x)$  for all  $x$  in  $G$ , then which implies that  $\lambda(g_1g_2) = \lambda_{g_1g_2} = \lambda_{g_1}\lambda_{g_2} = \lambda(g_1)\lambda(g_2)$  **(5)**. In addition,

$$g_0 \in \text{Ker}\lambda \Leftrightarrow \lambda(g_0) = \lambda_{g_0}(x) = x = g_0x \quad \text{(6)}$$

$$\Leftrightarrow g_0 = e.$$

*Answer the questions below.*

- a) What is the aim of the function defined in (1)?
- b) What is shown in (2)?
- c) What is shown in (3)?
- d) Is  $S_G$  a group? Why?
- e) Why is it needed to define of  $\lambda$  in (4)
- f) What is it shown in (5)? Why is it needed?
- g) What is the identity element of  $S_G$  and how is it used in (6)?
- h) Is  $\lambda$  surjective? Why?
- i) How can the proof be ended with the start of (6)?

*(4) Read the proof below and answer the following questions.*

Write  $\langle a \rangle = \{\dots, a^{-2}, a^{-1}, e, a, a^2, \dots\}$ . Denote this set by  $H$ . Then, for  $\forall i \in Z$ ,  $a^i, a^{-i} \in \langle a \rangle$  **(1)**. However,  $H \neq \phi$  **(2)**. Let  $x, y \in H$  then there exist  $k, l \in Z$  such that

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$x = a^k, y = a^l$  (3). We get  $xy^{-1} = a^k(a^l)^{-1} = a^k a^{-l} = a^{k-l} \in H$  (4). Hence, we get the result we look for (5).

- a) What is the method of the proof here?
- b) How was it ( $\forall i \in Z$  için  $a^i, a^{-i} \in \langle a \rangle$ ) found in (1)?
- c) What was shown in (1)?
- d) Why is  $H \neq \phi$  in (2)?
- e) How were they ( $x = a^k, y = a^l$ ) equated? Is  $k, l \in R$  taken? Why?
- f) What was shown in (4)?
- g) It is given  $a^{k-l} \in H$  in (4) What is the reason of this?
- h) How is  $((a^l)^{-1} = a^{-l})$  in (4) written?
- i) What was found in (5)?

### 2.3.2. Written Documents

After the comprehension test including above items was completed, the students were asked to write a composition including their opinions regarding the test and the instruction. Following questions were asked to students for guidance purpose; “What do you remember when you hear comprehension test?” and “What are your opinions about the instruction based on the comprehension test?” at the very beginning, the students were informed that their composition will be used for formative purpose and will shape the instruction. And further their writings will be evaluated and the results will be shared with them. The students wrote their compositions in 20-25 minutes.

### 2.3.3. Semi-Structured Interviews

The students interviewed were selected with the purposeful sampling method. Further, their responses in the comprehension test also play crucial role. Selection was done according to their answers in the test. They were grouped into three parts with regard to success in the

test as lower, medium and higher. This helped observe the effects of comprehension test on the students with different achievement level and get more sound results. For ethical concern, the students were left free to attend the study. At the very beginning, 22 students who were suitable for the study were selected, but 5 of them indicated that they didn't want to participate in the interview. Thus, the interview was realized with a total number of 17 students; 9 females and 8 males. 5 of the participants were from high level, 4 of them from medium level and 8 of them from lower level. Individual interview was conducted with four of them, and the rest was grouped into three and groups interview was performed with these groups separately. It took nearly 60 minutes. Students were asked not to give their name during the interview because of confidentiality reason. At the beginning of the interviews, the purposes of the interview were explained and the researcher used the questions of "why?", "explain", "how?" to get in-depth perspectives of participants. The clinical interview method was used (Gingsburg, 1981) and tried to obtain details of the students ideas regarding interview questions. All these interviews were carried out in a room of the researcher and the place was observed to be quite safe and comfortable. In the group interviews, the researcher used the tape-recorder and later transcribed verbatim and further all participants approved their own transcripts. On the other hand, the researcher only took notes while doing an individual interview since no permission was obtained from the participants.

#### **2.3.4. Participant Observation**

Since the researcher was the administrator of the instrument at the same time, he closely observed the students during the instructions and test administration. The researcher obtained students opinions through his informal discussions with the students and recorded these opinions into his note-book. He used them for up-dating the instructions.

#### **2.3.5. Non-participant Observation**

Total three lessons, each of which was randomly selected from different group, were video-typed. Total record time was about 50 minutes for each video-record. These records were analyzed by three experts: the researcher himself and two other educational specialist experts. Also, these specialists came to one of the classes to examine the one hour lesson. One of the specialists (educational sciences expert) focused more on the relationship between students and researcher (instructor), the attitudes of the students to the instruction, the teaching-learning environment. Based on what the specialist indicated, the instructor started to observe some of the students more closely and detect their learning difficulties. The other specialist (science education expert) focused more on the transitions between concepts and operations.

#### **2.4. Data Analysis**

The analyses of the data collected were continued until they reached saturation. In that way, the data was defined, explained and classified. The constant comparative method was used while analyzing the written documents, the interview transcripts and observations. The constant comparative method consists of open, axial and selective coding steps (Glaser & Strauss, 1967; Strauss & Corbin, 1998). In the open coding step, firstly, the participants written answers and the responses in the interviews were read more than one without considering any theory so as to understand the data logic, and then they were coded. 229 open coding were observed at the end of the coding process. Some of the open coding examples are, “to be directed to search” (open coding: 10), “I didn’t say that the teacher asked a hard question, it was hard to say that it was teacher’s fault and I thought I memorize the many knowledges.” (open coding: 16), “When I solved the test, I understood some of what I didn’t understand before.” (open coding: 173). In axial coding step, after the researcher examined the details of the opening codes, three categories and corresponding sub-categories were emerged. These categories were (1) What does the comprehension test measure?, (2) The

positive effects of the comprehension test?, and (3) the negative effects of the comprehension test? In the selective coding step, the relationship between the sub-categories and the major categories and other data were investigated and a central (core) category, which cover all major categories and would explain the phenomenon, were tried to be revealed.

### **2.5. Trustworthiness of the Study**

A triangulation was ensured among the data collected through the comprehension test, written documents, semi-structured interviews, participant and non-participant observations. No changes (wording, sentences...etc) were done over the interview transcripts and later the participants were asked to confirm what he wrote in the written documents and what he talked during the interview. Also, students' ideas and their perspectives were given in the text without any change. The analysis of the data were done during a process and until it reached the saturation, and it was observed that different participants reported similar results. These all showed that the study can be replicable. Moreover, the class activities and video records were analysed by the specialists and their ideas were considered. The content of the comprehension test was examined by an expert (math education expert) on algebra. The categories, their sub-categories and their appropriateness were given two educational specialists who know the qualitative research and coding procedures very well. Test items and codes emerged were revised by considering the feedback taken from experts. One of the taken feedbacks was given below.

Example (feedback): In category 2, whereas “the communication” the sub-category was explained by the researcher as “to realize the deficiency of mathematical communication”, the maths education specialist indicated that this communication referred to the differentiation among the table, graphics, verbal statement and symbolic representation, and it should be rewritten and find out the students ideas, or needed to be determined what

they referred to communication. After that, this category was re-defined as “explaining the problems in verbal format” and “using the symbolic language of maths”.

At the end of the examination of all categories, the concordance correlation coefficient between the researcher and the maths education specialist was calculated .86 between the researcher and the science education specialist was calculated .88.

### **3. FINDINGS**

After data analyses,, three categories were emerged. These categories were explained below:

#### **Category 1. What does the comprehension test measure?**

This category consisted of three sub-categories such as, “knowledge”, “individual differences” and “teaching-learning process”. Furthermore, the sub-category of knowledge was broken down into knowledge level, use of knowledge and self-assessment; the sub-category of individual differences included the capacity of understanding, learning differences, readiness and concentration; and the sub-category of the teaching-learning included learning in the process and the continuing the lesson. Some of the quotations about the descriptions of students’ written answers are as follows.

“In our exam system, learning was until the exam. But, in comprehension test, even in the test, I observed that I educated myself in the way of learning and thinking in the process” (open coding: 188; sub-category: teaching-learning process, description: learning in process).

“It helped not to forget the previous subjects. It helped both teachers and students look ahead, and helped the students construct their own learning foundation” (open coding: 165; sub-category: individual differences, description: readiness).

“Actually, I realized that I have not learned, but I assumed that I have learned. Although I have studied math, I realized that I am insufficient in the theory part of math for three years, and at the same time I understood that I am little clumsy in the this subject” (open coding: 159; sub-category: knowledge, description: knowledge level).

“It requires using all of your math knowledge that you earned during your life” (open coding: 78, sub-category: knowledge, description: use of knowledge).

When the quotations above were examined, the comprehension tests provides the students with the opportunities to determine their own knowledge level, to what extend they use their knowledge and their readiness level. Two of the quotations showing that the comprehension test measure the knowledge level of students are given below.

...

*R: ...For example, there was a broken off in last two lessons (he mentioned that he didn't come to the lesson. I was lost since a new lesson was based on the previous one When I go to home, I do the test again.*

*M: What is the relation of this with the comprehension test?*

*R: Sometimes, it is just written on a note-book. I am writing without knowing. Because of this test, I close up the writings and I can be able to think "That is like that, or like this?", "Does it happen like that? After that, I write. But, when I do not understand a note, I directly passed. Also, I could not write a reason in the comprehension test. However, in regular exam, I directly write from my memory because its reason is not asked.*

The other individual interview quotation is as below:

*İ: ...Comprehension test measure the students' knowledge cumulation more effectively. If you directly ask the proof, it can be half; some knowledge of the students inside can be measured. It can be fairer exam.*

These two interviews showed that students have done rote learning and memorization. It is observed that comprehension test can be assumed to provide an opportunity for the students to be far from the rote learning. Further, students' partial knowledge can also be measured with these tests.

## **Category 2.The Positive Effects of the Comprehension Test**

This category includes two sub-categories such as the effects on development of cognitive and affective skills. The details about these sub-categories are as below.

### **Sub-category 2.1.Cognitive skills to be developed with the comprehension test**

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This sub-category further includes four themes which are problem solving, reasoning, communication and connections. The codes of inquiring the knowledge, step by step solution logic, paying attention to the smallest details, the importance of definition and theories, intuitive thinking, determining the critical points, using the previous knowledge are the descriptions of the problem solving sub-category. The codes of being away from the memorization, the power of interpretation, doing all steps, and mathematical thinking are the descriptions of reasoning sub-category. The codes of expressing the presentation of a problem in a verbal form and using the mathematical symbolic language are in the communication sub-category. Some of the quotations of these themes are given below

“I learn why what I had done did. At least, I have started to pay attention.” (open coding: 111; sub-category: problem solving, description: inquiring the knowledge).

“I have learned that it is quite hard to put forward an idea on what I do not know. You can't know that I used my imagination not to submit to give empty paper. Also I noticed that I have a huge imagination power.” (open coding: 123; sub-category: problem solving, description: intuitive thinking).

“I got confused when (you) asked “according to what did we write this?” I do not know according to what I wrote this, but I had a headache because of thinking of how I should express this” (open coding: 134; sub-category: communication, description: expressing the presentation of a problem in a verbal form).

“... we need to use more scientific, more algebraic expressions. We understand how the transitions occur, but we had a difficulty while expressing.” (open coding: 93; sub-category: communication, description: use the mathematical symbolic language).

“I never think before where an object comes from with the relation of the last step.” (open coding: 96; sub-category: connections, description: relations between the mathematical concepts).

“The comprehension test is similiar to the text given and the questions asked regarding this text in the Turkish lesson. Some of the questions are based on the text while some others are based on

your interpretation.” (open coding: 196; sub-category: reasoning, description: the power of interpretation).

The examples above showed that students believed that their skills on problem solving, communication, reasoning and connections have not been adequately developed. However, they reported that the comprehension test seemed to be quite useful to develop their four basic skills. A quotation of an individual interview showing the development of these skills is given below.

*M: How did you feel when you are studying for the test and teaching the lesson according to the test?*

*M1: With a student psychology, students don't want to be randomly selected (He refers to this that students are randomly selected for the asked questions). But he thinks at that moment. We need to make a research and connection. We suggest to make connections with the past.*

...

*M: What did you feel while answering the comprehension test?*

*M1: I feel that I don't have adequate knowledge on the subject. I understand that I don't answer the questions by considering my whole knowledge. I understand that it is important to know the concepts with comprehension test.*

*M: Don't you understand it before?*

*M1:No.*

*M. Why?*

*M1: We do not use them that much. Application was more important in other classes. We never looked at definitions and even theorems.*

This interview showed that a student had difficulty with making connections among the concepts and had no adequate knowledge for subject. Also, the more important one can be that the interview revealed that the student seemed to have no idea about the effects of definitions and theorems on the mathematical problem solving and thinking. A quotation from

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Group interview -2 about the effects of comprehension test on development of mathematical communication skills is given below.

...

*H: I believe that I can be able to show how to express mathematical terms in verbal form with a comprehension test. As I said before  $2 \times 2$  is equal to 4, but why?*

*M: Is it mathematical speaking?*

*H: Yes, abstract thinking will be more concrete with written explanations*

A quotation showing students' lack of mathematical communication skills from an individual interview is as below.

*M: What does the comprehension test make you feel? What kinds of things come to your mind?*

*P: ... I think these tests will be more successful when they can be started at the primary schools and the students will be grown up with these tests. The students who talk about mathematics and make interpretation on the math will be trained.*

*M: What are the contributions to mathematical talking?*

*P: Firstly, a student needs to understand the question in the test and make a comment. This situation will motivate the student among his/her friends. Maths is not a subject talked among the students it is frightened. Even though I'm in the maths department, I still don't speak about it.*

*M: Why?*

*P: Especially, the classes are based on the theory. Until now, we have memorized all the theorems before exam, but the comprehension test is different.*

*M: Do you think that it is good or bad?*

*P: When I see the comprehension test, I understand that although I have been studying maths, I could not be able to make comments. I thought that I don't give right of my department.*

The open coding 134 given above, when the interview quotations and the observations during the lessons are considered, it is understood that students had difficulty with and are insufficient in the mathematical communication skills such as transferring their thinking to writing, interpreting the expressions, and symbolizing the verbal expressions. As reported by the students, the comprehension tests are seen as an alternative to solve the mentioned problems.

### **Category 2.2.Affective skills to be developed by the comprehension tests**

This category is further divided into six themes such as self-confidence, interest, anxiety, belief, motivation, and value. The self-confidence theme mainly concentrates on developing self-confidence. The interest theme concentrates on showing interest and making the students become curious. Decreasing exam anxiety was emerged under the anxiety theme. Believing is under the theme of belief. Enjoying of what has been done and motivating to study are the main codes of the motivation. Ensuring the equity/justice and showing respect to the teacher are the main codes of the value. Some of the quotations taken from students' writings are given below.

“I didn't understand what it was and why it was like that. Now, I really feel that I have learned. This gives me an enormous confidence.” (open coding: 126; sub-category: self-confidence, description: developing a self-confidence).

“I left blank when the proof of the theorem was asked as an memorization. But, in this application (test), I am thinking of some parts even I do not know the theorems...In this way, my interest stays alive.” (open coding: 153; sub-category: interest, description: becoming curious).

“ ... I took the exam without having any fear. I don't have any anxiety about when I forget the proofs of the theorems...” (open coding: 229; sub-category: anxiety, description: decreasing the exam anxiety).

“ ... I really enjoyed the lesson, because I tried to make interpretation.” (open coding: 215; sub-category: motivation, description: enjoying).

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“While answering the comprehension test, I believe that I can be able to solve the problems even if I did not see the theory before. I really believe myself.” (open coding: 194; sub-category: belief, description: believing to learn).

“The differences between the students can easily be observed; the ones who don’t follow the lesson and find the notes of the lesson and the ones who take his/her own notes. This is a big problem to be overcome for ensuring and bringing the justice.” (open coding: 169; sub-category: value, description: ensuring the justice).

The examples stated above indicated that the comprehension test help the students increase the affective skills such as interest, self-confidence, motivation toward the algebra in particular and learning in general, and also decrease the exam anxiety. A quotation from group interview-1 pertaining to the themes of the self-confidence and motivation:

...

*M: Will you use the comprehension test when you become a teacher?*

*H: Yes. Students’ self-confidence increases. When you ask a question with a proof, he/she becomes depressed when he/she doesn’t solve. But, let’s say s/he solves three by saying a, b, and c. S/he will think her/his motivation will increase by saying that I know something.*

*B: Especially for the questions we don’t know. Well, I don’t know, everything comes on your eyes in a moment. By saying” s/he may do like this form here, it can be possibly done like that”, everything comes true ... S/he says that I really learn”.*

*M: What increase?*

*F: Confidence*

*M: Okay, what happen when it increases?*

*F: The person’s performance increases. If it increases, a person automatically studies lesson, listen the lesson.*

An individual interview showing that the comprehension tests reduce the exam anxiety is given below:

...

*M: Do you have feedbacks from the other exams?*

*G: We partially have, but mostly for appraising the learning. In here, comprehension test is so different. The students are calmer and, more relax and because of it, there is no exam stress. They can take the more real feedback.*

These examples and two quotations from the interviews above are so important since they show the positive effects of the comprehension tests on development of the students' affective skills. This situation was also supported with the classroom observations. It is observed that the majority of the students' interests and curiosity were increased toward the class and they started to frequently ask "why is it like that?", "how does it happen?" and also started to discuss with their peers about the connections between mathematical concepts and operations. This situation makes the teacher-student and student-student interaction possible and active.

### **Category 3. The Negative Effects of the Comprehension Tests**

This category further consists of two main themes; "negative effects on individuals" and "the negative effects as a result of the test construct". The first theme is regarded as (1) directing the students to study on some other parts and (2) students' describing of the hardness of the exam. The second theme is more regarded as the following codes; (1) the practical level of the test is so low, (2) it includes the basic knowledge, (3) preparation of the test is quite hard and (4) it is hard to use the test with the students in the second level of primary school (e.g. 6<sup>th</sup>, 7<sup>th</sup>, and 8<sup>th</sup> grades). Some of the quotations related to these themes and descriptions are given below.

"It doesn't give a change to make operation. The level of operation is very limited." (open coding: 154; sub-category: the negative effects as a result the test itself, description: the practical level of the test is quite low).

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“Even though I don’t know the topic, I could write something by using my only basic mathematical knowledge.” (open coding: 170; sub-category: the negative effects as a result of the test itself, description: it includes the basic knowledge).

“You need to think more and complicated. Due to this, it becomes tiring.” (open coding: 207; sub-category: negative effects on individuals, description: the hardness of the exam).

“The structure of the questions should be well prepared. The questions the teacher asks should be same with what the students understand. If a student understand in a different way, her/his answer can be wrong.” (open coding: 188; sub-category: the negative effects as a result of the test itself, description: preparation is hard).

“...successive questions make a students tired I think I answered 30 questions in the exam.” (open coding: 160; sub-category: negative effects on individuals, description: the hardness of the exam).

“Since (the teacher) did not require us to prove a theorem entirely, it helps us to understand the important parts; it protects us to waste our time for the unnecessary parts. We need to search more than one source for understanding the important parts.” (open coding: 161; sub-category: negative effects on individuals, description: directing the students to work some parts).

When looking at the quotation above, students reported that practice level of the comprehension test is so low, preparation of the test is hard the answering part is hard and the test directs them to some basic parts. Another quotation from a group interview-3 reveals the hardness of the preparation part.

...

*G: The application needs courage. That is, even if the students complain about the memorization, you can possibly here some voices about the opposite ideas. But this point of view should not be change.*

*N: It is hard for the teacher. It requires to work more for making a transitions, going back and also preparing the questions.*

The quotation above shows us that it is hard to prepare a comprehension test, but still it should be used. Most of the students believed that when they become a teacher, they would use the comprehension test in many places (at the end of the subject, as a preparation for the exams, or as an exam; open coding: 8, 217). In addition, eight of the students claimed that the comprehension test would bring a workload when they become a teacher and for that reason they do not tend to use it (open coding: 17). An individual interview excerpt that reflects the effects of the comprehension test on the working style is as below:

...

*F: In here, I did not look at what we proved or what we did? I was even unaware of what the theorem was. I just focused on the transitions. Why did we pass from here to there?*

*M: But, there are in questions?*

*F: I was not aware of the questions.*

*M: For example in the, option f of the question 2 it was asked that “what was proved?”.*

*What did you do, then?*

*F: I didn't do it.*

*M: Did you stop there?*

*F: Yes*

*M: Doesn't it reveal something about the students for the evaluator?*

*F: Yes, but if there was not that option, I would never understand.*

The interview excerpt above shows the hardness of using the comprehension test. For this reason, the questions should be carefully designed and the transition points should be very well identified.

## **DISCUSSION**

The main goal of all curricula in general and of maths curriculum in particular is to realize meaningful learning for all levels of the students. The professional literature indicates

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that traditional teaching methods do not increase students' interests toward maths (Peng, 2002), meet their needs (Saye, 1997) and improve their academics achievement (Dede, 2003). The first aim in traditional teaching is to develop students' operational skills. In the standard test, to get a good grade, it is enough to choose the correct answer. The answer key or the teacher is the means which control the students' answers. Speed in the test is more important than thinking of finding the correct answer(s). Several behavior (e.g. comprehending the logic and the process of the test, explaining the process and criticizing) that contribute to development of students' mathematical thinking should not be ignored (Burns, 1985, as cited in Montgomery, 1987).

In this action research, the impact of use of comprehension test in Algebra class in mathematic teaching department on the 3<sup>rd</sup> year prospective teachers' opinions was investigated. The data was collected from the participants though the use of the comprehension test, written documents, individual and group interviews and classroom observations. All data was subjected to the content analyzed and they were grouped into three categories.(1) what does the comprehension tests measure?, (2) the positive effects of comprehension tests (thinking that they develop the cognitive and affective skills) and (3) negative effects of the comprehension tests.

At the end, it was found as a results of students' reports that comprehension tests measure knowledge, individual differences and also some components regarding teaching-learning process. To be able to use the knowledge and to make a self-assessment are more observable than the others. Also, in Turkey, the application of knowledge has been emphasized in new primary and high school maths curriculum. Moreover this point has taken place under the general goals of maths education as understanding the mathematical concepts, systems, and establishing a the relationship between concepts and systems, and integrating them into the daily life and other learning environments (The Ministry of National Education

(MoNE), 2005a, 2005b). Similarly, self-assessment method has taken place in new maths curriculum under the title of self-management proficiency “as questioning his or her works related with maths.” (p. 13). Self-assessment is a process including an individual aims, performance, and self -judgement, and also self-reactions to these judgement which are unacceptable and significant (Schunk, 1995). One of the examples showing this situation is as follow, “*I understand that I memorize the subjects. I understand that I could not pass the lesson with memorization.*” (open coding: 90). Positive self-assessment which helps the student to see their own capacities will motive them and feel themselves capable (Schunk, 1995).

Another result drawn from the research is that the comprehension tests have a positive effect on development of students’ cognitive skills. Under the category of cognitive skills, problem solving, making connections, communication and reasoning skills were observed and it was appeared that the test had an impact of development of these skills. Also National Council of Teachers of Mathematics (NCTM) (1989) always stresses the importance of improving these four skills. In Turkey, the new primary and high school maths curricula developed by considering the principles of NCTM put serious emphases on improving these four skills (MoNE, 2005a, 2005b). In that way, it has been aimed to develop and/or improve these skills of students. To this point, this action research points that the comprehension test is an effective mean.

Another important result of this research is regarded as the positive effects of the comprehension test on developments of affective skills of students. One of the important aims of the math education is to keep the affective skills of the students at the high level. Affective skills and features includes several components such as motivation, interest, attitude, self-efficacy, anxiety, belief and value. In the literature several research studies pointed out that affective factors have positive impact on learning and academic success of students (Bloom,

1979, Cates&Rhymer, 2003; Clute 1984; Dede, 2006, Hackett &Betz, 1989; Jingsong, 2003; Lumsden, 1999). In this regard this study is quite significant because it shows the valuable contributions of the comprehension test to development of affective skills.

Another result of the research showed the negative effects of the comprehension tests. They are related to individual and due to the test construct. Negative impact of the test on the individual is more regarded as directing the students to the special points (especially to transitions). A good example of this situation was reported in open coding: 161. This result and the hardness of the preparing the test was also observed in the study of Conradie and Frith's (2000). Another factor is related to the impractical level of the test. However, this can be easily overcome. Since the comprehension tests are dynamic in nature, the students can be required to indicate the next step while proving and/or solving any question and to complete the blanks. Further, in the test, the teacher can even ask students to produce new ideas about the new conditions. With this way, students' habits of working only some parts can be dealt with. Although there are practical items in the test, the students didn't pay adequate attention to these questions. For example, the questions given in the option *d* of the 3<sup>rd</sup> question, "Is  $S_G$  a group? Why?" and in option *h*, "Is  $\lambda$  surjective? Why?" are the practical questions, because these weren't given in the text and wanted students to find by their own. With the question in the option *e* of the question 4, "How do they  $(x = a^k, y = a^l)$  take? Are  $k, l \in R$  taken? Why?", a condition of the theorem was changed and the students were asked to take students' ideas about the new situation.

When the categories, the sub-categories, and themes emerged in the research are assessed, descriptions regarding memorization and reasoning skill can be found under each category. For this reason, the central phenomenon (or core category) of the research was named as "development of mathematical reasoning skill"

## **CONCLUSIONS and IMPLICATIONS**

The most significant point of the results is that the students reported their memorization of the mathematical proofs and concepts. At the same time, the students reported that their mathematical reasoning and interpretation skills were not developed. This situation is, of course, so bad, but the good point is that they would like to deal with this deficiency and try to find alternatives for developing their own skills. In the research, the class observations, written documents of the students and also the interviews with the students showed that even though the comprehension test has some negative points, it can be proposed as an alternative to overcome these problems. The most important advantage of the comprehension test is that this test helps reveal which point is very well understood by a student and which point isn't. For example, as a result of this research, students understood the injective function (option b of the question 3, the question was correctly answered by 90% of the student), but did not understand surjective function (option c of the question 3; the question was correctly answered by only 10% of the students, and there was no correct answer for the option h of the question 3). Another advantage of the test is that it helps teachers obtain feedback from the students with low success (look at the interview coded with I. This student's mathematics achievement was so low). It was observed by the researcher and the experts (observers) that majority of the students participated in all sessions of the classes since the instructions were designed in line with the items of the comprehension test and they were active during the lessons. Further, it was observed that students' interest to the class became higher day by day. As a result of this, the students started to solve the questions regarding the theorems which were proved in the lessons (question 2, 4). On the other hand, similar success was not observed for the questions regarding the theorems which were not proved in the lessons. Of course, it is hard to change the habits. In the light of the feedbacks gathered from the students and the experiences of the researcher during the research, despite the hardness of the preparation and assessment of the comprehension test, it

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is believed that this test should patiently be used and it is suggested to the math instructors and teachers use their own instruction and assessment process. In addition, since the comprehension tests include basic mathematical concepts, these tests should be started to be used at the first class of the university in order to use them more effectively and efficiently.

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