Study of the Relationship between Test Anxiety and the Epistemological and Problem-Solving Beliefs of Students on a General Chemistry Course

Emine Erdem

Faculty of Education, Hacettepe University, Turkey

Abstract: This study examines the relationship between test anxieties and the epistemological and problem-solving beliefs of students on general chemistry course. In the scope of this study in a scanning method was applied, data about the epistemological and problem-solving beliefs of university students on the general chemistry course and their test anxiety was collected through questionnaires. An arithmetic mean was used in the analysis of quantitative data and T-tests, ANOVA and Scheffe tests were applied to independent groups. The relationship between test anxiety and, epistemological and problem-solving beliefs of students was examined via the Pearson correlation coefficient. The study conducted has revealed that there are meaningful differences between the test anxiety and, epistemological and problem-solving beliefs of the groups. While a meaningful difference was found between test anxiety and problem-solving beliefs on a gender-based comparison, no meaningful difference was detected in terms of epistemological beliefs in the same comparison. When test anxiety scores are controlled a low-level negative and meaningful relationship was found between the epistemological beliefs and problem-solving beliefs of students (r = -0.187, p<0.05).

Key words: Epistemological belief · problem-solving belief · test anxiety

INTRODUCTION

The discipline, which analyzes the grounds for knowledge and the methods applied in disciplines in terms of limits and reliability, is called “theory of science” or “epistemology”. The question of “What is knowledge?” attracted attention of many philosophers for long periods and finally, these efforts gave birth to epistemology (the theory of knowledge). Epistemology defines knowledge encountered in any society as “data” and examines the place, role and efficiency of this knowledge in social change. In this sense, in today’s world that is called the “era of knowledge” and educated people and an educated workforce are important factors in the improvement and development of societies. Knowledge can only be generated by qualified and educated individuals [1]. Raising the individuals, needed to create information societies and to closely monitor the developments, has revealed the importance of education.

The reasons, behind the all decisions taken and all behaviors exhibited by individuals throughout their lives is the beliefs they adopt. Knowledge and learning-related epistemological beliefs of particularly university and high school students are related to their academic learning [2-4]. It was discovered that the more high school students believe that they have an innate learning ability the less importance they attach to education [5] and that the more the students believe in fast learning the more likely it is for them to get a lower grade-point averages [6]. The more the university students believe that knowledge is simple, the less possible it is for them to understand a test and to adopt the study strategies necessary for the comprehension of the text in the test [2].

How the knowledge is obtained and what kind of knowledge exists? can be questioned by different disciplines. Therefore, epistemology related studies have been widespread in the field of mathematics in recent years [1]. In the study he conducted on epistemological beliefs, Schoenfeld emphasizes that the problem-solving process is partially affected by the beliefs of students about mathematical knowledge and the nature of learning [7].

Studies on epistemological beliefs are based on the logic that these beliefs affect the emotions reflected in observable behaviors and on the academic performance. It has been revealed that epistemological beliefs affect academic success directly and the learning attitude of the student indirectly [8]. It was observed that the
epistemological beliefs of the students affect the
gender and school orientation [9, 41], that learning
settings affect the epistemological beliefs of the
students and that their epistemological beliefs can
change in computer-supported active learning settings
[10, 11]. Epistemic games have been developed for
students to be played in computer-game settings and
other interactive learning settings that are more active
than learning settings [12-14].

Studies on the training of teachers have pointed out
that there is a trend towards the examination of the
epistemological beliefs of prospective teachers and these
beliefs of teachers affect their activities in the classroom
and thus, the students' education [15-17].

Social structures and other developments bring
problems which an individual will either live with or try
to solve. A problem solving is process whereby, the
individual must exert effort to overcome difficulties
(the problem) in order to achieve their specific desired
objectives. There is one target for each problem. Raising
individuals who can overcome the difficulties that they
will encounter in the future is one of the primary
objectives of education. Detecting the level of problem-
solving abilities of students is as important as
developing such abilities in students. Problem-solving
abilities and (i) the ability of the students to “use
mathematics in problem-solving” can be evaluated in
terms of (ii) turning the problem into a mathematical
equation, the adoption of different methods in problem-
solving, the solving of problems and verification,
explanation and generalization of the results by the
students [18].

Studies conducted on cognitive issues show that
students actively participating in the learning process
learn in a better way [19]. Therefore, students should be
taught about the source of information, how to obtain,
evaluate and use this information in problem solving.

Problem-based learning, which enables students to
use the information they obtain and the abilities skills?
they gain from different sources and improves their
problem-solving abilities, is a student-centered approach.
At the end of the problem-based learning process,
students can develop problem solving, critical? thinking
and other similar abilities.

The relationship between help-seeking behaviors in
problem solving and problem-solving abilities was
examined in various studies [20]. It was found that the
attitudes of students towards natural sciences are
related to problem-solving abilities and that there is a
positive relationship between attitudes and success [21].
Studies conducted show that a curriculum ensuring the
development of teaching applications and the conceptual
understanding of students [22], together with creative
drama [23] will increase the success of students in
problem solving. In addition, the effects of the “semi-
structured interview” problem-solving process [24] and
“structured” problem-solving strategies [25] on problem-
solving abilities and conceptual understanding have
also been studied. Students’ problem-solving abilities
were evaluated using thinking strategies in a chemistry
course and [26, 27] problem-solving methodology in a
 genetics course [28]. In order to solve a mathematic
problem, a student should be willing to solve the problem
and select an appropriate strategy to be used in the
problem-solving process.

General epistemological beliefs and mathematical
problem-solving beliefs have an important role in the
problem-solving performances of students. When the
direct effects of both belief systems are analyzed, it is
seen that the less the students believe in that mathematics
is beneficial the less it is possible for them to solve
problems successfully. Both epistemological and
mathematical beliefs affect mathematics performance
and general academic performance.

In general terms, studies were conducted on test
anxiety where is information on anxiety. Test anxiety is the
hyper-arousal condition that results in physiological,
emotional and intellectual changes that prevent the
effective use of the previously learned information, while
taking the examination. Test anxiety is composed of two
components; namely, “worry” which is a cognitive
anxiety related with performance and “emotionality”,
the arousal of autonomic nervous system in evaluative
 situations. Test anxiety is an emotion negatively affecting
student success and student attitudes towards courses.
Studies conducted show that there is no relationship
between the emotionality component and performance
while there is a negative relationship between worry and
test performance [29].

The cognitive aspect of test anxiety is a serious
barrier that negatively affects student performance. Basic
thoughts which result in test anxiety in students are as
follows: failing the course, getting a lower grade, thinking
that other students achieve better grades, blaming
themselves for not studying at a sufficient level, thinking
that they have forgotten everything and know nothing,
thinking that they will disappoint their family and that
they will not be able to improve their grades in case when
they get a poor grade [30].

Studies on test anxiety can be classified into three
groups. The first group is conducted to understand the
nature of test anxiety, the second group focusing on
detecting the effects of test anxiety on academic success and the third group is carried out to find ways of reducing test anxiety” [31-33]. Test anxiety is an important problem for many students throughout their academic life. Studies conducted have revealed a negative and meaningful correlation between test anxiety and personal adjustment values [34,35]. As the student’s personal adjustment level increases, the test anxiety level lowers. Academic success and test anxiety are found to have a negative relationship [36, 37]. Studies have shown that failure can be correlated on high test anxiety levels [38]. It was detected that test anxiety levels of successful students are quite low compared with those of unsuccessful students. Students with high test anxiety levels have difficulty in reading and correctly answering the test questions, organizing their thoughts and expressing these thoughts using appropriate words. The student has to get rid of this thinking style to overcome test anxiety. In addition, time should be organized in a good manner as test anxiety results in disorganization in terms of time. Regular diet, breathing exercises and sleep all reduce test anxiety.

This study tested the hypothesis suggesting that test anxiety is related to epistemological beliefs and problem-solving beliefs. In order to examine the relationships and differences between these variables correlation, t-test and ANOVA statistical analysis methods were used.

The Aim of the Study: The study aimed to examine the relationship between test anxieties and epistemological and problem-solving beliefs of students in general chemistry course. Gender was included in the study as a variable in terms of beliefs and anxiety. Knowing which students have high anxiety levels in terms of epistemological and problem-solving beliefs will contribute into organization of learning settings for the chemistry course and in adopting appropriate attitudes towards the students with high anxiety levels.

The following questions were asked to achieve the study aim:

- Is there any meaningful relationship between test anxieties and the epistemological beliefs of students?
- Is there any meaningful relationship between epistemological beliefs and the problem-solving beliefs of students?
- Is there any meaningful relationship between test anxiety and the problem-solving beliefs of students?

METHODS

Study Pattern: The study, in which scanning method was applied, tried to detect the effects of epistemological beliefs and problem-solving beliefs of students on their test anxiety. To this end, data about the epistemological beliefs, problem-solving beliefs and test anxiety of students on a general chemistry course was collected through questionnaires. The reason behind the selection of general chemistry students for the study is that these students have difficulty in comprehending, understanding and succeeding in natural science courses and that they are particularly nervous in examinations, thus, these students have high anxiety levels.

Sample: The study sampling universe is composed of students in the Chemistry Education Department and Computer Education and Instructional Technologies Department (1st and 2nd Group) of Hacettepe University (H.U.) and the Chemistry Education Department of the Faculty of Science of METU (4th Group). During sampling, special importance was given to include students taking a general chemistry course. While a number of these students were those taking a general chemistry course as part of their professional training to become chemistry teachers (3rd and 4th Group), the other students were taking this course since it is included in their curriculum (1st and 2nd Group).

142 students from Education Faculty of H.U. and 31 students from the Faculty of Science of METU were included in the sampling universe, giving a total of 173. Study data was collected through the questionnaires for epistemological beliefs, problem-solving beliefs and test anxiety.

Data Collection Tool

Epistemological Questionnaire: The 22 item epistemological questionnaire was developed by a group of higher education researchers [39-41]. The questionnaire is consists of four sub-dimensions, which are quick/fixed learning, study aimlessly, omniscient authority, certain knowledge, The highest possible score
from the questionnaire is 69 while the highest negative score to be taken from the questionnaire is 57. The highest possible score to be obtained by marking "no idea" is 63. This option is the indicator of neutral situations. In other words, scores below 63 indicate negative beliefs and above 63 show positive beliefs. The scope validity of the questionnaire was tested by the questionnaire developers. Factor analyses were carried out on structural validity. Cronbach alpha values for these sub-dimensions are 0.77 for quick learning, 0.36 for certain knowledge, 0.55 for simple knowledge and 0.55 for fixed ability [41]. Students have expressed their thoughts on each statement by marking one of the following categories; "completely agree", "agree", "no idea", "disagree" and "completely disagree".

**Problem-solving Questionnaire:** The problem-solving questionnaire used in the study was developed from the Mathematical Problem-Solving Beliefs Questionnaire prepared by Kloosterman and Stage [42]. For the group of students being investigated the mathematical problems statement was replaced with those about chemistry. The questionnaire consists of 25 items and has the following seven sub-dimensions. These are effortful math, useful math, math persistence, math confidence, understanding math concepts, word problems and nonprescription math”.

In this Likert-type scale, students express their thoughts about each item by marking one of the categories from "completely agree" to "completely disagree". The Cronbach alpha values of this scale are in 0.54-0.84 range [41].

The questionnaire measures five beliefs, which are:

- I can solve the problems on time.
- There are verbal problems that cannot be solved in a step-by-step manner.
- It is important to comprehend the concepts.
- Verbal problems are important.
- Effort can improve mathematics ability.

**Test Anxiety Inventory:** The 20 item Test Anxiety Inventory used in the study was developed by Spielberg and his team [43]. This Likert-type inventory contains "worry" and "affective" sub-tests. The highest possible score on the inventory is 80 and the lowest is 20. The KR-20 alpha value of the inventory was found to be 0.87. It is emphasized that pre-post test reliability coefficients of the inventory is in 0.90-0.70 range for the whole inventory [43].

**Data Analysis:** Epistemological belief scores and the mathematical problem-solving belief scores of the students were studied to explain the test anxiety scores of the 180 students included in the sampling. An Independent T-test was applied while examining the effects of epistemological beliefs and problem-solving beliefs on the test anxiety of students in terms of gender. Paired-T test analyses were carried out while examining the effects of epistemological beliefs and problem-solving beliefs on the test anxiety in the group. One-way variance analysis was used to detect if there are any differences between the groups. The Scheffe Test was conducted to determine the differences between the groups. The correlation method was applied to detect the relationship between test anxieties, epistemological beliefs and the problem-solving beliefs of students.

**RESULTS**

The study examined the relationship between test anxieties, problem-solving beliefs and the epistemological beliefs of students taking a general chemistry course. The findings and comments of the study are given below on the basis of sub-problems.

Whether there are differences between the groups in terms of test anxiety, problem-solving beliefs and epistemological beliefs of students was examined. Descriptive statistics related to the student scores of test anxiety, problem-solving beliefs and epistemological beliefs are given in Table 1 and one-way variance analysis results are given in Tables 2-4.

Analysis of the results shows that there is a meaningful difference between the groups in terms of the test anxiety levels of students (F=2.920, p<0.05). According to Tukey test, there is a meaningful difference between 2nd and 4th groups (Table 2). Furthermore, the difference between the groups in terms of epistemological beliefs and problem-solving beliefs was found to be meaningful (Tables 3 & 4). In other words, epistemological beliefs and problem-solving beliefs of students change at a meaningful level on the basis of the departments they attend. The Scheffe test was conducted to determine which groups differ in terms of epistemological beliefs and problem-solving beliefs. According to the results of the Scheffe test, the epistemological beliefs of the students in the second (σ=59.31), third (σ=56.82) and fourth groups are more positive than those of the students in the first group (σ=51.0667). According to the results obtained from the Scheffe test, problem-solving beliefs of students in the
third ($\bar{x} = 95.82$) and fourth ($\bar{x} = 94.16$) groups are more positive than those of the students in the first ($\bar{x} = 87.57$) and second ($\bar{x} = 83.22$) groups.

Analysis was carried to determine whether the test anxiety, epistemological beliefs and problem-solving beliefs of the students differed according to gender. Similarly, the results were analysed to ascertain whether meaningful differences existed between females and males in terms of (i) test anxiety and problem-solving beliefs and (ii) test anxiety and epistemological beliefs. Student scores of test anxiety and problem-solving beliefs were used separately to conduct an “independent groups t-test” and the results are given in Table 5. The results obtained from the “independent groups t-tests” which separated the student scores of test anxiety and problem-solving beliefs are given in Table 6.

The Test anxiety of female students ($\bar{x} = 45.05$) is higher than the test anxiety of male students ($\bar{x} = 40.80$) (Table 5). According to the test results, there is a meaningful difference between the test anxiety of students on the basis of gender ($t = 2.632 p < 0.05$). Problem-solving beliefs of female students ($\bar{x} = 91.39$) are higher than the problem-solving beliefs of male students ($\bar{x} = 86.54$). There is a meaningful difference between problem-solving beliefs of students in terms of gender ($t = 2.972 p < 0.05$).

Table 6 shows that the mean epistemological believe scores of female students are higher than those of male students. However, according to the t-test results, there is no meaningful difference between the epistemological beliefs of students in terms of gender ($t = 0.665 p > 0.05$). According to the results in Tables 5 and 6, there is a meaningful difference between “the test anxiety scores and problem-solving belief scores of students” and “the gender”. On the other hand, it can be concluded that there is no meaningful difference between “test anxiety scores and epistemological belief scores of the students” and “gender”.

The relationship between (i) epistemological beliefs and problem-solving beliefs, (ii) between test anxiety and epistemological beliefs and (iii) between test anxiety and problem-solving beliefs was analyzed. To this end, relations between mean scores were analyzed by the Pearson Correlation analysis. Correlation results are given in Tables 7-9.

Table 7 represents the results pertaining to the relationship between epistemological belief scores and problem-solving belief scores of the students. According to the results of the Pearson correlation analysis, there is
Discussion and Suggestions: This study aimed to examine the relationship between test anxieties and epistemological beliefs and problem-solving beliefs of students on general chemistry course. Test anxiety, epistemological beliefs and problem-solving beliefs of students attending at different departments were taken into consideration.

The results show that there is a meaningful difference between the test anxiety levels, epistemological beliefs and problem-solving beliefs of students in terms of the groups. When the students’ mean test anxiety scores are examined on the basis of the groups, the lowest anxiety is observed in 2nd group and the highest anxiety in the 4th group. The reason for this situation can be the qualification of the education given to 4th group or their finding the education process quite difficult. When students’ problem-solving beliefs are analyzed, the scores of the students in the third and fourth group are found to be higher than the scores of the students in the first and second groups. The epistemological beliefs of the students in the second (X=59.31), third (X=56.82) and fourth groups are found to be more positive than the beliefs of the students in the first group (X=51.07). The epistemological belief scores of the students in the second group are higher than the scores of other groups and their problem-solving belief scores are lower than the scores of other groups.

When the epistemological belief scores of the students are examined on the basis of gender, no meaningful difference was detected. However, the test anxiety and problem-solving scores of female students are higher than the scores of the male students. Both problem-solving scores and test anxiety scores of the female students are higher than the scores of the male students. This is thought to result from the female students having a fear of being unsuccessful in a group.

In this study, no meaningful relationship was found between i) test anxieties and epistemological beliefs and ii) test anxieties and problem-solving beliefs of the students. However, when the test anxiety is controlled, a negative and meaningful relationship was revealed between epistemological beliefs and problem-solving beliefs. The idea of the students about “learning a subject in a fast way” is effective on their effort used to solve a problem in the general chemistry course. According to Schommer Akins (one authors or two? [41]), epistemological ‘belief is effective in problem solving. The belief in “fast learning” is effective on the ways of thinking of high school and university students. The more the student believes in fast learning, the less successful

### Table 8: Descriptive Statistics and Pearson Correlations related to test anxiety scores and epistemological belief scores of students

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>ρ</th>
<th>r</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Anxiety</td>
<td>173</td>
<td>45.50</td>
<td>-0.093</td>
<td>0.224</td>
</tr>
<tr>
<td>Epistemological Belief</td>
<td>55.94</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 9: Descriptive Statistics and Pearson Correlations related to test anxiety scores and problem-solving belief scores of students

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>ρ</th>
<th>r</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Anxiety</td>
<td>173</td>
<td>45.50</td>
<td>0.059</td>
<td>0.439</td>
</tr>
<tr>
<td>Problem-Solving Belief</td>
<td>90.19</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 10: Descriptive Statistics and Pearson Correlation results related to epistemological belief scores and problem-solving belief scores of students when the test anxiety scores are controlled

<table>
<thead>
<tr>
<th>Control Variable</th>
<th>df</th>
<th>ρ</th>
<th>r</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Anxiety Epistemological Belief</td>
<td>170</td>
<td>55.94</td>
<td>-0.187</td>
<td>0.014</td>
</tr>
<tr>
<td>Problem-Solving Belief</td>
<td>90.19</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A negative and meaningful relationship between epistemological belief scores and problem-solving belief scores (ρ=-0.192, p<0.05).

In Table 8, we see a negative correlation (which is not statistically meaningful) between mean scores of test anxiety and epistemological beliefs (ρ=-0.093, p>0.05). Table 9 reveals that there is a relationship between the mean scores of test anxiety and problem-solving beliefs, which is not statistically meaningful (ρ=0.059, p>0.05).

In the light of these results given above, it can be concluded that epistemological beliefs of students have negative effects on their problem-solving beliefs. Then, is there a meaningful relationship between the epistemological belief scores and problem-solving belief scores of students when the test anxiety scores are controlled. The results of the Pearson correlation analysis are given in Table 10.

When the test anxiety scores are controlled it was detected that there is a low-level negative and meaningful relationship between the epistemological beliefs and problem-solving beliefs of students (ρ=-0.187, p<0.05). Correlation (ρ=-0.187) between epistemological belief scores and problem-solving belief scores (when the test anxiety is controlled) is close to the correlation (ρ=-0.192) between the same variables when the test anxiety is not controlled (Table 7). The value of the correlation coefficient can be explained with the inverse proportion between “test anxiety” and “epistemological beliefs and problem-solving beliefs.”
s/he will be in understanding a concept, the less it will be possible for them to comprehend complex subjects and the less conceptual processes they will undergo in situations which require discussion. The most important finding of the study is that when the test anxiety of a student is controlled a negative and meaningful relationship is found between the epistemological beliefs and problem-solving beliefs of students.

Students’ anxiety levels are high in the chemistry course, as in other courses related to natural sciences. The reason behind this fact is that they have difficulty in understanding the concepts. The belief in learning fast results in easier learning of numerical problems and difficulties in solving verbal chemistry problems, which require explanation of a relationship. Teaching activities that will turn these beliefs into more positive ones and which will reduce test anxiety should be planned. Specialist assistance such as psychologists should be provided for the students with high anxiety levels.

This study presents the results pertaining to the results of the relationships between test anxieties, epistemological beliefs and problem-solving beliefs of university students. There are studies in the literature, which were conducted on the effects of epistemological beliefs and problem-solving beliefs on student success. However, the effects of test anxiety on this success should also be studied. Test anxiety is an important barrier to student success. Therefore, the effect of test anxiety should also be taken into consideration.

REFERENCES


