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A scale on logical thinking abilities

Nazan Sezen [a] *, Ali Bülbül [a]

[a]*Faculty of Education, Department of Mathematics Education, Hacettepe University, Ankara, 06800, Türkiye*

Abstract

Logical thinking ability, as has been discussed in several studies in literature, is one of the most important cognitive abilities which influence the success of students. This ability is seen in the concrete and abstract operations stage of Piaget's development stages. The aim of this study is to develop a scale to determine the logical thinking abilities of prospective mathematics teachers. The development process consists of two phases, namely, pre-study and validity-reliability studies. The scale was applied to 132 prospective mathematics teachers. The Cronbach α coefficient of the finalized scale was determined as 0,82.

Keywords: Logical thinking ability, ability, prospective mathematics teacher, cognitive skill, piaget;

1. Introduction

Logic, which is known as the discipline that examines the structure of knowledge and distinguishes correct and wrong reasoning, is also known as the tool of correct thinking. Logical thinking is seen as the key to the processes of mental reservation and complex problem solving. Logical thinking constitutes one part of problem solving. In other words, logical thinking is one of the sub-stages of problem solving. For this reason, it can be thought that people who can solve complex problems have sufficient logical thinking and reasoning abilities. Developing logical thinking, questioning and evaluation processes is realized during the teaching of problem solving (Askar, 1989, as cited in Orhun, 2003). Logical thinking is one of the ways used in acquiring advanced mental activities. Thus, this ability is an application level activity which depends on the knowledge and comprehension level of the objective's cognitive area stages (Bozdogan, 2007). We use logical thinking in evaluating an idea, information and our experiences. Our logic comes up with results related to the topic we are interested in, and then it puts them into the memory (Soylu, 2006).

One of the cognitive skills which influence the academic success of students is the logical thinking ability. Logical thinking ability refers to an individual's ability to solve a problem by using mental operations or his ability to reach principles or rules by making certain generalizations or abstractions (Yaman, 2005). This ability has become one of the most dealt-with subjects of the studies in the field of education (Barr, 1994, as cited in Yaman & Karamustafaoğlu, 2006). Piaget defines logical thinking an ability that is observed in the concrete and abstract operations stage. Students in the concrete operations stage can use logical thinking abilities in solving concrete problems. In the abstract operations stage, these students reach the level of adults in terms of logical thinking

* Nazan Sezen. Tel.: +90-312-2978601

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(Bozdogan, 2007). This ability refers to an individual's ability to solve a problem by using mental operations or his ability to reach principles and rules by making certain generalizations or abstractions (Korkmaz, 2002). Seen this way, logical thinking abilities require advanced behavior.

Logical thinking process means getting the ideas, facts and results of a problem, and to put them in a successive order. Logical thinking prevents a child saying "I don't know, this is too difficult" This ability enables him to comprehend better, and to reach the solution on his own by thinking more thoroughly (Cıbık, 2006).

It is possible to see in literature several studies from various fields on logical thinking. In their study, Boujaude and Giuliano (1994) applied a Logical Thinking Test to a group, and found that there is a meaningful difference between male and female students, which is in favor of male students (Soylu, 2006). In her study, Bozdoğan (2007) stated that teaching by study sheets has a positive effect on logical thinking abilities. In their study, Koray and Azar (2008) confirmed that logical thinking abilities show a meaningful difference according to the chosen field and gender. Sökmen and Bayram (1999) stated that in the teaching of basic chemistry concepts, the school students attend and their logical thinking abilities play an important role. In another study, Tekbıyık and İpek (2007) concluded that the logical thinking levels of prospective teachers show differences according to their gender, field of study in high school, and the level of the class they attend to. Sungur and Tekkaya (2003) emphasized that gender and logical thinking abilities are among the factors that affect students' attitudes towards positive sciences and their comprehension of positive sciences. In their study, Lawson, Banks and Logvin (2007) put forth that logical thinking ability is the primary factor that affects students' self-sufficiency and their accomplishment in science. In addition, Soylu (2006) emphasized that logical thinking ability has an important place in teaching scientific concepts. Moreover, there are studies which show that there is a positive relation between the logical thinking abilities of students and their comprehension of positive sciences (Cavallo, 1996; Johnson and Lawson, 1998, as cited in Yenilmez et al.,2005).

As can be seen above, it is clear that logical thinking, which has a wide range of applicability in various fields, has an important place in the field of mathematics. Topics that are built upon each other get stored in the mind only when they are comprehended separately and only when one constructs a relationship among them. Thus, necessary arrangements should be done in bringing in and developing these abilities. In the final analysis, logical thinking ability is not inherited but is learned (Çıbık, 2006).

2. Methodology

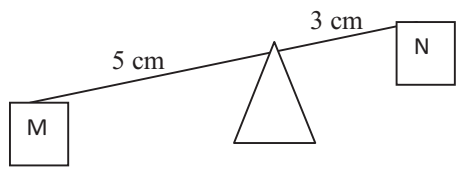
2.1. Pre-study

In the pre-study phase of the scale, first of all, Logical Thinking Abilities tests in literature were examined. One of these scales is Logical Thinking Ability Test (LTST) which is developed by Tobin and Copie (1981) and translated and adapted into Turkish by Geban et al (1992). The test comprises of a total of 10 questions in the categories of proportional thinking, controlling the variants, probabilistic thinking, relational thinking, and associated thinking. Another logical thinking ability test was developed by Norman (1997). This test was designed specifically to measure logical thinking abilities in chemistry topics (Yaman & Karamustafaoğlu, 2006). Another test one can come across with in literature was the Logical Thinking Group Test developed by Roadrangka et al (1982) and it was translated and adapted into Turkish by Aksu et al (Çıbık, 2006).

In this study, the items in the aforementioned tests in literature were examined, and items related to the geometry knowledge of prospective mathematics teachers were written, hence a new scale was developed.

This scale measures the abilities of defining the variants, checking them, the ability to draw relations, measuring probability, interpreting graphics, and the ability to transform numerical expressions into graphics. In the test, there are 12 questions related to these abilities. Each of these questions was prepared two-dimensionally. In the first dimension, there are 5 items related to the answer of the question, and in the second dimension, there are statements that students will give related to the explanation students for their given answer. Below is given a question related to the determining the students' ability of drawing relations:

The relation which is similar to the one between the weight of M and N is given in which option?



A) The volumes of two cylinders which have the same height and the base radius of which are 5 and 3 cm, respectively.
B) The volumes of two spheres whose radius are 3 and 5 cm, respectively.
C) The squares of two triangles which have the same height and the base length of which are 25 and 9 cm, respectively.
D) The squares of two squares whose side lengths are 3 and 5 cm, respectively.
E) The squares of two rhomboids whose base lengths are the same and the heights of which are 3 and 5 cm, respectively.

Figure 1. An example as a question of the determining the ability of drawing relations

The developed test was presented to the opinions of an expert in the field and the measuring-evaluation experts, and in the light of the suggestions they have made, it was finalized.

2.2. Study Group

The study consists of the students of the department of Mathematics Teaching at a university in Ankara. In this group there are a total of 132 students, 75 of which are female and 57 of which are male prospective mathematics teachers.

2.3. Analysis of the Data

After the pilot application of the test, the obtained data was analyzed in ITEMAN (an Item Analysis Program for Tests), and as a result of this analysis, two items were taken out of the test. The test was finalized with the remaining 10 items. For the second dimension of the finalized test, the solution of the explanations of students who gave the correct answer was written in the option belonging to the right answer, and the explanations of the students who gave the wrong answer were written in other options according to their frequency.

3. Findings

3.1. Validity of the Scale

To determine the validity of the scale, an expert's opinion was asked. For the expert opinion, two experts in the field and one measuring-evaluation expert was referred to. Thus, the proof for the validity of the scope of the test was provided. Item analysis was made for the scale, which was corrected in the light of expert opinion, in the Iteman program.

3.2. Reliability of the Scale

The reliability of a measuring tool is sign of its ability to measure the features it sets out to measure (Tekin, 2000). There are several techniques available to determine the reliability level of a scale. It is necessary to take into consideration the nature of points, the assumption about the scale, conditions of research and its aims when deciding on which technique to use (Tezbasaran, 1996).

In this study, Cronbach α internal consistency coefficient and item analysis results were evaluated as part of reliability study. As a result of the item analysis performed on Iteman program, Cronbach α internal consistency coefficient was determined as 0,82. According to this, the scale has a high level reliability. Other concepts which will be examined after the item analysis result are the difficulty and distinguishing indexes of the items.

Since the item difficulty index is the ratio of those who answered the question correctly over the total number of participants, it is the signifier value that shows the percentage of people who answered the question correctly. In this respect, as the item difficulty index approaches 0, the item gets more difficult, and as it approaches 1, the items gets easier. The fact that the item difficulty index is 0,50 shows that the question is of medium difficulty (Atilgan et al, 2006).

When the item difficulty index of each item was examined, two items were taken out of the scale since their distinguishing indexes were below 0,30. Difficulty values of the rest of the items were determined to be ranging between 0,30 and 0,65. According to this, we can say that many of the items in the scale are of medium difficulty.

It is required that the items in a test should be able to distinguish between item and the ones that have the required qualities and the ones that do not have these. This quality of items is called item distinguishing ability index, and at the same time, it is called the item validity coefficient since it reflects the measuring objective of the item (Atılgan et al, 2006). Öncu (1999) states that the items with a 0,40 or higher item distinguishing ability indexes are very good.

It was observed that the item distinguishing ability indexes of the items in the scale range between 0,36 and 0,72. According to this, we can say that the item distinguishing ability of this scale is very good.

4. Conclusion and Suggestions

In geometry teaching, the importance of visual perception and multidimensional thinking is undeniable. Thus, it is necessary to include such exercises through both curricular and extracurricular activities to improve these abilities. The aim should be to make scientific concepts more clearly understood, and then to enable the cognitive processes to follow through these concepts.

In her study, Yılmazoğlu (2004) argued that teaching via concept-map-supported simulation method is more effective than traditional teaching methods for students to comprehend scientific concepts. Similarly, in another study, Çıbık (2006) revealed the positive influence of project-based teaching on logical thinking ability, and backed her findings with several studies that can be found in literature. According to this, choosing the appropriate method or methods would be an important step in developing logical thinking abilities related to geometry classes.

The scale developed within this study can be developed more by taking into consideration different dimensions and different fields. Moreover, with the development of this and similar scales that target the cognitive sphere, these abilities can be observed and they can torch new ideas.

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