MICROSCOPE USAGE INFORMATION: SAMPLE OF SCIENCE TEACHER CANDIDATES

Sibel DEMİR KAÇAN
Ondokuz Mayıs University, Turkey

ABSTRACT: A qualified laboratory lesson is of great importance in science education. In a qualified laboratory lesson, there are so many essential elements such as material, tool and place. One of the most important elements of a qualified laboratory lesson is the equipment used, and usage information and ability of this equipment. Microscope which is frequently used in science education is one of such tools. Microscope usage information is very important for a science educator. Therefore, a teacher who acquired this information and usage ability will be effective in encouraging students to use the microscope correctly, to have interest in science and even to do research in this field. In parallel with this importance, it is thought that the science educators who study in faculties need to have a good ability of microscope usage information. Based on this expectation, the aim of this study is to identify the ability of microscope usage information of the candidate students who study at science teaching department in 2nd grade. This study has been conducted with 80 2nd grade students who study in science teaching department of a university in Black Sea region of Turkey. Microscope usage information scale which was improved by Benzer and Demir in 2014 has been used as obtainment tool in the study. Microscope usage information scale is composed of tripple likert type 20 articles and two open-ended questions. The data which were obtained from likert type articles have been evaluated with frequency calculation whereas the data which were obtained from open-ended questions have been evaluated with content analysis. According to Büyüköztürk et al. (2008), content analysis is defined as a systematic technique where certain words of a text are summarized with smaller content categories through coding. Based on the results that were obtained in the study, interpretations have been made and suggestions have been offered in order to enlighten other researchers.

Key words: Microscope usage information, teacher candidate, science education

INTRODUCTION

The innovative age we live in presents us with various technological products and new ideas. Each new idea leads to the development of a new product. In our age making creative thinking a necessity, it is considered vital to use the existing information and technology in an eligible and equipped manner to create innovative ideas. In that sense, sciences and having an accurate outlook on sciences have been gradually gaining more and more significance. Science does not only include technological thinking and application skills, but also makes laboratory usage and skills necessary. In science education, laboratory and the perspective on laboratory are of great importance. Laboratories, which can be considered as the fundamentals of science and its effective use bring out qualified teacher skills. In science education, laboratories are considered as environments, which almost make it necessary to minimize memorized knowledge. Laboratory works include students into the learning and discovery process via firs hand experiences and enable them to participate in scientific activities to ask questions, propose solutions, make assumptions, organize data, explain examples etc. (Kanlı and Yağbasan, 2008). Laboratories possess an uncontroversial place in the science education. One of the most effective methods in the science education is laboratory method (Hofstein, Kipnis and Kind, 2008; İlhan, Sadi, Yıldırım and Bulut, 2009; Demirbaş and Pektaş, 2010; Dahar and Faize, 2011). As a result of the nature of science, laboratories are considered as the only environment, where many high-level skills such as researching, investigating, and interpreting can be gained, developed and were applied activities and experiments can be conducted. As a matter of fact, it is stated that science courses must be completely instructed in laboratories or the classrooms must be organized as laboratories (Bahar, Aydın, Polat and Bertiz, 2008). Especially, open ended laboratory experiences enable students to criticize generally misunderstood conceptions through their intuitions and to look for creative solutions (MacLean, 2003). Many previously conducted studies have revealed that laboratory method is quite an effective method in science education (Lawson 2005). Laboratory activities require various materials, which are either simple or complicated, from everyday life to be used together (Güler and Çobanoğlu, 1997). The laboratory studies allow for scientific thinking, developing a positive attitude towards science and scientific applications, acquiring scientific process skills, and learning science subjects through living and experiencing them in a better manner (Harman, 2012). Laboratory materials cause students to structure scientific information by working like scientists and to obtain scientific habits (Jewitt, Kress, Ogborn, and Tsatsarelıs, 2001). In that sense, laboratories can be defined as the kitchen of science.

One of the biggest challenges the scientists, who focus on the field of experiment and observation, used to face with was the limitedness of sense organs. In overcoming this challenge, one of the two magical devices related to lenses was telescope, which enabled zooming from far distances, and the other one was microscope, which enabled focusing on very small areas (Evrim, 2011). In the study, they conducted, Flick and Bell (2000) has stated the significance of teachers' use of microscope for scientific and technological purposes. "Microscope" is one of the most significant tools, which makes it easier for students to learn conceptions related to the field of biology (Ekici, 2016). Microscope can be defined as "An optic tool consisting of lens systems, which enable the examination of living and non-living objects that are not macroscopic'' (Özata and Türe, 1999; Dökme, Doğan and Yılmaz, 2010; MEB, 2011). Thus, microscope is of importance in terms of making objects, which are abstract and cannot be seen with bare eyes, become visible. Microscope, which are available in most of primary education schools (Akpınar and Turan, 2002; Demir, Böyük and Koç, 2011) is a material, which makes understanding easier when used in education just like other technological tools (Yavuz and Coşkun, 2008). In their study, in which Şimşek, Hırça and Coşkun (2012) examined the teaching methods and materials used by science and technology teachers, they have stated that the science and technology teachers prefer conventional method such as question-answer and plain instruction, instead of methods such as actively including students into the process of learning and conducting activities such as using microscope, computer, project works, which help with improving students' scientific research skills. For this reason, it is believed that both teachers and prospective teachers should be qualified enough at microscope use. In fact, in the study conducted by Ural Keleş, Er Nas and Çepni (2009) it was also observed that prospective teachers had misconceptions at the stage of forming an image on a microscope. In that context, it is believed that prospective teachers should spend more quality time with microscope. In the study carried out by Yeşilyurt (2004), it has been revealed that prospective teachers have difficulty with understanding when they are less occupied with microscope. The results of the research conducted by Demir (2015) suggest that the microscope usage knowledge of prospective science teachers is usually at an intermediate level, which is deemed insufficient.

Considering all of these studies, it is assumed that it is of importance and necessity to find out whether prospective teachers have a competent use of microscopes or their level of microscope usage. Hence, the aim of this study is to detect the microscope usage knowledge of the prospective teachers, who are second year students at the department of science teaching.

METHODOLOGY

In this study, survey model has been used, since the aim of the research is to describe the microscope usage knowledge of prospective students, who study at the department of science teaching, through a measurement instrument and open-ended questions. It can be asserted that the studies in survey model describe, explain, and reveal what has been experienced and who has experienced them (Sönmez and Alacapınar, 2011).

This study was carried out with 80 second year students, who study at the science teaching department of a university in the Black Sea region of Turkey. In this research, the microscope usage knowledge scale, which was developed by Benzer and Demir in 2014 and validity and reliability which have been studied, was used as the data collection tool. This scale was applied to 273 prospective teachers in total, who were 1st, 2nd, 3rd, and 4th year students studying at the Department of Science Teaching, by the researchers. This scale developed by the researchers consists of sub-dimensions such as examining the image, technical knowledge and terms, sectioning, and the sectors in which microscope is used. The scale includes 23 items, to which students can answer give answers such as yes, no, or I do not know, and two open-ended questions, to which they answered by providing explanations.

In this research, the data obtained from the likert type items included in the scale were analyzed through frequency count; the data retrieved from the open-ended questions were analyzed through content analysis. According to Büyüköztürk et al. (2008), content analysis can be defined as a systematical technique, in which some words in a text are summarized in smaller content categories through coding.

FINDINGS

In this study, data obtained from the microscope usage knowledge scale were used. The data obtained from the scale were gathered and interpreted under three headings: "Percentages Obtained from Scale Items", "Themes about all of the Stages Required to Examine a Plant Tissue through a Microscope", and "Other Expressions Uttered by Prospective Teachers".

Table 1. Percentages obtained from scale items

Some items about the scale	yes	no	I do not know
1-Macroscrew helps with clarifying the image.	45	53.8	1.3
2-In order to examine something with microscope, firstly the tray is lifted and preparate is placed.	10.0	87.5	2.5
3-Diaphragm may be opened or closed based on the work to be performed.	65.0	22.5	12.5
4-The section taken from the plane, which is vertical to the long axis of the material, is transversely cut.	87.5	10.0	2.5
5-In general, there are three types of sectioning including transverse, longitudinal, and superficial sectioning.	95.0	5.0	0.0
7-While examining on microscope, 4-objective image is used for drawing.	25.0	67.5	7.5
8- It is necessary that macroscrew is not touched in 4-objective.	18.8	73.8	7.5
10-Glass slide and cover glass are called preparate.	21.3	76.3	2.5
11-In order to examine something with microscope, the objective is checked, preparate is placed and lastly tray is lifted.	88.8	7.5	3.8
12-The image on the microscope must be exactly drawn, and be verified through obtaining information.	95.0	5.0	0.0
13-The image in the microscope must be drawn in detail, just like those in the books.	43.8	43.8	12.5
14-Miscroscope is used in the health sector.	86.3	10.0	3.8
15-It is okay to play with the macroscrew in 40-objective.	20.0	70.0	10.0
17-Diaphragm is on the microscope tray.	21.3	72.5	6.3
19-Microscope magnification is written as "objective x ocular".	85.0	5.0	10.0
20-Examination environment refers to the solution dripped to get a better view of the taken section.	50.0	35.0	15.0
22-Microscope is used in criminal offenses.	78.8	2.5	18.8
23-In order to examine something with microscope, without checking the objective, the preparate is placed and the tray is lifted.	11.3	85.0	3.8

Examining the Table1 , it is apparent that the prospective teachers gave positive answers to many items such as *"The section taken from the plane, which is vertical to the long axis of the material, is transversely cut; In order to examine something with microscope, firstly the tray is lifted and preparate is placed;* In general, there are three types of sectioning including transverse, longitudinal, and superficial sectioning", whereas; they were in contradiction especially with the following items: *"Macroscrew helps clarifying the image; and The image in the microscope must be drawn in detail, just like those in the books"*.

Table 2. Themes about all the required stages to examine a plant tissue through a microscope

Themes	yes	no
Correct sorting	43.8	56.2
Full examination	3.8	96.2
Creating the correct preparate	71.3	28.7

When expressions obtained from the prospective teachers' writings of all the required stages to examine a plant tissue on a microscope, Table 2 suggests that the correct sorting theme was mostly accomplished, yet it was still almost equally distributed; the full examination theme was not accomplished for the most part; and the theme of preparing correct preparate was mostly accomplished.

Table 3 suggests that the other expressions most frequently uttered by the prospective teachers include *"It should be held from under, not be dragged; When the operation is done, it should be adjusted to 4x10 objective; Firstly, it is at 4-objective; In other objectives, the image is clarified without touching the macroscew; When the examination is completed, preparate is taken and microscope is turned off; Microscrew clarifies the image; When the operation is completed, the tray must be put down"*.

Table 3. Other expressions uttered by prospective teachers

Expressions	f
It should be held from under, not be dragged	6

When the operation is done, it should be adjusted to 4x10 objective	4
Firstly, it is at 4-objective.	3
In other objectives, the image is clarified without touching the macroscew.	3
When the examination is completed, preparate is taken and microscope is turned off.	3
Microscrew clarifies the image.	2
When the operation is completed, the tray must be put down.	2
When the operation is over, it should be picked and cleaned.	2
We should be careful not to break the preparate.	2
Other	26

RESULTS

The constructivist learning theory, which places the student in the center of learning, puts emphasis on the necessity and importance of providing students with a setting, where they can research, associate the information they learn with their everyday life in order to obtain in-depth knowledge (Çinici, Sözbilir, Demir 2011). Many science educators have stressed on the importance of laboratory activities in achieving success at science and developing positive attitude towards since as well as on the significant effect of laboratory activities (Renner, Abraham and Birnie, 1985; Roth, 1994; Okebukola, 1986; Shymansky and Kyle, 1988; Hofstein and ark. 2005; Renner, 1986). In the laboratory setting, students should design their own experiments by themselves, create and test their own hypotheses, determine the variables of the experiment by themselves, decide what data to record by themselves, draw tables on their own, make conclusions; in short, the students should participate in activities that will improve their scientific process skills and they should not spend effort to exactly and passively fulfill the duties assigned to them by a teacher or written on a laboratory sheet (Kanlı and Yağbasan, 2008). Laboratories make students active during learning, increase their curiosity in research, and lead them to think creatively (Büyükkaragöz and Çivi, 1996). Thereby, through laboratory activities the individuals' improvement of scientific process skills will be supported, thus knowledge will be created.

Direct teaching can be defined as teacher's creating knowledge by guiding students throughout a number of activities such as experiment designing, learning via using microscope, performing measurement etc. (Schroeder, Scott, Tolson, Huang and Lee, 2007). The constructivist learning is the learning philosophy, in which student is made active and learning occurs through living and experiencing. In order to realize the expected objectives of this field, it is essential to make the best use of laboratories and course materials-tools (Köseoğlu and Soran, 2006). Considering the results of the study carried out by Keskin, Özbek, Ulaş, and Müdok (2015), it is apparent that the students of our age, who grow up with technological improvements, mostly prefer digital microscope usage and work more comfortably with these images. The microscope usage includes a process, which requires experience. In the study conducted by Uzel et al. (2011), it was found out that ocular, tray, macroscrew, and microscrew are the components, which prospective science teachers accurately recognize; and condenser screw and condenser are the components inaccurately recognized by the prospective teachers. In this study, it was found out that the prospective teachers gave positive answers to many items in the scale; however, they were in contradiction with the following items "Macroscrew helps clarifying the image; and the image in the microscope must be drawn in detail, just like those in the books". In the study conducted by Uzel et al. (2011) regarding examining the image on the microscope, it was revealed that the prospective science teachers had difficulty with sectioning. When expressions obtained from the prospective teachers' writings of all the required stages to examine a plant tissue on a microscope, it is observed that the correct sorting theme was mostly accomplished; the full examination theme was not accomplished for the most part; and the theme of preparing correct preparate was mostly accomplished. In that sense, it is apparent that the prospective teachers do not have difficulty with creating preparate; however, they cannot conduct a full examination. Again, in this study it was observed that the most frequently uttered expressions by the prospective teachers include "It should be held from under, not be dragged; When the operation is done, it should be adjusted to 4x10 objective; Firstly, it is at 4-objective; In other objectives, the image is clarified without touching the macroscew; When the examination is completed, preparate is taken and microscope is turned off'. Examining the codes about capturing an image on microscope and examination touch in the study conducted by Benzer and Demir (2014), it is seen that the 3rd year students had the highest number of correct answers to capturing and clarifying an image codes; the 2nd and 4th year students had approximately same number of correct answers; 1st year students had no knowledge about this subject at all. In their study, Taşdelen and Güven (2012) found out that the prospective teachers wanted more experimental activities to be conducted and the observations to be performed by using microscopes.

In the laboratory activities at school, it is possible to enable student to obtain experience about learning through discovery by allowing them to use microscope (Puckering et al., 2003). In the study carried out by Dikmenli, Türkmen and Çardak (2002), the alternative conceptions of undergraduate science department students about microscope activities in the biology laboratories were found out; in the research conducted by Ekici (2016), metaphors and explanations, uttered by prospective biology teachers about microscope, which were quite rich, meaningful and had different perspectives, were discovered. It is accepted that microscope usage has an essential place in science education. That's why, it is deemed necessary for a science educator to possess enough level of knowledge on microscope usage and technical information about microscope. Thereby, it is believed that science educators will be effective at enabling students to bring nature to the laboratory and discover some invisible and unknown structures, organisms, and objects (Demir, 2015). Also, Ketelhut, Nelson, Clarke and Dede (2010) discuss that even through virtual microscopes it is possible for students to feel as if they are actively conducting an experiment and feel like a scientist. Detecting what the misconceptions about microscope are and re-arranging biology and biology laboratory activities in order to decrease or terminate these misconceptions are of utmost importance in increasing the success level of students (Yeşilyurt, 2004).

According to Doğan et al. (2003), students should be given a course on biology laboratory usage, in which they can acquire laboratory usage skills. The students should be given the opportunity to use the laboratories besides their course hours. Books, which are mostly visual, about laboratory lessons should be prepared. Students' motivation should be increased; thereby they should be enabled to come prepared to the laboratories. Some changes should be made in the curriculum of the laboratory courses; the number of experiments, which are applicable and can be conducted with basic materials, should be increased. Moreover, laboratory education should be attached importance in terms of improving innovative thinking skills in the field of science. With its setting, education, and materials, the laboratory happens to be an area, regarding which especially prospective science teachers should improve themselves. Thus, it is believed that the prospective science teachers should improve themselves about microscope usage and experiments and make the best use of each opportunity. Microscope is a tool, which does not only improve students' thinking, research, examination, comprehension, observation etc. skills in the laboratory activities, but also enables obtaining images by concretizing the prepared objects according to certain rules, usually with the help of teachers (Basey, Mendelow, and Ramos, 2000). In fact, Ekici (2016) also states that it is important to pay a special importance to microscope usage at all stages of education from primary school to university. That's why, it is believed that in order to improve microscope usage skills of the prospective teachers, they have to experience quite enriched experiment environments.

SUGGESTIONS

Considering this study:

1. It is believed that, especially in undergraduate programs, the subjects with biology content should be instructed by using microscope as much as possible, in an applied manner.
2. Also, it of high importance for the prospective teachers studying these programs to experience as many sample activities as possible.
3. The students studying this program must possess knowledge and skills about microscope usage in order to enable especially prospective science teachers to practice their profession in a qualified manner in future and enable primary and secondary school students to efficiently use microscope.

ACKNOWLEDGEMENTS

This study is the extended version of the research presented as a paper at ICEMST 2016.

REFERENCES

Akpınar, B., & Turan, M. (2002). *İlköğretim okullarında fen bilgisi eğitiminde materyal kullanımı.* V. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresinde sunulan bildiri. Orta Doğu Teknik Üniversitesi, Eylül 2002, Ankara.

Bahar, M., Aydın, F., Polat, M., & Bertiz, H. (2008). *Fen ve teknoloji laboratuvar uygulamaları 1-2.* Ankara: Pegem A Akademi.

Basey, J. M., Mendelow, T. N., & Ramos, C. N. (2000). Current trends of community college lab curricula in biology: An analysis of inquiry, technology and content. *Journal of Biological Education, 34* (2), 80-86.

Benzer, E. & Demir, S. (2014). Fen bilgisi öğretmen adaylarının mikroskop kullanım bilgilerinin incelenmesi. *Mersin Üniversitesi Eğitim Fakültesi Dergisi*, 10(3), 1-21.

Büyükkaragöz, S. S., & Çivi, C. (1996). *Genel öğretim metotları.* İstanbul: Öz Eğitim Yayınları.

Büyüköztürk, Ş., Kılıç Çakmak, E., Akgün, Ö. E., Karadeniz, Ş., & Demirel, F. (2008). *Bilimsel araştırma yöntemleri.* Ankara: Pegem A Akademi. 1.Baskı.

Çinici, A., Sözbilir, M., & Demir, Y. (2011). Effect of cooperativeandındividuallearning activities on students' understanding of diffusionand osmosis. *Eurasian Journal of Educational Research, 41*, 19-35.

Dahar, M.A., & Faize, F.A. (2011). Effect of the availability and the use of science laboratories on academic achievement of students in Punjab (Pakistan). *European Journal of Scientific Research, 51*(2), 193-202.

Demir, S. (2015). Evaluation of science teacher candidates' level of knowledge regarding the use of microscopes. *Journal of Education and Practice, 6*(24), 27-29.

Demir, S., Böyük, U., & Koç, A. (2011). Fen ve teknoloji dersi öğretmenlerinin laboratuvar şartları ve kullanımına ilişkin görüşleri ile teknolojik yenilikleri izleme eğilimleri. *Mersin Üniversitesi Eğitim Fakültesi Dergisi, 7*(2), 66-79.

Demirbaş, M., & Pektaş, H.M. (2010). Measurement of the skills of Turkish university students in using microscopes and the analysis of the problems faced in this process. *World Applied Sciences Journal, 11* (9), 1177-1182.

Dikmenli, M., Türkmen, L., & Çardak, O. (2002). *Üniversite öğrencilerinin biyoloji laboratuvarlarında mikroskop çalışmaları ile ilgili alternatif kavramları.* Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresinde sunulan bildiri. 16-18 Eylül 2002, ODTÜ, Ankara.

Doğan, S., Sezek, F., Yalçın, M., Kıvrak, E., Usta, Y., & Ataman, A. Y. (2003). Atatürk üniversitesi biyoloji öğrencilerinin laboratuvar çalışmalarına ilişkin tutumları. *Erzincan Eğitim Fakültesi Dergisi 5(*2), 33-58.

Dökme, İ., Doğan, A., & Yılmaz, M. (2010). *Fen öğretimi laboratuvar uygulamaları I-II.* Ankara: Palme Yayıncılık.

Ekici, G. (2016). Biyoloji öğretmeni adaylarının mikroskop kavramına ilişkin algılarının belirlenmesi: Bir metafor analizi çalışması. *Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi (KEFAD), 17(1), 615-636.*

Evrim (2011) Evrim Teorisi Ortaya Koymadan Önceki Felsefe, Bilim ve Biyoloji Tarihi. http://www.evrim.gen.tr/2011/12/evrim-teorisi-ortaya-koymadan-onceki-felsefe-bilim-ve-biyoloji-tarihi/ adresinden erişildi.

Flick, L., & Bell, R. (2000). Preparing tomorrow's science teachers to use technology: Guidelines for Science educators. *Contemporary Issues in Technology and Teacher Education, 1*(1), 39-60.

Güler, Ç., & Çobanoğlu, Z. (1997). *Sağlık ocağı laboratuvarı.* Sağlık Bakanlığı, Çevre Sağlığı Temel Kaynak Dizisi No: 49, Ankara: İlköz Matbaası.

Harman, G. (2012). Sınıf öğretmeni adaylarının fen ve teknoloji öğretiminde kullanılan laboratuvar araç gereçleri ile ilgili bilgilerinin incelenmesi. *Journal of Educational and Instructional Studies in the World, 2* (1), 122-127.

Hofstein, A., Kipnis, M., & Kind, P. (2008). Learning in and from science laboratories: enhancing students'meta-cognition and argumentation skills. Ed. C. L. Petroselli, In: Science Education Issues and Developments. Nova Science Publishers, Inc.: New York, 59-94.

Hofstein, A., Navon, O., Kipnis M. ve Naaman, M. (2005). Developing students'ability to ask more and better questions resulting from ınquiry-type chemistry laboratories. *Journal of Research in Science Teaching, 42*(7), 791-806.

İlhan, N., Sadi, S., Yıldırım, A., & Bulut, H. (2009). Kimya öğretmen adaylarının laboratuvar uygulamaları hakkındaki düşünceleri. *Kastamonu Eğitim Dergisi, 17*(1), 153-160.

Jewitt, C., Kress, G., Ogborn, J. & Tsatsarelıs, C. (2001). Exploring learning through visual, actional and linguistic communication: the multimodal environment of a science classroom. *Educational Review, 53*(1), 5-18.

Kanlı, U. & Yağbasan, R. (2008). 7E modeli merkezli laboratuvar yaklaşımının öğrencilerin bilimsel süreç becerilerini geliştirmedeki yeterliliği. *GÜ, Gazi Eğitim Fakültesi Dergisi, 28*(1), 91-125.

Keskin, İ., Özbek, H., Ulaş, F. & Müdok, T. (2015). Geleneksel mikroskop eğitiminden dijital mikroskop eğitimine geçiş. *Tıp Eğitimi Dünyası, 42*, 27-32.

Ketelhut, D. J., Nelson, B. C., Clarke, J. &Dede, C. (2010). A Multi-user virtual environment for building higher order inquiry skills in science. *British Journal of Educational Technology 41*(1), 56-68.

Köseoğlu, P., & Soran, H. (2006). Biyoloji öğretmenlerinin araç-gereç kullanımına yönelik tutumları. *H.Ü. Eğitim Fakültesi Dergisi (H.U. Journal of Education), 30*, 159-165.

Lawson, A.E. (2005). What is the role of induction and deduction in reasoning and scientific inquiry? *Journal of Reseach in Science Teaching, 42* (6), 716-740.

MacLean, J. (2003). *Exploring metacognition, student-generated rubrics and the development of scientific.* Unpublished master thesis, University of Alberta, Edmonton, Alberta.

MEB (Milli Eğitim Bakanlığı). (2011). *Ortaöğretim projesi: Laboratuvar hizmetleri, mikroskobik inceleme.* 524LT0021. Ankara.

Okebukola, P.A. (1986). An investigation of some factors affecting student's attitude toward laboratory chemistry. *Journal of Chemistry Education, 63*, 531–532.

Özata, A., & Türe, C. (1999). Mikroskop ve kullanımı. M. Zor (Ed.), *Laboratuvar uygulamaları ve fen öğretiminde güvenlik* içinde. 1. Cilt. Eskişehir: T.C. Anadolu Üniversitesi Açıköğretim Fakültesi Yayınları.

Puckering, A. L., Synenki, L. R., Moore, K., Steapleton, M., Hammond, P., Pomart, K., & Sisken, D. (2003). Become a laboratory investigator: Detect the presence of nuclei in red blood cells. *Science Activities: Classroom Projects and Curriculum Ideas, 39* (4), 22-27.

Renner, J.W., Abraham, M.R., & Birnie, H.H. (1985). Secondary school students'beliefs about the physics laboratory. *Science Education, 69,* 649–663.

Renner, J. W. (1986). Rediscovering the Lab. *The Science Teacher, January,* 44-45.

Roth, W. M. (1994). Experimenting in a constructivist high school physics laboratory. *Journal of Research in Science Teaching 31*(2), 197-223.

Schroeder, C. M., Scott, T. P., Tolson, H. Huang, T. Y. & Lee, Y. H. (2007). A meta-analysis of national research: effects of teaching strategies on student achievement in science in the united states. *Journal of Research in Scıence Teachıng, 44(*10), 1436–1460.

Shymansky, J. A. & Kyle, W.C. (1988). A summary of research in science education. *Science Education. 72,* 249–402.

Sönmez, V., & Alacapınar, F. G. (2011). Örneklendirilmiş bilimsel araştırma yöntemleri. Ankara: Anı Yayıncılık.

Şimşek, H., Hırça, N., & Coşkun, S. (2012). İlköğretim fen ve teknoloji öğretmenlerinin öğretim yöntem ve tekniklerini tercih ve uygulama düzeyleri: Şanlıurfa ili örneği. *Mustafa Kemal Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 9*(18), 249-268.

Taşdelen, Ö. & Güven, T. (2012). Hücre biyolojisi (sitoloji) laboratuvar dersinin öğrenci görüşlerine göre değerlendirilmesi. *TÜFED-TUSED, 9*(2), 155-167.

Ural Keleş, P., Er Nas, S. & Çepni, S. (2009). Fen bilgisi öğretmen adaylarının mikroskop kullanımı ile ilgili kavram yanılgılarının belirlenmesi, *3. Uluslararası Bilgisayar ve Öğretim Teknolojileri Sempozyumu* (7-9 Ekim 2009), Karadeniz Teknik Üniversitesi, Trabzon.

Uzel, N., Dikmen, E. H., Yılmaz, M. & Gül, A. (2011). *Fen ve teknoloji ile biyoloji öğretmen adaylarının mikroskop kullanımında karşılaştıkları sorunlar ve bu sorunların nedenlerinin belirlenmesi.* 2nd International Conference on New Trends in Education and Their Implications'da sunulan bildiri. 27-29 April, 2011, Antalya-Turkey, Ankara: Siyasal kitapevi.

Yavuz, S., & Coşkun, A.E. (2008). Sınıf öğretmenliği öğrencilerinin eğitimde teknoloji kullanımına ilişkin tutum ve düşünceleri. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 34,* 276-286.

Yeşilyurt, S. (2004). Biyoloji ve fen bilgisi öğretmen adayları ile lise öğrencilerinin biyoloji laboratuvarlarında mikroskop çalışmalarına dair bilgi düzeyleri üzerine bir araştırma. *Erzincan Eğitim Fakültesi Dergisi, 6* (2), 83-103.