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How Middle School Students' Science Process Skills Affected by Turkey's National Curriculum Change?

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ABSTRACT

Learning the process of scientific knowledge is a crucial skill for students. Some studies focused on this process by defining Science Process Skills (SPS) which help students to construct scientific learning and assist them in becoming active participants to learn research techniques. SPS have an important role in the Turkish Science Curriculum and this study examined the relation between the changes in Turkish national curriculum and the representation of middle school students' scientific abilities. This is the only study reporting a comparison between the last cohort of 8th graders who were taught with the previous curriculum and the first group of students taught with the new curriculum. In addition the role of gender, the correlation between academic success and science process skills are examined.

Key Words: Science Process Skills; Gender; Academic Success; Curriculum Change; Middle School.

INTRODUCTION

The Committee on Science Learning defined science as "a body of knowledge" and also included "the process whereby that body of knowledge has been established." (Duschl et al., 2007 p.26) In the history of science, heredity is an excellent example of how knowledge and process are combined. In 1866, Mendel announced his Laws of Heredity. In the next decade Watson and Crick discovered nucleic acids. Today researchers discovered the human genome.

Science has a process for establishing knowledge and the same can be applied to learning science. In this process middle school students have a basic idea of science; they also want to explore and learn from their experiences outside and inside the classroom. In the process of learning science, students are expected to show some abilities.

These abilities have been referred to as *scientific abilities* by the Physics and Astronomy Education Research (PAER) group. The PAER group identified scientific abilities as; "ability to evaluate theoretical assumptions, ability to represent ideas in multiple ways, ability to make a prediction based on an idea under test, ability to evaluate the effects of assumptions, ability to represent ideas in multiple ways, ability to identify assumptions, ability to distinguish

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between a hypothesis and a prediction, ability to evaluate experimental uncertainty.” (Etkina et al., 2008 p.3) On the other hand, many scholars (Kaptan, 1999; Gömleksiz & Bulut, 2007; Aktamış & Ergin, 2008) named these abilities science process skills and in this study we will also use the term science process skills.

Science process skills help students to become active participants in the learning process and teach students scientific procedures (Çepni et al., 1996). Similarly Kaptan (1999) noted that science process skills help students to construct scientific learning. To illustrate this idea Aktamış and Ergin (2008) noted that training with science process skills increased the academic achievement of 7th grade students. Science process skills are part of Science as a Process Approach. In this approach scientific abilities are defined into two groups, basic (observing, using time/ space relationships, classifying, using numbers, measuring, communicating, predicting and inferring) and integrated (controlling variables, formulating hypothesis, interpreting data, defining operationally and experimenting) abilities. We define these steps briefly as:

- Observing: To collect information by watching, listening.
- Using time/space relationships: To understand the relationship between physical space and time.
- Classifying: To categorize into groups or categories.
- Using numbers: To use Mathematical abilities.
- Measuring: To ascertain by use of a measuring instrument.
- Communicating: To describe an event or object.
- Predicting: To estimate based on evidence. It is a hard process for middle school students. In this step, student hypothesizes.
- Inferring: To draw a conclusion by reasoning. In this step, student tests his/her hypothesis and makes the statement about hypothesis.
- Controlling variables: To identify the dependent and independent variables.
- Formulating Hypothesis: To ask the research question to state the problem.
- Interpreting Data: To convey the information by using tables, graphs.
- Defining operationally: To construct the procedure to solve the problem.
- Experimenting: To find and construct the right investigations to test hypothesis. It is the process to find out whether the hypothesis is right or wrong.

Besides playing a major role in student learning, science process skills are a crucial component of the curriculum. Turkey is one of the countries which adopted these abilities into the science curriculum. Turkey has a national curriculum and this curriculum has changed six years ago. As Demirarslan (2008) noted, the new curriculum is first tested in 120 schools in the 2004-2005 academic year, and then it was implemented countrywide in the 2005-2006 academic year.

The new curriculum is based on constructivism, the theory suggesting that students build their own knowledge by connecting to their prior ideas. The previous curriculum was product-based and students had insufficient opportunities to elicit the critical thinking. For instance, Taşar and colleagues (2002) studied the previous science curriculum in Turkey from 4th grade through 8th grade and found that in the science curriculum measuring, inferring, predicting, interpreting data and hypothesizing are the least represented science process skills. In addition, Dökme (2005) found that classifying, predicting, and formulating hypothesis are represented less than the other science process skills in the 6th grade textbook published by the Turkish Ministry of Education.

In contrast, the new curriculum is designed to create more opportunities for learning in diverse settings (Koç et al., 2007). The new science curriculum focuses on these skills more than the previous one which did not emphasize all science abilities equally. Gömleksiz and

Bulut (2007) worked with teachers from different cities and found that 90% of the teachers participated in that study noted that new science curriculum prompted students to become individual learners who question their own learning process; however teachers' views about the curriculum differ in terms of city variable (Gömleksiz & Bulut, 2007).

In this study we examined how the new national science curriculum changed middle school students' representation of these skills. The 2006-2007 academic year was a milestone for the curriculum change. The 8th grade students participated in this study were taught with the previous curriculum; the 6th and 7th graders in this study were the first group of students learning science via a new curriculum which has a goal to increase scientific understanding.

METHODOLOGY

The purpose of this study is to find representations of science process skills in 6th, 7th and 8th grade by focusing on how curriculum has affected them. To achieve this goal our research questions are:

- How did the curriculum change affect the representation of science process skills of 8th graders and other middle school students (6th and 7th graders)?
- Is there a significant difference in the scores that students received on the Science Process Skills test across grade levels?
- Is there a relationship between academic achievement and the scores that students receive on the Science Process Skills test?
- Does gender affect the scores students receive on the Science Process Skills test?

We collected data from two urban schools in the Buca district of Izmir, Turkey. Izmir is the third largest city of Turkey. However the urban schools participated in this study are located in a low socioeconomic area. One middle school science teacher from each school voluntarily participated in this study. Both teachers participating in this study were teaching two 6th, 7th and 8th grade classes. In total twelve classes participated (four different classrooms from each grade) in the study and the total number of students was 290. The 8th graders were taught with the previous curriculum, the 6th and 7th were graders taught with the new one. This helped us to make a comparison between the new and previous curriculum.

a) Data Collection Tools

The science process skills test used in this study is a new version of the test created by Aydoğdu (2006). Seven questions were selected from Aydogdu's test and two questions were added by the researchers to represent each science process skill (see Table 1). The reliability of this new test is (KR-20) 0.64. In the new test, all questions have four choices. If students selected the right answer, they received one point and if they selected one of the wrong answers, they got zero for that question.

Using time/space relationships, using numbers**,** communicating and measuring were not tested seperately because they are embedded in other process skills. Compared to Aydoğdu (2006) we decided to create a shorter test because both teachers noted that middle school students lose their concentration during long tests. The new test takes around 20-25 minutes.

In addition to the science process skills test, we gathered data about gender and academic achievement. Academic achievement was measured by the grades taken last year. For instance, if a student was in 6th grade, his/her final grade from science class in 5th grade was used as academic achievement.

Table 1. *Representation of science process skills in the test*

QUESTION NUMBER	ABILITIES REPRESENTED
1	Interpreting Data/Inferring
2	Predicting
3	Formulating Hypothesis
4	Interpreting Data/Inferring
5	Observing
6	Classifying
7	Experimenting/ Controlling variables
8	Classifying
9	Defining operationally

b) Data Analysis

The data collected during this study was analyzed by using SPSS 11.0 data analysis program. Arithmetic mean and standard deviation were computed from data and for the variables t-test and ANOVA are used for the analysis.

FINDINGS

a- How did students perform in science process skills test?

The maximum score was nine points. Students participating in this study scored just a little above the average (average of the test is 4.50).

Table 2. *The results of science process skills test*

Number of Students	Number of Questions	Minimum Point	Maximum Point	$\overline{X}$	SS
290	9	0	9.00	4.617	1.63

b- How did gender affect science process skills?

No significant difference found between male and female students in relation to science process skills test results. The average score of male students' ($\overline{x}$ = 4.64) was higher than the female students' average score ($\overline{x}$ =4.60).

Table 3. *Science process skills test points and gender*

Gender	N	$\overline{X}$	SS	t	p
Female	139	4.60	1.62	-0.196	0.845
Male	148	4.64	1.61		

c- How did grade level affect science process skills?

Grade level also affected the representation of science process skills. 7th graders scored better than 6th and 8th graders. Table 4 presents the differences across grade levels.

Table 4: *Comparison of science process skills test points by grade levels*

Grade Level	N	$\overline{X}$	SS
Six	90	4.18	1.52
Seven	109	5.03	1.65
Eight	91	4.53	1.62

d- Is there a significant difference between grade levels in science process skills test scores?

The ANOVA test is used to examine the difference between the grade level and science process skills test scores. In addition, the Scheffe test showed a difference between groups.

The results of the analysis show a significant difference between the 6th and 7th degrees ($F_{(2–287)}$ =7.047, p<0.05).

Table 5: *ANOVA results of Science process skills test points by grade levels*

Source of Variance	Sum of Squares	Sd	Average of Squares	F	p	Significant Difference
Between Groups	36.25	2	18.12	7.047	0.001	Six-Seven
Internal Groups	738.25	287	2.57			
Total	774.51	289				

e- How did students represent science process skills across grade levels?

In this step, we calculated the percentages of right answers among grade levels. After calculating the average scores for science process skills test, we excluded the students who declined to write their names for further analysis, which caused a loss in the student population. Our population decreased to seventy-eight for 6th graders, sixty-one for 7th graders and forty-two for 8th graders.

Table 6: *Representation of science process skills at grade levels*

Science Process Skills	6th grade	7th grade	8th grade
Interpreting Data/Inferring	24%	33%	17%
Predicting	55%	59%	64%
Formulating Hypothesis	46%	41%	26%
Interpreting Data/Inferring	38%	36%	55%
Observing	29%	26%	31%
Classifying	37%	36%	50%
Experimenting	15%	33%	36%
Classifying	41%	41%	45%
Defining operationally	31%	18%	21%

Forty percent of the 6th graders showed the following abilities; formulating hypothesis, predicting, inferring and classifying. Experimenting was the least represented skills among 6th graders. For 7th graders predicting, formulating hypothesis, classifying were the highest represented skills; defining operationally and surprisingly observing were the lowest represented skills among 7th graders. For 8th graders predicting and classifying were the highest represented skills; defining operationally and formulating hypothesis are the lowest represented skills.

Although we asked a question for each scientific ability, we changed this for interpreting data and inferring. 6th and 7th grade students showed relatively similar percentages between two different interpreting data/inferring questions. However 8th graders showed this ability 17% in the first question and 55% in the second question.

f- Is there a correlation between science process skills and academic success?

Pearson correlation technique is used for the analysis. There is a significant and positive link between the academic success and science process skills (r=0.23, p<0.01). The R-square is 0.05 for academic success. This shows that 5% of the variation in science process skills test score is accounted by academic success.

DISCUSSION

In this study we have tested 290 middle school students from Izmir, Turkey. 199 of them (6th and 7th graders) were taught with the new science curriculum and 91 of them (8th graders) were taught with the previous science curriculum. Students participating in this study scored an average of 4.617 of a possible 9 points in science process skills test. Students participating in this study represented around 50% of science process skills. This finding is also consistent with previous studies. Aydoğdu, Yıldız, Akpınar and Ergin (2006) found that students scored below average in science process skills test in elementary education. These results can explain Turkey's place in science education in The Trends in International Mathematics and Science Study (TIMMS). Turkish students scored below average in TIMMS 1999 (Kılıç, 2003).

If we look at the differences between grade levels, there is a significant difference between 6th and 7th graders (see Table 5). On the other hand there is a decrease between 7th and 8th graders (see Table 4). As noted by Gömleksiz and Bulut (2007) the new science curriculum emphasizes on students' knowledge construction. It also offers more opportunities for student learning (Koç et al., 2007). We believe the new curriculum had a positive impact on the difference between the 7th and 8th graders. Although we have excluded some of the students for the second analysis on representation of each science process skills in different grade levels (the total number of the participants decreased to 181), other findings of this study support this claim. Comparing to other grades, 8th graders represent formulating hypothesis less than 6th and 7th graders. To elaborate this idea, Taşar and colleagues (2002) found that hypothesizing is one of the least represented skills through 4th grade to 8th grade in the previous curriculum.

Despite a weak ability to formulate hypothesis, 8th graders scored best in observing and classifying. Taşar and colleagues (2002) found that observing and classifying are the two well represented skills through 4th grade to 8th grade in the previous curriculum. Thus, we believe curriculum has an impact on the representation of science process skills and the curriculum change affected the representation of science process skills.

When we look at the differences in gender, we see that boys (4.64) scored higher than girls (4.60). However, this difference is not significant between males and females. Similarly, Aydoğdu (2006) also could not find a significant difference in science process skills between boys and girls, but he noted that science process skill test scores of boys are higher than girls. To explain this difference we can look at gender roles in science classes. The first author of this study made observations in the schools participating in this study. The laboratory observations proved that boys were the active members in the groups to make the experiments, while girls were recording the data and writing the final report.

Finally, we found a positive relationship between academic success from the previous year and science process skills. Five percent of the variation in science process skills test score can be accounted by academic success in science classes in the last year. Similarly, Aktamış and Ergin (2008) noted an academic achievement increase for 7th grade students who are trained with science process skills. To elaborate this idea, Aydoğdu, Yıldız, Akpınar and Ergin (2006) noted a positive relationship between science process skills test and academic achievement in elementary education.

LIMITATIONS

We had a small sample size in this study. More research and data collection with bigger student populations needed to demonstrate the efficacy of the new curriculum in improving science process skills. In future research, the effect of new curriculum on representing scientific abilities needs to be studied with larger student populations and with more questions. While preparing the test, the teachers noted that students lose their concentration in longer tests, and this led to the creation of a test with nine questions. We tried to ask one question for each skill. But the difference between two interpreting data/ inferring questions among 8th graders (see Table 6) underlines that it would be better to test all abilities with multiple questions.

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