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# Learning and reasoning styles of pre service teachers': inductive or deductive reasoning on science and mathematics related to their learning style

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## Abstract

The purpose of this study is to determine the relationship between reasoning styles and learning styles of pre service teachers. In this research, science and mathematics reasoning were examined in order to propose suggestions to reduce gaps between mathematics and science education curriculums. The data was collected through two open ended-reasoning questions and "Learning Styles Inventory" developed by Kolb (1984). Participants were pre-service teachers who are training on science, mathematics and primary school in two different faculty of education (Uludag University in Bursa and Istanbul University). © 2009 Elsevier Ltd. Open access under [CC BY-NC-ND license](https://creativecommons.org/licenses/by-nc-nd/4.0/).

*Keywords:* Inductive reasoning; deductive reasoning; learning style; science and mathematics education; teacher education

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## 1. Introduction

Many researchers have pointed out that reasoning is an important dimension of science and mathematics education (Kanari & Miller, 2004; Lawson, 1995; Park & Han, 2002; Türkmen, 2006; Oehrtman & Lawson, 2008). Reasoning ability can help students to understand and evaluate scientific and technological society. Because, reasoning is highly effective for students' ability to analyze new situations which are faced in all aspects; make logical assumptions, explain their thoughts, reach conclusions and defence their conclusions. In spite the necessity of developing students' reasoning skills proposed by researchers and educators there is great difficulty in defining it and consequently in assessing it.

*Reasoning* is defined as the act of using reason to derive a conclusion from certain premises. In general, a distinction is made between reasoning from the general to the particular (called deductive reasoning) and reasoning from the particular to the general (called inductive reasoning) (Webster dictionary 2008).

Deductive reasoning plays an important role in scientific explanation and prediction. Given general causal laws and statements describing initial condition deductive reasoning can be viewed as a specific domain of knowledge.

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Deductive reasoning can help students to recognize cognitive conflict and to resolve it (Park & Han 2002). To define the functional unity of any deductive construction, Duval and Egret (1989) uses the term "Arc Transitive of Substitution" (A.T.S.) which corresponds either to a minimal length demonstration, or to a step in a demonstration constituted by a continuation of recurring substitution. According to Duval and Egret (1989) two aspects of deductive reasoning are, the number of conditions to be taken into account to apply correctly a rule of substitution and the ternary structure -not binary- of the A.T.S.: the basic unity of any deductive construction contains three statements (given statement, rule of substitution, new statement), each having a different status.

Different students give different reaction and learn in different ways from each other. Reasoning styles or their components may be arising from students learning styles. Some of the discouragement of students for the activities based on reasoning skills may come from learning style differences. Stewart and Felicetti (1992) define learning styles as those "educational conditions under which a student is most likely to learn". Thus, learning styles are not really concerned with "what" learners learn, but rather "how" they prefer to learn. If educators teach exclusively in a manner that favors their students less preferred learning styles, the students discomfort level may be great enough to interfere with their learning. On the other hand, if educators teach exclusively in their students preferred modes, students may not develop the mental dexterity they need to reach their potential for their achievement in schools and as professionals (Felder, 1996).

Identifying relationship with the learning and reasoning styles of students can provide educators with valuable information in designing their curriculum. According to Hawk and Shah (2007), adult students learn in different ways, faculty in higher education would have a responsibility to expand their repertoire of learning activities to embrace as wide a field of adult student learning styles as possible in order to achieve more effective learning.

There is a need for ongoing researches that clarifies the different dimensions of reasoning and to determine students existing reasoning styles including how reasoning styles are related with other components of the didactical system. Among these components, the relationship between scientific and mathematical reasoning; and the connections of these reasoning to the learning styles form the purpose of this research.

## 2. Method

### 2.1. Participants

The study was conducted in the fall of 2008 academic year at Uludag University and Istanbul University in Turkey. Participants were 463 preservice teachers who were studying at secondary science, primary teaching, and secondary mathematics education departments in faculty of education. Participants were 253 first and 210 third class preservice students.

### 2.2. Data Collection

The data collected through two open ended-reasoning questions and "Learning Styles Inventory" developed by Kolb (1984) and translated into Turkish by Aşkar and Akkoyunlu (1993).

Data were entered into SPSS (Version 16.0) for analysis. Descriptive statistics were calculated, including frequency, mean and, standard deviations. Chi-square analysis was used to determine whether there were different frequencies of students in each of the learning style categories.

*Kolb Learning Style Inventory:* The twelve-item Kolb Learning Style Inventory (LSI) was administered to assess learning style. A total score for each of the four learning styles was obtained for each student. The LSI measures an individual's preference for each of the four dimensions using a self-description format based on 12 questions with four alternative responses (Kolb, 1984; Kolb & Kolb 2005). Respondents are required to rank (1–4) according to the extent to which they feel the adjective. The inventories reliability and validity were tested by Aşkar and Akkoyunlu, (1993). Learning style inventory was used in order to investigate the relationship between students' learning styles in science, primary and in mathematic education, to compare the reasoning styles (inductive, deductive and transitional) at different departments.

Kolb (1984) developed his model of learning as a four-stage cycle, Concrete Experience (Feeling) (CE), Reflective Observation (Watching) (RO), Abstract Conceptualization (Thinking) (AC), and Active Experimentation (Doing) (AE). Kolb (1984) develops two dimensions that form the four stages in this cycle and suggests that the CE dimension is dialectically opposed to AC, and likewise RO to AE. These two dimensions form four quadrants depicting learning styles that Kolb (1984) labels as Divergers, Assimilators, Convergents and Accommodators. Divergers have a strong imaginative ability, are good at seeing things from different perspectives, are creative, and work well with people. The style is labelled "diverging" because a person with it performs better in situations that

call for generation of ideas, such as a “brainstorming” session. Assimilators have abilities to create theoretical models, prefer inductive reasoning, and would rather deal with abstract ideas. Convergers have a strong practical orientation, are generally deductive in their thinking, and tend to be unemotional. People with this learning style have the ability to solve problems and make decisions based on finding solutions to questions or problems. Accommodators are risk takers and solve problems intuitively. In solving problems, individuals with an accommodating learning style rely more heavily on people for information than on their technical analysis (Kolb, 1976; Kolb 1984; Kolb & Kolb 2005).

*Open ended reasoning questions:* Open ended reasoning questions were administered to determine whether preservice teachers implement inductive or deductive reasoning. Each item is based on a limited number of propositional statements. Each multiple choice item is followed by a space for student to complete the reason why the particular option of the multiple choices was selected. To analyze the role of reasoning style in science and mathematic education, we examined three types of reasoning: inductive, deductive and transitional (mixed inductive and deductive characteristics). In this reason one of the questions was selected from mathematics education (Fig.1) and the other one from science education (Fig. 2).

**Even number question:** Which of the following statements is or are correct

- ( ) The sum of two even numbers is always an even number.
- ( ) The sum of two even numbers is always an odd number.
- ( ) It can't be said anything definitive for the sum of two even numbers.

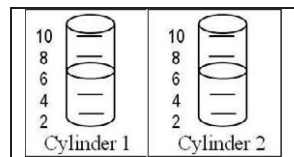
**Explain your response.** (by giving arguments).

Fig. 1. Mathematics question

The mathematical proposition may naturally be justified by induction, but also it may be proved by deduction. In deed, the question of oddness and evenness is a concept which is in the center of the mathematics, but its justification is not treated with the same importance.

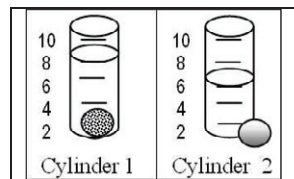
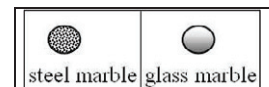
So, it is considered as a justification problem that can be understood and solved by students at different level of mathematical knowledge. For the answer of the multiple choices, the response expected by students was only the correct answer i.e. “The sum of two even numbers is always even”. Nevertheless we have given two other false propositions and the question was prepared in the multiple choice format in order to make mathematics and science questions to have the same structural format.

**Volume Puzzle Question**



Here are drawings of two vertical tubes (cylinders) which are filled to the same mark with water: the cylinders are identical in size and shape.

The steel marble is heavier than the glass one; both marbles will sink if placed in one of the cylinders. We are going to put one marble into each of the cylinders.



After we have put the glass marble into cylinder 1, both cylinders and their contents look like this:

If we put the glass marble into cylinder 2, what will happen to the water level? Please tick your answer:

- ( ) Rises
- ( ) Falls
- ( ) Stays the same

Explain why you predicted the above result:

Fig. 2. Science question

Volume puzzle question from Lawson (1995) was used in order to investigate inductive, deductive, and transitional reasoning as student scientific reasoning styles. This question which involves abstract concept of water displacement was also used by Berger (1976).

*2.3. Data Analysis*

Open ended reasoning questions classified into four categories: inductive, deductive, transitional (mixed inductive and deductive characteristics) and non-classifiable. As explained in the previous paragraph, one of the questions prepared by Lawson (1995) is used for our experiment. Whereas, for the analysis of the students’ answers

to this type of questions concerning the determination of the reasoning style, analyses made by Lawson (1995) appeared to have gaps. Indeed, Lawson (1995) uses an analysis method in which the condition for a response to be classified as hypothetical-deductive is based on the correctness of the chosen item. However, in this study, data analyses are conducted through the assumption that "deduction" refers to the same notion whether it is in the mathematics or in the science. So, the correctness of the multiple choice answer chosen by the student was not taken into consideration for the students' answers' classification in four categories quoted above; but the analyses were based on the organization of students' reasoning in the structure of his written answer.

Thus, both for the science question and for the mathematics question, an answer is classified as deductive if the student tries to support his ideas by a theory, bases himself on mathematical or scientific properties of the theory, and applies the elements of this theory to a particular case which is the case given in the question. An answer is classified as inductive if the student considers at first the case given in the problem, and starting from this given case he tries to find a generalization or a theory. The category transitional concerns the answers which contains both deductive and inductive elements. Although there are many reasoning styles, this research was limited by inductive, deductive, and transitional reasoning.

### 3. Results

For the mathematics question, the expected answer from student was "The sum of two even numbers is always an even number"; and as expected, 98.5 % of the students gave this answer. For the science question, 73.7 % of the students gave the right answer as shown in Table 1.

Table 1: Percentages of answers given to science and mathematics questions

Questions	Right Answers	Wrong Answers
Mathematics question (valid $n = 468$ )	98.5% ( $n = 461$ )	1.5% ( $n = 7$ )
Science question (valid $n = 457$ )	73.7% ( $n = 337$ )	26.3% ( $n = 120$ )

Chi-square test was used to determine whether there is a significant relationship between science and mathematics reasoning. According to the chi-square tests, no relationship was found between science and mathematics reasoning. ( $X^2 = 1.887$ , d.f. = 4,  $p = 0.583$ ). And, Chi-square test shows that there was a significant relationship between science and mathematics reasoning who have Converger and Diverger learning style at mathematics education ( $X^2_{converger} = 9.833$ , d.f. = 4,  $p = 0.043$  and  $X^2_{diverger} = 15.000$ , d.f. = 4,  $p = 0.005$ ).

Science education and primary education department students' responses for the mathematics question and science question were mostly composed by inductive arguments. On the other hand, all department students' responses for the mathematics question were mostly formed by inductive arguments. Result of the scoring can be seen from Figure 3.

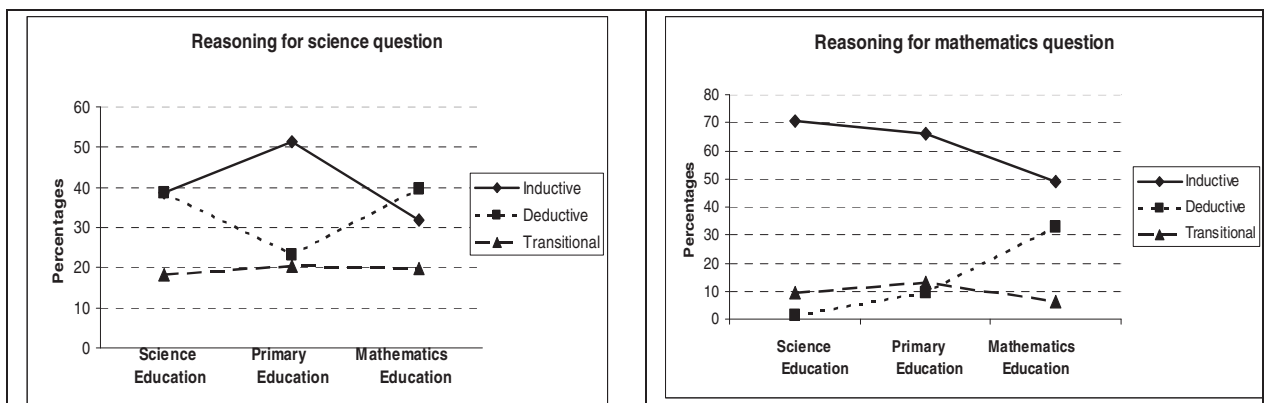


Fig. 3. Comparison of reasoning styles for the science and mathematics questions among students grouped by departments

#### 4. Conclusion

The findings of this study show that there is no relationship between science question's answer and mathematics question's answer. This may arise from question types. The mathematics question's answer was almost evident for the university level but science question was requiring reflection. This may be the reason of the inexistence of any relation between the answers to these two questions found in the data analyses. Berger (1976) had used similar question in his research. According to Berger (1976), while incorrect in a physical sense student teachers' responses indicate a consistency of reasoning.

Although, some researchers (Park&Han, 2002; Yang, 2004), assumed that deductive reasoning widely applied to daily problem solving, this research shows that students in education faculty prefer induction than deduction. One of the reasons of the deductive reasoning's non-use may be caused by the ternary structure of the A.T.S. in deductive demonstrations as to Duval and Egret (1989). In deed, many researches show that one of the difficulties of secondary and high school students in proof activities is based on the non-consideration of this ternary structure and also on the non-comprehension of the statements' different status in this structure (Abrougui-Hattab, 1998; Tapan, 2002). On the other hand, students at mathematics department use deductive argument more than science education and primary education department.

Why induction is widely preferred by education faculty students? May be, because, induction is based on conducting experiments or gathering observations and many inferences in daily life are inductive. In addition, Yang (2004) found that most students were able to formulate and use personal theory in reasoning. Such a finding suggest that high school students do not have proper understanding about the role of theory in scientific investigation and the ways evidence is used to test theories and hypotheses derived form them.

This research shows that there was a significant relationship between science and mathematics reasoning for students who has *Converger* and *Diverger* learning style at mathematics education. As to Kolb's learning style, *Convergers* considered being pragmatic and logical; therefore, they have the ability to solve problems and make decision. In addition *Diverger's* problem solving strengths lie in identifying the multitude of possible problems and opportunities that exist in reality (Kolb, 1984).

The fact that Mathematics Education students' make more reference to the deduction might be interpreted to the familiarity of these students to formal mathematical structures. However, figure 1 show that this multitude of the deduction's use by mathematics education students is also preserved for their answers to the science question. Hence, it can be said that it is not the familiarity of the mathematics education students to the formal mathematical structures that, a fortiori affects the use of deduction; indeed more generally these students developed deductive reasoning that they utilize not only for the mathematics question but also for the science and may be for the other branches.

This study's limitations are also to be mentioned. A particular one was the use of limited number of questions. The other one was limited number of participants from mathematics and science education departments. Nevertheless, our research can be useful to give emphasis for future research on students' reasoning.

In future studies the different dimension of reasoning and their interrelations should be studied in depth.

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