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An Evaluation of Integrated Approach for Developing Laboratory Application Skills of Physics Pre-Service Teachers

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Abstract

The purpose of this research is to improve and evaluate a different approach to develop the lab application skills of the physics pre-service teachers in the courses of Secondary Physics Experimental Design (SPED), School Experience (SE) and Teaching Practices (TP). In this context, action research was used to achieve the purpose of the research. The research carried out with 20 pre-service physics teachers studying in the 5th grade of a Northern University in Türkiye in the academic year of 2015-2016 and 2016-2017. Physics pre-service teachers implemented micro-teaching applications for the lab applications in the SPED course, practiced applications in the schools within the SE course in the fall semester and reinforced the lab skills in the TP course in the spring semester. Implemented activities carried out the applications significantly contributed to the development of the lab methods' application skills of the physics pre-service teachers.

Keywords: Physics pre-service teachers, Lab methods, Physics experiment design in secondary school, School experience, Teaching practice.

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Introduction

Today, the developments in science and technology have a great impact on the life of the individual and society, and this leads to the need for a change in human nature. Teachers play crucial roles in raising individuals who will adapt to the targeted change and development in society. The quality of a teacher is the most important factor regarding the success of the educational activity (Büyükkaragöz, Muşta, Yılmaz, & Pilten, 1998). Today, teacher competencies are evaluated in terms of subject matter, pedagogical, and general knowledge (Özden, 2017; Sağlam, 2011). Teacher training and development are generally examined under two headings: pre-service training and in-service training. In pre-service education programs, teacher candidates are supposed to acquire knowledge, skills, attitudes and values which are necessary for their profession. In this regard, three dimensions, subject matter, pedagogical knowledge on how to teach subject matter, and general knowledge are vital in pre-service teacher education process. Since teaching practices act as a bridge between theory and practice, the teaching activities of pre-service teachers in practicum schools have special importance in the pre-service teacher education process (Görgen, Çok Çalışkan, & Korkut, 2012). Teaching practices course is taught within a 14-week (minimum 12-week) program. Each week consists of two-hour class in the faculty and six hours in practicum schools (in those affiliated with the Ministry of National Education). Teaching practice is a course that provides pre-service teachers with teaching skills in their subject matter regarding the levels of students in the practicum schools. It enables them to teach a specific course or lesson in an organized manner, in an environment where practical activities are discussed and evaluated (Özenç, 2014). During the course, pre-service teachers have the opportunity to observe and question themselves as teachers-in-practice with the intent to realize and overcome their deficiencies (Poulou, 2007; Wagler, 2007). Field-based experiences have always been an indispensable part of teacher training programs (Barnes, 2010; Conderman, Morin, & Stephens, 2005). Conducting the teaching practice course is very important to train qualified teachers. (Baran, Yaşar, & Maskan, 2015). Besides, mentor teachers play a major role in the professional skill development of pre-service teachers through the activities carried out in teaching practice courses (Schwille, 2008). Teaching practices in practicum schools have positive contributions to teacher education and development (Beck & Kosnik, 2002; Brooks, 2006).

Two important aspects of the pre-service education process, which forms the basis of teacher education, are the practical courses, that provide the necessary theoretical knowledge for the teaching profession. In this context, laboratory practices have special importance in teaching physics as it is an application-based discipline (Hofstein ve Lunetta, 2004; Taitelbaum, Mamlok-Naaman, Carmeli & Hofstein, 2008). The students of physics consider laboratory activities more lively and profitable (Cerini, Murray & Reiss, 2003). Laboratory practice, the most frequently used method in physics education, is significant as it provides permanent learning by focusing on mental activities and allowing students to work individually or in groups (Staeck, 1995). Laboratory applications have contributed to the main objectives of physics education for more than a century, such as improving students' understanding of physics concepts and applications, providing problem-solving and scientific thinking skills, enabling them to understand how science and scientists work, and increasing their interest and motivation (Hofstein & Naaman, 2007 Taitelbaum, Naaman, Carmeli & Hofstein, 2008). In this regard, laboratory teaching methods have several positive effects on student learning such as developing reasoning, critical thinking, scientific perspective, and problem-solving skills (Hofstein ve Naaman, 2007). However, some factors like lack of planning in laboratory practices (Backus, 2005), low interest (Cheung, 2007), insufficient knowledge and skills (Furtak, 2006; Singer, Hilton & Schweingruber, 2005) caused teachers to be insufficient regarding practice. Besides, it has been observed that teachers do not consider themselves competent in laboratory applications (Böyük, Demir & Erol, 2010; Güneş, Şener, Topal Germi, & Can, 2013) and that they cannot perform laboratory applications as expected (Akkuş & Kadayıfçı, 2007, Çepni, Kaya and Küçük, 2005) although they are aware of the importance of laboratory applications in physics teaching. Similarly, it is demonstrated that pre-service physics teachers cannot acquire the necessary equipment, theoretical knowledge, and practical skills at the desired level due to reasons such as the inconvenience of laboratory environments during their pre-service training and the fact that the instructors conducting laboratory applications are not experts in the relevant field or do not give the necessary importance to laboratory lessons (Şahin, 2001). The knowledge, skills, and attitudes that are aimed to be acquired by students through laboratory studies are directly proportional to the knowledge, skills, and attitudes of teachers (Kaya & Böyük, 2011). Insufficient pre-service training of teachers for laboratory applications was shown as an important reason why teachers feel insufficient for laboratory practices and therefore do not include laboratory activities in their lessons (Kılıç, Keleş, & Uzun, 2015; Roehrig & Luft, 2004). In this regard, it is pointed out that teachers do not receive sufficient training on laboratory practices in pre-service teacher education processes (Böyük, Demir & Erol, 2010; Cheung, 2007; Uluçınar, Cansaran, & Karaca, 2004; Wilkinson & Ward, 1997; Chin & amp; Chia, 2006; Howit, 2007; Zion, Cohen & Amir, 2007; Domin, 2007; Mc Donnell, O'Connor, & Seery, 2007; Kocakulah & Savas, 2011; Hard Chips, İnce Aka & Kayacan, 2016). Also, it is emphasized that the differences between the laboratory activities of the teachers in the pre-service teacher education processes and the laboratory activities in the secondary education program cause them to feel inadequate (Akdeniz, Cepni, & Azar, 1998; Nakiboğlu & Sarıkaya, 2000). Regarding this, it is noted that physics pre-service teachers cannot educate themselves about performing laboratory applications in the targeted quality (Singer, Hilton & Schweingruber, 2005). Pre-service teachers acquire contemporary teaching approaches through the lessons and practices they take in the pre-service teacher education process, and teachers acquire these approaches only through in-service training programs to be organized in the in-service teacher education process (Demir, Böyük, & Erol, 2012). This situation makes it necessary to organize teacher training programs to improve pre-service teachers' self-confidence and skills such as using the laboratory effectively, designing experiments, and applying designed experiments (Diesterhaft & Jaus, 1997).

In the pre-service teacher education process, physics pre-service teachers gain experience in applying the theoretical knowledge they have learned in faculty in a real school environment in SE and TP courses. SE is a learning process designed to teach pre-service teachers components of the school, students, teachers while teaching practice provides the opportunity to apply the theoretical knowledge learned by pre-service teachers. In this process, pre-service teachers reinforce the professional skills acquired, and design students and self-assessment and teaching environment (Poulou, 2007). In this context, in the pre-service teacher education process, physics pre-service teachers have the opportunity to apply the laboratory methods related to designing and executing the teaching environment in the application schools in the SPED and then in the SE and TP courses. Hence, implementing more teaching practice in the pre-service teacher education process is essential to improve pre-service teachers' skills regarding the acquaintance with different laboratory methods. This situation necessitates pre-service teachers's preparation in practice and internalization of a variety of laboratory methods during pre-service teacher education. Therefore, It is a must to develop and evaluate the different methods for improving teachers' skills in laboratory methods (Saka, 2004).

Purpose

The main purpose of this research is to develop and evaluate a different approach to enhance skills in laboratory methods of physics pre-service teachers in the course process of SPED, SE, and TP during the physics pre-service teacher education.

Methodology

This section includes the study design, study group, data collection process, data collection tools, and data analysis. Since the scope of this research requires the collection and analysis of quantitative and qualitative data, the mixed method was used (Creswell, 2006). In this context, it is collected quantitative data with the survey and qualitative data with the semi-structured interviews.

Study Design

The research was conducted within the scope of practical action research, which aims to provide practitioners with new knowledge, skills, and experiences. In this type of research, practitioners are expected to critical of their practices (Yıldırım & Şimşek, 2008). The researchers participated in the practices and collected systematic data for the solution and analyzed the problems they detected. In this context, data were collected using questionnaires and interviewing methods.

Sample

The research consisted of 20 pre-service physics teachers (6 males+14 females) attending the 5th-grade courses of SPED, SE, and TP in the Physics Teaching Program of a Northern University in Türkiye in-springs semesters of 2015-2016 and 2016-2017 academic years.

Data Collection Tools and Analysis of Data

Data were collected through semi-structured interviews conducted with pre-service teachers before and after the SPED, SE and TP. In the first phase of the study, the researchers developed the SPED questionnaire which was applied to 20 physics pre-service teachers before and after the SPED course, to determine the opinions of the physics pre-service teachers about the efficacy of the applied laboratory methods. In the second phase of the study, the same questionnaire was applied after the SE and TP courses to determine the levels of laboratory methods of physics pre-service teachers. At the end of the third stage, the survey data collected before and after SPED course as well the one's after SE course and TP course were compared in terms of pre-service teachers' levels of physics laboratory methods application. In this regard, pre-service teachers evaluated themselves in terms of developing their skills in different laboratory methods. At this stage, within the scope of the approach applied in the first dimension, the laboratory approaches, methods, and techniques used by the candidates were listed, and the opinions about the application levels of the relevant methods before and after the practice in the other dimension were examined by a 5-point grading criterion (completely: 5, mostly: 4, partially: 3, very little: 2, none: 1). The obtained questionnaire data were analyzed according to their average values and the interview data were examined considering their level of expression.

Application Process

The following steps were followed in the implementation of the research: To determine the effect of the applications, the opinions of the physics pre-service teachers on the level of application of laboratory methods and at the beginning of the process were determined. In this context, the research has been carried out in three stages:

First Stage (SPED Course Process):

The instructor who carried out the course provided theoretical information about the methods of Physics Laboratory Methods within the scope of SPED course to the physics pre-service teachers. He presented experimental activity plan and application examples and distributed the results in the physics teaching program to the three-person groups. Each of the group member was responsible for choosing a different laboratory method and preparing an activity plan that will be suitable for the group's gains included in the physics curriculum. The group members implemented their activity plans in the laboratory in 20-25 minutes. At the end of the applications of pre-service teachers in the same group, each physics pre-service teacher was asked to evaluate his/her own practice first, and then to evaluate his/her peers in the same group in terms of "gains-method suitability" in the laboratory environment. In addition, during the evaluation phase, their peers examined the application of each group at the end of the applications and selected methods and the level of efficacy of the methods according to the gains. Thus, the group members were given the opportunity to examine the level of influence in practices of different laboratory methods by taking the same gains into consideration. However, video recordings made during the applications of the group members were given to the physics pre-service teachers at the end of the application. In this way, it is aimed to provide the opportunity of the physics pre-service teachers to develop their strengths and weaknesses related to the physics laboratory activity practices realized in micro teaching applications for physics laboratory applications until the next applications by perceiving the features they need to develop effectively. The survey was conducted at the beginning of the research process, and at the end of the SPED course, it was re-applied to determine the levels of physics pre-service teachers in order to apply laboratory methods.

Second Stage (SE Course Process):

Physics pre-service teachers were asked to reapply the skills gained in physics laboratory methods after micro-teaching methods in SPED course, within the scope of the school experience they received during the same period in the application schools in the real school environment. Thus, it was tried to ensure that the physics pre-service teachers integrate and reinforce the skills they gained in SPED course by applying them in real school environments. In addition, the applications of the physics pre-service teachers in this process were evaluated by the physics pre-service teachers, their peers who participated in the applications in the SE course. Thus, both self-evaluation and peer evaluation were tried to be provided for the physics pre-service teachers in terms of the level of developing their skills in implementing laboratory methods. The survey applied at the beginning of the research process was repeated at the end of the SE course in order to determine the level of the physics pre-service teachers' ability to apply laboratory methods.

Third Stage (TP Course Process):

In the TP course, physics pre-service teachers were expected to achieve skills for laboratory methods at the desired level in a more comprehensive application in the real school environment. In addition, the applications of the pre-service teachers in this process were evaluated by themselves and their peers, who participated in the applications in the TP course. Thus, both self-evaluation and peer evaluation were tried to be provided for the pre-service teachers in terms of the level of developing their skills in implementing laboratory methods. The survey was conducted at the beginning of the research process, at the end of the SPED course, SE course and the TP course. By this way, the whole research process was compared with the level of efficacy of the physics pre-service teachers' skills development in laboratory methods.

Findings

The effects of the applications carried out within the scope of the research on the laboratory techniques of physics pre-service teachers. The SPED-SE and TP courses are organized based on the questionnaires and semi-structured interview results applied to the physics pre-service teachers in the pre and post-processes.

Survey Findings

Mean values regarding preservice teachers' views about the level of skills development before and after SPED course, after SE and TP course are given in Table 1.

Table 1. Mean values of the physics pre-service teachers' views on the levels of laboratory application' before and after SPED course, after SE course and after TP course

Laboratory Methods	Before SPED Course	After SPED Course	After SE Course	After TP Course
	Mean	Mean	Mean	Mean
Induction	2.15	4.45	4.05	4.35
Deduction	2.20	4.50	4.10	4.35
Demonstration	2.40	4.70	4.00	4.40
POE	2.70	4.80	3.95	4.50
Simple Course Tools	2.35	4.80	4.15	4.55
Station	1.95	4.80	4.10	4.60
Worksheet	3.60	4.80	4.25	4.70
Hypothesis Testing	1.45	2.95	2.10	1.95
Research Based App.	1.35	2.45	1.70	1.95

As shown in Figure 1; Prior to the SPED course, physics pre-service teacher: POE (2.70), show (2.40), simple tools (2.35) think that laboratory methods can be applied at the highest level, whereas research-based methods (1.35) and hypothesis testing (1.45) think that laboratory methods can be applied at the lowest level. After the of SPED course, physics pre-service teachers: station (1.95-4.80), worksheet (3.60-4.80) simple course tools (2.35-4.80), deduction (2.20-4.50), induction (2.15-4.45) and demonstration (2.40-4.70) think that they have greatly improved their application skills, but POE (2.70-4.80), hypothesis testing (1.45-4.80), research-based approach (1.35-2.95) think that they have improved their application skills significantly. Following the SE course, there was a partial decrease in the methods of: deduction (4.50-4.10), induction (4.45-4.05), demonstration (4.70-4.00), simple course tools (4.80-4.15), station (4.80-4.10) and worksheet (4.80-4.25), POE (4.80-3.95), hypothesis testing (4.80-2.10) and research based approach (2.95-1.70).

After the TP course, physics pre-service teachers: POE (3.95-4.50), station (4.10-4.60), worksheet (4.25-4.70), simple course tools (4.15-4.55), and demonstration (4.00-4.40) although they think the levels of application of the methods increased, induction (4.05-4.35) deduction (4.10-4.35), research-based approach (1.70-1.95) hypothesis testing (2.10-1.95) the method is thought to be less applicability after school experience, while the application of TP after the course has decreased significantly. The mean values of the physics pre-service teachers' views on laboratory methods' application levels before and after SPED course, after SE course and after TP course are given in Figure 1.

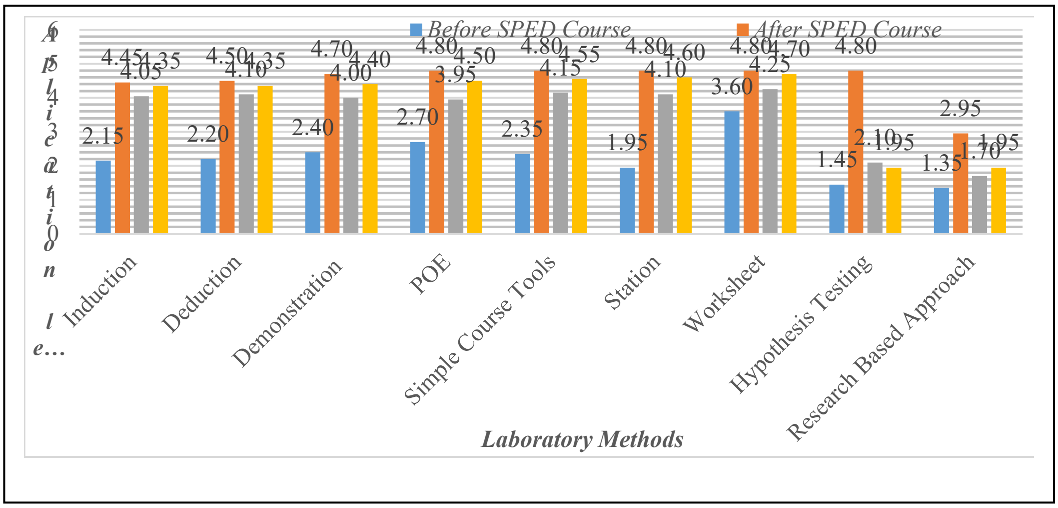

Figure 1. The average mean values of the physics pre-service teachers' views on laboratory methods' application levels before and after SPED course, after SE course and after TP course [Color online.]

When the applications of three courses conducted within the scope of the research are fully evaluated; although, before and after the SPED course, physics pre-service teachers thought that they had significantly developed their ability to apply laboratory methods, they realized that they had a lower level of application skills at the end of the applications in the real school environment. After the TP course, it was observed that the applicability of laboratory methods in schools increased. When the process between the beginning and the end of the research was examined, the highest development was in the station method (1.95-4.60) while the lowest development in the station method (1.45-1.95) and the research based approach (1.35-1.95) in the station method (Figure 1). General evaluation for the SPED, SE and TP courses in the form of sequential applications within the context of integrated approach reveal that it has significantly contributed to the development on the application skills of the laboratory methods of physics pre-service teachers (Table1, Figure 1).

Interview Findings

Within the scope of the research, here are some examples of semi-structured interviews (K2 and K7 coded physics pre-service teachers) with the aim of determining the views of the applications of the SPED course on the effect of SE and TP on:

K2-SPED: *"The applicability of laboratory approaches varies according to the situation of schools. Because the sheer number of classrooms in the real school environment does not have enough material, the size of the classroom-small size can prevent implementation. I couldn't see how I would behave in crowded classrooms in video recordings because the people in the classroom were scarce and they didn't reflect the truth because we didn't address the same level of Education."*

K2-SE: *"Before I took the experimental design course, I knew about most laboratory methods. With the experimental design course, I learned laboratory methods and applied them in my SE, and learned how to bring the path of discovery to an effective learning level. He's a big contributor to this floating. The principles and stages can be partially ordered. Although we can do this in experimental design, the applicability of this is lower whether it is a SE or a TP. Because we have a lot of people and we have a lot of time. When I observed my friends again, I saw the difficulty of class domination, the tone of voice and the importance of field knowledge."*

K2-TP: *"When I applied the laboratory methods I learned in experimental design within the context of SE and TP lessons, I encountered great differences. For example, in experimental design, I found that I could not fit the station method for twenty minutes in a real school environment in the course of teaching practice. I further developed myself when I applied the knowledge that existed in theory. When classroom management was easy in experimental design, I saw the difficulty of classroom management in the real school environment and I observed that theory and practice were different. The principles and stages cannot be fully applied. Because, as our time is limited, when we extend the event for a long time, we will encounter the problem of raising the program. Maybe this experience can develop even more when we do a lot of practice in the name of teaching."*

K7-SPED: *"While taking the SPED course, we have prepared materials before applying the applications in the classroom environment, after confirming the applicability of the teacher before the course, the positive negative aspects of the teacher gave us more persistence."*

K7-SE: *"Observing the practice of our friends in the SE course has made us aware of what we are doing and what we need to be aware of. I have a pre-knowledge of any problem encountered in the application and I have learned how to overcome it when we encounter any problem."*

K7-TP: *"We tried to apply the methods that we learned in experimental transport in a real school environment, and we observed that the practices we learned in experimental design were inadequate, which means that they reflect the truth. Because in SE and TP, we have encountered even more different situations in the real school environment."*

As seen, it was observed that although the execution of the practices carried out in SPED course in the face of their peers contributes theoretically to the application of the laboratory methods, the development of the laboratory methods contributed to the development of the application levels at a limited level. SPED applications of physics pre-service teachers in the course did not reflect the actual school environment because of their practice against their peers and did not have enough time to practice and because the age groups addressed were different. They stated that the SPED course was insufficient because the peers did not have feedback in the activities and they had problems in the management of class and time. To overcome this inadequacy, pre-service teachers were more realistic than the micro teaching applications they carried out in the SPED course, by monitoring and evaluating the practices of other laboratory students about the physics laboratory methods. Because they can perceive the deficiencies and to realize more effective applications within the scope of SE and TP courses, especially in the application schools, has a significant development on the of application skills of physics laboratory methods as they provide the transfer of theoretical knowledge to practice in real school environment.

Discussion

In the research, pre-service physics teachers pointed out that they developed their skills by learning the theoretical principles of laboratory methods within the scope of the SPED course during the pre-service teacher education process. On the other hand, when process before and after the SPED course was considered it was observed that they realized that their application skills in the real school environment were partially at lower levels although they thought that pre-service physics teachers had significantly improved their ability to apply laboratory methods regarding the SE course. Pre-service physics teachers stated that the classroom did not reflect the real school environment in the applications carried out within the scope of the SPED course and they had difficulty in getting the desired level of feedback from their peers during the applications because of inadequate time and classroom management. Similarly, when the literature was examined, it was revealed that pre-service physics teachers did not receive sufficient training to use laboratory methods within the process of their university education (Demir, Böyük & Koç, 2011; Akıncı, Uzun & Kışoğlu, 2015) and often had difficulties in designing and conducting experimental activities (Kocaküllah & Savaş, 2011; Backus, 2005; Booth, 2001). It was also emphasized that pre-service physics teachers had problems with time (Backus, 2005) and classroom management (Deters, 2005; Cheung, 2007) in the application of laboratory methods. Considering these situations, it can be stated that although the SPED course was significantly effective on the theoretical dimension of physics laboratory methods, it contributes to the development of the ability of pre-service physics teachers to apply laboratory methods at a limited level.

In the second dimension of the applications they conducted within the scope of the SPED course, pre-service physics teachers applied the laboratory methods for providing the opportunity for them to perceive the deficiencies more effectively in the real school environments in the application schools during the SE course. At this stage, pre-service physics teachers had the opportunity to comprehend deficiencies and considerations in the application process of laboratory methods and at the same time to put into practice more effective applications. When the pre-service physics teachers observed and evaluated the practices of their peers' physics laboratory methods in SE course, applications were more realistic and efficient than those carried out in the SPED course. It can be said that this process helps pre-service teachers to have their first experiences in a real school environment, improves their deficiencies, and make them learn how to perform physics laboratory applications. In this regard, the practical courses given in education faculties have a significant effect on the professional development of pre-service teachers (Kavcar, 2002; Görgen, ÇokÇalışkan & Korkut, 2012; Güler & Tuncel, 2023). On the other hand, it is stated that teachers do not want to include laboratory activities in their lessons due to their lack of knowledge, skills, and experience (Aydoğdu, 1999; Güneş, Şener, Topal Germi, & Can, 2013; Uluçınar, Cansaran, & Karaca, 2004). It is stated that pre-service teachers also have problems in designing and applying experiments (Böyük, Demir & Erol, 2010; Yalın, 2001). They have difficulties due to the lack of knowledge and self-confidence with regards to the application of laboratory methods (Kocakülah & Savaş, 2011; Şeker, Yalçın, & Yurdanur Altunay, 2006; Cheung, 2007; Brown, Abell, Demir & Schmidt, 2006). These situations are thought to result from the lack of applied training for pre-service teachers on laboratory methods during their university education (Akkuzu Güven & Uyulgan, 2022; Öztaş & Özay, 2004). The fact that the pre-preparatory course for TP and the pre-service teachers' had first experiences and their learning how to teach a lesson led the teachers to transfer their theoretical knowledge on the laboratory methods to the practice and led them to be more confident. The applications carried out in SE and TP courses proved more efficient than the applications in the SPED course as pre-service physics teachers have the opportunity to comprehend things to pay attention and deficiencies that need to be considered in the process of the application of laboratory methods, and they were able to perform more effective applications.

When the process between the beginning and the end of the research is examined regarding the pre-service teachers the highest level of development of laboratory methods in terms of the development of skills is in the station method (1.95-4.60), the lowest level of hypothesis testing (1.45-1.95) and research-based approach (1.35-1.95) (Figure1). When the literature is examined, it is understood that teachers include hypothesis-based laboratory activities at the lowest level in their physics lessons (Welch, Klopfer, Aikenhead & Robinson 1981) and they generally use laboratory activities for demonstration or verification (Wilkinson & Ward, 1997). The fact that physics pre-service teachers develop at the highest level in the station method necessitates the inclusion of different dimensions of the activity in the stations formed in a staged structure. On the other hand, because research-based approach and hypothesis testing methods are developed in a minimum level according to other laboratory methods and the applications of these methods require a time-consuming course outside the course, can explain their inability to win. Since pre-service teachers have developed their research-based approach and hypothesis testing methods at the lowest level compared to other laboratory methods, and the application of these methods requires a time-consuming process outside of the classroom, the pre-service physics teachers have not gained application experience from these methods at a sufficient level in real teaching contexts within the scope of SE and TP courses. It is emphasized that TP serves as a bridge between theory and practice, allowing pre-service teachers to recognize classroom atmosphere in a real school environment and to communicate directly with students (Beck & Cosnik, 2002; Brooks, 2006; Uluay, 2021). Physics pre-service teachers point out that SE and TP courses contribute to the development of vocational skills related to the preparation of the course, the planning of the course and the application of the methods (Hascher, Cocard & Moser, 2004). In this process, it is emphasized that pre-service teachers contribute to the participation of students, students to get to know each other, and to develop the application of laboratory methods in creating different alternatives for different situations by giving them the opportunity to peer assessment in the process of the application of different laboratory methods (Saka, 2012). It is stated that teachers should improve some of their competencies to apply different laboratory methods in the targeted quality. These competencies are stated as having the necessary knowledge about the application principles of different laboratory methods, choosing the most effective laboratory method, and applying different laboratory methods for the gains in the curriculum (Bedweel, Hunt, Touzel & Wisaman, 1991). It is emphasized that this process is an inspiration for the pre-service teachers to develop laboratory skills in terms of providing different alternatives for all kinds of situations and reflections by providing the opportunity for teacher participation, recognition of student relations, and application of different laboratory methods (Saka, 2012). However, it was observed that the applications carried out within the scope of SPED, SE and TP courses was carried out with a consecutive application with integrated approach, and that the physics pre-service teachers contribute to the development of the skills of applying the laboratory methods (Table 1, Figure 1). In addition, the practices carried out in this research contributed to the professional development of pre-service physics teachers for the application of laboratory methods by increasing their skills of preparing an experiment activity plan, designing experimental setup, planning and application levels of them. The application process of the research also enables pre-service physics teachers to develop their skills in applying different laboratory methods. Similarly, when the literature is examined, it can be seen that pre-service teachers develop their ability to apply laboratory methods and gain professional experience as a result of designing experiments and making applications (Akkuzu Güven & Uyulgan, 2022; Dinçol Özgür, Odabaşı & Erdoğan, 2017; Kocakülah & Savaş, 2011). In this context, it is indicated that teachers need to have an approach to integrate the principle of professional development in the process of the teaching process. However, the reflective practitioner has crucial importance on raising interest in relation to elaborate practice teaching in laboratory classrooms to emerge an interactional profitable climate (Chitpin, 2006).

Conclusion and Suggestions

Regarding the SPED course, the theoretical information of the laboratory methods in the faculty was made, and it was stated that the practical applications of the physics pre-service teachers was evaluated by their teachers and they were attempted to be developed with micro-teaching applications, and the pre-service teachers had the opportunity to see their deficiencies and gain different opinions. It was seen that the physics pre-service teachers’ practice of micro-teaching in the laboratory environment in their SPED course gives practicality to the applications in the real school environment. At the same time, in the practices carried out in the SPED course, it was observed that the pre-service physics teachers could not experience the real school environment and did not have the desired level of feedback from the activities they perform. They also had problems in classroom management and time management. Therefore, it can be stated that the SPED course was insufficient in developing the skills of the pre-service physics teachers to apply laboratory methods. This situation revealed that although these practices in the SPED course contributed significantly to the pre-service physics teachers’ application of laboratory methods especially in theoretical level to, they contributed to the development of laboratory methods at a limited level. Also, the SPED course alone did not develop the pre-service physics teachers' ability to apply laboratory methods at the desired level.

It can be stated that the applications carried out within the scope of the research contributed to the professional development of physics pre-service teachers by preparing the experimental activity plan, designing the experimental setup, increasing the skill levels of the planning and application and applying the laboratory methods. In this context, it was concluded that combining the applications for the applications of the micro teaching carried out within the scope of the SE and TP courses in the practicum schools and the physics pre-service teachers in the form of sequential applications within the scope of SPED-SE and TP courses has developed the skills of applying the physics laboratory methods. On the other hand, this process provides multiple alternatives for physics pre-service teachers with respect to ensuring to gain a variety of laboratory methods.

Based on the results of the study, considering the efficacy level of SPED course on SE and TP courses and the efficacy level of pre-service teachers on developing laboratory skills, the course content should be updated in line with the new researches and it should be ensured that pre-service teachers form the basis for increasing the quality of the skills of designing current laboratory activities. Besides, the needs of physics teachers in the field of applying different laboratory methods for eliminating the gap between theory and practice should be met by developing a holistic approach considering the theoretical and practical application processes acknowledged in in-service training courses.

Policy Implications

- Especially in the pre-service teacher education process, physics education or other courses in the undergraduate programs should be included in the activities of the courses, eliminating the deficiencies encountered of pre-service teachers in the development of professional skills.

- The course contents and applications interrelated and coherent courses should be integrated by taking into account the balance of theory and practice.

- It should be taken into consideration that the applications in this process require the importance and continuity of the pre-service teachers' professional skills development.

- It should be kept in mind that when the applications in the related courses in the undergraduate programs are integrated, it can contribute to the expected level of professional skills development of physics pre-service teachers.

- The pre-service teachers should be guided at the required level by the instructor and the application teacher to prevent the problems experienced by the pre-service teachers in the process of applying laboratory methods that may create negative attitudes towards the teaching profession.

- Application practices including different perspectives should be considered for developing laboratory application skills of physics teachers and pre-service teachers by consulting the views of the stakeholders such as instructors and application teachers who have different views on laboratory practices.

- It should be ensured that pre-service teachers take an active role in the preparations for the laboratory applications of pre-service teachers during their teaching practices.

- Considering the big affection of micro-teaching method in teacher education is need to take place micro-teaching applications in professional skills development of teachers in pre-service and in-service teacher education as much as possible.

- The effect of integrating the related courses in terms of the theoretical-practical dimension such as Secondary Education Physics Experiment Design (SPED)-School Experience-Teaching Practice in the physics teacher and other undergraduate programs should be taken into account for the professional skill developments of pre-service teachers. If we aim at providing significantly pre-service teachers to gain professional experience and emerge an interactional profitable leaning climate for professional skills development, it could integrate courses according to corresponding to gain practical skills to the pre-service teachers in the pre-service teacher education programs.

- Similar practices should be taken place by integrating different courses that can be combined in physics teaching and other undergraduate programs in the process of pre-service teacher education. Besides, this approach could be used all kind of pre-service and in-service teacher education programs aim at to develop professional skills development.

- Thus, it will contribute to the professional skills development of pre-service teachers at the targeted level by placing more emphasis on the applications that integrate theory-practice dimensions.

- In this way, the problem of not establishing a bridge between theory and practice, which is one of the most common criticisms about the implementation process of education policies towards higher education level, can be largely eliminated for the pre-service teacher education process.

Statement of Responsibility

All authors contributed to the study conception and design. First author performed data collection and analysis. Second and third author wrote the first draft of the manuscript and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Conflicts of Interest

The authors have no relevant financial or non-financial interests to disclose.

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