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The effect of gender and socio-economic status of students on their physics conceptual knowledge, scientific reasoning, and nature of science understanding

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**Abstract**

We examined the effect of gender and socio-economic status of Turkish 8th graders on their conceptual knowledge, scientific reasoning, and nature of science (NOS) understanding. Results showed females performed better than males on physics conceptual knowledge test. However no difference between males and females was found for scientific reasoning and NOS understanding. Besides high SES students performed better than low SES students on scientific reasoning and NOS test. No physics conceptual knowledge difference was found between low and high SES students. Implications for science education were discussed according to these findings.

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**Keywords**: Gender, socio-economic status, conceptual knowledge, scientific reasoning, nature of science

1. **Introduction**

Factors affecting students’ science achievement have been a concern in science education. Self efficacy (Lawson et al., 2007), prior knowledge (Acar, 2014a; Coletta & Phillips, 2005; O’Reilly & McNamara, 2007; Yenilmez, Sungur, & Tekkaya, 2006), and scientific reasoning (Johnson & Lawson, 1998) have been found to affect science achievement. Besides these factors, students’ SES explained more of the science achievement variance in an international assessment (The Organisation for Economic Co-operation and Development, 2013). In addition it was found that females perform better than males on topics related to biology (Alparslan, Tekkaya, & Geban, 2003; Yenilmez et al., 2006) however this case turns to reverse on topics related to physics (Cavallo, Potter, & Rozman, 2004).

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In Turkey, females perform better than males in science (Bursal, 2013; Milli Eğitim Bakanlığı, 2013). Moreover high SES students perform better than low SES students (Milli Eğitim Bakanlığı, 2013). Although gender and different SES groups’ science achievement differences have been studied in Turkey, paucity of study exists in the literature which examined the effect of these factors on student nature of science understanding and scientific reasoning. Furthermore although gender conceptual knowledge differences were examined in biology related topics (Alparslan et al., 2003; Yenilmez et al., 2006), few study exists which examined this issue in physics related topics. To close these gaps in the literature, this study examined the effect of student gender and SES on their physics conceptual knowledge, nature of science, and scientific reasoning. Following research questions were sought for this aim:

R.Q.1. Are there any gender differences in physics conceptual knowledge, nature of science, and scientific reasoning?

R.Q.2. Does student SES has an effect on their physics conceptual knowledge, nature of science, and scientific reasoning?

2. Method

2.1. Research Context and Participants

This study was conducted in an industrial city in Turkey. Two school regions were selected for the aim to categorize students under different SES groups. One of these regions was in a suburban area. Families residing in this region were mostly emigrants from other cities and had low SES. The other region was in an urban area. Families in this region, on the other hand, mostly had high SES. Two 8th grade classes from each region were selected. Although 96 students participated in this study, only students who completed all the instruments used in this study remained in the final sample. As a consequence a total 26 8th grade students in low SES region and 20 students in high SES region constituted the final sample. 20 students were female and 26 students were male.

2.2. Instruments

2.2.1. Conceptual knowledge test

This test was used to assess 8th graders conceptual knowledge about sound, heat and temperature, matter states and heat, electricity in our life, and natural processes. Since this test was administered before students were instructed about these concepts, it assessed students’ prior knowledge about these concepts. There were 17 multiple choice items in the test. Several items were selected from different student study books. Other items were constructed by the researchers. Science teachers participated in this study examined the test for content validity before the study took place. Student responses were coded as 1 if they answered an item correct otherwise they were coded as 0.

2.2.2. Scientific reasoning test

This test was originally developed by Lawson (1978). In its original form, there were questions about conservation of mass, control of variables, proportional reasoning, correlational reasoning, and probabilistic reasoning. Questions related to hypothetical reasoning were included in a modified version (Lawson, 2000). There were 24 items in the test. This version of the test was translated to Turkish by the first author and an expert from Teaching English as a Second Language department edited any vague statement in this translation. Students’ responses were coded as 1 if they answered a question correct otherwise they were coded as 0.
2.2.3. Nature of science test

Bora (2005) used selected items from nature of science (NOS) test developed by Aikenhead and Ryan (1992) to examine NOS understandings of high school teachers and students. This modified version was used in this study to assess 8th graders’ NOS understanding. There were 25 multiple choice items in the modified version. Each item’s multiple choices were rated by scientists for their relation to contemporary understanding of NOS as realistic, acceptable, and insufficient in Bora’s (2005) study. We adopted this coding in the present study. Accordingly, multiple choices that were defined as realistic were coded as 3, acceptable were coded as 2, and insufficient were coded as 1.

3. Results

3.1. R.Q. 1. Is there any gender differences in conceptual knowledge, nature of science, and scientific reasoning?

To test the first research question, analyses of variances (ANOVA) was performed for physics conceptual knowledge, scientific reasoning, and nature of science understanding separately. In these analyses, gender was the independent variable. According to the result of the first ANOVA, conceptual knowledge scores between females and males differed significantly ($F (1, 44) = 12.65, p = .00$). This result means that females performed better than males on physics conceptual knowledge according to the mean scores seen in Table 1. According to the result of the second ANOVA, scientific reasoning performances of females and males were similar ($F (1, 44) = 1.69, p = .20$). Finally, the result of the last ANOVA showed that females and males did not differ significantly on NOS scores but the difference got closer to .05 significance level ($F (1, 44) = 3.15, p = .08$).

Table 1. Descriptive statistics of female and male students on study measures

<table>
<thead>
<tr>
<th></th>
<th>Conceptual Knowledge</th>
<th>Scientific Reasoning</th>
<th>Nature of Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Females*</td>
<td>M = 8.20, SD = 2.04</td>
<td>M = 8.95, SD = 3.09</td>
<td>M = 50.30, SD = 3.34</td>
</tr>
<tr>
<td>Males**</td>
<td>M = 6.35, SD = 1.50</td>
<td>M = 7.73, SD = 3.21</td>
<td>M = 48.42, SD = 3.71</td>
</tr>
</tbody>
</table>

*$n=20$, **$n=26$

3.2. R.Q.2. Does student SES has an effect on their conceptual knowledge, nature of science, and scientific reasoning?

An ANOVA was performed separately for each study measure to examine the second research question. In these analyses, SES type was the independent variable. Result of the first ANOVA showed that low and high SES students did not differ on conceptual knowledge scores ($F (1, 44) = 1.46, p = .23$). On the other hand, second ANOVA’s result showed there was a statistical difference between these groups on scientific reasoning scores ($F (1, 44) = 7.13, p = .01$). If we examine the mean scores in Table 2, this result means that high SES group students scored higher than low SES group students. A final ANOVA was performed on NOS scores. The result showed low and high SES group students’ NOS scores were different from each other ($F (1, 44) = 5.89, p = .02$). This result suggests that high SES group students scored higher than low SES students on NOS test according to the mean scores at Table 2.

Table 2. Descriptive statistics of low and high SES students on study measures

<table>
<thead>
<tr>
<th></th>
<th>Conceptual Knowledge</th>
<th>Scientific Reasoning</th>
<th>Nature of Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low SES*</td>
<td>M = 6.85, SD = 1.95</td>
<td>M = 7.23, SD = 2.70</td>
<td>M = 48.15, SD = 3.44</td>
</tr>
<tr>
<td>High SES**</td>
<td>M = 7.55, SD = 1.96</td>
<td>M = 9.6, SD = 3.32</td>
<td>M = 50.65, SD = 3.48</td>
</tr>
</tbody>
</table>

*$n=26$, **$n=20$
4. Discussion

According to the results females performed better than males on physics conceptual knowledge test but both genders scientific reasoning and NOS scores did not differ. In addition, high SES students outperformed low SES students on scientific reasoning and NOS tests but not on physics conceptual knowledge test. Result regarding females’ conceptual knowledge advantage over males is consistent with the results of previous research conducted in Turkey (Alparslan et al., 2003; Yenilmez et al., 2006). Since scientific reasoning is a good predictor of science achievement (Johnson & Lawson, 1998) and no gender difference was found on this measure, we can be hopeful to expect similar science achievement between males and females in the future. In fact, fostering argumentation in science classrooms can reduce the conceptual knowledge gap between males and females (Acar, 2014b). Our result regarding NOS understanding relation to students’ SES is alignment with the finding of Bora (2005). We recommend including more instructional activities regarding scientific reasoning and NOS understanding in science classrooms for low SES students to enhance their science achievement. On the other hand, low and high SES students’ physics prior conceptual knowledge seems to be similar because they may be exposed to similar information about these concepts before the formal science instruction.

References


