Methodological and Statistical Errors Found in Science Education Master's Theses

(Fen Bilgisi Eğitimi Alanında Hazırlanan Yüksek Lisans Tezlerindeki Yöntemsel ve İstatistiksel Analiz Hataları)

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Abstract: In the scientific research process, it is very crucial for researchers to determine methodology of study, to choose appropriate statistical analysis and to report results obtained correctly. In our country, one can confront with many methodological and statistical errors in science education studies. To decrease the number of errors, there is a need for studies reporting kinds of errors and giving recommendations to correct them. With this perspective, the aim of this study is to examine Master's theses written in the field of science education in terms of appropriateness of their methodology and statistical analysis used. In the present study, 30 theses that can be accessed from the National Theses Center of Council of Higher Education are examined. In the study, errors frequently confronted in these theses are examplified and some recommendations are given to correct these errors.

Keywords: scientific research, statistical errors, methodological errors, science education

Öz: Bilimsel araştırma sürecinde, araştırmacıların çalışmanın yöntemini ve çalışmaya uygun istatistiksel analizleri doğru bir şekilde belirlemesi ve elde edilen bulguları raporlaştırması son derece önemlidir. Ülkemizde fen eğitiminde yapılan çalışmalarda yöntem ve istatistiksel analiz hatalarına sıklıkla rastlanmaktadır. Hataların en aza indirilebilmesi için yapılan hataları ortaya çıkaran ve bunların nasıl düzeltilebileceğine ilişkin öneriler sunan çalışmalara ihtiyaç duyulmaktadır. Bu gereksinimden hareketle bu çalışmada, fen bilgisi eğitimi alanında yazılan yüksek lisans tezlerini, yöntem ve kullanılan istatistiksel analizlerin uygunluğu açısından incelemek amaçlanmıştır. Araştırmada, Yüksek Öğretim Kurulu Ulusal Tez Merkezi'nde erişime açık olan fen bilgisi eğitiminde yapılmış toplam 30 yüksek lisans tezi incelenmiştir. İncelenen tezlerde sıklıkla rastlanan hatalar örneklerle açıklanmış ve çözüm önerilerinde bulunulmuştur.

Anahtar kelimeler: bilimsel araştırma, istatistiksel hatalar, yöntemsel hatalar, fen bilgisi eğitimi

Introduction

Researchers commit many methodological and statistical errors while constructing research questions, determining population and sample of studies, developing data collection instruments and analyzing the data they gather. These errors make the validity and reliability of a study questionable. In order for research studies not to lack academic value, researchers should be more knowledgeable, rigorous, and serious about the methodology and statistical analyses they use. Besides, researchers should be aware of the possible methodological and statistical errors to be confronted with while conducting their study and the ways of avoiding such errors.

When the related literature is reviewed, various studies focusing on the methodological and statistical errors can be encountered. In one of these studies, Sayın (2008) examined the articles published in journals with respect to the methodological and statistical errors. Sayın found that the articles under investigation were lacking the required rigor, and the authors did their research without having the necessary qualifications to conduct a study. In another study, Toy and Tosunoğlu (2007) expressed the steps that should be followed during conducting a research study in the field of social sciences and the points that should be carefully considered at these steps. In addition, in their study, authors outlined the common errors observed in the studies to prevent similar errors to occur. In their study, authors stated that researchers conducted several errors in determination of the sample and the population of the study, determination of reliability and validity of instruments used and selection of appropriate statistical analysis techniques.

In related studies, authors have several suggestions to prevent the errors confronted in research studies. In one of these studies, Arda (2003) underlined the fact that first researchers should be qualified enough to decide the feasibility of the study, yet many are not in fact, and this shortcoming on the side of the researcher leads to methodological errors. Hence, according to Arda, before starting to research, a scholar should first determine the missing parts in their knowledge base required to conduct a scientific study and look for the ways of filling in these gaps. Besides, Tonta (1999) made some suggestions by touching upon the basic points concerning statistical techniques used to determine the correlations among the variables of scientific research and the presentation of the findings. According to Tonta, more assistance should be provided for graduate students in the interpretation of the statistical results obtained during the study and the theses found to be successful in the use of statistical techniques and presentation should be rewarded by the related institutions.

When the importance of the issue is considered, it seems to be clear that there is a need for further research on the errors committed in the research studies and this will make a great contribution to the reduction of errors made. Therefore, the main purpose of the present study is to provide information for the researchers studying in the field of science education to help them to avoid similar errors and in this way, to make contribution to the literature. With this respect, in the present study, master's theses prepared in the field of science education were examined in terms of the appropriateness of the methods and statistical analyses used.

Method

In the present study, master's theses written in the field of science education in Turkey were examined. For this purpose, the theses in National Thesis Center of Higher Education Council were examined to find the related ones and then among these theses, those with full texts were included in the study. The criteria adopted in the study to determine the related theses were looking for the key words specific to the field of science education and then looking at their contents. During this quest of the related theses; key words such as 'science', 'science education', 'science teaching' were used. Then the contents of the theses found through these key words were examined and those concerning the science education were included in the study. After the examination, 30 master's theses were selected for further analyses. Theses obtained by using above-mentioned criteria were then separately examined by three researchers in relation to the research method used, sampling selection, data analysis, and statistical and methodological errors. At the end of this examination, the errors found were analyzed by the researchers together and the frequently committed errors were elicited, and then

they were reported with examples. As it is thought to be ethically appropriate, the names of the theses and authors were not mentioned, instead they were coded (Thesis A, Thesis B etc.).

Findings

The findings of the present study aiming to investigate the master's theses written in the field of science education in terms of the appropriateness of the methodologies, and statistical analyses employed are presented below under separate headings.

Examples of Errors Concerning the Research Model

When the master's theses included in the present study were examined, it was found that not enough information is provided about the research methods employed in the studies, the terms used to define the research methods are different from the ones commonly used in the literature, and the reasons for the selection of the research methods employed were not explained clearly.

As can be seen from the below-given excerpts of Thesis A and B (See Table 1 and Table 2), the terms used to define the research model employed exhibit some differences from the ones used in the literature. The design defined by the researchers as 'pre-test post-test experimental model' and 'experimental design with control and experimental groups' are called as 'pre-test post-test control group model' (Karasar, 2002). Moreover, no other explanation was given about the experimental models used in both of the studies.

Tez A:

Yapılan bu araştırmada ön-test son-test deneme modeli kullanılmıştır. İlköğretim ikinci kademe 7. sınıf öğrencilerinin "Kuvvet ve Hareketin Buluşması-Enerji" ünitesinin içerdiği "İş Yap, Enerji Aktar" konusundaki başarıları ve kavramsal öğrenme düzeyleri değerlendirilmiştir. Çalışma bizzat araştırmacı tarafından yürütülmüştür.

In Thesis A it is expressed that:

In the present study, pre-test, post-test experimental model was used. Achievement levels and conceptual acquisition levels of the primary school secondary level seventh graders were evaluated in connection with the topics of "Do Work and Transfer Energy" in the "Energy" unit.

Table 1: An Example of Errors Concerning the Research Model

Tez B

Bu araştırmada, deney ve kontrol gruplu deneysel desen kullanılmıştır. Araştırmada 2005 fen ve teknoloji dersi öğretim programını uygulayan okul öğrencileri deney grubunu, 2000 fen bilgisi dersi öğretim programını uygulayan okul öğrencileri ise kontrol grubunu oluşturmuşlardır.

In Thesis B it is expressed that:

In the present study, experimental design with control and experimental groups was used. The experimental group of the study consists of the students of a school following 2005 science and technology curriculum, and the control group consists of the students of a school following 2000 science and technology curriculum.

Table 2: An Example of Errors Concerning the Research Model

In another example, thesis C, the research model employed in the study was not clearly explained. As the study was conducted in 50 schools among 89 teachers and aimed to determine the current state, it was conducted according to 'Survey' method. It is seen that the thesis does not make any reference to the survey method in its method section. Example excerpt from thesis C is represented in Table 3.

Tez C:

3.1 ARAŞTIRMANIN MODELİ

Araştırmada veri toplamak için konuyla ilgili yerli ve yabancı litaratür taranmıştır. Fen ve Teknoloji Öğretmeni İhtiyaç Belirleme Anketi, üniversite öğretim üyeleri ve Fen ve Teknoloji dersi öğretmenleriyle yapılan görüşmelerden elde edilen veriler ile Moore'un (1978) geliştirdiği "Fen Öğretmeni İhtiyaç" anketine dayalı olarak oluşturulmuştur. Moore'un (1978) likert anketindeki bazı maddeler aynen alınmış, bazı anket maddeleri de araştırmanın amacına uygun olarak değiştirilerek kullanılmıştır. Anketin uygulanması için Ankara İl Milli Eğitim Müdürlüğü'nden Ankara ili merkez ilçe okullarındaki öğretmen sayıları ile okullarda anket yapılabilmesi için gerekli izinler alınmıştır. Anket sonuçlarından elde edilen veriler SPSS programı ile analiz edilmiştir.

In Thesis C it is expressed that:

3.1. Research Model

In order to collect the data of the study, literature review was carried out. "Determining the Needs of Science and Technology Teachers Scale" was developed through the data obtained from the interviews made with university faculty members and the teachers of science and technology course and the "Science Teacher's Needs" questionnaire developed by Moore (1978). Some items from the Likert type questionnaire of Moore were directly adopted and some were adjusted in line with the purpose of the study. The number of the teachers working in Ankara and its provinces and the required approval to conduct the study were taken from the Ankara Directorate of National Education. The data obtained from the questionnaire were analyzed through SPSS.

Table 3: An Example of Errors Concerning the Research Model

In thesis D, the researcher defines the research model used in the study as 'achievement test design' (see the excerpt in Table 4). In the literature, there is not a research model called 'achievement test design'. The study was carried out according to survey method.

Tez D:

Araştırma modeli olarak başarı testi deseni uygulanmıştır. İlköğretim, lise ve üniversite öğrencilerinin fen bilgisi konularını günlük hayatla ne düzeyde ilişkilendirildiğini belirlemek için genel tarama modellerinden tekil ve ilişkisel tarama modeli uygulanmıştır.

In Thesis D it is expressed that:

Achievement test design was used in the study as a research method. Simple and correlative survey models from the general survey methods were administered to elicit the extent to which the primary, high school and university students associate science topics with daily experiences.

Table 4: An Example of Errors Concerning the Research Model

In thesis E, the researcher defines the model used, as 'an experimental model' (see Table 5), yet the model used in reality is 'pre-test post-test with a control group'.

Tez E:

İlköğretim 8. sınıf öğrencilerinin mitoz ve mayoz hücre bölünmeleri konusundaki başarılarına bilgisayar destekli öğretim yönteminin etkisi deneysel olarak belirlenmeye çalışılmıştır. Bu çalışma deneysel bir modeldir.

In Thesis E it is expressed that:

The study aims to experimentally determine the effects of computer-assisted teaching method on the achievement level of the primary school eight graders on the topic of mitosis and meiosis divisions.

Table 5: An Example of Errors Concerning the Research Model

Examples of Errors Concerning the Selection of the Population and Sampling

Population is defined as the structure consisting of all the phenomena, objects and people within the scope of the study, and sample is defined as the ones selected to qualitatively and quantitatively represent the population (Sönmez, 2005). For a sampling to be considered valid and reliable, population of the study should be defined, elements of the population should be listed, type of the sampling should be determined, size of the sampling should be compared with the size of the population and the representative power of the sampling should be tested (Karasar, 2000). No sampling has the power to completely represent the population; that is, a hundred percent match is not possible.

The study needs to explain the determination process of the population and sampling in detail. In many of the research studies, they are correctly determined. However, in some others, there are scientific errors committed in the determination of the population, sampling and participants. These errors usually result from lack of information about statistical information and erroneous applications (Sönmez, 2005). Some shortcomings and errors were detected in the master's theses examined in the present study. Examples of these errors are presented in tables below.

As can be seen in the below-given excerpt (see Table 6), though the study consists of 60 primary school students, it is claimed that the findings of the study can be generalized to the whole country. It is very clear that the population and sample was incorrectly defined. As a consequence, since the sample does not have the power to represent the population, the results obtained from the sample cannot be generalized to the stated population.

Tez F:

Deney ve control grupları 30'ar öğrenciden oluşmuştur. …. Araştırma evreni olarak bu iki okulun seçilmesinin nedeni, bu okulların zorunlu hizmet bölgesi kapsamında olması, eğitim-öğretim için gerekli imkânların oldukça az olması, Türkiye genelindeki ilköğretim kurumlarının genelini temsil edebilecek nitelikte olmasıdır.

In Thesis F it is expressed that:

Both the control group and the experimental group consist of 30 students ….. The reason why these two schools were selected as the population of the study is their being in a poor district, shortage of the educational materials and facilities, hence having power to represent the schools in Turkey.

Table 6: An Example of Errors Concerning the Selection of the Population and Sampling

Another common error can be observed in Theses G and H (see Table 7 and Table 8). In these two studies, although some information is given about the method used for the selection of the sampling, not enough explanation is provided about how the selection process is carried out. In addition, in these two examples, it was stated that the samples were selected through random sampling. However, random sampling is not used on its own in both quantitative and qualitative research, it is usually used together with other possibility-based sampling methods (systematic, stratification, and cluster) (Yıldırım ve Şimşek, 2006). Besides, since the classrooms are very constructed in schools, it is nearly impossible to select the participants randomly and form new classes for the study. Therefore, authors should clearly explain how they selected the sample of the study and applied random sampling in their contexts.

Tez G:

…Bu araştırmanın evreni, Hatay İli Merkez İlçesine bağlı devlet ilköğretim okullarında 2005-2006 eğitim öğretim yılında okuyan 5. sınıf öğrencileridir. Araştırmanın örneklemini, Hatay İli Antakya Merkez İlçesine bağlı Cemil Şükrü Çolakoğlu İlköğretim Okulu'nun tesadüfi örneklem (random) yoluyla seçilmiş 5. sınıf öğrencilerinden oluşan 2 şubesi oluşturmaktadır.

In Thesis G it is expressed that:

The population of the study is the fifth grade students attending primary public schools of Hatay city in 2005-2006 school year. The sampling of the study consists of the students in the two fifth classes of Cemil Şükrü Çolakoğlu primary school in Antakya, Hatay. The students were randomly selected.

Table 7: An Example of Errors Concerning the Selection of the Population and Sampling

Tez H:

... Araştırmanın örneklemini 2007–2008 eğitim-öğretim yılı Sakarya ilindeki bir ilköğretim okulunda okuyan 24 kız, 34 erkek olmak üzere toplam 58 altıncı sınıf öğrencisi, oluşturmaktadır. Araştırmaya katılan 58 öğrencinin 29'u deney, 29'u kontrol grubunu oluşturmaktadır. Deney ve kontrol grupları rastgele atanmıştır.

In Thesis H it is expressed that:

The sample of the study consists of totally 58 sixth graders (24 female and 34 male students) attending a primary school in Sakarya province in 2007-2008 school year. 29 of the 58 participants were assigned to the control group and 29 to the experimental group. The assignment of the students to the groups was random.

Table 8: An Example of Errors Concerning the Selection of the Population and Sampling

As can be seen in the excerpt from thesis I (see Table 9), some of the theses examined in the study do not mention the size of the sampling but a good study should tell the size of the sampling.

TEZ I:

...Araştırmanın evrenini İzmir ili Buca ilçesinde bulunan Saadet Emir İlköğretim Okulu'nda okumakta olan 5. sınıf öğrencileri oluşturmaktadır. Saadet Emir İlköğretim Okulu'nda bulunan 5 adet 5. sınıf bulunmaktadır. Evrenin küçük bir grup olmasından dolayı öğrencilerin tümü örneklem olarak kullanılmak istenmiş fakat bir sınıfın islenen konu bakımından çok geride olması bu sınıfın çalışmaya katılamamasına neden olmuştur. Bundan dolayı araştırmaya 4 adet sınıf katılmıştır.

In Thesis I it is expressed that:

...the population of the study consists of the fifth graders enrolled at Saadet Emir Primary School in Buca, İzmir. There are five fifth classes in this school. As the population of the study is relatively small, all of the population was intended to be used as the sampling but as one of the classes is quite behind the other classes in relation to the subjects studied, it was not included in the study. Therefore, the sampling of the study consists of four classes.

Table 9: Examples of Errors Concerning the Selection of the Population and Sampling

Examples for the Statistical Analysis Error

Many important errors were detected in the selection and application of statistical analyses in the theses. Depending on the structure of the data and analyses, parametric or non-parametric tests should be opted for. For instance, in comparative tests, depending on whether the data exhibit normal distribution or not, the test to be used should be determined. In cases where the data show normal distribution, t-test, variance analysis etc. should be used; otherwise, non-parametric tests such as Mann Whitney U, Kruskal Wallis H test should be used (Bayram, 2004; Büyüköztürk, 2005; Toy ve Tosunoğlu, 2007). In the present study, it was found that parametric tests were employed without considering whether the data are normally distributed or not. On the other hand, in the comparative tests, equality of variances is of great importance (Toy ve Tosunoğlu, 2007). Depending on whether the variance is equal or not, multiple comparison test should be preferred. For instance, if the variances are homogenous, multiple comparison tests such as Scheffe, Tukey HSD should be opted for and if they are not homogenous, Dunnet C test etc. should be preferred (Büyüköztürk, 2005). Many of the theses examined here did not pay attention to the above-mentioned points. Some examples of such errors are given below;

In thesis J, the comparisons were made with One-Way Analysis of Variance (one-way ANOVA), and multiple comparisons were performed with Tukey test. For this parametric test to be carried out, testing normal distribution and homogeneity of the groups are prerequisites but the study did not test these prerequisites. Moreover, as in this example, the significance level is shown to be "<0.05" and ">0.05" in tables (see Table 10). It seems to be more appropriate to write the value obtained at the end of analysis and "Statistical difference is significant at the level of $p = 0.05$" should be written under the table.

Tez J:

Varyans Kaynağı	Kareler Toplamı	Serbestlik Derecesi	Kareler Ortalaması	F Değeri	Anlamlılık Düzeyi
Gruplariçi	101.978	2	50.989	24.33	<.05
Gruplararası	2009.869	959	2.096		
Toplam	2111.847	961			

In Thesis J it is expressed that:

Source of Variance	Sum of Squares	Degrees of Freedom	Mean of Sum of Squares	F Value	P
Within Group	101.978	2	50.989	24.33	<.05
Between Groups	2009.869	959	2.096		
Total	2111.847	961			

Table 10: An Example for the Statistical Analysis Error

Besides, as can be seen in Table 11, the results presented in tables showing the results of Tukey test are not explained and presented in a usual way. The tables showing the results of multiple comparison tests should be presented in a more orderly manner.

TEZ K:

	Düşük SED	Orta SED	Yüksek SED
Düşük SED	1.00		
Orta SED	0.226	1.000	
Yüksek SED	0.001	0.000	1.000

In Thesis K it is expressed that:

	Low SES	Middle SES	High SES
Low SES	1.00		
Middle SES	0.226	1.000	
High SES	0.001	0.000	1.000

Table 11: An Example for the Statistical Analysis Error

In thesis A, comparisons were made with independent samples t-tests. As in many other studies, normal distribution and equality of variances were not tested in this study. Moreover, as can be seen in the Table 12, the significance level is not indicated for the groups for which no significant difference was found and for the groups where significance difference was found, it was shown as '$p<.01$'. As already stated above, for this study, it seems to be more appropriate to write the value obtained at the end of analysis and "Statistical difference is significant at the level of $p = 0.01$" should be written under the table.

Thesis A:

	N	X	s.s	s.d	t	p
Ön Tutum	45	75.76	10.07	44	1.969	-
Son Tutum	45	71.69	8.33			

* Ön Tutum stands for Pre-Atttitude

Son Tutum stands for Post-Attitude

Table 12: An Example for the Statistical Analysis Error

In thesis L, the state of the normal distribution of the data was not tested. However, this is one of the rare studies looking at the equality of variances. On the other hand, results of descriptive statistics such as means, standard deviation and the results of t-test and analysis of variance are presented in separate tables. The results of such tests can be presented in the same table.

In some studies, the findings are presented both in tables, graphs and in the form of explanations. Presenting information in just one form either in a table or in a graph would be more suitable. The data presented in tables or graphs can be appropriately interpreted. In other words, when the tables, graphs and explanations are separately examined, they should be informative enough on their own. In the theses, some findings not relating to the purpose of the study were found to have been included in the tables. It is better not to include information that does not have any relevance to the purpose of the study and that cannot be interpreted in tables.

Conclusion

Within the scope of the present study, some master's theses written in the field of science teaching are examined under the headings of 'research model', 'population and sampling' and 'statistical analyses'. When the information presented under these headings was investigated, some errors were detected. These errors raise questions related to the reliability and validity of the study. For the societies and science to develop, faultless and reliable scientific research is of great importance. Researchers should complete the study from its beginning to the end with a great care. Researchers should be knowledgeable about some issues such as statistical techniques and research models to do correct and reliable studies. For researchers to be knowledgeable about such issues, the number of the courses given at undergraduate and graduate levels about research methods and statistical analyses should be increased. Moreover, practice opportunities to apply the theoretical knowledge should be provided in these courses to prevent future errors from occurring. When the fact that all the theses examined in the present study underwent to the scrutiny of at least one jury, it becomes clear that the juries controlling the theses should pay greater attention to the content.

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