THE VIEWS OF UNDERGRADUATE STUDENTS ABOUT THEIR INTRODUCTORY STATISTICS COURSE PROCESS

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This paper aimed to present undergraduate students' views about statistics and its learning. During statistics courses students meet with exhaustive calculations and formulas. We expected them to hold various conceptions, ideas about the topics of statistics and to express their experiences during the course process. In this regard, fifty students studying at different undergraduate programs were interviewed. The interviews included students' definitions of statistics, their expectations about the course, and evaluations of their learning outcomes. Findings revealed that students' definitions of statistics coincide with the related literature. Consistent with expectations, students mentioned positive-negative experiences during the course in the regard to their success and failure. They were also aware of the necessity of referring statistical methods rather than indicating personal thoughts or making simple estimations.

INTRODUCTION

Statistics as an interdisciplinary field is taught in different departments at undergraduate level as a compulsory course. Within these lessons, students learn new concepts while at the same time encountering new formulas and carry out long and exhausting calculations. In many research showed that students thought that statistics was difficult (Batanero, Estrada, Furtuny, & Diaz, 2005; Ben-Zvi & Garfield, 2004; Carmona, Martinez, & Sanchez, 2005; Hannigan, Gill, & Leavy, 2013; Hedges & Harkness, 2017; Zieffler, Garfield, Alt, Dupuis, Holleque, & Chang, 2008). Leavy, Hannigan, and Fitzmaurice (2013) addressed that students' difficulties could arise from the fact that statistics requires language, thinking and reasoning skills in different ways from mathematics. Similarly Hedges and Harkness (2017) remarked the attitude of students toward statistics and their mathematical experience are important predictors of students' achievement and their perception of statistics.

In the related literature, there are various studies trying to picture the perception, experiences, or attitude of students toward statistics (Bond, Perkins, & Ramirez, 2012; Gordon, 2004; Hedges & Harkness, 2017; Reid & Petocz, 2002). Bond et al. (2012) examined and compared the students' perceptions of statistics as analyzing their pre-course and post-course answers. These studies provide important implications for statistical teaching and learning. Also reform movements in statistics education draw attention to some recommendations to make instructions more appropriate such as incorporating more concepts rather than heavy calculations, considering real life situations, developing statistical literacy, thinking and reasoning (Ben-Zvi & Garfield, 2004). It is important that whether statistics instructions meet these requirements. In this regard determining difficulties, learning outcomes, and opinions of students related their instructional process and the usefulness of statistics in their daily and professional lives are important to design and develop the statistics instructions.

THE PROBLEM

Statistics is often seen as difficult to learn due to reasoning, attribution, prediction, heavy calculations, and many concepts and formulas. Because of these views, students generally have negative attitudes towards statistics. The reform efforts in statistical education can be effective in coping with these difficulties. Before attempting to design and develop the course content in parallel with the reform efforts, it is important to determine the students' perceptions of statistics, its learning and teaching. Therefore, this study aimed to examine the views of undergraduate students about the introductory statistics course they have taken. Depending on this purpose, the research question of the study can be identified as follows:

"*How undergraduate students think about their statistics course process?"*

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METHOD

This study focuses on the views of undergraduate students about their statistics course and tries to interpret from different dimensions. In order to achieve this, we adopted a qualitative approach. Data was collected through semi-structured interviews and analyzed qualitatively.

Participants

The participants of the study are fifty undergraduate students taking statistics course at nine different programs in a university in Turkey. It has been taken into account that students should be taking the course and be in nine different programs in order to ensure that they represent the population when selecting the sample. Six students (3 female and 3 male) from labor economics and industrial relations (LEIR), six students (3 female and 3 male) from geological engineering (GE), six students (5 female and 1 male) from elementary mathematics teacher (EMT), six students (4 female and 2 male students) from counseling and psychology (CP), five students (5 female) from mathematics teacher (MT), five students (4 female and 1 male) from biology (BIO), five students (2 female and 3 male) from urban and regional planning (URP), six students (5 female and 1 male) from general medicine (GM), five students (2 female and 3 male) from forest industrial engineering department (FIE) were selected. The students were coded considering their department. For example, GMS1 represents the first student of the general medicine department.

Data Collection Tools

The data of this study was collected through semi-structured interviews with fifty undergraduate students. Interviews were conducted at the end of the course process. Interviews generally took from ten to fifteen minutes. In these semi-structured interviews four main questions were used to start conversations with students and catch their views about statistics and its learning and teaching: *How they define statistics? What about their expectations before attending the course? Could you explain the most difficult, the most necessary, and the easiest concept in course process? What kind of learning outcomes do you think you gained in this statistics course?*

Data Analysis

The data obtained from the interviews were analyzed qualitatively. Students' responses during the interviews were recorded, transcribed and coded. Common codes were determined and these codes were incorporated into main themes. For example, GMS4 defined statistics as below:

> *Statistics is a discipline, helps us for any field of our daily lives. We refer statistics knowledge as well sample events. In medicine field, we use statistics for any tasks. When we watch TV, percentages are used in news. We could meet statistics.*

GMS4 referred the daily life theme. After all the responses were analyzed, common themes were determined and sample answers were presented in findings section. If more than one category is emerged in any answer, these statements were evaluated for each theme separately. Therefore, total frequencies of the answers for any questions could be more than the number of the students. Frequencies and percentages of the themes were determined and presented in findings section.

FINDINGS

In this section, we presented the views of undergraduate students related the introductory course process under four main themes: statistics definition, expectations of students before attending the course, difficult-necessary-easy concepts of statistics, learning outcomes.

Statistics Definitions of Students

Students' responses regarding the definition of statistics were categorized under seven separate themes. These themes are: *inferential statistics (21 students), numerical-calculation based (22 students), research (5 students), daily life (8 students), probability (5 students), terminology (15), collecting-organizing-analyzing data (statistical process-11 students)*. In inferential statistics theme, students generally focused on skills such as deciding, predicting, interpreting, inferring, evaluating and comparing of data. For numerical-calculation based theme, students referred to numerical data, calculations, and mathematical operations ideas. In daily life theme, students focused on the usefulness of the statistics. In research theme, students underlined future research,

and surveys. Some students preferred to link directly probability and statistics in probability theme. Students focusing on collecting-organizing-analyzing data concepts referred a statistical process in their definitions. Also some students underlined specific terminology (arithmetic mean, table-graph, population, sample etc.) in their definitions. For example, BIOS5 defined statistics as below:

> *Statistics is sampling. It is estimation and requires determination. We use it in all cases. For example, a country has many incomes. We estimate the future incomes of the country based on current incomes. And we decide future incomes.*

BIOS5 pointed out the importance of statistics in daily life and she linked statistics with the estimation and decision sub-themes of inferential statistics. On the other hand, URPS3 defined as:

> *Statistics is a discipline based on collecting, analyzing numerical data (quantitative) and inferring results towards policy related social events.*

In her definition, she underlined a statistical process as collecting and analyzing of data and making inference themes. Also she linked to numerical data in her definition. When students' definitions analyzed it was seen that some themes were repeated in a department more than others. For example, LEIR students linked statistics numerical data and operations concepts than others. In addition, CP and GM students drew attention to the research theme in their definitions rather than others. And EMT students generally centered upon inferential statistics in their definitions.

The Expectations of Students before Attending the Course

We asked students to talk about their expectations before attending the introductory statistics course. Students generally mentioned *difficult, calculation based, research, daily and professional life, basic topics, data analysis* themes. Most of students thought that statistics would be difficult, include heavy calculations. Students also underlined that they hoped that statistics would be related their daily and professional life. EMTS3 stated her expectations as below:

> *When I have heard statistics course at first, I hoped that we would make calculations. I imagined numerical data and heavy operations. As a result of surveys, it includes this kind of operations. I thought that it is related surveys.*

She thought that they would deal with numerical data, make operations and work on surveys. Therefore, her expectations are related with the calculation and research themes. Some of the students underlined that they would hope to learn only basic concepts such as arithmetic mean, standard deviation, probability etc. For example, GES6 talked about his expectations as below:

> *I hoped that we would make operations. Such as; calculating the arithmetic mean of a class scores. And calculating standard deviation. Also I think that I would calculate my own grade score.*

He drew attention to learn calculating arithmetic mean, standard deviation and his own grade scores. He underlined basic statistical concepts to learn. Also he drew attention to operations and calculating his grades as a requirement of his daily life.

The Most Difficult, Understandable and Necessary Subjects

We asked students to answer the most difficult, necessary and the easiest subjects in statistics. It was seen that when students determined difficult subjects they evaluated the subjects through operations of requiring (9 students) and the extensive of the formulas of involving (11 students). While 8 students stated that they are uncomfortable at inferential statistics such as correlation, regression analysis or hypothesis testing, two students had difficulties at graphs. Also two students said that they had difficulties at using SPSS (Statistical Package for The Social Sciences) Besides, students associated the most difficult subjects with the difficulties of determining the relevant methods (20 students). For example, GES1,

> *Hypothesis tests are the most difficult one. I had challenges with z and t distributions. Indeed, I could not determine on which I would prefer. Of course, I know the characteristics both of them. I am weak at determining the relevant one. But ANOVA was easier. When we have more than three populations, we refer ANOVA. But operations are difficult in ANOVA.*

He focused on the determining the appropriate method as his challenges. And EMTS5 stated:

> *I think the most difficult was the calculation of correlation coefficient. Because it requires heavy calculations. There are many calculation steps. You must perform*

> *many operations by the help of the calculator. If you have not calculator, it takes a long time to carry out necessary operations.*

He stressed that correlation was the most difficult due to requiring many calculations. Parallel with this idea student decide the easiest subject considering the extensive of the formulas and operations. Students thought that descriptive statistics such as arithmetic mean, standard deviation, table and graphs is the easiest topics in the extent of the statistics course. BIOS3 thought that:

> *Arithmetic mean, mod and median were easy. Making calculations were also easy and took very little time. We could calculate them practically.*

BIOS3 considered the facilities of the operations and descriptive statistics.

When we asked students to determine the necessary topics, they focused on the relation with the daily and professional life. While some students gave importance on descriptive statistics (arithmetic mean, standard deviation) some students drew attention to the inferential statistics (hypothesis testing, normal distribution). Especially GM, URP, CP students underlined the importance of p-value, statistical significance and statistical package program. For example, BIOS5 stressed the necessity of inferential statistics due to transferring in their professional lives as below:

> *Confidence interval, estimation and hypothesis testing. Hypothesis testing is the most important among the statistical subjects. Because we use these concepts in biology. They are useful for biology. We could use in our research.*

It was seen that BIOS5 underlined the necessity of the hypothesis testing as a requirement of her professional life. Besides, EMTS5 explained the importance of descriptive statistics as below:

> *We will be teacher in the future. We will examine of the grades of our students. Are the questions easy or difficult? Could students solve the questions? Could I ask convenient with their level? I give importance on interpreting these results each other. I think confidence interval or hypothesis testing are not necessary in my professional life, unless I study on future research. But there are a lot of teacher assigned nowadays. It is important that teachers could interpret the success level of students considering mode, median and arithmetic mean.*

He gave importance on descriptive statistics due to referring in his professional live.

Learning Outcomes of Undergraduate Students during the Course

We asked undergraduate students to consider their learning outcomes during the course. We wanted them to imagine themselves as comparing before and after taking the introductory statistics course. Students' answers were categorized under seven main themes: *inferential statistics (13 students), mathematical thinking and interpretation skills (17 students), descriptive statistics (8 students), professional and daily life (11 students), terminology (7 students), calculation skills (6 students), and research process (5 students)*. For their learning outcomes, students generally underlined that they learned various statistical methods during the course process. Students stated that they were aware of determining situations, which they encountered, not only personal thoughts, non-basic estimations but also following statistical methods. These students underlined that they have learned statistical methods and also had knowledge of inferential statistics. For example, BIOS5 stated her learning outcomes as following:

> *I think this course is too important. We must do something as a biologist. Our profession is directly related with the measurement. We accept or reject to accept. Hypothesis testing is very important. If I did not take this course, I would not feel as a biologist. For example, there are limits in some cases and there is 3 cm difference. However, it has not known whether this difference is important. I learned to examine whether this difference is important.*

She drew attention to the adopting statistical methods (hypothesis testing) to decide on cases. Meanwhile she underlined to the inferential statistics knowledge as a learning outcome. While 13 students drew attention to the inferential statistics knowledge as an outcome, 8 students underlined descriptive statistics. Besides, 17 students stated that they developed mathematical view of point and interpretation skills as a learning outcome. For example, GMS2 stated that:

> *When I met a statistical data anywhere, I could interpret it. Therefore, I can produce knowledge about illness and their distributions in our medical science. And I also learned the characteristics of the statistical tests.*

She underlined that she developed interpreting skills in her life. Also she realized the importance of statistics in medical science. And she emphasized to be aware of the statistical analysis. Therefore, she referred professional life, interpretation skills, and inferential statistics themes. Also students considered terminology and calculation skills themes as a learning outcome. BIOS3 stated that:

> *I have learned variation and assumption concepts. I did not know these concepts and I have learned them. In fact, this course did not get my attention. But I have adopted new terminology. I think these concepts would be useful in my life later.*

Although she was not eager to learn statistical concepts, she drew attention to be equipped with statistical terminology at the end of the course. Besides, students stated that they developed research skills at the end of the course. As their learning outcomes, they referred to gain and develop research scientist skills. Generally, GM, CP, and URP students drew attention to this learning outcome. Due to their professional lives require statistical research and analysis, they could emphasize this outcome more than others. When students talked about their learning outcome they drew attention to the usefulness of statistics in their daily and professional lives. Therefore, they stated that they learned new statistical concepts, and methods and they feel more comfortable themselves toward the situations encountering their daily and professional lives.

CONCLUSION

In this study findings illustrated that statistics definitions of the students were similar with the studies in the literature. In their studies, Reid and Petocz (2002) addressed six different themes related to statistics definitions. Being numeric, including statistical methods, data analyzing and interpretations of data, understanding daily life, developing personal meanings by statistical tools. Similarly, in this study undergraduate students think that statistics includes numerical steps and related with daily life situations. On the other hand, Gordon (2004) underlined five categories about statistics definitions: no meaning, algorithms, statistical methods, tools related daily life, and critical thinking. Unlike these two studies, in our study students thought that statistics is related research or surveys and they referred terminology and probability concept in their definitions and these themes differed from Reid and Petocz (2002) and Gordon (2004). Bond et al. (2012) investigated statistics definitions of undergraduate students at the beginning and at the end of their course. They found that statistics definitions of students moved from descriptive statistics to inferential statistics, from techniques to the usefulness and meaningfulness of statistics at the end of the course. Bond et al. (2012) also pointed out that students drew attention to descriptive statistics or basic equations at the end of the course. On the other hand, some of our students stated that statistics include numerical data and calculations at the end of the course. This difference could be arisen from the negative attitudes of our students prior to taking the course, as well as the teaching skills and methods of the teacher during the course. Besides, most of the students stressed that they thought statistics course would be difficult as an expectation before taking the course. Their negative attitudes toward statistics course appeared to be effective on these definitions. Furthermore, Zieffler et al. (2008) stated that students came to the statistics courses with different and various expectations and perceptions. At this point, it is important that instructors should design and facilitate their course contents to deal with or meet these expectations and perceptions.

It was seen that when students pointed out difficult and easy topics they evaluated the topics in terms of including reasoning, calculations and the extensive of the formulas. Therefore, students underline that correlation, regression, hypothesis testing as the most difficult topics. It is though that the intensity of the calculation in these topics has an important role on students' decisions to label a topic as difficult or easy. Students also referred descriptive statistics among the easy subjects. Besides, students determine the necessary topics they focused on the relation with the daily and professional life. While some students gave importance on descriptive statistics (arithmetic mean, standard deviation) some students drew attention to the inferential statistics (hypothesis testing, normal distribution). Nevertheless, students appreciate the importance of inferential statistics in their professional life, although they think it is a difficult subject. Statistics course contents should design through conceptual knowledge and applications of the concepts rather than just following procedural steps. Also, GAISE (2016) underlined the emphasis of conceptual and contextual understanding among the recommendations for statistics courses.

Considering learning outcomes, students generally underlined that they learned various statistical methods during the course. Some students stated that they were aware of determining situations, which they encountered, not only personal thoughts, or basic estimations but also following statistical methods. This was a quite promising that students could appreciate the usefulness and meaningfulness of statistics. Similarly, Batanero et al. (2005) suggested that instructors should design course contents to help students valued statistics and improve students' statistical literacy skills. In our study, some students drew attention to gaining research process skills at the end of the course. When taken into consideration the importance of statistics on different research fields, we can say that we would be hopeful about to Rumsey's (2002) second goal refers to raising students as equipped with research scientist skills. As learning outcomes almost 40% of students stated that they developed mathematical thinking and interpretation skills during the course process. This result coincides with the findings of Bond et al. (2012).

In this study, the views of undergraduate students were investigated. Although this study was carried out with students at various departments, it is limited with semi-structured interviews. Besides, the course process was summarized with limited numbers of interview questions. For further research, we aim to seek relations between the attitudes toward statistics and the process of statistics instruction.

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