



Pre-Service Teachers' Views about their Competencies in Biology Applications

Esin ATAV^{1✉}, Bahattin Deniz ALTUNOĞLU²

¹ Assoc. Prof. Dr., Hacettepe University, Faculty of Education, Department of Secondary Science and Mathematic Education, Ankara-TURKEY

² Research Assist., Hacettepe University, Faculty of Education, Department of Secondary Science and Mathematic Education, Ankara-TURKEY

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ABSTRACT

This study examined the perceptions of pre-service biology teachers about their competencies in biology applications. The study was conducted on pre-service biology teachers who have taken all application courses since the first year of the university. One hundred and fifty pre-service biology teachers participated in the study. The data were collected between the years of 2003-2007 period, each year with a different group consisting of 30 pre-service biology teachers. The pre-service teachers were asked how competent they perceived themselves in effectively using the instruments in the biology laboratory, in teaching the subjects covering laboratory techniques and methods, ensuring maintenance of the instruments in the biology laboratory and establishment of a biology laboratory in a secondary education institution. The responses were on a 5-point Likert type scale, ranging from 5 (quite competent) to 1 (quite incompetent). In addition, by means of two open-ended questions, the students were asked if they considered themselves inadequate, and if they felt themselves inadequate, whether or not they had suggestions to overcome their inadequacy. The responses were analyzed by using content analysis procedures. The study results showed that pre-service teachers found themselves "partially competent" in "using effectively the instruments in the biology laboratory" and "teaching the subjects covering laboratory techniques and methods" ($\bar{x}=3.33$; $\bar{x}=3.29$, respectively). Moreover, a significant, positive relationship was found between pre-service teachers' scores on "using effectively the instruments in the biology laboratory" and "teaching the subjects covering laboratory techniques and methods" ($r=0.73$, $p=0.01$).

Key Words: Pre-Service Biology Teacher; Teacher Competencies; Biology Laboratory; Teacher Education.

INTRODUCTION

As a discipline of science, biology includes many concepts that have complex relationships with each other. Experiments and observations are two indispensable components that are necessary for shaping biology concepts and relating these concepts to each other. Therefore, experiments and observations, which are necessary information production tools for biology science, are also indispensable for biology education in all levels (Berck, 2001). In this scope and as a necessity of their profession, biology teachers have to

✉ Corresponding Author email: esins@hacettepe.edu.tr

develop not only methodological competencies related to experiments and observations but also competences related to the laboratory equipment used in implementing these methods. As a matter of fact, “teacher competence” can be defined as having the professional knowledge, skills and attitudes required for the performance of duties unique to teaching profession. “General Competencies for Teaching Profession” which is prepared by Ministry of National Education (MoNE) should be considered in the first place in terms of teacher competences (MoNE, 2006). “Learning and Teaching Process” is one of these competency areas and it includes some performance indicators such as “a competent teacher takes into consideration the usage principles of the related tools and materials while organizing the learning environment”, “takes measures to ensure safe use of tools and materials” and “ensures maintenance of course tools and materials, keeps them ready-to-use”. These performance indicators show that biology teachers are expected to have a sufficient level of knowledge and skills related to use of laboratory equipment. On the other hand, new curriculum reviewed within the scope of constructivist approach focus on the active participation of students in the course and underline student activities. Teachers are expected to be more active in guiding students and making more experiments and activities. This new approach raises the issue of “re-questioning the application-based skills and competences of teachers”. Due to its nature, biology is an area open for experiments and activities. For instance, it is sometimes possible to teach a subject by using only a microscope (Killermann & Rieger, 1996). Studies emphasize the importance of laboratory applications in not only biology but also in science education generally (Wenglinsky, 2000; Wenglinsky & Silverstein, 2007).

Studies on teacher effectiveness especially in laboratory applications have shown the problems faced by teachers and students. In Korkmaz’s (2000) study, it was investigated that the teachers who participated in the study were sufficient in half of the competencies related to laboratory applications. In another study by Köseoğlu and Soran (2004), biology teachers considered themselves partly sufficient in terms of using educational tools which required technical knowledge. Studies by Coştu, Ayas, Çalık, Ünal and Karataş (2005) and Hacıeminoğlu, Özgelen and Yılmaz-Tüzün (2008) have found that pre-service teachers felt themselves inadequate in terms of using laboratory tools. All of these studies indicate that there are problems in teachers’ and pre-service teachers’ self-competencies in regards to using laboratory tools. These studies also point at the need for interrogating and assessing the value of teacher education especially by focusing on to what extend the teacher education curriculum prepares pre-service teachers to teaching in laboratories. Hence, identifying biology pre-service teachers’ self-competencies in regards to laboratory applications is necessary in building onto the knowledge-base specific to the field of biology teaching.

The present study examined the perceptions of pre-service biology teachers about their competence in biology applications. The participants were selected among the students who took “general biology, systematic botany, plant morphology and anatomy, invertebrates, vertebrates, histology, parasitology and microbiology laboratory” courses throughout their university education. Having required competencies in biology applications and being well-equipped at the time of graduation is of great importance for pre-service biology teachers who will start professional life soon. The problem this study was based on was about the perception of pre-service teachers about their competence in biology applications after successfully graduating from the university.

METHODOLOGY

This study was conducted on pre-service biology teachers who have taken all application courses since the first year of the university. In total, 150 Hacettepe University

pre-service teachers participated in the study between the years of 2003-2007, each year with a different group of 30 pre-service teachers. The study was based on “teacher competencies” presented in the Secondary Education Biology Applications Guide prepared for biology teachers by Higher Education Council (YOK) and only “laboratory safety” component was added to these competencies (Ohlsson & Ergezen, 1997). Accordingly, by using the 61-item scale, students were asked how competent they found themselves as pre-service teachers in “using the instruments in the biology laboratory”, “teaching the subjects covering laboratory techniques and methods”, “ensuring maintenance of the instruments in the biology laboratory” and “establishing a biology laboratory in a secondary education institution”. The answers were grouped in a 5-point Likert type scale ranging from quite competent (five points) to incompetent (one point). Apart from the scale, the pre-service teachers were asked two open-ended questions, namely, “If you feel yourself inadequate in the skills necessary for conducting biology applications, what are the reasons behind this inadequacy?” and “What are the ways you suggest for acquiring these skills?” The responses of the students were evaluated by content analysis.

The relationship between pre-service teachers’ scores related to “using laboratory equipment” and “teaching the subjects covering laboratory techniques and methods” was determined by using Pearson correlation coefficient.

FINDINGS

This part presents the findings obtained from the competence scale administered to pre-service teachers to determine their self-competencies in biology applications. Scores on “using laboratory equipment” and “teaching subjects covering laboratory techniques and methods” are presented in Table 1 and Table 2, respectively.

Table 1. *Competence perception scores of pre-service teachers about “using laboratory equipment”*

Biology Laboratory Equipment	n	\bar{X}	SD
Microscope	150	4.71	0.54
Pipette	150	4.62	0.63
Thermometer	150	4.47	0.96
Scales (mechanical or electronic)	150	4.29	0.85
Tape measure	150	4.22	0.98
Burette	150	4.16	0.91
Spirit and Bunsen burner	150	3.74	1.02
pH meter and pH paper	150	3.57	1.30
Water bath	150	3.50	1.31
Dissecting set	150	3.19	1.25
Autoclave	150	3.10	1.07
Connecting and running tubes or air gas	150	3.10	1.27
Spring balance	150	2.96	1.45
Incubator	150	2.95	1.18
Volumetric flask	150	2.86	1.50
Barometer	150	2.75	1.24
Egg incubator	150	2.29	1.33
Distillation apparatus	150	2.12	1.09
Cutting and shaping glass rods and pipes	150	2.07	1.23
Total	150	3.33	0.60

Examining Table 1, it is observed that pre-service biology teachers found themselves most competent in using “microscope” among the instruments listed. It is also found that the pre-service teachers found themselves “quite competent” and “very competent” in using

laboratory equipment such as pipette, thermometer, scale, tape measure, buret and pH meter. Also, they found themselves “partially competent” in using the barometer, volumetric flask and spring balance. Pre-service teachers found themselves “barely competent” in using distillation apparatus and egg incubator. In general, pre-service teachers found themselves “partially competent” in using laboratory equipment.

Table 2. *Competence perception scores of pre-service teachers about “teaching subjects covering laboratory techniques and methods”*

Teaching of Laboratory techniques and methods	n	\bar{x}	SD
Cross-sectioning	150	4.27	0.76
Laboratory safety	150	4.15	1.05
Accurate measurement and weighing	150	4.10	0.89
Sterilization	150	3.95	0.99
Preparation of preparats	150	3.90	1.13
Culture medias	150	3.79	0.94
Simple microbiology	150	3.61	1.08
Biological staining	150	3.39	1.16
Preparation of sterile liquid	150	3.31	1.17
Preparation of permanent and temporary preparats	150	3.25	1.16
Chemical solution	150	3.25	1.07
Reservation of animals and plants	150	2.98	1.08
Use and storage of chemical substances	150	2.85	1.19
Serial dilution	150	2.66	1.19
Molar, percentage solutions	150	2.46	1.16
Simple embryological techniques	150	2.37	1.26
Chromatography	150	1.55	0.86
Total	150	3.29	0.64

Table 2 shows that pre-service teachers regarded themselves most competent in teaching the subjects of “cross-sectioning, laboratory safety and accurate measurement and weighting”. They found themselves “very competent” in teaching subjects of “sterilization, preparation of preparats, culture medias and simple microbiological techniques”. However, chromatography is the only subject pre-service teachers found themselves “incompetent” in teaching. Pre-service teachers found themselves “partially competent” in teaching the subjects of “biological staining, preparation of sterile liquid, preparation of permanent preparats, use and storage of chemical substances, serial dilution, molar and percentage solutions and simple embryonic techniques”.

Table 3 lists the results of the correlation analysis between the competence of pre-service teachers in “using laboratory equipment” and “teaching methods and techniques”.

Table 3. *The relationship between the competence perception of pre-service teachers about using laboratory equipment and about teaching laboratory methods and techniques*

	Laboratory Equipment	Teaching Laboratory Methods and Techniques
n	150	150
Mean	3.33	3.29
St. Deviation	0.60	0.64

$$r=0.73^{**}, ** p < 0.01$$

As can be seen in Table 3, a positive relationship (at significance level of 0.01) can be observed between the scores related with “using laboratory equipment” and the scores related

with “teaching students the laboratory methods and techniques”. Table 4 lists competence perception scores of pre-service biology teachers about “organizing living environments required for enabling some living things to survive and making some observations”.

Table 4. *Competence perceptions of pre-service biology teachers about organizing living environments*

Living environments	n	Mean	St. Deviation
Growing plants in a pot	150	4.32	0.89
Aquarium	150	3.67	1.25
Terrarium	150	1.83	1.13
Total	150	3.27	0.86

Table 4 shows that pre-service teachers found themselves “barely competent” in establishing a terrarium within the scope of the competence in organizing and maintaining some living environments to enable some observations; however, they found themselves “quite competent” in growing plants in a pot and “very competent” in building an aquarium. Table 5 lists the findings related with the competence of pre-service teachers in isolating some simple organisms from nature and reproducing them.

Table 5. *Competence perceptions of pre-service teachers about isolating from nature and reproducing some simple organisms*

Simple organisms	n	Mean	St. Deviation
Bacteria	150	3.21	1.16
Protozoa	150	3.18	1.22
Fungi	150	2.98	1.16
Algae	150	2.67	1.12
Total	150	3.01	0.95

As can be seen in Table 5, pre-service biology teachers found themselves “partially competent” in isolating some microscopic living beings such as the bacteria, protozoa, fungi and algae from nature and reproducing them.

Table 6 presents the findings related with the competencies of pre-service teachers in keeping some animal groups alive under laboratory conditions.

Table 6. *Competence perception of pre-service teachers about keeping some animal groups alive under laboratory conditions*

Animal groups	n	Mean	St. Deviation
Birds	150	3.36	1.32
Insects	150	3.07	1.33
Amphibians	150	2.76	1.28
Reptiles	150	2.75	1.29
Total	150	3.01	1.11

Table 6 reveals that pre-service biology teachers found themselves “partially competent” in keeping animal groups such as birds, insects, amphibians and reptiles alive under laboratory conditions.

The findings related with the perceptions of pre-service teachers about their competence in using teaching technologies are given in Table 7.

Table 7. *Perceptions of pre-service teachers about their competence in using teaching technologies*

Teaching technologies	n	Mean	St. Deviation
Overhead projectors	150	4.69	0.51
Video players-TV	150	4.51	0.78
Cameras	150	4.49	0.74
Cassette players	150	4.39	0.95
Computers	150	4.18	0.88
Slide machines	150	4.00	1.06
Total	150	4.38	0.56

As can be seen in Table 7, pre-service biology teachers found themselves “very competent” in using cameras, computers, overhead projectors, slide machines, cassette players, video players and television.

In addition, the study also revealed that pre-service teachers found themselves “very competent” in establishing a secondary education biology laboratory and in ensuring maintenance of the instruments in such laboratory ($\bar{x}=3.66$; $\bar{x}=3.73$, respectively).

Table 8. *The reasons reported by pre-service teachers for feeling inadequate in biology applications (n=150)*

Main Reasons	Sub-reasons	f	%
Physical reasons	Deficient, defective equipment	70	47
	Inadequate laboratory capacity and physical conditions	19	13
	Lack of branch laboratory	2	1
	The frequency of physical reasons	74	49
Instructional reasons	Lack of adequate application (theoretical courses)	70	47
	Impossibility of conducting personal applications (the students are not allowed to use the equipments)	45	30
	The content and inadequacy of laboratory courses	22	15
	Inadequate number of laboratory lessons	17	11
	Inadequate number of the teaching staff	6	4
	Exam-oriented lessons which encourages memorization	2	1
	Education in foreign language	5	3
	The frequency of instructional reasons	120	80
Personal reasons	Lack of interest, inadequate studying habits, lack of enough effort	15	10
	Exam-oriented studying	4	3
	The frequency of personal reasons	18	12

The responses of the pre-service teachers to the first open-ended question inquiring the reason behind their failure in acquiring the necessary skills for biology applications are given in Table 8 under three main categories.

When the responses of the pre-service teachers were analyzed it was found that they reported three main titles “Physical reasons”, “Instructional reasons” and “Personal reasons” respectively. The analyses of pre-service teachers’ response revealed that 80% of them considered instructional reasons as an important factor affecting their inability in acquiring necessary skills in biology applications. It was also found that 49% of them felt inadequate in laboratory skills due to physical reasons and 12% of them felt inadequate in laboratory skills due to personal reasons.

Table 9 shows pre-service teachers’ suggestions for acquiring the skills required for biology applications.

Table 9. *The suggestions of pre-service teachers for improving biology applications (n=150)*

Suggestions	f	%
Deficient and insufficient equipment should be eliminated	71	49
Capacity of the laboratory should be increased and physical conditions should be improved	33	23
Living material should be provided (sample animals)	4	3
Students should be allowed to conduct applications and use the equipments	58	40
Exemplary applications should be made in laboratory lessons	54	38
Hours of laboratory lessons should be increased	22	15
Content of laboratory lessons should be improved	13	9
Teaching staff should be better educated	10	7
New laboratory courses should be added	8	6
Instruction should be given in Turkish	5	4
Lessons should not be exam-oriented	3	2
Exams should be practical	2	1
Instructors should be more helpful in utilization of equipments	1	1
Number of teaching staff should be increased	1	1
Laboratory brochures should be prepared	1	1
Teaching staff should pay necessary attention to laboratory lessons	1	1
Students should study harder and should show more interest	6	4
Students should actively participate in laboratory activities	1	1
Excursions and field trips should be organized	3	2
Laboratory-oriented projects should be carried out	2	1
Students should be allowed to use the laboratory in addition to their lab lessons	4	3

Suggestions of the pre-service teachers for acquiring necessary skills for biology applications show that 40% of them would like to have the opportunity to use the laboratory on their own, 38% reported that they would like necessary applications to be carried out in laboratory lessons and 22% want the number of laboratory lessons to be increased. Nine percent of the pre-service teachers reported that they would like the content of laboratory lessons to be improved, 7% would like the teaching staff to be more educated and 6% would like new laboratory courses to be put into the curriculum. Lower number of them claim that the exams should be practical, instructors should be more helpful in utilization of equipments, the number of teaching staff should be increased, a laboratory brochure should be prepared and the pre-service teachers should be allowed to use the laboratory in addition to their lab courses.

DISCUSSION AND CONCLUSION

According to the findings obtained from the study, the participants found themselves “partially competent” or “barely competent” in using half of the instruments in a biology laboratory of a secondary education institution. Similarly, another study on the examination of the competencies of pre-service teachers in using laboratory equipment and applications within science education showed that pre-service teachers could develop only half of the required competencies (Korkmaz, 2000). Moreover, the study conducted by Köseoğlu and Soran (2004) on biology teachers employed in Ankara Province revealed that teachers found themselves “partially competent” or “barely competent” in using laboratory equipment. In another study on the competencies of pre-service science teachers in using laboratory equipment for the right purposes and in the right manner, it was found out that pre-service teachers had wrong or imperfect information and they were not competent in using laboratory equipment for the right purposes and in the right manner (Costu, Ayas, Çalık, Ünal & Karataş, 2005). A study conducted on pre-service science teachers measured the interest and motivation of pre-service teachers towards science laboratory by using “science laboratory

environment inventory” and showed that pre-service teachers had low level of competence in using laboratory equipment ($\bar{x}=2.82$) (Hacıeminoğlu, Özgelen & Yılmaz-Tüzün, 2008).

The present study showed that pre-service teachers found themselves “partially competent” in teaching various laboratory methods and techniques. Taking into consideration the possibility that this result may be related to the results about the use of laboratory equipment; the relationship between the competence of pre-service teachers in using laboratory equipment and their competence in teaching laboratory techniques was examined and a positive relationship (at the significance level of 0.001 ($r=0.73$)) was determined (Table 3). Taking this relationship as the basis, it can be suggested that pre-service teachers should be quite competent in using laboratory equipment in teaching methods and techniques of biology applications to students in an effective manner.

Relevant studies underline the importance of laboratories in science education. In the study conducted by Killermann and Rieger (1996), teaching via microscope was compared with teaching via video player. Nearly 80% of the students who have participated in that study preferred microscope to video player and students who were taught the subject with the help of a microscope were found to be significantly more successful in understanding the content than those who were taught with the help of a video recorder. In his study, Wenglinsky (2000) discovered that students educated by the teachers competent in laboratory-related issues, giving applied courses and using teaching technologies were more successful than the students educated by teachers lacking such features. On the other hand, it was revealed that the students of the teachers who took laboratory courses in universities for their professional development were more successful at the end of academic year and participated in the science projects and organizations more frequently than the students of those teachers who did not take such courses (Wenglinsky & Silverstein, 2007). In another study conducted on two groups of elementary teachers trained according to two different education programs, the teachers in the group who have taken applied science education were found to have significantly higher self-efficacy in teaching science course than the teachers in the group which did not (Andersen, Evans, Dragsted & Sørensen, 2006).

In this study, it was determined that pre-service teachers found themselves “very competent” in using teaching technologies. Such a positive result points out to the possibility that pre-service teachers made used of these instruments during their university education. On the other hand, pre-service teachers may have gained experience in using some of these instruments owing to out-of-school applications. Unlike the pre-service teachers included in the present study, a study conducted on biology teachers showed that teachers found themselves incompetent in using teaching technologies (Köseoğlu & Soran, 2004). It shows that, as technology continuously develops and changes, teachers did not deem themselves competent by only depending on the pre-service education they received and they were in need of more trainings. A study conducted on biology teachers about teachers’ expectations put forward that most of the teachers needed in-service training on innovations about both instruments and the content (Altunoğlu & Atav, 2005).

The analyses of responses to the two open-ended questions showed that the pre-service teachers felt inadequate in laboratory applications due to instructional (80%) and equipment-related (47%) reasons. It was also found that among instructional inadequacies, the pre-service teachers emphasized that laboratory lessons did not involve enough applications, the lessons involved theoretical information and the students were not allowed to conduct applications on their own. In addition, the pre-service teachers reported that inadequate content of laboratory lessons, low number of laboratory lessons, inadequacy of the teaching staff in terms of knowledge or skills and the lack of a laboratory brochure for many laboratory lessons were the other problems to be solved. It was found that, deficient and defective equipment and material, deficient laboratory capacity and inadequate physical conditions and

lack of branch laboratories were among other physical inadequacies. Similarly, in another study carried out on pre-service primary education teachers it was found that the pre-service teachers wanted to conduct applications on their own; the number of laboratory lessons to be increased and laboratory lessons to fully involve application (Küçükyılmaz & Duban, 2006). In another study carried out on pre-service chemistry teachers, the students had negative thoughts on physical conditions of the laboratory and the content of laboratory books (İlhan, Sadi, Yıldırım & Bulut, 2009).

It can be stated that the most important reasons causing pre-service biology teachers' feeling inadequate in utilizing the equipments is their inability of making sufficient applications in laboratory lessons, theoretical laboratory lessons and quantitative and qualitative deficiency of laboratory equipments.

When the suggestions of the pre-service biology teachers were analyzed it was found that the majority of them reported that laboratory lessons should involve applications and that the inadequacy of laboratory equipments should be eliminated. This indicates that basic problems that should have been solved long ago are still prevalent today. Other significant suggestions of the pre-service teachers include allowing them to conduct experiments on their own, improving the content of laboratory lessons, increasing the number of laboratory lessons, making laboratory-oriented project studies and opening the laboratory to the students apart from lessons. The fact that suggestions are reported by lower number of the pre-service teachers indicates that the above mentioned basic problems remain to be solved.

It is clear that this feeling of inadequacy held by pre-service students will affect their students when they start teaching in their future contexts. Studies indicate that the characteristics of the teachers have an impact on academic achievement of their students which is more significant than other known factors (Sanders & Horn, 1994; Wright, Horn & Sanders, 1997; Kukla-Acevedo, 2009). For this reason, the most important problem to be solved in education policies is that more student-centered classroom should be targeted which attach importance to scientific processes by educating individuals who inquire and discover and who acquire laboratory application skills during their educational lives.

As revealed in this and previous studies, existence of teachers and pre-service teachers who find themselves incompetent in biology and science applications may be an indicator of the deficiencies resulting from the pre-service teacher education. To eliminate such insufficiencies, pre-service teacher education institutions should be reviewed particularly in terms of their application components.

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