THE EFFECT OF A PROFESSIONAL DEVELOPMENT PROGRAM ON PHYSICS TEACHERS' KNOWLEDGE AND THEIR STUDENTS' ACHIEVEMENT IN MODERN PHYSICS UNIT

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ABSTRACT

THE EFFECT OF A PROFESSIONAL DEVELOPMENT PROGRAM ON PHYSICS TEACHERS' KNOWLEDGE AND THEIR STUDENTS' ACHIEVEMENT IN MODERN PHYSICS UNIT

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This study offers an in-service training course model for teacher professional development titled "teachers teaching teachers" (TTT), where teachers from nearby schools congregate once a week, share their instructional practices, narrate and discuss the subjects that they will present to their students in the following week. The aim of the study was to investigate the effect of the TTT course on physics teachers' knowledge and their students' achievements in high school Modern Physics Unit (MPU).

The study was conducted in the second semester of the 2012-2013 academic year with six high school teachers and 306 students from Anatolian high schools located in Yenimahalle, Altindağ, and Mamak districts of Ankara. Initially, the TTT course was pilot studied by conducting a two-week adaptation meeting. Then, the participant teachers taught (pre-teaching) the tenth grade MPU to one of their classes, and the achievement test was applied to all these classes as pre- and post-tests. Two months later, four (treatment group) of these six teachers taught the MPU to one of their other classes after participating to the TTT course (post-teaching), and the remaining two teachers (placebo group) also taught the same unit to one of their other classes as usual without participating to TTT course. The aim of constructing the placebo group was to eliminate any possible effect of pre-teaching on post-teaching. After post-teaching, the same achievement test was applied to students and a separate achievement test was applied to teachers as pre- and post-test. On the other hand, 12 classes in total were observed and lessons were video recorded in due course of both pre- and post-teachings. Additionally, the TTT courses were also observed and were evaluated by the participant teachers.

Document analysis was conducted for the qualitative data that was obtained through class observations including video recordings. For the placebo group, these analyses showed that there was no effect of pre-teaching on the post-teaching of the teachers. For the treatment group, these analyses showed that the TTT had a positive effect on the post-teaching of the teachers. When compared to pre-teaching, an increment was observed in the treatment group teachers' subject matter knowledge and pedagogical content knowledge, however, no change was observed in teachers' pedagogical knowledge during post-teaching.

ANCOVA was used to analyse the quantitative data, which was collected from the MPU achievement test that was applied to the tenth grade students. The results of ANCOVA for the placebo group showed that there was no effect of pre-teaching. The results of ANCOVA for the treatment group showed that there was a significant effect of the TTT on the students' achievements.

The separate achievement test applied to the teachers showed that while the means of the pre- and post-test scores of placebo group teachers were approximately the same, the means of the post-test scores of the treatment group teachers were higher than their means of the pre-test scores. Additionally, the course evaluation form results showed that the participant teachers had positive attitudes toward the TTT course.

The successful implementation of the TTT and its positive effects indicate that the programs that possesses effective characteristics of PD can improve teachers' knowledge and can positively impact student achievement.

Key Words: Physics education, professional development, in-service training, modern physics, teacher knowledge.

ÖZ

BİR PROFESYONEL GELİŞİM PROGRAMININ FİZİK ÖĞRETMENLERİNİN MODERN FİZİK ÜNİTESİNDEKİ BİLGİLERİNE VE ÖĞRENCİLERİNİN BAŞARISINA ETKİSİ

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Bu çalışma, öğretmenlerin profesyonel gelişimine yönelik "öğretmenin, öğretmene öğretmesi" (ÖÖÖ) isimli, birbirine yakın okulların öğretmenlerinin haftada bir toplandığı, bir sonraki hafta öğrencilerine sunacakları konuyu birbirlerine anlattığı, tartıştığı ve öğretme deneyimlerini paylaştıkları yeni bir hizmet içi eğitim kurs modeli sunmaktadır. Bu çalışmanın amacı, ÖÖÖ profesyonel gelişim kursunun öğretmenlerin bilgilerine ve onuncu sınıf öğrencilerinin Modern Fizik Ünitesindeki (MFÜ) başarılarına etkisini araştırmaktır.

Bu çalışma, 2012-2013 eğitim-öğretim yılının ikinci döneminde, altı öğretmen ve 306 öğrencinin katılımı ile Ankara'nın Yenimahalle, Altındağ ve Mamak ilçelerindeki Anadolu liselerinde yürütüldü. Başlangıçta, iki haftalık bir adaptasyon buluşması yürütülerek, ÖÖÖ profesyonel gelişim kursunun pilot uygulaması yapıldı. Daha sonra, katılımcı öğretmenler MFÜ'sini birer sınıfta anlattılar (önce anlatma) ve başarı testi bu sınıflarda ön-test ve son-test olarak uygulandı. İki ay sonra, katılımcı öğretmenlerden dördü (uygulama grubu) MFÜ'sini başka bir sınıflarında ÖÖÖ profesyonel gelişim kursuna katıldıktan sonra (sonra anlatma), kalan iki öğretmen ise (plasebo grup) aynı üniteyi başka bir sınıflarında ÖÖÖ profesyonel gelişim kursuna katılmadan her zamanki gibi anlattılar. Plasebo grubu oluşturmanın amacı, önce

anlatmanın, sonra anlatma üzerindeki muhtemel etkilerini ortaya çıkartmaktır. Sonraki anlatmadan sonra öğrencilere aynı başarı testi, öğretmenlere ise farklı bir başarı testi, ön-test ve son-test olarak uygulandı. Diğer taraftan, öğretmenlerin önce ve sonra anlatımları sırasında toplam 12 sınıfta gözlem yapıldı ve dersler videoya çekildi. Ek olarak, ÖÖÖ kursları da gözlemlendi ve katılımcı öğretmenler tarafından değerlendirildi.

Sınıf gözlemleri ve video kayıtları ile elde edilen nitel veriler için doküman analiz yöntemleri kullanıldı. Plasebo grubu için yapılan bu analizler, öğretmenlerin dersi önce anlatmalarının sonra anlatmaları üzerinde bir etkisinin olmadığını gösterdi. Uygulama grubu için yapılan bu analizler, ÖÖÖ profesyonel gelişim kursunun, öğretmenlerin sonraki anlatımları üzerinde pozitif bir etkisinin olduğunu gösterdi. Önceki anlatımları ile karşılaştırıldığında, uygulama grubu öğretmenlerinin sonraki anlatımları esnasında konu alan bilgilerinde ve pedagojik alan bilgilerinde artış gözlemlendi, fakat pedagojik bilgilerinde bir değişim gözlemlenmedi.

Onuncu sınıf öğrencilerine uygulanan MFÜ başarı testinden elde edilen nicel veriler ANCOVA ile analiz edildi. Plasebo grubunun ANCOVA sonuçları, dersi önce anlatmanın bir etkisinin olmadığını gösterdi. Uygulama grubunun ANCOVA sonuçları, ÖÖÖ profesyonel gelişim kursunun öğrencilerinin başarısı üzerinde istatistiksel olarak anlamlı bir etkisi olduğunu gösterdi.

Öğretmenlere uygulanan farklı başarı testi, plasebo grubu öğretmenlerinin ön-test ve son-test ortalamalarının hemen hemen aynı olduğunu, uygulama grubu öğretmenlerinin son-test ortalamalarının ön-test ortalamalarından daha fazla olduğunu gösterdi. Ek olarak, kurs değerlendirme formu sonuçları, katılımcı öğretmenlerin ÖÖÖ profesyonel gelişim kursuna karşı olumlu tutum içinde olduklarını gösterdi.

ÖÖÖ kursunun başarılı bir şekilde uygulanması ve pozitif etkileri, etkili profesyonel gelişim karakteristiklerine sahip programların öğretmenlerin bilgisini geliştirebileceğini ve öğrencilerinin başarısına pozitif etki yapabileceğini gösterdi.

Anahtar Kelimeler: Fizik eğitimi, profesyonel gelişim, hizmet içi eğitim, modern fizik, öğretmen bilgisi.

This dissertation is dedicated to my parents Halil and Miskal, to my wife Hülya and to our children, Nuriye, Kemal Faruk, Cemal Adil, Muhammed Sami, for their support, patience, and sacrifices made so I could fulfill a lifelong dream. Thank you for the invocation and inspiration to get it done.

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LIST OF ABBREVIATIONS

PD: Professional development

SMK: Subject matter knowledge

PK: Pedagogical knowledge

PCK: Pedagogical content knowledge

JiTT: Just-in time teaching

TTT: Teachers Teaching Teachers

PCG: physics course grades

TE: Teacher experience

NAS: Needs analysis survey

COF: Classroom observation form

TOC: Treatment observation checklist

TFC: Treatment fidelity checklist

TTTEF: Teachers teaching teachers course evaluation form

MPUAT-S: Modern physics unit achievement test-Student

MPUAT-T: Modern physics unit achievement test-Teacher

pre-MPUAT-S: Students' Pre-test Scores on the Modern Physics Unit Achievement Test

post-MPUAT-S: Students' Post-test Scores on the Modern Physics Unit Achievement Test

MC: Main Course

TF: Treatment Fidelity

MANCOVA: Multivariate Analysis of Covariance

ANCOVA: Analysis of Covariance

CHAPTER 1

INTRODUCTION

Education refers to the process of learning and acquiring information (Alexis, 2014). In schools this process is mostly conducted under the control of teachers. In this respect, currently teachers are one of the core elements of education. They are the actors in the class and they manage the learning process in the classroom. One way to improve schools is improving teacher quality (Deily, 2002). The failures or successes of students mostly depend on the teachers. Since educational context, such as the curriculum and teaching strategies, continuously alters, teachers have to cope with all these changes through the professional development (PD) programs. In other words, teachers always need help in the case of educational innovations. That's why their PD is of considerable importance. Many reports and researchers indicate that the quality of schools depends on the teachers' competency and accordingly depend on their PD (Borko, 2004; Fendler, 2003; Fishman, Marx, Best, & Tal, 2003; Garet, Porter, Desimone, Birman, & Yoon, 2001; NCTAF, 2003). Therefore, increasing teacher effectiveness through PD programs or courses is crucial to improving and reforming schools. Moreover as Birman et al. (2000) remarked PD plays a key role in addressing the gap between teacher preparation and educational improvements.

Teacher PD is categorized differently by different researchers. Briefly it is the process of teacher development which involves the use of different teaching activities, the development of beliefs and conceptions underlying the activities, and the development of subject matter knowledge (SMK) and skills. PD involves not only the use of teaching activities in the classroom, but also the development of the beliefs and conceptions underlying the practice. For example, Bell and Gilbert (1996) see teacher development (i.e. learning) as a form of human development and offer three dimensions for effective teacher development. They are social, professional, and personal developments. Social development involves developing ways of working with others to foster the kinds of social interaction necessary for renegotiation and reconstructing what it means to be a teacher of science. Personal development involves each teacher constructing, evaluating, and accepting (or rejecting) the new socially constructed knowledge, including the personal management of emotive and cognitive change associated with changing their beliefs, knowledge, and practices.

Among these dimensions, this study is related to the professional development dimension of teacher PD. This dimension of PD includes many elements, such as improving classroom practice, increasing teacher knowledge and skills. For the sake of clarity, not all but mostly the effect of the PD course conducted in this study on "teacher knowledge" (Shulman, 1987), especially SMK is taken into consideration. The reduction of teacher PD to a more specific study is figured through Figure 1.

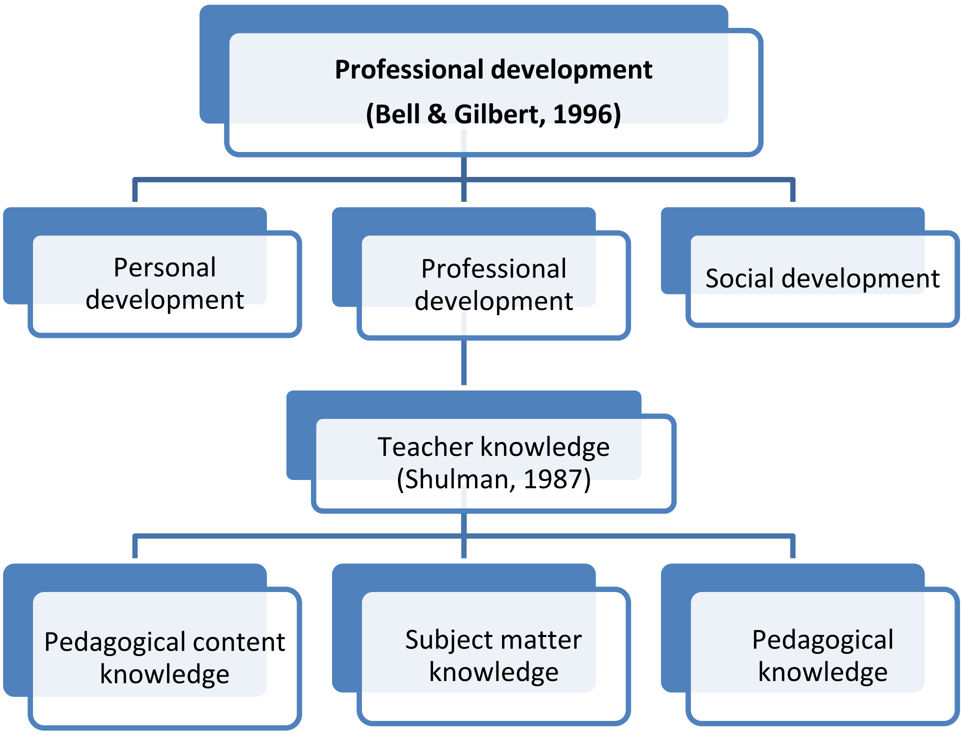

Figure 1 The specification of the study

The next to last step in Figure 1, that is "teacher knowledge", needs some explanation. While the general idea of teacher knowledge is not clear, Shulman (1987) defined a professional knowledge base for teaching that included seven specific categories of teacher knowledge:

> General pedagogical knowledge, with special reference to those broad principles and strategies of classroom management and organization that appear to transcend subject matter; knowledge of learners and their characteristics; knowledge of educational contexts, ranging from workings of the group or classroom, the governance and financing of school districts, to the character of communities and cultures; knowledge of educational ends, purposes, and values, and their philosophical and historical grounds; content knowledge; curriculum knowledge, with particular grasp of the materials and programs that serve as “tools of the trade” for teachers; pedagogical content knowledge, that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding (p.8).

Above, the teachers’ need for PD was briefly mentioned. Many PD programs, from several years long to daylong programs, from content focused to pedagogy focused programs have been conducted both abroad and in Turkey for the aim of improving teacher quality. Are all these programs effective? What are the characteristics of effective PD programs? Below, the effective characteristics of PD programs/courses are given to have a clear comparison with the characteristics of the PD model of this study. The characteristics of effective PD that have been compiled below are a result of reviewing the literature on this topic. Recent and distant research on PD programs have included (a) content focus, (b) active learning, (c) coherence, (d) long duration, (e) collective participation, (f) sustained and intensive, and (g) delivered in conductive settings as effective features of PD programs (Birman, & Jacobson, 2007; Borko, 2004; Fullan, 1993; Garet et al., 2001; Guskey, 1994; Loucks-Horsley et al., 1998; Yoon, Garet, Desimone, 2008; Wayne et al., 2011; Wei et al., 2009;). These characteristics have the potential of improving teacher knowledge, skills and improving their practice, which accordingly improve student achievement.

On the other hand, as discussed in the review of the literature section, even though it has not been proposed in the literature, just-in time teaching (JiTT) that is implemented to shorten the time between learning and application, can also be another effective characteristic for PD programs. Mostly, teachers apply what they have acquired during PD activities to their classes, long after attending PD programs. This reduces the effectiveness of PD courses. Nevertheless, teachers do try to implement their acquired practices to their classes after several months and they forget most of the acquirements. That's why JiTT has to be adapted to the PD programs.

Before explaining the format of the PD used in this study it will be informative to state the PD designs in Turkey. Do they possess the effective features of PD programs? The PD of teachers in Turkey has been conducted under the name of In-Service Training Courses (Hizmet içi eğitim kursları) by In-service Training Department of the Ministry of National Education (Özer, 2004). This department prepares an annual teacher training program every year, which includes training events for all teachers (Köyalan, 2011). Frequently, teachers from several schools are obliged to attend occasional summer courses that are full-day in-service sessions. Moreover, the topics are selected by administrators and presented by outside experts who rely primarily on direct instruction and draw upon their own experiences (Bayrakcı, 2009).

Problems about PD programs/in-service training courses have been well documented by many other researchers (Ateşkan, 2008; Bayrakcı, 2009; Özer, 2004; Seferoğlu, 1996). The general problems of in-service training courses in Turkey are; (a) lack of qualified instructors in the programs, (b) no collaborative partnerships between teachers, (c) no provision for feedback, (d) lack of motivational factors for PD, (e) accommodation and dining problems in the places where in-service training activities take place, (f) improper date and length of the training course, and (g) no systematic in-service training model.

To sum up, when PD programs designed in Turkey are assessed in terms of the effective characteristics of the PD programs, almost none exist. For example, they neither are sustained nor coherent and neither collective nor do they contain active learning properties.

How can these problems be overcome? How can courses be designed that include effective characteristics of the PD programs? Some private schools and university preparation courses in Turkey have solved these problems partially. In fact, many private schools and private courses apply successful teacher training models. Unfortunately, since all activities conducted by these educational institutions are informal, their training model is not documented. Below explanations are the results of the researcher's own 20 year observations.

To prepare their teachers, these schools have integrated teachers PD to teachers' daily school works (Job-embedded). While usually formal in-service courses are implemented during summer, private institutions usually implement it during the school year (sustained). Many of these private schools and courses educate teachers periodically, such as every other week or every month (intensive). Furthermore, some well-organized private schools conduct teacher training courses every week or every other week within the school, conduct it every two months between schools of a city and conduct it every summer within the schools of a geographic region (sustained and intensive). What these private schools implement during training courses is very different from public schools' in-service training courses. Rather than abstract information, these private institutions, as literature mentions, mostly focuses on the improvement of the SMK of the teacher (content focused). During the courses teachers of the same subject (collective participation), determine their needs (coherence), narrate the topic, discuss the unclear points of concepts and conduct lab experiments (active learning). The aim of this study is to enhance the model of teacher PD of these private schools and provide data to validate its effectiveness academically. Briefly, our country seeks a striking format of the PD program and this study aims to offer an applicable and feasible PD program for Turkey.

Teacher PD is a process of design, in which organizers consider a broad array of issues in order to design all the activities that constitute an effective PD program (Fishman, Marx, Best & Tal, 2003; Loucks-Horsley et al., 2003). Many successful types of PD can be seen in literature. Their common feature is that they have structured time for teachers to come together, discuss issues of teaching practice and student learning and they are related to actual work of teachers in classrooms. Croft, Coggshall, Dolan, Powers, and Killion (2010), briefly describe twelve formats (Action research, case discussions, coaching, critical friends groups, data teams/assessment development, examining student work/tuning protocol, implementing individual professional growth/learning plans, lesson study, mentoring, portfolios, professional learning communities, study groups) in which job embedded PD can occur. Some of these formats will be discussed in detail in the "review of literature section".

Wei, Darling-Hammond, Andree, Richardson, and Orphanos (2009) in discussing and comparing several PD formats, stated one of the difficulties in evaluating the design and structure of PD programs as the lack of information about program design and the wide variability in implementation. Based on this fact they say that clean comparisons between PD formats are difficult. In the future, studies similar to this study may appear. Thus, to enable a clean comparison with future studies the format of this PD design is described in Section 1.1. However, contrary to Wei et al. (2009) the researcher of this study believes that information about some designs such as the Japanese lesson study is satisfying. That’s why, for a brief comparison, some famous design is explicitly given in the section 2.2.

1. 1 Teachers Teaching Teachers (TTT)

The PD intervention used in this study originates from the teacher preparation program of some private schools in Turkey. The PD design of this study is called TTT which basically depend on teachers teaching to each other. The PD format of this study which is explained below is the combination of coaching-critical friends group or coaching-study groups. The most striking feature of the structure of the design of this study is that its content focus is very different from those stated in section 2.2. Namely in this design teachers narrate, discuss and teach the topic (for example teaching electric circuits, teaching grammar, teaching probability and so on) to each other. This is a format which focuses on the content and aims to generally improve teacher knowledge, especially knowledge of the subject matter. Among the teacher knowledge, Ball and McDiarmid (1989), specifically have interest, for example, in changes in teachers' role conceptions, their beliefs about their work; their knowledge of students, curriculum, or of teaching strategies. These researchers further explain the central component of what teachers need to know as:

> That subject matter is an essential component of teacher knowledge is neither a new nor a controversial assertion. After all, if teaching entails helping others learn, then understanding what is to be taught is a central requirement of teaching. The myriad tasks of teaching, such as selecting worthwhile learning activities, giving helpful explanations, asking productive questions, and evaluating students' learning, all depend on the teacher's understanding of what it is that students are to learn (p.1).

Focusing on the subject matter in PD programs accordingly increases student achievement and this is consistent with the results in the Kennedy’s (1998) systematic review of the effects of PD on student achievement. That review analyses the relative effects on student outcomes from PD programs for math and science, examining the professional development’s subject, content focus, skill level, form, and other features. On the basis of her analysis, Kennedy (1998) concluded:

> Programs whose content focused mainly on teachers’ behaviors demonstrated smaller influences on student learning than did programs whose content focused on teachers’ knowledge of the subject, on the curriculum, or on how students learn the subject (p. 18).

Along with the Kennedy’s seminal review, the studies conducted by Desimone, Porter, Garet, Yoon, and Birman (2002), Garet et al. (2001), Yoon, Garet, Birman, and Jacobson (2007) indicate the importance of content focus in high quality PD programs. Moreover, Loucks-Horsley, Hewson, Love, and Stiles (1998), complain about the ineffectiveness of the PD programs in providing teachers with sufficient time, activities, and content necessary for increasing teacher knowledge and fostering meaningful changes in their classroom practice.

Why did the researcher aim at the teachers' knowledge of the subject? First of all, what is taught during teacher education programs in universities as a knowledge of subject and what teachers teach to students are mostly different. Secondly, the high schools educate students for three or four years and there is a broad curriculum. There are many topics in the curriculum. A teacher usually teaches to one or two grades each year. It is generally possible for both novice and expert teachers to forget the topics of the other grades. They always need support when they start to teach a new topic or a topic they have not taught for a long time. Thirdly, for teachers to feel comfortable in their classes they must not have problems with the content of the topic they present to their students. They have to be ready for non-routine questions from their students, if they know the content of the subject very well then they can apply the required instructional strategies. Fourthly, just as students, teachers also have many misconceptions, teachers need to struggle with both theirs and their students' misconceptions. During the discussions, teachers easily reveal the misconceptions. So, presenting the subject and then discussing it has a great importance in developing teachers professionally and increasing their quality. To sum up, the researcher has worked as the head of a physics department for more than 20 years in schools who are using TTT for their teachers' PD. The personal observations of the researcher throughout this time span showed that when the format offered in this study is applied, teachers teach to each other, discuss the content, get ready for teaching, gain confidence, increase self-efficacy, learn new strategies to go beyond their regular class practice and once they enter their classes they carry the gained practices to their classes and make similar activities and discussions with their students.

This type of PD study is naturally cooperative and collaborative which focuses on the SMK of the participant teachers and involves many issues that teachers need to collaborate on. It is cooperative because teachers work together to accomplish shared goals and understand the same material such as learning the topics together and it is collaborative because participant teachers use different skills or expertise to complete a task such as the 10th grade modern physics unit (MPU). The unit is being taught and learnt by dividing the objectives of the subject and each teacher teaches some of them. The format for this study is clearly described below for those who want to replicate and make comparison.

The TTT should not be mixed with ‘‘Teaching teachers to teach’ model. This model principally focuses on teachers who are teaching how to teach and it mainly includes the pedagogy of teaching. For instance, Witt and Dickinson’s (2008), program design uses "teaching teachers to teach" format and there were two goals of the program; to improve librarian-teacher cooperation through instruction in the information literacy skills and to mentor pre-service teachers in practical methods of integrating information literacy instruction in both their student teaching and for their future professional lives. However, as mentioned above TTT focuses on the SMK of the teachers and "teaching teachers to teach" focuses on the pedagogical knowledge of the teachers.

In the TTT format there is an experienced coach or leader that plans all activities that take place during the courses or workshops. Each teacher in the group prepares and teaches a topic alternatively each week. It is a content focused intensive PD program, and usually conducted on the weekends. Teachers of the same subject meet every week or every other week to collaborate and cooperate. The duration of the meetings are not restricted to a certain time, it depends on the weekly course hours and on the concepts of the topic being taught and is usually around two-three hours. Usually one-two hour is allocated for teaching the lesson and the other hour is devoted to other school and education related issues. The TTT has five main phases.

Preparing the lesson: The coach assigns the lesson to a teacher usually one week before the course. This teacher is aware that he/she is going to teach to his/her colleagues. Hence, he/she usually tries to prepare the best lesson. The teachers who prepare the lesson usually communicate with the coach and with his/her colleague when necessary. Especially if he/she has problems in preparing an appropriate lesson, he/she usually asks for some help.

Teaching the lesson to teachers: The presenting teacher (sometimes the coach) prepares the lesson and teaches it in a classroom where other teachers observe, listen, take notes, ask questions, and learn the content. The presenting teacher not only teaches the lesson, but also presents his/her teaching style so that the participating teachers acquire the pedagogy of the subject being taught.

Observing the lesson: While the lesson is being taught, the other teachers observe and take notes on what the presenting teacher does and says. Usually teachers are free to do the observations. Namely, no observation checklists are filled by the teachers; the aim is to reveal the teachers' experiences and to share these natural experiences.

Discussing the lesson: Once the lesson is finished, the other teachers ask (sometimes they ask questions during the lesson) questions about the topic being taught. Usually passionate discussions take place on the topic's unclear points, on students' and teachers' misconceptions, and on pedagogical strategies.

Teaching the lesson to students: TTT courses are usually about the subject of the following week that teachers will teach to their classes. Once the course or the workshop ends, teachers present the same topic to their classes in the following week.

On the other hand, in the TTT model, teachers engage on some other issues such as lab activities, assessing the results of the exams, discussing the homework of students, organizing physics related activities (i.e. water rocket, catapult, mousetrap) and so on. Moreover, during workshops teachers are allowed to discuss challenges and successes, express concerns and goals, critique the curriculum materials, and explore a variety of strategies that they considered important for engaging students in scientific discussions.

Although the PD within the teachers' own classroom (job-embedded) was perceived as an effective PD activity (Pedretti, Mayer-Smith, & Woodrow, 1999) it is not proper for the TTT format to take place in the classroom during the instruction. In the TTT model, teachers discuss too many issues; they especially discuss the topic, that's why it has to take place in a classroom setting where there are no students present. For instance, if these are physics teachers they sometimes discuss high level physics which is difficult for students to follow and understand. For example, when the reason behind the friction force is being discussed some experienced teachers can go further and explain it by describing the relation between friction force and the electromagnetic force. The higher order discussions may bore students and they may not want to be in a class where teachers are engaging in discussion. Furthermore, students with approximately 10 teachers together in a class bring the possibility of an undesired classroom learning environment. Moreover, in the TTT model, participating teachers do not critique the presenting teacher as in the Japanese lesson study. Since the focus is on the topic being taught, TTT discussions take place around what is being presented. Rather than mostly critiquing the pedagogy used by the trainer, the topic's concepts, facts and principles are discussed by the teachers. Meanwhile, the role of the presenting teacher and that of the coach is to introduce the topic, guide the discussions and prevent the irrelevant matters to intervene the topic of interest.

1. 2 TTT and Effective Characteristics of PD Programs

In this study, TTT lasted only five weeks and it covered only one 'unit'. The aim was to show that TTT was an applicable and an effective model. In fact, TTT should maintain throughout the school year and should cover all units. The PD that was provided for this study met many of the characteristics of effective PD programs. One of the most important features of this PD effort is that it directly focuses on the SMK of the participants. A comparison of TTT, lesson study and coaching with the effective PD programs compiled from the literature is given in Table 1.1. There are many PD programs; comparing TTT with all these programs is a little bit troublesome. For having an idea about TTT the comparison is done only with lesson study and coaching. Moreover, another reason for comparing TTT with these two PD models is that they are well documented.

Table 1.1 A comparison of TTT, lesson study and coaching with effective characteristics of PD

Characteristics of Effective PD programs	Does TTT include it?	Reasons for inclusion or non-inclusion	Does lesson study include it?	Reasons for inclusion or non-inclusion	Does coaching include it?	Reasons for inclusion or non-inclusion
Intensive	Yes	Teachers meet every or every other week	Partially Yes	The frequency of meetings can vary from several times a year to a more intensive schedule of meeting once a month or even once a week. (Allen, Donham, & Tanner, 2004).	No	Coaches do not regularly and intensively help teachers
Sustained	Yes	Continuous through school year. (For this study it lasted only five weeks)	Yes	Continuous through school year.	Partially Yes	Coaches usually do not focus on a specific teacher through a year
Job-embedded	No	It does not take place during the classroom practice but takes place in a classroom-like environment	Yes	It takes place during the classroom practice.	Yes	It takes place during the classroom practice and immediate feedback is given
Focused on the content of the subject that teachers teach	Yes	Teachers teach the subject to each other	Partially Yes	Participating teachers immerse themselves in a cycle of instructional improvement focused on planning, observing, and revising "research lessons" (Lewis, & Tshuchida, 1998).	Yes	The focus is on both what teachers teach in the class and teacher's teaching strategies.
Active learning	Yes	Teachers actively participate in the discussions and present the lessons in turns	No	Lesson study is not about the teacher; it is about the lesson (ETS, 2009). Teachers participate in the discussion of planning.	No	Teachers do not actively learn but learn through the suggestions

Table 1.1 (continued)

Characteristics of Effective PD programs	Does TTT include it?	Reasons for inclusion or non-inclusion	Does lesson study include it?	Reasons for inclusion or non-inclusion	Does coaching include it?	Reasons for inclusion or non-inclusion
Coherence	Yes	The program includes a structure that is coherent with teachers' and schools' needs (when the needs assessment conducted for this study is referred)	Yes	The program includes a structure that is coherent with teachers' and schools' needs	Yes	The coaches help the teachers with what they need
Collective participation	Yes	Teachers of neighboring schools, from same subject and same grade participate in TTT	Partially Yes	Teachers of neighboring schools participate in the lesson study	No	The coach observes a single teacher, there is no Collective participation of teachers
Delivered in conducive settings	Yes	Teachers can easily allocate three hours each week and congregate in neighboring schools	Yes	Teachers usually congregate after school	Yes	It is conducted in teacher's classroom
Long duration	Yes	It covers the whole academic year and repeats each year	Yes	Teachers take part in lesson study and are involved in two or three cycles per year. (Burghes, and Robinson, 2009).	No	Certain teachers are not coached throughout the year
Just-in time teaching	Yes	Teachers transfer their acquired practices to their classes in two weeks at the latest.	Yes	The immediate feedback is given to teachers	Yes	The immediate feedback is given to teachers

While most PD initiatives for teachers are not designed to meet the key characteristics of effectiveness (Corcoran & Foley, 2003; Garet et al., 2001; Desimone et al., 2002), as seen in Table 1.1 the TTT along with the lesson study possess almost all characteristics of effective PD programs. However, as shown in the same table, coaching lacks four of the ten characteristics. For instance, while in TTT and lesson study, teachers actively learn and collectively participate in the PD program. In coaching teachers are just observed and they do not find opportunities to discuss the topics. Besides when arranged, TTT can be applied throughout the school year but it is difficult for coaching to continue on a single teacher throughout the whole school year.

Among the 23 experimental studies analysed by Yoon et al. (2007), and Blank and Alas (2009) only three of them have utilized the known PD formats (one of them have included both lesson study and coaching, two of them have included the lesson study), all others have utilized different models of PD. Their studies showed that although many studies have been conducted on 'lesson study', except three (META Associates, 2006; Palmer & Nelson, 2006; Scott, 2005), the experimental research has not been conducted with regards to this. It shouldn't be forgotten that when we talk about experimental PD studies we mean the studies that have experimentally searched for the effect of PD programs on student achievement. In other words, having two groups of teachers, giving some treatment and comparing their results is not accepted as an experimental study. The conducted study must look at the effect of PD on the students' success rates.

1. 3 Purpose of the Study

This study was twofold. The purpose for the first part of this study was to investigate the impact of a five-week TTT course on six tenth grade high school physics teachers' knowledge in the MPU. This unit was chosen because of the fact that it was recently added to the national tenth grade physics curriculum (2007) and teachers had experienced problems in teaching this unit (Eryılmaz, 2012). Another reason in handling this unit during the TTT course was to increase the participation of the teachers in the courses. The focus of the PD course was on enhancing teachers' grade and unit specific knowledge of the physics content, thereafter its effect on physics teacher knowledge. The purpose of the second part of this study was to investigate the effects of the TTT course via the achievements of the students from participating teachers.

1. 4 Research Questions

This research attempts to shed light on some of these issues with data from high school physics teachers and their students. These tenth grade teachers and accordingly their students are chosen from different types of high schools, such as vocational and private high schools in Ankara. The effect of the TTT course on teachers' knowledge, practices and perceptions and on their students' achievements was investigated. The quantitative and qualitative methods have been used in tandem to supply answers to the research questions of the study. The research questions of this study can be categorized into two groups as the first two questions are qualitative in nature and the last two questions are quantitative in nature. Therefore, the following research questions guided this dissertation study:

1. What is the perception of tenth grade physics teachers about the TTT professional development course?
2. What is the effect of the TTT professional development course on participant teachers' knowledge (PCK, PK, and SMK) regarding the modern physics unit?
   - What is the effect of the TTT professional development course on SMK of tenth grade physics teachers in the modern physics unit?
   - What is the effect of the TTT professional development course on PCK of tenth grade physics teachers in the modern physics unit?
   - What is the effect of the TTT professional development course on PK of tenth grade physics teachers in the modern physics unit?
3. What is the effect of the TTT professional development course on achievements of tenth grade physics teachers in the modern physics unit?
4. What is the effect of the TTT PD development course on physics achievements of tenth grade students in the modern physics unit?

1.5 Null Hypothesis

Since the number of the participating teachers is not enough to conduct inferential statistics, among the two quantitative problems only the null hypothesis of the research question related to student achievement is stated below.

1. There is no significant effect of TTT professional development course on the population means of tenth grade high school students' modern physics unit achievement post-test scores when students' modern physics unit achievement pre-test scores, students' first term physics course grades, their teachers' experiences and their teachers' achievements are controlled.

1.6 Definition of Important Terms

Main terms used in the study are defined as follows:

Professional Development: PD produces the desired changes in teachers' classroom practices, values, beliefs, and strategies designed to improve student achievement and ultimately enhance their capacity for continued learning and professional growth (Corcoran, 2007). In this study, it is the professional growth of teachers' in the area of the teacher knowledge (Shulman, 1986, 1987) through TTT professional development course.

TTT professional development program: In this study, TTT is a model of PD which enables teachers to learn from their peers. In TTT teachers congregate and teach each other through cooperation and collaboration.

Just in time teaching: Just-in-time teaching is a pedagogical strategy that employs the Internet to develop and utilize a feedback loop between students and instructors that exists both in class and out of class (Formica, Easley, & Spraker, 2010). In this study, teachers learn during course and soon after go to their classes and teach what they have gained during the course.

Teacher Knowledge: Teacher knowledge was categorized by Shulman (1987) as general pedagogical knowledge, knowledge of learners and their characteristics, knowledge of educational contexts, knowledge of educational ends, content knowledge, curriculum knowledge, and PCK. In this study, among all these categories only PCK, PK and SMK are examined.

Student achievement: In this study, it was measured by MPU achievement test, consisting of 30 multiple choice items from MPU of the physics course, the content of which determined by the physics curriculum of year 2007 (Appendix A).

1.7 Significance of the Study

This study is significant in several aspects. First and foremost one fold of this study is experimental and few experimental studies are designed in this PD research arena both in Turkey and abroad. Since the literature states 23 experimental studies ranging from 1986 to 2009 (Yoon et al., 2007; Blank & Alas, 2009), the obvious gap in research on PD are experimental studies. So, as Wayne et al. (2008) argue, experiments have a major role to play in future research on PD. Moreover, most experimental studies, can be counted on the fingers of one hand, employed simple one-group pre-test/post-test designs without a comparison group (Wei et al., 2009). Possessing the nature of an experimental research with a comparison group, this study is expected to be valuable in the area of PD and also expected to initiate new studies in PD.

Secondly, as Bransford, Brown, and Cocking (1999) stated research studies are needed to determine the efficacy of various types of PD activities, including pre-service and in-service seminars, workshops, and summer institutes. As shown in Table 1.1 the design of this study surpasses many known PD models (such as coaching) and as in lesson study possesses almost all aspects of effective PD programs. Importantly, this study offers a practical and rigorous design (see Sections 3.4) in this arena for experimental studies. The reason behind the abundance of one-group pre-test/post-test designs is that arranging a PD design requires great effort and rigorous design. However, the design of this study easily leads to a control group.

As Wayne et al. (2008) states we cannot assume that teachers who typically receive PD (experimental group) are equivalent in every way to teachers who do not (control group). Thus, instead of finding two equal groups of teachers, giving a treatment to one of the groups and then comparing their students' achievements, this study uses only one group of teachers and solves the problem of equivalent groups. In this study teachers initially teach to one of their classes (control group) then teach to their other class (experimental group) after the treatment that they receive.

Thirdly, as Wei et al. (2009) stated high quality and sustained professional learning throughout the school year, at every grade level and in every subject is required. The TTT model is consistent with what they suggest because the model offers a long term cooperative and collaborative work between the teachers throughout the school year.

Moreover, this study includes JiTT which enables the usage of the gained practices immediately. Thus, the application of this model in the PD programs is expected to result in considerably large effects.

Fourthly, a strong base of research is needed to guide investments in teacher PD and evidence on their effects. Policy makers seek models for designing and implementing effective PD and particularly models supported by research evidence (Blank & Alas, 2010). Thus, the results of this study may encourage decision makers in funding teachers' development programs. Moreover, when taken into consideration, the results of this study can help the PD program organizers to improve their programs and plans. The findings of this study can also form a basis for further research in which the PD process is examined.

Fifth, as Desimone (2009) and Akiba, LeTendre, and Scribner (2007) stated more work is needed that links PD and changes in teaching practices in order to acquire student achievement. The results of this study may enhance this link. Therefore, more research must be conducted in order to understand the relationship between teacher learning and student achievement. Success of this program will provide empirical evidence that correct implementation of the TTT PD model can affect student achievement. This procedure may be of assistance to other researchers as they attempt to raise student achievement scores.

Sixthly, on the other hand, educators in Turkey are recently engaged in a considerable debate and self-analysis about how to best improve general education. For instance, the curriculums have been broadly renewed at every grade level and in every subject since 2005. The primary and secondary education has been restructured and the 4+4+4 model has been applied since 2012. However, as Dori and Herscovitz (2005) stated teachers play a crucial role in educational reforms and unfortunately one of the keys to improving the quality of education, teacher PD, is ruled out in our country (Özer, 2004). The TTT model will be offered to policy makers in Turkey as an applicable and effective program for teacher PD programs.

Seventhly, this study primarily aims to increase teachers' SMK which is a key factor in increasing student motivation and achievement. For instance, in his doctoral dissertation, multiple case study on how physics teachers' characteristics affect students' motivation in physics, Korur (2008) found two factors that mostly affected the students’ motivation. The teachers’ SMK and their personal characteristics were the two categories that mostly affected the students’ motivation. He goes further and states that teachers who possess effective characteristics like "SMK" or "making students active in the class setting" prevent them from failure in learning the concepts. His research results showed that among 27 effective teacher characteristics "‘possessing necessary knowledge of subject matter" took first place in positively increasing student motivation.

Eighthly, the purpose of this study is to investigate the power of the TTT model to improve teachers’ knowledge and student achievement. In doing so, this study will provide the physics education community with specific data regarding the link between the TTT PD model and student achievement in the area of the MPU on the tenth grade level. Since the number of studies that consider the effect of PD programs with specific reference to physics is considerably smaller; this study will be a significant contribution to the literature. Moreover, in Turkey there is very little published work on the PD of physics teachers. Furthermore, this study will enrich physics teacher PD literature with its qualitative and quantitative results.

Finally, it is hoped that this study is significant in showing the benefits of using cooperation and collaboration in PD as it enables teachers to connect to each other and to share ideas which improves their knowledge, skills and experiences in their profession and widens their horizons towards becoming informative, active professionals.

CHAPTER 2

REVIEW OF THE LITERATURE

The purpose of this chapter is to review the relevant literature in order to provide a justification for conducting this study and a theoretical perspective allowing for the interpretation of the research results. To restrict and delimit the literature review, the primary focus was given to the studies about PD of science and mathematics teachers. This review is divided into the following main sections: the first examines the role of the teachers in education, the second examines the effective PD program designs, the third purports the effect of PD programs on student achievement, the fourth displays the teacher collaboration and cooperation, the fifth examines the teacher PD programs in Turkey and the last examines the studies conducted about modern physics (special relativity).

2.1 The Role of Teachers in Education

With the improvement of technology in 20th century human power was replaced mostly with machine power. Teachers also once believed to be replaced with radio, TV or computers. However, as technology increased the teachers did not replace with any technological devices (Clark, 1991); instead their importance understood better than before.

The importance and the quality of teachers in leading to the improvement of education have been stated by many researchers. For instance, the main factors, stated by Tekin and Ayas (2005), which affect the quality of education, are teacher, student, curriculum, and learning environment. Among these factors teacher, in planning, implementing and evaluating activities, learning outcomes and conducting lessons has a special importance. Likewise, Büyükkaragöz (1998) and Küçükahmet (1999) purport three fundamental components determining the functions and mechanisms of education system; curriculum, teacher, and student. Of these components they specify the teachers responsible for ensuring the desired behaviours of individuals entering the system and applying the school curriculum developed for training quality individuals. Besides, policymakers, practitioners, and researchers are all on consensus that the teacher quality is the most powerful school-related influence on a child’s academic performance (National Academies, 2007). Education policy makers around the world have also seen the teacher quality as a major vehicle to improve student learning (OECD, 2005; UNESCO Institute for Statistics, 2006). Shortly, as stated by Seferoğlu (1996), the quality of teaching in schools cannot be significantly improved without improving the quality of teachers.

In attempting to finding a relationship between teacher quality and students success Darling-Hammond (1999) stated that "a growing body of research suggests that schools can make a difference, and a substantial portion of that difference is attributable to teachers" (p.5). One of the reasons why reform efforts are often unsuccessful is that it is failed to understand that teachers play a key role in making educational reforms successful (Dori, & Herscovitz, 2005). Guskey (2003) stated that high-quality teachers are the key to improve student learning. With the beginning of the 21 century it is understood that without development of the teacher learning the development of student success is difficult (Fullan, 1996). Wei et al. (2009), relates the efforts to improve student achievement to two factors; building the capacity of teachers to improve their instructional practice and the capacity of school systems to advance teacher learning. Goldberg (2001) relates the single most important factor of student’s success to the knowledge and skills of a child’s teacher.

So, as stated above many experts see the teachers as ‘sine quo non’ for education. Many of the researchers remark the teachers as the single most important factor leading to student success. Since, it is nearly impossible substituting the teachers with technology and since they are so effective in educational issues, their PD is of great importance. This study also endeavors to offer a method for their PD.

2.2 Effective PD Program Designs

The nature of research on teacher PD in science is complicated and difficult; it is inherently complex, consisting as it does of a number of interrelated components (Hewson, 2007). The practice of PD requires a rigorous design, which involves a broad array of issues such as the cost, the duration, the participants and the content of the program. Professional developers have to consider all the activities that constitute an effective PD program (Loucks-Horsley et al., 2003; Fishman, Marx, Best, and Tal, 2003). For example, according to Thompson (2008), for the PD to yield student learning, there has to be potent content and good design, not only of the PD, but of the workplace in which that content is to be implemented. A comparison of teacher PD of this study with known PD designs would be of great importance. Thus, description of the types of PD designs undertaken can be informative, below are the PD designs that literature often mention.

Action Research: It has evolved in the education community as a process of a systematic research in which teachers examine their own practice and take action to improve teaching and learning within their own classroom or school milieu (McNiff, 1993). It is a process of systemic study in which teachers can examine both their and their colleagues' practice, and take action to improve teaching and learning within the classroom. More specifically, it involves cycles of problem formulation, planning, action, reflection, evaluation, and communication (McKernan, 1996). It is based on the following assumptions:

1. Teachers and principals work best on problems they have identified for themselves.
2. Teachers and principals become more effective when encouraged to examine and assess their own work and then consider ways of working differently.
3. Teachers and principals help each other by working collaboratively.
4. Working with colleagues helps teachers and principals in their PD (Watts, 1985, p. 118).

As in most of other formats the intent of action research is to improve the teachers' immediate classroom teaching; moreover, if applicable, the intent is to generalize it across other contexts in the school or beyond (Cochran-Smith & Lytle, 1990).

Coaching: Coaching is a PD strategy that provides one-on-one learning opportunities for teachers focused on improving teaching by reflecting on one's own or another's practice. It takes advantage of the knowledge and skills of experienced teachers, giving them and those with less experience opportunities to learn from each other (Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2009). An instructional coach helps less experienced teachers by way of demonstrations, observations, and conversations with teachers as they implement new strategies and knowledge. Typically, instructional coaches have expertise in the applicable subject area and related teaching strategies (Croft et al., 2010). Russo (2004) describes school-based coaching in this way:

> School-based coaching generally involves experts in a particular subject area or set of teaching strategies working closely with small groups of teachers to improve classroom practice and, ultimately, student achievement. In some cases coaches work full-time at an individual school or district; in others they work with a variety of schools throughout the year. Most are former classroom teachers, and some keep part-time classroom duties while they coach (p.1).

Lesson Study: Lesson study, which originates from Japan, is a cycle of instructional improvement which has planning, observing, and discussing research lessons steps. The primary goal of the lesson study PD is to improve teachers' lesson planning and implementation skills by increasing the teachers' abilities to observe, predict and react effectively to students' thinking (Woodruff, Cox, Tosa, & Farrell, 2013). During sessions known as "research lessons," teachers alternate in preparing a best possible lesson to demonstrate a specific teaching and learning goal. Other teachers observe while the lesson is taught and usually record the lesson in a number of ways, including videotapes, audiotapes, and or pencil and papers. After the lesson, the teachers meet and discuss the lesson's strengths and weakness, ask questions, and make suggestions to improve the lesson (Fernandez, 2002). Further, the observers observe the lesson ones more to see the effect of feedback.

Critical Friends Groups: A critical friends group generally ranges between six to twelve teachers who come together and work together with the aim of establishing student learning outcomes and increasing student achievement (NCRF, 2013). Teachers meet and help each other think about better teaching practices, look closely at curriculum and student work, analyse each other's work, including artefacts such as student work, a lesson plan, or assessment. They also may discuss challenges they are facing with presenting the subject matter or with meeting a particular student's needs. Hord (1997) stated that critical friends group visit and observe each others' classrooms as a regular practice of their PD. In these groups peers provide feedback and assistance to support individual learning, community improvement and ultimately student learning.

Study Groups: It is more or less same as critical friendship groups. Through study groups, teachers meet others, make friends, learn more, save time, work as a team and expand their thinking. In small groups, teachers generate topics for study related to school improvement and student learning. Teachers can make preparation for class discussions and prepare the exams by using a study group. Especially for starters studying with others in a small group is helpful to everyone because they think out load, share ideas and learn from one another. They engage in structured dialogue or discussion that explores issues deeply and considers the implications for school or classroom practices (Croft et al., 2010).

Above are the some general examples of PD programs. Their formats vary depending on the purpose of the PD program. However, they are more or less similar in most of their aspects. For instance, they are all conducted with group of teachers and they are generally based on cooperation and collaboration. When issue is the PD, in one hand, there are effective PD designs; on the other hand, there are effective characteristics of PD designs. Thus, above some effectively used PD designs are explained, below, the effective characteristics of PD designs are discussed. The characteristics of effective PD that have been compiled below are a result of reviewing the literature on this topic.

Recent and distant research on PD programs has included several characteristics as effective features of PD programs: (a) content and pedagogy focus, (b) active learning, (c) coherence, (d) duration, and (e) collective participation (Birman et al., 2000; Borko, 2004; Desimone, 2008; Fullan, 1993; Garet et al., 2001; Guskey, 1994; Loucks-Horsley et al., 1998; Yoon, Garet, Birman, and Jacobson, 2007; Wayne et al., 2011; Wei et al., 2009). These characteristics have the potential of improving teacher knowledge and skills and improving their practice, and which accordingly improve student achievement. Additionally, Corcoran (2007) summarizes the effective PD programs as follows: PD programs should produce the desired changes in teachers' classroom practices and enhances their capacity for continued learning and professional growth, which in turn contributes to improvements in student achievement.

Wayne et al. (2008) states, "it is generally accepted that intensive, sustained, job-embedded PD focused on the content of the subject that teachers teach is more likely to improve teacher knowledge, classroom instruction, and student achievement" (p. 470). Teachers should possess deep knowledge about the subjects they teach and understand how to effectively teach those subjects to their students. That's why as Desimone (2009) states the most influential feature of PD programs is the content focus and as Loucks-Horsley (1995) states the effective PD programs should focus on both content knowledge and PCK. Contrary to others Schibeci and Hickey (2000) states that the emphasis on the content in PD programs alone do not necessary lead to more effective teaching. To them, the general predominance of the scientific dimension as a focus for the development of elementary science teachers' practice has perhaps masked the importance of the other two dimensions in learning about science teaching and learning. Moreover they assert that finding real examples in the literature of the professional and personal dimensions of science teachers as learners is difficult.

"When it comes to learning teachers are like students" says Darling-Hammond (1996) in her review of literature on PD. Moreover, she reports that the most effective learning occurs as teachers engage in the process. Birman, Desimone, and Porter (2000) conducted their study with over 1,000 teachers who participated in PD programs; found that active involvement by participants resulted in a more successful PD experience for teachers. Shepardson, Harbor, Cooper, and McDonald (2002) did a survey study with 39 teachers who participated in a two-day or two-week PD program, ascribed the part of the success of a PD study to teacher engagement and involvement in the design of the program.

Birman et al. (2000) found that coherence of PD goals with school policies and other PD experiences was directly related to increased teacher learning and improved classroom practice. For the PD programs to guide practice they should be "school based" or "integrated into the daily work of teachers" (Hawley & Valli, 1998; Joyce & Showers, 2002).

Many researchers such as Birman et al. (2000) and Garet et al. (2001) specify collective participation as the same department/school, some subject, or same grade. Collective participation has a number of advantages. It enables the teachers of same school, subject or grade to discuss concepts and problems in detail. It leads effective collaboration and feels free communication. In addition, it gives teachers the opportunity to share common curriculum materials, course offerings, and assessment requirements (Birman et al., 2000). Moreover, it also may enable teachers who teach the same grade or subject to develop a common understanding of instructional goals, methods, problems, and solutions (Ball, 1996; Newmann & Associates, 1996).

The duration of the PD program or the number of contact hours the teachers are engaged in PD programs is one of the factors that are associated with teacher learning, and student learning. While there is consensus that the more intense participation in the PD for teachers and the more exposure to the resulting reform based teacher instruction the more teachers benefit from PD programs. There is not a consensus on the threshold duration of a PD program which may professionally develop teachers (Banilower, 2002; Corcoran, McVay, & Riordan, 2003; Desimone, 2008). According to Banilower et al. (2006), consistent effects are found when teachers receive over 100 hours of PD. On the other hand, Tanrıverdi and Günel (2012) claim 18 months as critique duration for a PD programs to yield desired results and they add that this duration may change because it is aim and content dependent. Moreover, Yoon and colleagues (2007) found in their review of research that PD programs of 14 hours or less showed no effects on student learning, while longer duration programs (about 49 hours) showed positive and significant effects on student achievement. Since features of effective PD programs are stated above, below initially the traditional PD programs are criticized then the views of different researchers on characteristic of effective PD programs are summarized.

In his doctoral dissertation, conducted at a large urban high school in the western Unites States, Hessee (2011) sees the traditional model of PD no more than an approach in which teachers attend workshops and seminars where they are provided with new and innovative instructional strategies. He rightfully complains that these teachers, without any practice, return to their classrooms where they are left to implement these strategies in isolation. This typically results in teachers failing to implement the instructional strategies presented. He stated that this is consistent with the findings of Joyce and Showers (1988) that only one in ten teachers actually implemented strategies which they encountered in PD sessions while these same strategies were adopted by ninety percent of the teachers when job-embedded assistance was provided. Why teachers do not carry their gained practices to their classes? There are several reasons however the most important reason is that teachers mostly forget what they learn during PD programs.

Murphy (2002) described the old approach to PD still used in many schools today and stated that for years, staff development programs have planned with the intend to achieve dramatic improvement in classroom teaching and student performance. However, in many cases, these efforts are frustration because what the teachers learn in these programs has little relationship to actual practice. He concludes: "As a result, teachers tend to regard the “in-service” as the fulfilment of a mandatory requirement rather than an improvement opportunity" (p. 16).

Mouza (2002/2003) stated the following reasons cited in the literature as being responsible for the inadequateness of many PD efforts: 1) the development of activities away from the school site, 2) the irrelevance of activities to teacher classroom practices, 3) provision of one-shot workshops without follow-up support, and 4) the inability to address the individual needs and concerns of the teachers.

The traditional PD programs and their inadequateness are stated above. Besides, research on effective PD is considerably large. Each researcher has different conclusions about the effective PD programs. Table 2.1 summarizes the characteristic of effective PD programs evaluated by various studies by Zhao (2008) and Guskey (2003).

Table 2.1 Characteristic of effective PD programs (adopted from Zhao (2008) and Guskey (2003))

Author	Characterises
Little (1993)	Effective PD: 1. offers meaningful intellectual, social, and emotional engagement with ideas, with materials, and with colleagues both in and out of teaching 2. takes explicit account of the contexts of teaching and the experience of teachers 3. offers support for informed dissent 4. places classroom practice in the large contexts of school practice and the educational careers of children 5. prepares teachers to employ the techniques and perspectives of inquiry 6. ensures bureaucratic restraint and a balance between the interests of individuals and the interests of institutions.
Abdal-Haqq (1995, p.1)	Effective PD: 1. is ongoing 2. includes training, practice, and feedback; opportunities for individual reflection and group inquiry into practice; and coaching or other follow-up procedures 3. is school based and embedded in teacher work 4. is collaborative, providing opportunities for teachers to interact with peers 5. focuses on student learning, which should, in part, guide assessment of its effectiveness 6. encourages and supports school-based and teacher initiatives 7. is rooted in the knowledge base for teaching 8. incorporates constructivist approaches to teaching and learning 9. recognizes teachers as professionals and adult learners 10. provides adequate time and follow-up support 11. is accessible and inclusive.
Corcoran (1995)	Effective PD: 1. stimulates and supports site-based initiatives (schools', districts' and teachers' initiatives) 2. is grounded in knowledge about teaching 3. models constructivist teaching 4. offers intellectual, social and emotional engagement with ideas, materials and colleagues 5. demonstrates respect for teachers as professionals and as adult learners 6. provides sufficient time and follow-up support for teachers to master new content and strategies and to integrate them into their practice 7. is accessible and inclusive.

Table 2.1 (continued)

Author	Characteriscs
Guskey (1995)	Effective PD must: 1. recognize change as being both an individual and an organizational process 2. think big, but start small 3. work in teams to maintain support 4. include procedures for feedback on results 5. provide continuous follow-up, support, and pressure 6. integrate programs.
Loucks-Horsley, Stiles, and Hewson (1996)	Effective PD (in science and math): 1. is driven by a clear, well-defined image of effective classroom learning and teaching 2. provides teachers with opportunities to develop knowledge and skills and broaden their teaching approaches, so they can create better learning opportunities for students 3. uses instructional methods to promote learning for adults which mirror the methods to be used with students 4. builds or strengthens the learning community of teachers 5. prepares and supports teachers to serve in leadership roles if they are inclined to do so 6. consciously provides links to other parts of the education system 7. includes continuous assessment.
Little (1998)	Effective PD: 1. ensures collaboration adequate to produce shared understanding, shared investment, thoughtful development, and a fair, rigorous test of selected ideas 2. requires collective participation in training and implementation 3. is focused on crucial problems of curriculum and instruction 4. is conducted often enough and long enough to ensure progressive gains in knowledge, skill, and confidence 5. is congruent with the contributes to professional habits and norms of collegiality and experimentation.

Table 2.1 (continued)

Author	Characteriscs
Hawley and Valli (1999)	Effective PD: 1. focuses on what students are to learn and how to address the different problems student may have 2. is driven by analyses of the differences between goals and standards for student learning and performance 3. involves teachers in the identification of what they must learn and the development of the learning process 4. is primarily school based and integral to school operations 5. provides learning opportunities related to individual needs organized around collaborative problem solving 6. is continuous and ongoing, involving follow-up support for further learning, including support from sources external to the school 7. incorporates evaluation on outcomes and processes that are involved in the lessons learned through professional development 8. provides opportunities to engage in developing an understanding of the knowledge and skills to be learned 9. is integrated with a comprehensive change process that addresses impediments to, and facilitations of, learning.
Loucks-Horsley, Love, Stiles, Mundry, and Hewson (2003, p. 44)	Effective PD: 1. is driven by a well-defined image of effective classroom learning and teaching 2. provides opportunities for teachers to build their content and pedagogical content knowledge and examine practice 3. is research based and engages teachers as adult learners in the learning approaches they will use with their students 4. provides opportunities for teachers to collaborate with colleagues and other experts to improve their practice 5. supports teachers to serve in leadership roles 6. links with other parts of the educational system 7. has a design based on student learning data and is continuously evaluated and improved.
The American Educational Research Association (2005, p. 4)	Effective PD: 1. focuses on the subject matter 2. aligns teachers' learning opportunities with their real work experiences, using actual materials and assessments 3. provides adequate time for professional development and ensure that the extended opportunities to learn emphasize observing and analyzing students' understanding of the subject matter 4. ensures that school districts have reliable systems for evaluating the impact of professional development on teacher's practices and student learning.

Adapted from Zhao (2008, p: 25-33)

When Table 2.1 is examined, even though some experts states some distinctive characteristics such as supporting teachers to serve in leadership roles (Loucks-Horsley, et al., 2003) similar characteristics are generally remarked as effective by all these researchers. Actually the effective characteristics that recent research agreed on are the summary of above features. Brief descriptions of the effective characteristics of PD programs are as follows:

Content focus: This characteristic includes the activities that focus on subject matter content and how students learn that content. As Desimone (2000) and Corcoran (1995) state this is the most influential feature of teacher learning. After arguing the importance of content focus and reviewing the related studies, Garet et al. (2001) view the degree of content focus as a central dimension of high-quality PD programs. Parenthetically, the PD course designed for this study primarily focuses on the content and aims to increase teachers'' subject matter knowledge.

Active learning: As opposed to passive learning, when teachers are given opportunities to engage in active learning is also related to the effectiveness of PD (Garet et al., 2001; Loucks-Horsley et al., 1998). Opportunities for active learning can take a number of forms, including the opportunity observing expert teachers, being observed by expert teachers and having interactive feedback from them, making discussions, reviewing student work in the topic areas being covered, planning how new curriculum materials and new teaching methods will be used in the classroom etc. (Carey & Frechtling, 1997; Borko, 2004; Lieberman, 1996).

Coherence: A third core feature of PD concerns the coherence, the extent to which teacher learning is consistent with teachers' knowledge and beliefs (Elmore & Burney, 1997). As Garet et al. (2001) stated PD for teachers is frequently criticized on the ground that the activities are disconnected. They assessed the coherence of a teacher's PD in three ways:

> the extent to which it builds on what teachers have already learned; emphasizes content and pedagogy aligned with national, state and local standards, frameworks, and assessments; and supports teachers in developing sustained, ongoing professional communication with other teachers who are trying to change their teaching in similar ways''(p.927).

Long duration: In terms of duration effective PD programs has two dimensions, that is, time span and contact hours. Time span is the duration of the time over which the activity is spread (e.g., one month or one semester) and the contact hours is the number of hours spent in the activity (e.g., 15 hours). Research shows that PD is likely to be of higher quality if it comprises sufficient duration (Cohen & Hill, 2001; Fullan, 1993; Guskey, 1994; Supovitz & Turner, 2000). Garet et al. (2001) showed that time span and contact hours exert a substantial influence on the core features of PD experiences. That is to say, longer activities tend to include substantially more opportunities for active learning, also tend to promote coherence and enable teaching the content.

Sustained-Intensive: If a program continues over time and offers substantial contact hours it can be said that it is sustained and intensive. Moreover, PD that is sustained and intense has a greater chance to change teaching practices and foster student learning (Cohen & Hill, 2001; Desimone et al, 2002; Garet et al, 2001). Research on teacher PD programs reveals that intensive PD programs can help teachers to increase their knowledge and change their instructional practices (Borko, 2004).

Collective participation (Collaboration): Another critical feature of effective PD programs is collective participation of teachers. This feature can be accomplished through design of the PD program for groups of teachers from the same school, department, or grade level. Teachers who work together, who teach to same grade and who are in the same subject (e.g. physics, math, chemistry etc.) are more likely to collaborate and have the opportunity to discuss concepts, skills, and problems that arise during their PD experiences or are likely to share common curriculum materials, course offerings, and assessment requirements (Garet et al., 2001). Collaboration is a process by which small groups of teachers work together, using a variety of methods and structures, for their own PD. A collaborative learning environment is one of the characteristics of PD courses that brings along the student achievement (Knapp, 2003; Darling-Hammond & McLaughlin, 1995).

Delivered in conductive settings: The success of a PD is also depends on its settings. The time and the place of congregation, the environment of the workshops have to be proper to teachers' needs. In other word, a PD should have an easy nature of planning. Wayne et al. (2011) showed that PD, when delivered in conductive settings, by those who designed the PD, can have a positive impact on student achievement.

Just-in time teaching (JiTT): Originally JiTT is a technique for teaching and learning that uses the Internet to improve student success by enhancing and extending classroom instruction via the Web (Novak, Patterson, Gavrin, & Christian, 1999). However, in this study JiTT has slightly different meaning then the pre-class assignments used to prompt thinking about the upcoming lecture topic. In this study JiTT is used to describe the immediate application of the practices that teachers gain during the PD course. First of all, JiTT used in this study is not related to Internet which is a base for Novak and Patterson's (2000) JiTT. Second, in this study JiTT is used to imply the immediate application of the practices that teachers gain during the "teachers teaching teachers" PD course to classes. The JiTT in this study is similar to just-in time training which refer to rolling-out, or launching it, immediately prior to its usage. The advantage to implementing JIT is the shortened time between learning and application.

2.3 Teacher PD Programs and Student Achievement

The ultimate goal of a PD program should be to prepare teachers to be effective in their classes and accordingly increase students' achievement (Hawson, 2007; Lingard, Hayes, Mills & Christie, 2003). Tienken (2003) supported this idea and stated that one goal of PD is a change in teacher behavior leading to positive gains in student achievement. Many other researcher also talks about the direct relation between PD for teachers, and improving classroom instruction and student achievement (Cohen & Hill, 2000; Corcoran, Shields, & Zucker, 1998; Darling-Hammond & McLaughlin, 1995; Elmore, 1997; Little, 1993). While there is more literature on the effects of PD on teacher learning and teaching practice, they are falling short of demonstrating effects on student achievement (Garet et al., 2001). Even though it was not an empirical study, Darling-Hammond (1999) analyzed large-scale assessment data across United States, and her research results showed that teacher preparation in PD programs was positively related to student achievement.

Finding relation between PD studies and students achievement empirically is of great importance (Wayne et al., 2008). This is a virgin area, and experimental studies can be counted on the fingers of one hand (Wei et al., 2009). The results of review of Yoon et al. (2007) and Meta-analysis of Blank and Alas (2009) report 23 experimental studies in the area of teacher PD ranging from 1986 to 2009. Moreover, the literature review conducted by the researcher did not yield any experimental studies between 2010 and 2012. Since the literature review conducted for this study culminated in approximately 2012, and no extensive review was conducted during the implementation phase of the study, experimental studies from 2013 (if they exist) were not included. The lack of studies in this area could be because of the complexity and difficulty in conducting and designing PD studies. As Hewson (2007) stated conceptually, research in this area is very difficult.

> Although the immediate focus is on the professional development activity itself and the teachers who participate in it, the ultimate purpose of professional development is the improvement of student learning. The pathways of influence of professional development from the original activity to student learning proceed through the intervening variables of teacher learning and classroom enactment. These pathways are complicated, not only by the time it takes for teachers to clarify their learning from professional development activities and translate this into effective curriculum and instruction, but also by everything else that is happening concurrently in the lives of students, teachers, schools, and the community; teacher learning in professional development activities, teachers teaching in classrooms, and student learning are not isolated from the educational and social environments of schools and communities (p.1182).

Because of scarceness of the experimental studies, the studies mentioned here are from various areas such as mathematics, science, elementary school subjects and so on. Unfortunately it is difficult to find a study directly related to physics. Below are some examples ranging from science to reading and ranging from middle school level to kindergarten level.

For instance, Carpenter et al. (1989) investigated whether mathematics teachers who had participated in a program designed to help them understand children's thinking employ different instructional processes in their classrooms than did teachers who had not participated in the program. They assigned 20 first grade teachers, randomly to an experimental treatment, participated in a month-long workshop (80 hours) and other first grade teachers (n = 20) were assigned randomly to a control group. The goal of the workshop they designed for the treatment group was to help teachers understand how children develop "addition and subtraction" concepts and provide them the opportunity to explore how they might use that knowledge for instruction. (They called the program Cognitively Guided Instruction). Throughout the following school year, they had trained observers to observe all 40 teachers and their students during mathematics instruction. They measured teachers' beliefs by using a 48-item questionnaire designed to assess their assumptions about the learning and teaching of "addition and subtraction". Students in the 40 teachers' classes completed a standardized mathematics achievement pre-test and post-test. They also had students completed several measures of attitudes and beliefs developed for their study. They found that experimental teachers encouraged students to use a variety of problem-solving strategies, and they listened to processes their students used significantly more than did control teachers. Moreover, they found that students in experimental classes exceeded students in control classes in number fact knowledge, problem solving, reported understanding and reported confidence in their problem solving abilities.

Similarly, Cole (1992) conducted a randomized controlled trial to determine the effects of a one-year comprehensive staff development program on the reading, language, and mathematics achievement scores of fourth grade students. Twelve fourth-grade teachers and their intact classes of totally 268 students were randomly assigned into treatment and control groups. A comprehensive staff development training program was applied to six teachers. In order to assess fidelity of implementation, classes of these teachers were observed. However, the details of the treatment or any PD that control group teachers may have had were not provided. Students' scores on the Stanford Achievement Test for math, reading, and language were the outcome measures. Students' third-grade test scores were used as pre-tests, and their fourth-grade test scores were used as the post-tests. Statistically significant differences were found on the results of eight student subgroups. For comparability with the other studies the average effect sizes for math, reading and language were reported as 0.50, 0.82 and 0.24 respectively. First two effects that are in math and the reading were statistically significant in favour of treatment group, however, the average effect in language was positive but was not statistically significant.

Scott (2005) also investigated the effect of PD on student achievement in her dissertation. She initially sought to determine the effect of the PD model (Teachers Engaged in Authentic Mentoring Strategies) on instructional practices of third grade science teachers. Afterward she examined the effect of instructional practices, as impacted by the PD model, on student achievement in third grade science. Similar to the current study, the effect of the PD model on teachers' instructional practice was qualitatively examined by her. Further, she collected quantitative data through a quasi-experimental design. Teachers in the experimental group received an initial PD intervention with ten follow-up interventions. The ITBS science test was administered to the students of the experimental and control group teachers during the second grade as pre-test and during the third grade as post-test. She compared the pre-test and post-test scores of experimental and control groups by using an independent samples t-test. Her qualitative and quantitative data showed that several results: The applied PD model (a) changed instructional practices, (b) increased student engagement, (c) increased collaboration among teachers and students, (d) changed teacher behaviour (e) improved student educational outcomes.

In terms of the subject area and grade level a study which was tangentially related to the current study was conducted by McCutchen et al. (2002). They worked with groups of kindergarten and first-grade teachers (the experimental group) during a 2-week summer institute and throughout the school year. They recruited teachers by letters of invitation and teachers from 40 schools responded and 44 teachers (24 experimental and 20 control groups) participated in their study. They followed the teachers into their classrooms for a year, collecting learning data on 492 kindergarten and 287 first-grade students across 43 classrooms. During the summer institute they shared with them research about learning disabilities and effective instruction, stressing the importance of explicit instruction in phonological and orthographic awareness. Comparisons between experimental group teachers' pre-test and post-test scores on phonology indicated that this group did deepen their phonological knowledge after the instruction ($F(1, 23) = 11.43$, $MSE = 59.33$, $p < .01$). They followed the experimental group and a control group into their classrooms for a year, assessing teachers' classroom practices and their students' learning. Their study yielded that teachers in experimental group used the knowledge they acquired in the program to change their classroom practice and their classroom practice improved their students’ learning.

According to Yoon et al. (2007) to substantiate the empirical link between PD and student achievement, studies should ideally establish two points: One is that there are links among PD, teacher learning and practice, and student learning. The other is that the empirical evidence is of high quality. Moreover they theorize three steps for PD to effect student achievement (Figure 2.1). First, PD enhances teacher knowledge and skills. Second, better knowledge and skills improve classroom teaching. Third, improved teaching raises student achievement. They stress the importance of these links and for them, all these steps are required; otherwise, better student learning cannot be expected. If a teacher fails to carry new ideas from PD to classroom practice, students will not benefit from the teacher's PD. Yoon et al. (2007) describe the links between PD, teacher learning and practice, and student learning as in Figure 2.1.

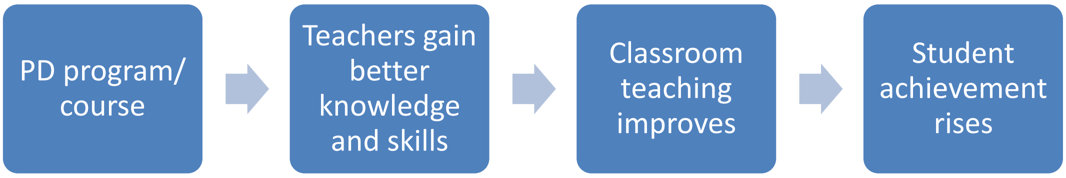

Figure 2.1 Steps of the link between PD program and student achievement

How does teacher PD affect student achievement? This question was also answered by Yoon et al. (2007) by reviewing the evidence on how teacher PD affects student achievement. They examined more than 1,300 studies identified as potentially addressing the effect of teacher PD on student achievement in three key content areas (mathematics, science, and reading and English/language arts). They found nine that meet "what works" evidence standards, as well as a strong evaluation design and the development and use of valid and reliable instruments. Differently, while the current study was conducted with high school students none of the nine studies reviewed by Yoon et al. focused on PD's effects on middle or high school students. In other words, among more than 1300 studies they reviewed none of the studies related to middle or high school meet 'What Works Clearinghouse' evidence standards. Due to concerns about the external validity of the findings, they restricted the studies with the countries Australia, Canada, the United Kingdom, and the United States. The studies adapted from Yoon et al. are listed in Table 2.2 with their key characteristics.

Table 2.2 List of studies identified by Yoon et al. (2007) and key study characteristics

Study	Study design	Content area	School level	Contact hours-duration (months)	Student outcomes	Effect Size
Carpenter et al., 1989	RCT	Math	Elementary (1st grade)	83 (4)	Iowa Test of Basic Skills Level 7: computation Same test: problem solving	0.41 0.41
Cole, 1992	RCT	Math and reading and English/language arts	Elementary (4th grade)	40 (12)	Average for math Average for reading Average for language	0.50 0.82 0.24
Duffy et al., 1986	RCT	Reading and English/ language arts	Elementary (5th grade)	10 (1)	Gates-MacGinitie Reading Test	0.00
Marek & Methven ,1991	QED	Science	Elementary (K–3rd, 5th grades)	100 (1)	Average for conservation test	0.39
McCutchen et al., 2002	QED	Reading and English/language arts	Elementary (K–1st grades)	100 (10)	Gates-MacGinitie Word Reading Subtest	0.39
McGill-Franzen et al., 1999	RCT	Reading and English/language arts	Elementary (kindergarten)	30 (6)	Concepts about print Letter identification Writing vocabulary Ohio Word Test Hearing sounds in words	1.11 0.69 0.32 0.66 0.97
Saxe et al., 2001	QED	Math	Elementary (4th–5th grades)	60 (6.5)	Fraction concepts Fraction computation	2.39 -0.53
Sloan, 1993	RCT	Math, science, reading and English/ language	Elementary (4th–5th grades)	5 (2)	Comprehensive Test of Basic Skills: Reading Same test: Math Same test: Science	0.68 0.26 0.63
Tienken, 2003	RCT	Reading and English/ language	Elementary (4th grade)	14 (3.5)	Content/ organization score on narrative writing test	0.41

Source: The synthesis of Yoon et al.' (2007) study.

The results of the studies they examined showed that average experimental group students increased their achievement by 21 percentile points. The average effect size (Cohen d) across the nine studies was 0.54, ranging from -0.53 to 2.39. All nine studies they reviewed focused on elementary school teachers and their students. About half focused on lower elementary grades (kindergarten and first grade), and about half on upper elementary grades (fourth and fifth grades). Six studies were published in peer-reviewed journals; three were unpublished doctoral dissertations. The studies were ranging from 1986 to 2003. Studies that had more than 14 hours of PD showed a positive and significant effect on student achievement from PD. The three studies that involved the least amount of PD (5–14 hours total) showed no statistically significant effects on student achievement. All nine studies employed workshops or summer institutes.

A more comprehensive Meta-analysis built on prior studies in education (Borman et al., 2002; Yoon et al., 2007) was conducted by Blank and Alas (2009). Their analysis focused on completed studies of effects of PD for K-12 teachers of science and mathematics. Their study has criteria such as (a) the document discusses the effects of in-service teacher PD on student learning, (b) the study sample focused on teachers of mathematics and/or science and their students in grades K-12, (c) the document discusses an empirical study, (d) The document must report direct student achievement outcomes, not distal student outcomes such as feelings, impressions or opinions from students about their learning, (e) the document had to be released between 1986 and 2007 and (f) the study had to take place in the United States. The coding and review process and the post-coding statistical analysis yielded 16 documents of studies to be included in their Meta-analysis.

They categorized all the studies under mathematics or science and the method of measuring effect (pre-post analysis vs. post-analysis only). In the mathematics education studies that employed pre-post measures for determining effect size, a total of 21 effect sizes were reported and the mean effect size was 0.21. Among the math studies that used a post-test only method of measuring effects, a total of 68 effect sizes were reported and the mean effect size was 0.13. The number of effect sizes for science teacher PD studies was small (pre-post: 10 effect sizes, post-analysis: 7 effect sizes) and the means for the effect sizes in each category were small and not significantly different from zero. Moreover, they concluded that studies that used randomized control trials had significantly larger effect sizes than studies that were based on quasi experimental designs. Furthermore, they found that studies that targeted the elementary grades had larger mean effect sizes than studies that targeted middle school or high school grades. An adaptation of their study is presented in Table 2.3.

Table 2.3 Experimental studies identified by Blank and Alas (2009) and key study characteristics

Study	Study Design	Content Area	School Level	Contact hours - duration (months)	Student outcomes	Effect Size
Carpenter, et al., 1989	RCT	Math	Elementary	80 (4.5)	Average posttest results from Iowa Test of Basic Skills (ITBS) Interviews on number facts & problem Average across Scales 1-3 of study-specific test	0.39 0.68 0.32
Dickson, 2002	QED	Science	Middle (8^{th}) & High (9^{th} & 10^{th})	24 (8)	Texas Assessment of Academic Skills (TAAS) (8th) End-of-Course Biology Test (9th & 10th)	0.10 0.43
Heller et al., 2007	RCT	Math	Elementary (2^{nd}, 4^{th}, 6^{th})	10 (8)	Pretest-posttest gain (4th) on Math Pathways and Pitfalls (MPP) Pitfalls Quiz	0.69
Jagielski, 1991	QED	Math	Elementary (3^{rd}-6^{th}), Middle (7^{th}, 8^{th})	36 (8)	Average of pretest-posttest gains of both treatment groups on study-specific assessment-Level 250 NAEP test item	0.77
Lane, 2003	QED	Math	Elementary	17 (8)	Pretest-posttest gain on Constructed CSAP	0.13
META Associates ,2006	QED	Math	Middle (6^{th}, 7^{th}, 8^{th})	120 (7,5)	Average of pretest-posttest gains (6th, 7th, 8th) on Colorado Student Assessment Program (CSAP)	0.13

Table 2.3 (continued)

Study	Study Design	Content Area	School Level	Contact hours - duration (months)	Student outcomes	Effect Size
META Associates ,2007	QED	Math	Middle 6th, 7th, 8th)	120 (7,5)	Pretest-posttest gain on Colorado Student Assessment Program (CSAP)	-0.19
Meyer & Sutton, 2006	QED	Math	Middle (6th, 7th, 8th)	540 (16)	Average of overall posttests (6th, 7th) in Metropolitan Achievement Test (MAT) Overall posttest in Criterion Referenced Test	-0.02 0.1
Niess, 2005	RCT	Math	Elementary & Middle (3rd-8th)	304 (8)	Pretest-posttest gain (Middle) in Technology Enhanced State Assessment (TESA)	0.11
Palmer & Nelson, 2006*	QED	Science	Elementary (5th, 6th), Middle (7th, 8th) & High (9th, 10th)	60 (8)	Pretest-posttest gain (Grades 3rd, 5th, 6th) in Northwest Evaluation Association (NWEA) assessments	0.11
Rubin & Norman, 1992	RCT	Science	Middle	30 (3)	Pretest-posttest gain (Treatment vs. Control II) in Middle Grades, Integrated Process Skill Test (MIPT) Pretest-posttest gain in (Treatment vs. Control II) Group Assessment of Logical Thinking Test (GALT)	0.64 0.12
Saxe, Gearhart, & Nasir, 2001	QED	Math	Elementary	41 (8)	Average posttest results from study-specific assessments (Conceptual Scale)	1.63
Scott, 2005	QED	Science	Elementary (3rd)	168 (8)	Pretest-posttest gain on Iowa Test of Basic Skills (ITBS)	0.20
Siegle & McCoach ,2007	RCT	Math	Elementary (5th)	2 (1 day)	Cluster result on Math Achievement Test	0.20
Snippe, 1992	RCT	Math	High	14 (3 days)	Terra Nova ACCUPLACER WorkKeys	-0.01 0.20 0.06
Walsh-Cavazos, 1994	QED	Math	Elementary (5th)	12 (3days)	Pretest-posttest gain PSG Achievement Assessment	0.26

When the two Meta analyses are compared, only two studies intersect: Carpenter et al., (1989) and Saxe, et al., (2001). The rareness of coincidences is mostly because of the selection criteria. While the average effect size (Cohen d) across the nine studies of Yoon et al. (2007) was 0.54, that of studies of Blank and Alas (2009) was 0, 21. What is significant in both studies is that the hypothesis "correct implementation of PD can increase student achievement" has experimentally and Meta-analytically been proved. "For good or ill" both studies show that there is a scarcity in the area of experimental PD studies. So the conclusion is that experimental PD research is a virgin area for researchers.

2.4 Teacher PD Programs in Turkey

In Turkey the PD programs are conducted under the name of "in-service teacher training" and generally designed by Ministry of National Education. In-service teacher training was started in 1960s in Turkey by the In-service Teacher Training Department at the Ministry of National Education (Ateşkan, 2008). Teacher PD programs in Turkey are generally conducted as seminars and conferences arranged at weekends, the end of the school days, or mostly during the summer holidays (Köyalan, 2011). Further, theoretical information is presented in these seminars. Teachers are compelled to participate to these programs and they generally listen without active participation. Başaran (1993) documented some of the major problems of in-service education in Turkey as follows: activities are limited when compared to great number of teaching staff in schools, the finance for activities is definitely not enough, the participant teachers' travel fees are not paid, there is no award or diploma for teachers who successfully finished course, generally abstract information is presented during the courses and it is insufficient for development of professional skills. Yalın (2001) suggests the in-service training courses in Turkey to be planned systematically and organized in detail, participants to be selected based on their needs, effective learning environment to be provided and focus groups to be determined, the subject area specialty of the instructor and the facilitating capacity of the instructor to be taken into account. Özer (2004) lists the problems in in-service training courses as; organizational problems, the selection of teachers, the motivation of teachers, and administrators' negative attitudes towards in-service training. It is difficult to see an in-service training course regarding only one subject (Bağcı &

Şimşek, 2000; MEB, 2002). They are usually courses related to language, computer, web and technology teaching (Tekin, 2004).

Even so, recently relatively longer and well organized PD programs can be seen especially on the area of physics. The groups of physics teachers were congregate under the control of experienced coaches and were trained by discussing the physics science demonstrations and by conducting physics laboratory activities (Eryılmaz, 2012). However these were extra programs designed by a team who prepared the 2007 national physics curriculum and they designed the programs to help teachers to comprehend the structure and the content of the curriculum.

Nevertheless, among European countries Turkey is the least that have designed PD programs for teachers. The report prepared by a research team, from the University of Twente, Netherlands, revealed that when countries are ranked in descending order the percentage of teachers having had some PD in the 18 month (2007-2008) is the least in Turkey (OOPEU, 2010). Moreover same report declares that most of types of PD undertaken in Turkey are education conferences and seminars (%75). Whereas courses and workshops was most in Austria (92%), Estonia (93%), Lithuania (96%) and observation visits to other schools were most in Estonia (63%), Iceland (60%) and Korea (67%).

As OOPEU (2010) remarks, until recently the PD programs are held in Turkey as education conferences and seminars. Nevertheless, for the 2012 year nothing has been changed (ÖYGGM, 2012). To have an idea about in-service courses in Turkey following data were collected from the web page of ÖYGGM (2012) which is the bureau responsible for improvement and education of teachers since 1989. Totally 562 different in-service training courses were planned to be conducted centrally or locally all over the Turkey in 2012. However, 181 of them were cancelled. Of them only one was related to physics which was planned for national physics Olympiads, none were related to mathematics, biology and chemistry. The programs were mostly conducted as seminars ranging from 2 day to 103 days. The average 70, 8 participants were subjected to an average duration of 10.5 days of training. However 16 of the courses were about English language and some of these courses lasted 96 and some of them lasted 103 days. When these long courses are excluded the remaining was an average of 6.5 days and 72, 5 participants. 62 % of these courses were conducted during holidays. The content of the courses were changing from the "course of educating mentally retarded students" to the "course of calibration of biomedical devices".

Elementary school teachers' perceptions of teacher development practices in Turkey were studied by Seferoğlu (1996). He selected a representative sample of 500 subjects from 52 schools in Ankara. Through a questionnaire he collected the data. His results show that teachers know that collaboration is needed however there is less interaction among teachers. Based on teachers' views he concluded that economic problems are the most important barrier preventing teachers' professional growth.

The purpose of the study conducted by Tanrıverdi and Günel (2012) was to determine the reasons of the teachers' resistance to change. They conducted a longitudinal research project that examined the effects of in-service training courses. 13 science and technology teachers participated to their study. These teachers participated to 4 in-service training courses for their project. They conducted semi-structured interviews with the teachers. During the interviews teachers' beliefs about learning and teaching and teachers' thoughts about classroom practices were asked. They determined the themes about the reasons for teachers' resistance to change. Several themes, such as teachers' inability to practice, in some topics the lack of field knowledge, classroom management problems and unavailability of materials were emerged from their study. They concluded: in-service training courses of short term and courses that do not include practices are not possible to change teachers' pedagogical beliefs. For this reason, in-service training courses should be widen to longer periods, and teachers should be given opportunities to reflect what they have learned during the in-service training course and the in-service courses should be supported by visiting teachers classroom to see teachers practices.

Tekin (2004) designed an in-service program to develop chemistry teachers' knowledge, skills and perspectives about conceptual understanding and contemporary methods of concept teaching. Moreover, she investigated its influence in practice. Her sample was 37 chemistry teachers working at Trabzon and Akçaabat. She used case study research methodology and, gathered the data with questionnaires, interviews, observations, achievement test, researcher diary, and document analysis. She initially conducted a need assessment, then she developed and designed an in-service program, she then implemented it and finally evaluated the program. She used System Approach Model to prepare the course program. The implementation phase of her study lasted ten working-days. She implemented the course in four phases and in the order of presentation of theory, modeling, application, discussion. Her findings showed that in-service course designed was quite successful. She conducted five case studies to investigate the teachers' use of knowledge, skills, and perspectives in their classes. Her results showed that what teachers learn in in-service courses is not directly carried to the classrooms, while some teachers are able to apply and reflect sufficiently what were learned during the in-service training courses others were not.

Küçüksüleymanoğlu (2006) examined and described the in-service training programs for English language teachers in Turkey, during the 1998-2005 academic year. She randomly selected 186 teachers and 5 instructors who participated in programs from 2003 to 2005 as sample. She collected data by means of interviews and questionnaires. Her results indicated that the number and the content of the in-service training programs for English language teachers were insufficient, the in-service training programs should be practiced widely all over the country, all teachers should take part in programs periodically, the courses should be practice-based, each school should perform a needs analysis for its teachers and find out the necessary topics and inform the Ministry of Education.

The aim of this study of Ateşkan (2008) was to investigate science teachers' perceptions about the online teacher PD program. She initially designed the online PD program. Then she implemented the program with the participation of biology teachers. The implementation lasted ten weeks. The online program consisted of instructional activities such as reading case studies, self-reflection, forum discussions, watching videos of a sample lesson, hands-on activity and WebQuest. Her study was mainly qualitative. She collected data through pre- and post-interviews, online questionnaire, observations and documentation that include weekly assignments, forum discussions, e-mail correspondence, weekly e-journals, detailed notes of phone calls and the researcher's journal. Her findings demonstrated that teachers were not satisfied with PD programs that they got before her online PD program. Her participants found the earlier programs problematic in terms of because of the problems about content, process and organization connected with them. She concluded that participants preferred online PD program, because of its flexibility and versatility, sharing information among colleagues from different parts of the country, and self-paced learning. Moreover teachers found some aspects of online PD program problematic such as technical problems, not having face-to-face sessions and the timing of the program.

Yiğit (2008) developed and evaluated the effectiveness of an intensive in-service training course for primary school teachers in Trabzon. The course was about the use of instructional technologies and material development and was given to teachers for two weeks by the field experts that are university academicians. In the course totally 80 hours of instructional activities were carried out. He applied a semi-structured pre-questionnaire to teachers at the beginning of the course. He used this questionnaire's results to determine the final content of the course and method of application. He collected quantitative data through a post-questionnaire and based on the results he illustrated that there was a meaningful difference in between teachers' pre-course expectations and after-course views. Moreover, he pointed out the importance of carrying out needs assessments before conducting an in-service course. Briefly, he conducted a needs analysis, applied a treatment to teachers through a course and determined the attitudes and perceptions of primary school teachers about the course with questionnaires.

The aim of the study carried out by Altuna and Gök, (2010) was to determine what kind of an in-service teacher training program is ideal according to the teachers. In order to expose teachers' expectations from the in-service education a conjoint questionnaire was prepared. They used quantitative research method for the data collection, data analysis, and interpretation of the data. They found that, the training should be held in seminars, should be held in the same province, the person who gives the training should not be an expert from university instead should be a teacher with PhD degree, should be a seminar in which teachers actively take part, the topic of the training should be decided in accordance with interests of teachers or participant teachers should decide the topic. Moreover, teachers perceived the seminar times as a waste of time and teachers wanted to spend seminar time more effectively, teachers did not believe that lecture type training was useful and adequate. Furthermore, they found that although male and female teachers agreed with other and with general results, female teachers thought that the topic of the in-service training should be determined by the Ministry of National Education.

To sum up, the literature review conducted by the current researcher showed that an experimental study that is a PD study that searched the effect of a treatment given to teachers and its subsequent effect on student achievement has not yet being conducted in Turkey. This study is expected to be the first. Many research results conducted in Turkey points out the effective characteristics of PD programs. For instance, Küçüksüleymanoğlu, (2006), Tekin & Ayas, (2006), and Akar (2007) stated it is crucial that in-service training programs be steady and continuous (sustained), so that training can be beneficial. When in-service education programs are prepared according to the needs and expectations of the participants (coherence) the success of the program will be inevitable (Küçüksüleymanoğlu, 2006; Yiğit, 2008; Altuna and Gök, 2010). Yiğit (2008) remarked that practical applications are more powerful than any other practices, the meaningful differences in teachers development could be related to more hands on activities (active participation) involved in the course. Teachers prefer a method in which they actively take part, they don't want lecture type training and they don't believe lecture type training is useful and adequate (Özen, 2004; Altuna and Gök, 2010). Despite the favourable results of all these studies nevertheless almost nothing has been changed about teacher PD in our country. Finally, it is 2014th year and Turkey still does not have an effective PD program for teachers.

2. 5 Modern Physics (special relativity)

In this study, the effect of the "teachers teaching teachers" PD on teachers' knowledge and on student achievement was searched through the modern physics unit. That's why some examples of studies related to modern physic (special relativity) will be informative. However, when the physics education literature was examined, it was observed that until today the number of studies done about students' understanding of relativity is quite small in number and their focus is mostly on Galilean relativity (Selçuk, 2010). Previous studies about theory of special relativity are not very numerous and they showed that students fail in defining and using the concepts of theory and thus confuse most of its concepts (Hewson, 1982;

Scherr, 2007; Villani and Pacca 1987). The results of the examples listed below supports these findings.

First, Hosson, Kermen and Parizot (2010) in their study aimed at exploring prospective physics teachers' reasoning associated with the concepts of reference frame, time and event which form the framework of the classical kinematics and that of the relativistic kinematics. The research was conducted in France and 94 prospective physics teachers were surveyed by means of a questionnaire. The students responded to eight multiple choice questions including a request for justification. Their results showed that students show a deep lack of understanding of both concepts of reference frame and event.

Second, the aim of the study conducted by Dimitriadi and Halkia (2012) was to investigate students' learning processes towards the two axioms of the theory of special relativity (the principle of relativity and the invariance of the speed of light) and the consequences of the two axioms. They developed a teaching and learning sequence consisting of five sessions after analysing the physics college textbooks, reviewing the relevant bibliography and conducting a pilot study. To collect the data they used experimental interviews. Their sample consisted of 40 10th grade students. They collected the data by interviews, as well as by two open-ended questionnaires filled out by each student, one before and the other after teaching theory of special relativity. Their results showed that upper secondary education students were able to cope with the basic ideas of the theory of special relativity, however they found that the conceptions; (a) there is an absolute frame of reference, (b) objects have fixed properties and (c) the way events happen is independent of what the observers perceive were difficult for students to understand.

Third, Selçuk (2010) investigated the pre-service teachers' understanding of and difficulties with some core concepts in the special theory of relativity. The 185 participants were from the Departments of Physics Education and Elementary Science Education at Dokuz Eylul University. She used both quantitative and qualitative research methods in her study. She applied a paper-and-pencil questionnaire including four questions and conducted in-depth interviews with the participant teachers after the instruction of related modern physics topics. Pre-service teachers' understanding of and difficulties with core elements of special relativity such as time, length, mass and density were tested. Teachers' specific and considerable difficulties with proper time, time dilation, proper length, mass and relativistic density concepts were among the results of her study. After examining the related literature she summarized that no matter from which academic level (i.e. from secondary to university) the students are obviously have difficulties in understanding and comprehending special relativity subjects.

A brief search of the literature revealed that the number of publication on modern physics (special relativity) is limited. Moreover due to counterintuitive nature of the concepts students find it hard to learn and to understand the deep implications of the theory. Further, no studies about modern physics that was related to teacher PD were found.

2.6 Summary of the Literature Review

The literature of PD reviewed in this chapter can be summarized as the following:

- Among the main factors that affect the quality of education, the teachers have a special importance. Shortly, teachers are sine quo non for education, without them it is difficult for learning to take place (Darling-Hammond, 1999; Goldberg, 2000; Tekin & Ayas, 2005). High-quality teachers are the key to improved student learning (Dori & Herscovitz, 2005; Fullan, 1996; Guskey, 2003; Wei et al., 2009).
- Practice of PD is a process of design and especially in science is itself inherently complex, consisting as it does of a number of interrelated components (Hewson, 2007; Thompson, 2008).
- Due to the ineffectiveness of traditional PD programs, teachers do not carry their gained practices to their classes (Hessee, 2011; Joyce & Showers, 1988; Murphy, 2002). For teachers to be affective in their classrooms they have to possess deep understanding of the subject matter and pedagogy. Increasing the quality and the performance of the schools is directly related to improving the teacher effectiveness in the classroom (Blank & Alas, 2009).
- The characteristics of effective PD that have the potential of increasing teacher knowledge and skills and improving their practice, and which accordingly increase student achievement are a) content and pedagogy focus, (b) active learning, (c) coherence, (d) duration, and (e) collective participation (Abdal-

Haqq,1995; Corcoran, 1995; Guskey, 1995; Hawley & Vall, 1999; Little, 1993-1998; Loucks-Horsley, Stiles, & Hewson,1996; Loucks-Horsley et al., 2003).

- Any PD program focused on the content has the most influential feature of teacher learning. Accordingly having adequate SMK helps teachers to feel free and to motivate students (Corcoran,1995; Desimone, 2000; Korur, 2008; Loucks-Horsley, 1995).
- Any study that looks at the effect of PD on student success is accepted as experimental study. Moreover, experimental study on teacher PD is a virgin area for researchers. Especially the subsequent effect of PD on student achievement has been studied by only 23 studies (Blank & Alas, 2009; Yoon et al., 2007).
- The PD in Turkey is usually conducted under the in-service training courses. The PD in these courses is reported as ineffective (Ateşkan, 2008; Seferoğlu, 1996; Tekin, 2004). Recently, several individual effective programs have been conducted (Eryılmaz, 2012; Tanrıverdi & Günel, 2012).
- The special relativity concepts are so counterintuitive and contradicting with our daily understanding of space and time that physics students find it hard to learn relativity (Hewson, 1982; Scherr, 2007; Villani & Pacca 1987; Hosson, Kermen & Parizot 2010; Selçuk, 2010).

Based on the results of the literature review it can be said that teachers are one of the most important factor which is responsible for either students' success or failure. Thus, increasing their quality and skills through PD programs/courses is of great importance. Relatedly, there is an explicit lack of experimental study in the area of teacher PD. More studies are required to improve this area and accordingly to lead to working PD programs. Further, two of the reasons why there are so little experimental PD studies are that they are inherently complex and designing PD programs require great effort. Thus, there is not a feasible design that attracts researchers to start to make search in this area without fear. What is more, the literature has specified the features of effective PD programs, however there are not any studies that possess all or most of the effective characteristics of PD programs. Especially studies that focus on the content of PD program and accordingly increase teachers SMK are desired. Additionally, although the collaboration of teachers have been studied widely few studied were found that have adapted the collaboration to experimental PD programs. Furthermore, in Turkey an experimental study in the area of teacher PD which subsequently looks at the effect of program on student achievement has not yet being conducted. Finally, among the 23 known experimental studies none has physics related content. Similarly, none is related to modern physics (special relativity) at tenth grade level.

CHAPTER 3

METHOD

In this chapter; population and sample of the study, variables, instruments, research design, procedure, implementation of treatments, researcher role, treatment fidelity, treatment verification, analysis of data, power analysis, assumptions and limitations, ethical issues, and time and budget are discussed.

3. 1. Population and Sample

The target population of the study is all tenth grade students from Anatolian high schools in Yenimahalle, Mamak, and Altındağ districts of Ankara. The accessible population is all tenth grade students from Anatolian high schools located at Demetevler quarter of Yenimahalle district and city centres of Mamak and Altındağ districts of Ankara. The selection and the characteristics of all participants, namely that of teachers and students are given in Sections 3.1.1 and 3.1.2. The schools in the target and accessible populations of the study are summarized in Table 3.1.

Table 3.1 The schools and their representativeness

District	# of Anatolian high schools (Target	# of Anatolian high schools (Accessible Population)	# of Anatolian high schools (This study)	Accessible Population (%)
Yenimahalle	21	9	3	33
Mamak	16	10	1	10
Altındağ	12	5	2	40
Total	49	24	6	25

The representativeness of the sample is ensured through Table 3.1. There are 49 Anatolian high schools in Yenimahalle, Mamak and Altındağ districts of Ankara, Turkey. There are 24 Anatolia schools in the accessible population and only six of them were convenient to be included in the present study (Table 3.2). Thus, 25 % of the schools of the accesible population are participating to this study.

The focus of this study was the effect a physics professional development (PD) course has on teacher knowledge and their student achievement. Therefore the sample of the study was consisting of both teachers and their students. The selection of students was completely depending on the selection of their teachers. Teacher participants of the study were selected on the volunteer bases. Besides, the purpose of the study also affected the sample selection. That’s why combination of both convenience and purposive sampling procedures were utilized to generate a sample that data were collected for both the quantitative and qualitative portions of this study. A convenience sampling is a group of individuals who are available for study and a purposive sampling is based on previous knowledge of a population and the specific purpose of the research (Fraenkel & Wallen, 1996). Both sampling procedures were applied as follows: teachers were selected based on their availability to attend to the "teachers teaching teachers" (TTT) course, their availability for five weeks of training, as well as their interest in receiving the benefits of the course for their subject matter knowledge (SMK) related PD (convenience sampling). Secondly, the sample of the study was chosen (purposive sampling) from those teachers who accepted the conditions and requirements of the study stated in the next section.

Table 3.2 The sample of the study

		Treatment		Placebo	
		Experiment	Control	Pre	Post
School #	Type of School	Class Size	Class Size	Class Size	Class Size
1	Public Anatolian	-	-	29	30
2	Private Anatolian	-	-	22	21
3	Public Anatolian	18	30	-	-
4	Public Anatolian	30	29	-	-
5	Public Anatolian	31	31	-	-
6	Vocational Anatolian	25	35	-	-
	Total	104	125	51	51

The first two schools in Table 3.2 are the placebo group students' schools. The characteristics of teachers and students are given in Sections 3.1.1 and 3.1.2.

3.1.1 Selection and Characteristics of Teachers

Two procedures were followed in finding the candidates of the teacher participants of the study: Applying needs analysis survey (NAS) by visiting schools and using friendship groups. To minimize the transportation problems and ensure easy congregation, the teachers at schools that are closer to each other were prioritized. In order to find teacher participants of the 35 schools in Yenimahalle district of Ankara 26 schools were visited by the researcher. Thus, in order to determine the sample of the study approximately 74 % of teachers in Demetevler and Batıkent quarters of Yenimahalle district of Ankara were visited at their schools. The school visiting and calling results are summarized in Appendix B. As seen from this appendix, 12 teachers accepted to participate to current study.

During the visits unstructured interviews were conducted with teachers and NAS was applied to teachers who accepted to fill out it. The aim of the study, the requirements of the study, the necessities and the features of the treatment that would be given to them were clearly explained. The advantages of participating to study, especially, gaining the competency of teaching the modern physics unit (MPU) was explained in detail. Nevertheless, most of the interviewed teachers complained about the "time", some of them only replied to NAS and refused to participate to the study. Some schools were visited twice and some of unavailable teachers were interviewed through phone calling.

Second procedure in selecting teachers was searching friendship groups. During the school visits, the teachers were asked to invite their friends. In this way, two teachers were found. Moreover, two of the researcher's friends also participated in the study and one of them found three more teachers. Thus, seven teachers were found through friendship groups.

Totally 19 teachers were initially determined to participate to the teachers teaching teachers (TTT) PD course, however, two of them never participated to course and 17 of them participated in different percentages. Among these 17 teachers six of them composed the implementation group (placebo +treatment) of the study. The entire implementation group teacher participants involved in this study were employed in one of the six high schools in Ankara as a full-time teacher. Participants in the study were regular classroom teachers who teach physics at tenth-grade level in one or more classrooms.

To increase the participation rate of the sample and conduct the study safely; (a) the TTT courses took place in a school near city centre of Yenimahalle, (b) were start by eating dinner altogether, (c) tea and coffee were free for drinking during the sections, (d) teachers' road fee was offered to be paid, however none of them accepted and they all paid by themselves (e) some course materials such as books and USB's that include smart board applications were donated both during class observations and during the TTT courses, (f) the course hours were arranged so that it was appropriate to all participating teachers, (g) the teachers who accepted to participate to the study was reinforced by emails. Namely, some useful materials about physics topics were sent to them via email. For example, the researcher sent the pdf version of some useful books to them, (h) the course hour and the school of congregation was determined according to needs analysis results, (i) to provide extra cooperation and collaboration between teachers, a mail group was constructed to maintain the participant teachers' communication.

The teacher participants of the study were determined (purposive sampling) on the following guidelines: Firstly, in order to maximize the collaboration and cooperation and to increase the variety of the sample, teachers from various types of schools such as science, private and vocational high schools were included into the study. Secondly, since this is a PD program that aims to maximize the collaboration and cooperation of teachers, the research focused on teachers having various experiences. For instance, novice teachers, teachers of 20 or more years of experience in classroom, teachers who have master or PhD degree and teacher who have prepared students for national and international physics project contests were tried to be included into the study. Thirdly, teachers who accept the following additional terms and conditions were selected: (a) accept video capturing during the lesson (b) accept the attending of the researcher to their lessons to make class observations (c) accept the achievement test to be applied to both her/him and her/his students (d) accept to teach the modern physics unit (MPU) earlier in one of her/his classes (e) promise to finish the first semester's units on time and do not leave any topics to the second semester.

The selected teachers were divided in to four groups. The distribution of all participant teachers to groups is shown in Figure 3.1 The groups in the larger circles comprise the groups in the smaller circles.

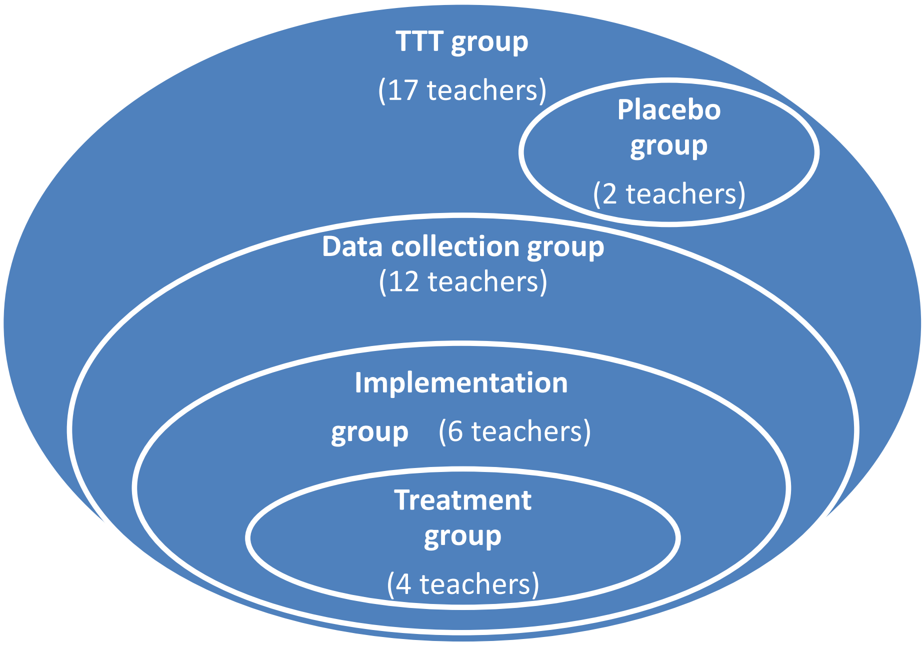

Figure 3.1 The distribution of all participant teachers to groups

As seen from Figure 3.1, the selected teachers were categorized into five groups. Teachers those participated in one or more TTT courses constituted the TTT group (17 teachers). Of them two teachers were assigned to placebo group. They never participated to the main course. This group was constituted to control the effect of pre-teaching. On the other hand, of the remaining 15 teachers, data were collected over only 12 of them and they constituted the data collection group. As seen from Table 3.3, teachers who attended less than 80% to the main course (Teacher-13-14-15-16) were not included into data collection group. Even though Teacher-17 in Table 3.3 participated 80 % of the TTT courses since she was not a school teacher (she was teaching only in university preparation course) she is not included into data collection group. Further, four teachers from this group were selected to constitute the treatment group. The treatment group was designed to see the effect of TTT PD course. Along with the placebo group teachers these are the teachers who accepted the requirements of the study. For instance, they accepted to teach MPU earlier in one of their classes and teach again to their other class after two months. Moreover, these are the teachers whose classes observed and whose students were pre- and post-tested; shortly this is the treatment group over which the inferential statistics was conducted (data were gathered from their students). Table 3.3 is designed to represent the attendance and the teachers' groups.

Table 3.3 The teachers' groups and their attendance to the courses

Teacher	Type of school	Group	Attendance (Main course)*	Attendance (Adaptation meeting)**	% attendance (Main course)
Teacher-1	Public	Placebo	0	1	0
Teacher-2	Private	Placebo	0	2	0
Teacher-3	Public	Treatment	5	2	100
Teacher-4	Public	Treatment	5	0	100
Teacher-5	Public	Treatment	5	2	100
Teacher-6	Public	Treatment	5	2	100
Teacher-7	Public	Data collection	5	1	100
Teacher-8	Private	Data collection	4	2	80
Teacher-9	Private	Data collection	4	0	80
Teacher-10	Public	Data collection	5	2	100
Teacher-11	Public	Data collection	4	2	80
Teacher-12	Public	Data collection	4	0	80
Teacher-13	Public	TTT**	2	0	40
Teacher-14	Public	TTT	0	2	0
Teacher-15	Public	TTT	1	0	20
Teacher-16	Public	TTT	1	0	20
Teacher-17	Private course	TTT	4	2	80

* Main course lasted 5 weeks, ** Adaptation meetings lasted 2 weeks, *** Except the placebo group, the below groups in this table comprise the upper groups.

As seen from Table 3.3 the treatment group teachers (Teacher-3-4-5-6) 100% and placebo group teachers (Teacher-1-2) never participated to TTT PD courses. Since the effect of TTT PD course was investigated through the treatment group, the 100% attendance was a must for treatment and 0% was a must for placebo groups. In other words, in order to see the effect of TTT PD, four teachers had to participate to the designed courses and two of them had to make the placebo group and they hadn't to participate to the designed courses. Teachers' attendance to TTT PD courses partially affected the formation of these two groups.

The experiences of the treatment and the placebo group teachers were used as a covariate. Table 3.4 was developed to represent the experiences of the teachers. The dimensions of teachers' experiences (TE) were determined according to the total years of teaching, the type of school they work in, experience in teaching tenth-grade MPU, preparing students for national project competitions or for national physics Olympiads, writing physics books, and giving private lessons or working in university preparation courses at the weekend. The total score for each teacher was calculated and that score demonstrated the experience of the teacher. The TE was used for equating the groups by covariate analysis. The importance of dimensions was taken into consideration and scoring was based on the relative importance of each dimension. (See the end of Table 3.4). The scores of each dimension of the data collection group teachers' experiences are given in Table 3.4. In all analysis of this study, only the TE of treatment and that of placebo groups were used. However, for having an idea about all teachers the TE of data collection group is presented in Table 3.4.

Table 3.4 Data collection group teachers' experiences

Teacher	[a]Total years of teaching	[b]Type of school	[c]Physics Projects Olympiads	[d]Master or PhD degree	[e]Teaching 10^{th} grade MPU	[f]Writting physics books	[g]Extra works	Total experiences
T-1	4	1	0	0	2	0	2	9
T-2	1	2	0	0	2	0	2	7
T-3	2	1	0	2	2	2	2	11
T-4	3	1	0	0	1	0	2	7
T-5	3	1	0	0	3	0	2	9
T-6	4	1	0	0	1	0	0	6
T-7	4	1	0	2	0	0	0	7
T-8	4	2	0	2	3	2	0	13
T-9	3	2	0	2	3	0	0	10
T-10	3	1	0	2	2	0	2	10
T-11	5	1	0	0	3	0	0	9
T-12	3	1	0	2	3	0	2	11

[a]0-5 years=1, 6-10 years=2, 11-15 years=3, 16-20 years=4, 21-25 years=5, over 25 years=6

[b]Public =1, Private = Science =2

[c]Preparing students for national project competitions = Preparing students for national physics Olympiads = 2, no experience in this dimension =0

[d]Competent Teacher = Master degree or master student =2, PhD degree or PhD student=3, Regular teacher=0

[e]Teaching tenth grade MPU each year is 1 point, starting to teach tenth grade MPU this year is 0 point.

[f]Writting each physics book is 2 points, if no physics book is written 0 point.

[g]Giving private lessons = working in university preparation courses at the weekend =2, Giving private lessons and at the same time working in university preparation courses at the weekend is 4 point, no extra work is 0 point.

Through Table 3.4, the TE variable has been changed to a continuous variable. As seen from this table, the participant teachers' experiences are ranged between six and 13. These experiences effected the formation of the placebo and treatment groups.

Of the 17 teachers, data were collected over 12 of them. These 12 teachers participated in the TTT PD courses in different percentages and eventually they all evaluated the course. Namely TTT evaluation form was filled out by these 12 teachers. Among the 12 data collection group teachers, six of them were selected for implementation group. The criteria for selection of implementation group teachers are as follows: First of all, teachers who have at least two equivalent tenth-grade classes were given priority. For treatment group, one of these classes became control group and the other one became experimental group; for placebo group, one of these classes became placebo pre and the other one became placebo post group. Second, teachers who allowed their classes to be observed, to be pre- and post-tested and who accepted the video recording of their lessons were added to this group.

On the other hand, even though, six teachers were enough to conduct the study it started with 17 teachers who teach tenth grades. Because of the possibility of losing some subjects, the researcher initially decided to start with a high number of participants. Since the participant teachers should be observed in their classes, in the case of more than six teachers it would be difficult for the researcher to organize class observations. Moreover, power analysis (see Section 3.10) results required 80.67 subjects for each groups of the study. Since there are two groups (control and experimental) for the specified power, totally 161 students were required. This number of students was safely supplied with the participation of the four teachers of treatment group. Meanwhile, of the six teachers, two of them constituted the placebo group. Since no research questions were identified, initial power analysis was not conducted for placebo group.

3.1.2. Selection and Characteristics of Students

The participant students were chosen among the implementation group teachers' classes. It should not be forgotten that teachers who had at least two classes of equal academic achievement were assigned to the implementation group. For instance, if one of the participant teacher had four tenth grade classes and if let's say three of them were equal in academic achievement one of these classes was randomly determined to be control group and was taught the MPU earlier. One of the other two classes was determined to be experimental group and they were taught the same unit after the TTT PD course. The equality of the classes was determined on the declaration of the teachers. The implementation group teachers and their classes are tabulated in Table 3.5.

Table 3.5 Implementation group teachers and their classes

Teacher	Group	# of students in control group	# of students in experimental group	Weekly course hours	# of classes this semester
Teacher-1	Placebo	29	30	2	3
Teacher-2	Placebo	22	21	3	5
Teacher-3	Treatment	18	30	2	2
Teacher-4	Treatment	30	29	3	2
Teacher-5	Treatment	31	31	2	3
Teacher-6	Treatment	25	35	2	2

Of the 12 teachers, six of them constituted the implementation group and each of their two classes was pre- and post-tested. Thus, as seen in Table 3.5, 12 classes and totally 331 students were planned to be pre- and post-tested. The implementation group teachers were divided into placebo and treatment groups. Thus, there were four treatment group teachers (Teacher-3-4-5-6) and 8 treatment group classes. Treatment group teachers taught to four of their classes (control groups) before the TTT PD course (104 students) and taught to their other 4 classes (experimental groups) after (during) the TTT PD course (125 students). Thus the number of subjects in control groups and experimental groups are more than the sample determined according to power analysis results (see Section 3.10). Moreover, the ages of students ranged from 15 to 17 and they were all at 10th grade.

3. 2. Variables

The treatment variable of the study was TTT PD course. Independent variables of the study are pre-test scores of students on MPU multiple choice achievement test (pre-MPUAT-S), scores of teachers on MPU open-ended achievement test (MPUAT-T), teacher experience (TE) and students' first term physics course grades (PCG).

Treatment variable indicates group membership which has two levels: teaching before TTT PD course, and teaching after TTT PD course. TE was determined through Table 3.4. Pre-MPUAT-S, MPUAT-T, TE and PCG independent variables were planned to be used as covariate in order to ensure equality between control and experimental group students. Some characteristics of the independent variables are shown in Table 3.6. Dependent variable of the study is the post-test scores of students on MPU achievement test (post-MPUAT-S). Some characteristics of the dependent variable are also presented in Table 3.6.

Table 3.6 Variables used in the study

Name of variable	Dependent (DV) / Independent (IV)	Continuous/Categorical	Scale
Treatment Variable	IV	Categorical	Nominal
PCG	IV	Categorical	Ordinal
TE	IV	Continuous	Interval
Pre-MPUAT-S	IV	Continuous	Interval
Post-MPUAT-S	DV	Continuous	Interval

3. 3. Instruments

The measuring tools used in this study are needs analysis survey (NAS), tenth grade MPU achievement test for the students (MPUAT-S), tenth grade MPU achievement test for the teachers (MPUAT-T), classroom observation form (COF), treatment observation checklist (TOC), treatment fidelity checklist (TFC), and the TTT PD course evaluation form (TTTEF). Details of these instruments are discussed in the following sub-sections.

3. 3. 1 Needs Analysis Survey

Although the TTT model of PD has a certain structure; some aspects of the design of the course had to be proper to the participating teachers' needs. In designing a feasible course for teachers, their opinions were of great importance. That's why a needs analysis survey (NAS) was developed and conducted. The aim of the survey was (a) to determine the nominees, (b) to regulate the organization of the course, and (c) to get opinions of the teachers about the content of the topic (that is, MPU) that would be emphasized during the TTT PD course.

There were three main sections in this survey. In the first section, the teachers were asked for personal information such as gender and school they work in. These questions were asked to identify the relationship between teachers' personal information, and the results of in-service training program and class observations, more specifically that of TTT PD course. The second section was devoted to identifying the experience of the teachers. The third section included questions about content of the tenth grade MPU. These questions were asked to maximize the efficiency of the course and to determine the points of the content of the unit that would be emphasized.

The questions of the NAS were mostly written by the researcher. By taking the aim of the NAS into account the researcher developed the rough form of the survey. The supervisor of the study revised this version and made some suggestions. The researcher than made some modifications and together with the supervisor they evaluated the changes once more. Then, the supervisor offered some more modifications and advised looking at the similar NAS developed by Oktay (2013) for her dissertation. The researcher worked on the rough version of the NAS once more and he made some more changes. He took the table presented in Question B1 (Appendix C) from Oktay’s (2013) needs analysis survey. Together with the supervisor the last changes were analysed and the initial form of the NAS was prepared (Appendix C). Once the initial version of the NAS was ready the researcher developed an expert checklist. This checklist was also revised by the supervisor. He recommended some changes and the final version of the checklist (Appendix D) was prepared by taking these recommendations into account.

The NAS and the expert checklist for developing the needs analysis survey were sent to 20 experts via electronic mail. They were asked to fill out the expert checklist and seven of them were replied. According to the suggestions of the experts necessary corrections were made on the survey. In order to see all changes, the initial and final versions presented in Appendix C and Appendix E can be compared. For instance, in Question B5 (see Appendix C) the difficulties that teachers encounter in teaching tenth grade MPU were listed. One of the experts suggested asking to teachers to score these difficulties in terms of their importance. This suggestion was carried out and teachers were asked to score these difficulties between 1 and 8. Moreover, in Question C1 (see Appendix C) the teachers were asked to tick up the activities that are listed to be conducted during the course. An expert suggested that some of the teachers may need the assessment techniques specific to MPU. This suggestion was added to the survey form. On the other hand, one of the experts replied that the table presented in Question B1 (see Appendix C) does not have enough space for teachers to write their opinions in and she suggested redesigning the table. Since instead of writing their opinion in the cells, teachers were supposed to choose a choice listed below the table, this suggestion was overlooked.

The final form of the NAS was applied to 21 teachers. The application was done either via email or during school visits. The data collected through this instrument was used in determining the experiences of teachers, deciding the place and time of meetings, picking up volunteer teachers, relating the findings of the study to the personal information of the participant teachers and deciding about some of the activities to take place during the TTT PD course.

3.3.2 Achievement Test-Students

In order to measure students' academic achievement in tenth grade MPU, an achievement test was developed by the researcher. Before starting construction of the test, objectives of the unit, which were determined and declared by the Ministry of Education, were examined (see Appendix A). A table of test specification (Appendix F) that represents the content of the tenth grade MPU was prepared. Five objectives are specified for this unit in the curriculum. However, since one objective (Appendix A- 5th objective) is not taught in schools which have weekly two physics course hours, this objective was not represented by any questions. However, this objective was held in the TTT PD course to complete the tenth grade MPU in the course. The weight of each objective was determined according to the time allocated to teach each of them (see Appendix F). Further, the questions' difficulty level was determined according to the specifications of the curriculum and thereby was determined according to Bloom's revised taxonomy (Krathwohl, 2002).

In developing the achievement test, following issues were taken into consideration. First, one lecture hour is 40 minutes in high schools and the test must be finished in a class hour. Second, the curriculum requires context based questions. Third, context based questions generally have long stems and this property usually bore students. On the other hand, finding or writing questions on tenth grade MPU is a little bit troublesome. This unit has been added to the curriculum since 2008 and textbooks published by various companies do not include desired questions that reflect the aim and the requirements of the curriculum. That's why except two, all 32 questions on the final version of the MPUAT were written by the researcher.

The development phase of the achievement test approximately took three months. Initially, two successive rough versions of the achievement test (Appendix G and Appendix H) were prepared by the researcher, then the first version (Appendix I) was developed by the researcher and the supervisor. Afterwards, the first version was checked by the experts and upon their requests second version was (Appendix J) generated, then the validity of the second version was confirmed by the second expert review process and finally, the final version (Appendix K) constituted after item analysis.

At the very beginning, the researcher prepared the first rough version of the achievement test. He prepared 26 questions by referencing the tenth grade physics course books. The researcher and the supervisor of the study discussed all questions one by one. However, questions (see Appendix G) that were problematic in terms of objectives (5, 12, 13, 15, 20) were removed, that were not comprehensible (1, 2, 4, 7, 9, 10, 11, 14, 19, 23) were revised and that included conceptual errors (3, 16, 18, 21, 22, 25) also were removed. Thus, 11 questions were deleted from the first rough version of the achievement test. The supervisor recommended to examine books such as Conceptual physics (Hewitt, 2006), The Physics for Everyday Phenomena (Griffith, 2001) and Physics for Scientist and Engineers (Serway, 2004). The researcher than read the tenth grade MPU related topics from these books and he prepared a second rough (15 questions were from the previous version) test consisting 30 questions. None of the added questions were directly taken from the books. They all were written by the researcher after studying the related chapters from the aforementioned books. The researcher and the supervisor of the study again did long discussion on almost all questions to prepare the first version of the achievement test. They revised some questions (2, 10, 12, 14 and 19), changed the structure of some questions (3, 5, 8 and 18) and removed some questions (4, 6, 11, 16, 21, 24, 25, 27 and 29) from the second rough version (Appendix H). Then, they added some new multiple choice questions (5, 15, 19, 21, 23, 27), added some new true-false (28, 29, 30, 31, 32, 33 and 34) questions, added one matching question (35) (Appendix I) and finally they generated the first version of the achievement test.

To ensure face and content validity expert views were asked from four experienced teachers that were serviced full-time in private high schools. Moreover, expert views of four research assistants in the department of Secondary Science and Mathematics Education at METU were taken. Furthermore, the views of two physics course book writers of a special company were also taken. Together with the achievement test, (1) the tenth grade modern physics unit curriculum, (2) the table of test specification, and (3) the expert opinion form for 10th grade modern physics test (See Appendix L) were sent to all these experts.

Upon the request of experts major modifications made in the first version of MPUAT-S. Some of the questions (1, 2, 3, 13, 14, 17, 20, 25, 27, 28, 29, 30, 31, 32, 33) were removed and replaced with new questions. The reason for removing so many questions was not that they were wrong questions; upon the request of experts they were replaced with true-false and matching questions. Actually most of these questions changed their structure from multiple choices to true-false, matching or open ended. Moreover, distractors of some questions were revised (4, 6, 7) and some of the questions (10, 12, 15, 22, 26) were reworded upon the request of the experts. Two questions (8, 11) were declared by the experts that they were not related to the objectives of the tenth grade MPU, that's why they were replaced with new questions. Moreover, 34th question was a matching question it was both reworded and its structure was redesigned. Furthermore, upon their requests a sixth distractor (I don't know the answer) was added to all questions. Thus, the initial extensive expert views leaded to major revision in the first version of MPUAT-S.

After the expert views, since too many changes were made on the first version of MPUAT-S, one more expert view became necessary for the second version. The second version of the MPUAT-S was examined by four experts, three of which were the same experts who examined the first version of MPUT-S and one was a new expert. Except some minor changes all experts were agreed on the face and content validity of the second version of the MPUAT-S. Additionally they were asked to generate an answer key for MPUAT-S questions. The answer key generated by these experts was same as that of the researcher. Thus, the validity of the second version of MPUAT-S was confirmed by the experts and thus the achievement test was developed after two stage expert view process. After the final revision, the second version of the MPUAT-S (See Appendix J) had 32 items: 6 true-false, 6 matching, 18 multiple-choice, and 2 open-ended items.

Prior to pilot study of second version of MPUAT-S, two students at different achievement levels in physics read the questions loudly. The researcher listened to the students and tried to catch the points where students have difficulties in understanding. However, the researcher didn't saw any problems; moreover, the students didn't report any misunderstandings. These two students were from a private school and they were at 12th and 11th grades. The former was a high achiever and the later was a normal student. Both were taught MPU previously. Each of these practices lasted approximately 45 minutes.

As a pilot study, the MPUAT-S (second version) was administered to 42 11th and 12th grade students from a private high science school in Ankara. These are the students who have learned the MPU in 10th grade and among them the 12th grade students have re-taught this unit in university preparation courses. There were several reasons to choose such a school and the combination of 11th-12th grade students for pilot study. First of all, the test had to be applied to a sample which already has mastered MPU. However, there weren't such a sample. Secondly, since MPU was newly added to the curriculum many teachers had superficially taught this unit. However, private schools relatively teach better and educate their teachers in the case of any changes of curriculum. Thirdly, MPU is not interrelated to remaining 10th grade and 11th grade units, that's why students who participated to the pilot study didn't find any chance to repeat at least some of the concepts of this unit. Fourthly, the science high schools generally consist of students at high achievement level.

Item difficulty and item discrimination were conducted with data gathered from these students. Table 3.7 shows the item analysis results.

Table 3.7 Item analysis results of the MPUAT-S for pilot study

Item #	Difficulty	Discrimination	Item #	Difficulty	Discrimination
1	0.78	0.27	17	0.31	0.55
2	0.5	**-0.1**	18	0.37	0.45
3	0.31	0.45	19	0.33	0.27
4	0.64	0.36	20	0.48	0.73
5	0.55	0.64	**21**	0.24	**0.09**
6	0.48	**0.09**	22	0.52	0.73
7	0.56	**0**	23	0.26	0.27
8	0.83	**0**	24	0.43	0.64
9	0.4	0.45	25	0.81	0.27
10	0.62	0.36	26	0.48	0.45
11	0.64	**0.18**	**27**	0.88	**0.18**
12	0.76	**0.09**	28	0.27	0.55
13	0.26	0.36	**29**	0.18	**0.18**
14	0.12	**0.09**	**30**	0.81	**-0.3**
15	0.76	0.45	**31**	Not enough correct answers were given to these two open ended questions	
16	0.54	**0.09**	**32**		

# of Items	30	Variance	0.79	Kurtosis	-0.29
# of Examinees	42	Std. Dev.	4.56	Alpha	0.72
Mean	14.98	Skew	0.35	Mean item difficulty	0.50
				Mean item discrimination	.30

*Bold are the questions having improper item discrimination indices. In other word those have indices smaller than 0.19.

It can be seen from Table 3.7 that the item discrimination indices of items are in the range of -0.30 to 0.73. The items that have values under 0.19 should be removed or completely revised. Moreover, the items that have values between 0.20 and 0.29 can be checked for modification (Crocker & Algina, 1986, p. 315). Table 3.7 indicates that items 2, 6, 7, 8, 11, 12, 14, 16, 21, 27, 29 and 30 should be removed or completely revised and items 1, 19, 23 and 25 can be modified. Since removing so many items would affect the validity of the test, the item correction or reformation was postponed to the data gathered from the post test scores of the experimental group. Moreover, the average item difficulty for test items was 0.50 and the internal reliability coefficients for the test were found as 0.72. Except the changes made on the distractors of 13 questions, the MPUAT-S was not revised with respect to the results of the pilot study.

Since none of the students correctly answered the two open ended questions (31st and 32nd items) they were not included into item analysis. According to these analyses, a total of 12 questions (Table 3.7) were problematic in terms of item discrimination they were considered to be removed from the test. However, because of several reasons all items kept their places in the test. Firstly, average score on the test was medium (an average of 15 correct answers), that’s why it was taught that the selected sample might not be favourable. Secondly, the number of questions was appropriate; during the application of the test it was seen that students could easily find enough time to answer all questions, that’s why there were no need to decrease the number of items. Thirdly, a sample, who has just learnt MPU, could give more accurate results. Due to all these reasons the items that were going to be removed was postponed. However, distractor analysis was performed on the data gathered from this sample. According to item analysis conducted via ITEMAN program, some mild to moderate modifications, based on alternative statistics, were made on the choices of 13 questions of second version of MPUAT-S.

In questions (Appendix J) 13, 15, 17, 18, 19, 23, 25, 26 and 28, since one distracter of each were selected with a low rate, the alternatives were rearranged. In question 22, since one distracter was selected with a low rate the figure of this distracter were redrawn. In question 14 and 21 since one distracter of each were selected with a high rate it was replaced with a new alternative. In question 30, two distracters were selected with a low rate. The alternatives of this question were revised. Thus, the final version (Appendix K) of the MPUAT-S was constituted. Except two (23rd and 27th questions), all other questions were written by the researcher.

Each question in the MPUAT-S has an extra option “I don’t know / I can’t do”. If students had chosen this option, in the scoring process it was coded as “0”. In this way, we can see if unanswered questions are missing or students read the questions and do not know the answer. During the application of the tests which was done by the researcher, the students were encouraged to circle the “I don’t know / I can’t do” alternative in the case of having no idea about the answer of the question. After the test was applied to all implementation group students, it was checked and seen that all students have either chosen one of five alternatives or have chosen the sixth alternative (“I don’t know / I can’t do”). In other words, there were no unmarked items in the answers.

The questions that were excluded from the analysis were determined according to the item analysis made on the data gathered from the post test scores of the experimental group. Totally, the data of 116 subjects of experimental group students were used for this analysis. Since (1) the experimental group students had newly learned the MPU, (2) their teachers participated to TTT PD and (3) the number of subjects were good enough, item analysis were conducted on data gathered from this sample. As in the case of pilot study, the two open ended questions’ results were undesirable, that is almost all students in the experimental group either gave wrong answers or didn’t give any answers. In other words the mean of the 31st question was 0.11 and that of 32nd question was only 0.01. Consequently they were excluded from item analysis. Item analysis results of the MPUAT-S for post test scores of experimental group subjects is given in Table 3.8.

Table 3.8 Item analysis results of the MPUAT for experimental group subjects

Item #	Difficulty	Discrimination	Item #	Difficulty	Discrimination
1	0.62	0.35	17	0.33	0.45
2	0.16	**-0.10**	18	0.20	0.26
3	0.58	0.65	**19**	0.15	**0.03**
4	0.34	0.35	20	0.14	0.39
5	0.43	0.32	**21**	0.41	**0.10**
6	0.55	0.26	22	0.17	0.29
7	0.48	0.39	**23**	0.06	**0.10**
8	0.66	0.29	**24**	0.19	**0.06**
9	0.42	0.61	25	0.41	0.39
10	0.50	0.61	26	0.27	0.55
11	0.43	0.58	27	0.55	0.61
12	0.77	0.35	**28**	0.05	**0.06**
13	0.21	0.35	29	0.28	0.42
14	0.37	0.52	**30**	0.28	**0.06**
15	0.41	0.55	**31**	Not enough correct answers were given to these two open ended questions	
16	0.32	0.19	**32**		

# of Items	30	Variance	18.41	Kurtosis	0.21
# of Examinees	116	Std. Dev.	4.29	Alpha	0.70
Mean	10.76	Skew	0.64	Mean item difficulty	0.36
				Mean item discrimination	.34

Table 3.8 indicates that the item discrimination indices are in the range of -0.10 to 0.65. Moreover, the average item difficulty for test items is 0.36 which means only 36% of the participants answered test items correctly. According to results of last item analysis, 9 of the items were excluded and all statistical analysis was conducted with remaining 23 items. Items 2, 19, 21, 23, 24, 28 and 30 were removed because their item discrimination indices were smaller than 0.19. In addition the item 6 has a

discrimination index of 0.26 and item 16 has an index of 0.19. These two questions were kept in the test in order to keep the percentages of the objectives in table of test specification. Moreover, they were checked and it was seen that there was no need for the changes. The two open ended questions (31 and 32) were removed because, as mentioned above, students either didn't give answers to these questions or mostly gave wrong answers.

Removing these items neither affected the content validity of the MPUAT-S nor did not decreased the number of items too much. There were four objectives assessed with the achievement test. Before removing these items each objective, in average, was assessed by eight items and after removing these items the objectives, in average, were assessed by 5.75 items. Moreover, the achievement test include questions at two levels (understanding and analysis) of Bloom 's taxonomy and removing these items didn't affected the percentages of these levels of Bloom's taxonomy (See Appendix F for table of test specification).   Furthermore, it seemed that totally items were so difficult for the students (0.36). This could force the students to guess answers even they did not really have any idea about them. Thus, the item discrimination indices could be affected by guessing. Once 9 questions were not included into analysis MPUAT-S's final version remained with (See Appendix K) 23 items: 5 true-false, 6 matching, and 12 multiple-choice items. The table of specification and answer key of the final version of the MPUAT-S can be seen in Appendix F. The internal reliability coefficients for the data collected from experimental group was found as 0.70. After the extraction of the 9 items those do not work properly, the reliability of the test rose to 0.75. This value indicates high-medium reliability. This value could be because of guessing and unconscious answers of the students who faced with many concepts in the MPU for the first time. Since most of the items extracted from the test were difficult questions, average item difficulty decreased to 0.41 after extraction.

Finally, all test items (true/false, matching and multiple-choice) are coded as "0" for wrong and 'I don't know' answers, and "1" for correct answers. Each question was one point and for the lastly remaining 23 items subjects could have achievement scores ranged from 0 to 23. Higher scores indicate higher achievement level and lower scores indicate lower achievement level. The average completion time for the

MPUAT-S was 40 minutes. The following research question was answered through the data collected from MPUAT-S.

What is the effect of TTT PD development course on physics achievement of tenth grade students in modern physics unit?

3.3.2 Achievement Test-Teachers

This was a four question open ended test (Appendix M) which has the same table of test specification (see Appendix F) with that of the students. The PMUAT-T was applied to six teachers as pre- and post-tests. The test was applied as pre-test to these teachers after they taught the MPU to one of their classes. The test was sent to teachers via email and they were given one day to write the answers. The written answers of the test were collected by the researcher after 24 hours. The same test was applied as post-test to all teachers after they taught their second class. In other words, the treatment group teachers had it after the TTT PD courses and placebo group teachers had it without having a treatment. The post-test was applied to the four treatment group teachers at the end of the last meeting and it was applied to the two placebo group teachers at their schools by the researcher just after they finished teaching to their second class. All teachers were given 40 minutes to complete the post-test. Post-test scores of the teachers were used as covariate and the difference between post-test and pre-test was perceived as an indicator of the effect of TTT PD on the participating teacher's subject matter knowledge.

This test was containing questions mostly at understanding and analysis levels of Bloom's taxonomy. There seemed no problem in applying the same achievement test, which was applied to the students, to the teachers. However, in the case of seeing/answering the test, it was possible for teachers to teach the test questions to their students and lead to a high post-test result of their students. That's why a separate achievement test was developed for teachers. Since there were only four open ended questions and it was applied to only six teachers there were no need to conduct reliability studies for this test. Moreover, the researcher and the supervisor of this study spent a considerable effort in deciding the items of this test. Still the MPUAT-T was checked by two experienced physics teachers who were not participants of the study. The teachers were informed about the purpose of the MPUAT-T and the table of test specification was provided to them. At this step, they

were asked to review the items with respect to appropriateness of the content and grade level. They found the MPUAT-T items to be consistent with objectives of the MPU and appropriate to the high school physics teachers' achievement level.
Each of the four items of MPUAT-T was matched with the one of the four objectives of the tenth grade MPU. When the items of the MPUAT-T are compared to the MPU curriculum provided in Appendix A, this matching can be seen easily. Actually, the first three questions of the MPUAT-T were produced from the objectives themselves and were at analysis level of Bloom's taxonomy. Only the last question was at understanding level of Bloom's taxonomy. The following research question was answered through the data collected from this instrument.

What is the effect of TTT professional development course on achievement of tenth grade physics teachers in modern physics unit?

3.3.3 Treatment Fidelity Checklist (TFC)

Fidelity of implementation is the extent to which the user's current practice matches the ideal (Loucks, 1983). By referencing several studies O'Donnell (2008) defines the fidelity of implementation as:

> Fidelity of implementation is traditionally defined as the determination of how well an intervention is implemented in comparison with the original program design during an efficacy and/or effectiveness study (p. 33).

One of the steps in purveying the treatment fidelity of this study was to prepare a treatment fidelity checklist. This was a checklist (Appendix N) including the effective characteristic of PD programs/courses derived from the literature. Different researchers have specified different characteristics for the effective PD programs. That's why the characteristics that the experts have consensus on were added to this checklist.

The coherence of TTT PD with these effective characteristics was asked to the experts. These experts are explained in 'treatment fidelity' section. In the TFC, each effective characteristics of PD is followed by an explanation concerning that aspect of TTT PD. Moreover, each explanation is followed by three point Likert scale questions. The experts were asked to tick up either of three choices 'completely include, partially include, never include'. For instance ''coherence'' is one of the effective characteristics of PD courses, the ‘‘coherence’’ aspect of TTT PD was explained and the experts were asked to identify up to what extant does the TTT PD include the ‘‘coherence’’ characteristic. Moreover, they were asked to add some more effective characteristics. Two more characteristics, ‘practice oriented and needs analysis centred’, offered by these experts were added to TFC. Thus, TFC had 13 dimensions. Furthermore, the experts were asked to tick the characteristics that are not effective. However, all experts were agreed that the effective characteristic specified in TFC were essential. The results of TFC are explained in the treatment fidelity section.

3.3.4 Treatment Observation Checklist (TOC)

This checklist was developed by the researcher to verify the treatment. In other words, whether the TTT PD course was conducted as planned or not was checked by this list. Just as in the case of preparing the COF, the Shulman’s (1987) teacher knowledge was a guide during the preparation of this checklist. The items of the TOC were prepared by the researcher and the supervisor by taking the structure of TTT PD course and the teacher knowledge dimension into account. The expert views of five experts were taken for the validity of the TOC. Upon their requests some minor changes were made on the checklist. Treatment observation checklist was filled out either by direct observation of the course, video analysis or asking to the teachers. Most of the items of TOC were Likert type, besides there were some items that would be filled out without scoring. For example the 33rd item on the TOC (see Appendix O) was about the duration of the course. All observers wrote a time span for this item. Some of the items were observed only by the researcher. For example ‘does the course continue each week? was an item that was observed only by the researcher. In the three-point Likert type scale, 2 corresponded to ‘yes, 1 ‘partially yes, 0 ‘no’, and NA ‘not observed. There were 12 dimensions and totally 63 items on the checklist. A typical item (item 32) in the ‘‘intensive’’ dimension was: how much time was spent on the objective that was handled in the course? Further details of this checklist can be found in ‘results of treatment verification’’ section.

3.3.5 Classroom Observation Form (COF)

In order to check the effect of the TTT PD on teachers' knowledge and see the applications of this knowledge in the classroom, an observation form was prepared by the researcher. In other words, this form was primarily used to find answers of the qualitative research questions.

The classroom observation form was essentially composed of three dimensions. The form's dimensions were arranged according to Shulman's (1987) teacher knowledge specifications. Of them, subject matter knowledge (SMK), pedagogical content knowledge (PCK) and general pedagogical knowledge (PK) composed the structure of the form. Moreover, the teacher knowledge was topic (modern physics unit) specific; therefore teachers were analysed based on their knowledge of content and strategies chosen for the topic that they were teaching during the observed lessons.

The initial version of the COF was prepared by taking some of the Shulman's (1987) teacher knowledge dimensions into account. In other words, the items were prepared to assess the PK, the PCK and SMK of teachers. The researcher initially intended to find a form from literature however, since he couldn't find one, he wrote all items together with the supervisor of the study. The initial version of the COF (Appendix P) was essentially composed of three-point Likert scale questions. There was an explanation section for each question. The aim of these questions was to enable the observers to record the teacher knowledge related behaviours of the teachers.

The initial version of COF was examined by five experts (two research assistant, one PhD and two associate professors) from different universities in Turkey. Upon their requests the structure of the COF was changed from ''checklist'' to a ''form''. The experts recommended that observing the teacher knowledge through items would restrict the observation; instead, recording the teachers' practices would be more easy and proper for the study. Moreover, they recommended that it would be difficult to score too many items (73 items) during an observation. Thus, the final version of COF (Appendix R) which was much simpler and conductive was developed by the researcher.

COF was used to observe the classrooms of treatment group teachers both during pre-teaching and after the TTT PD course and was used to observe the classrooms of placebo group teachers both in the case of pre-teaching and post-teaching. The following research questions were answered through the data collected from this instrument.

What is the effect of TTT professional development course on participant teachers' knowledge (PCK, PK, and SMK) regarding the modern physics unit?

a. What is the effect of TTT professional development course on PCK of tenth grade physics teachers in modern physics unit?
b. What is the effect of TTT professional development course on PK of tenth grade physics teachers in modern physics unit?
c. What is the effect of TTT professional development course on SMK of tenth grade physics teachers in modern physics unit?

3.3.6. TTT evaluation form (TTTEF)

The researcher developed a TTT PD evaluation form to evaluate the course and the effect of the course on teacher's knowledge. In other words, the aim of this instrument was to take teachers' opinion about the TTT PD course organized by the researcher. The instrument has six dimensions and consists of five-point Likert scale questions. The dimensions are; (a) attitude toward the TTT program (b) usefulness of the TTT program, (c) the role of the researcher in the program, (d) the effect of the program on teachers' MPU related PCK, (f) the effect of the program on teachers' general PK, and (g) the effect of the program on teachers' MPU related SMK. In the five-point Likert type scale, 1 corresponded to 'strongly disagree, 2 'disagree, 3 'neutral', 4 'agree', and 5 'strongly agree'.

At the end of the TTT PD course the TTTEF was applied to data collection group, which were a group of 12 teachers. The TTTEF covered 85 items and its reliability coefficient of Cronbach alpha was calculated as 0.97.

The initial rough items of the TTTEF were prepared by the researcher by examining similar evaluation forms from the literature. It than was revised by the supervisor of the study. Upon his requests necessary changes were made and the initial version of the TTTEF was produced. Views of four experts were taken for validity of the TTTEF. Together with the first version of TTTEF, an expert view form (Appendix S) was attached and they were sent to the experts via email. The aim of the TTTEF and the Shulman's (1987) teacher knowledge dimension was explained in this form. The experts were asked to tick the items that have to change dimensions, the new items that have to be added to dimensions, the items that have to be removed and the items that are not clear. Upon their requests some changes were made on the form. One of the experts remarked the following cases: One of the five point Likert scale is not proper; in order not to canalize the teachers, the names of the dimensions in the form should be deleted; the items 2 and 3 do not measure the attitude; items 1 and 7, 5 and 9, 14 and 15, and 37 and 45 are similar; the item 25 should be removed because it can disturb the teachers. All these requests were carried out. Moreover he made little revisions on the items 21, 51, 52 and 60. Furthermore, he wanted to remove the dimension which was assessing the researcher. However, since it was necessary, this request was not performed. Similarly another expert made following comment: The beginning of the items should be similar, for example all should start with upper case letter or with lowercase letters. Moreover, he revised item 9. Further, he recommended not to use negative items (for example 11th item) and to revise items 14, 15 and 21. All these requests were performed. Another expert made following comments: The 2nd item do not measure attitude instead it measures motivation; put 'dot' at the end of all items; 21st item is not about usefulness move it to the attitude dimension; items 24 and 25 should be removed they are not about usefulness; item 32, 33 and 34 should be revised. Moreover, she revised the item 45 and recommended to move the 56th item to attitude dimension and to move the 79th item to pedagogical content knowledge dimension. All these requests were carried out. Furthermore, she recommended adding one more item to subject matter knowledge dimension however; this request was ignored because it was not proper to that dimension. The last expert made only minor changes on items 13, 14 and 23.

Both initial (Appendix T) and final versions (Appendix U) of the TTTEF are added to Appendixes sections. The instrument was prepared such that the following research question was answered through the data collected from this instrument.

What is the perception of tenth grade physics teachers about TTT professional development course?

3.4. Research Design

This study aims to develop a PD program for physics teachers by taking the TTT PD into account. The effect of the TTT PD on teacher's knowledge was searched through their students' achievement. Having this purpose in mind, this study was developed to have two steps. In other words, first, teachers were subjected to a PD program than the effect of that PD was tested on students. Accordingly, separate designs were prepared for both teachers and students. Additionally, one part of this study was experimental and other part of the study was carried out within the qualitative research paradigm. The overall design of the study is represented in Figure 3.2 and then the separate designs for teachers and students are explained in Sections 3.4.1 and 3.4.2.

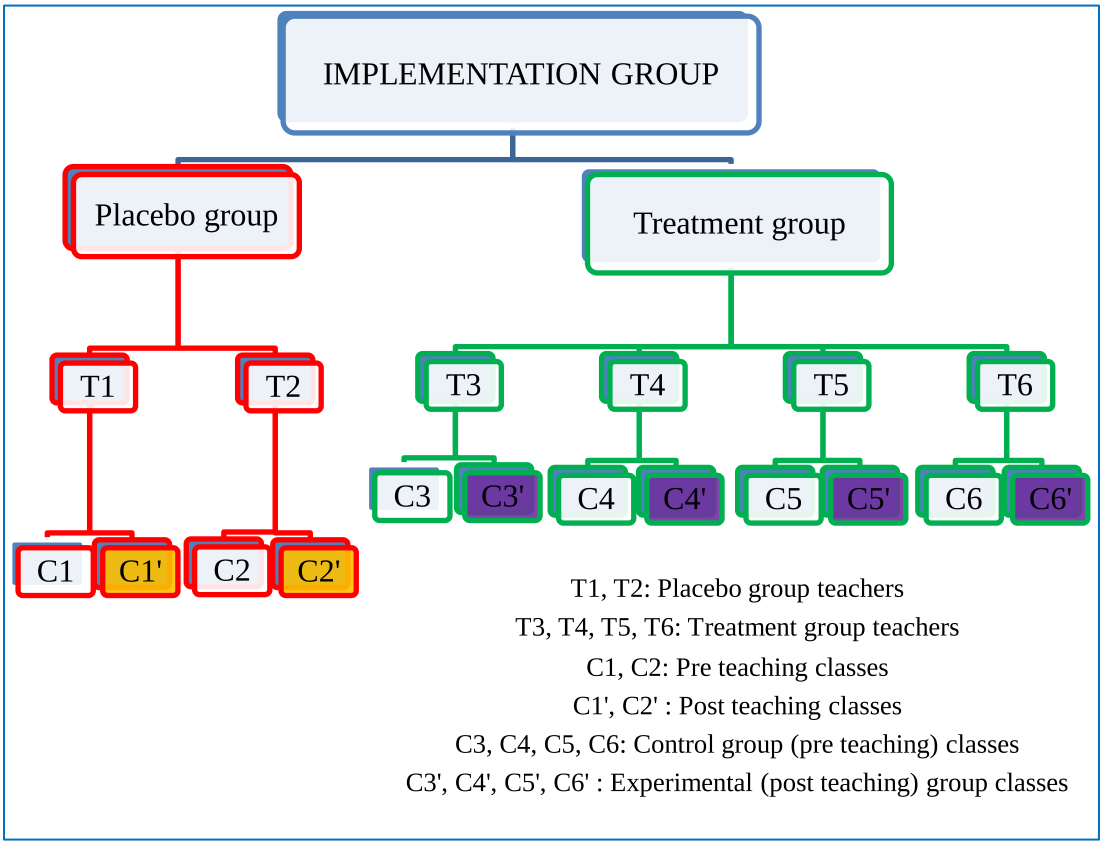

Figure 3.2 The overall simple form of research design of the study

As seen from Figure 3.2 there are six teachers, of which two are from placebo and four are from treatment group. Besides there are 12 classes, of which four are from placebo and eight are from treatment group. All qualitative and some of quantitative data is collected through the teacher participants of the study and through students, only quantitative data were collected.

3.4.1 Research Design for Teacher Participants

Two groups of teachers were specified for the implementation of the study: Placebo and treatment groups. There were two teachers in placebo and four teachers in treatment groups. Generally qualitative data were collected from the teacher participants of the study. They taught to one of their classes earlier and they taught to another classes later. They were observed in their classes both before and after TTT PD. Besides, the placebo group teachers taught to their both classes as regular and the treatment group teachers had TTT PD course between the two teachings. The design regarding the qualitative part of the study is pictured in Figure 3.3.

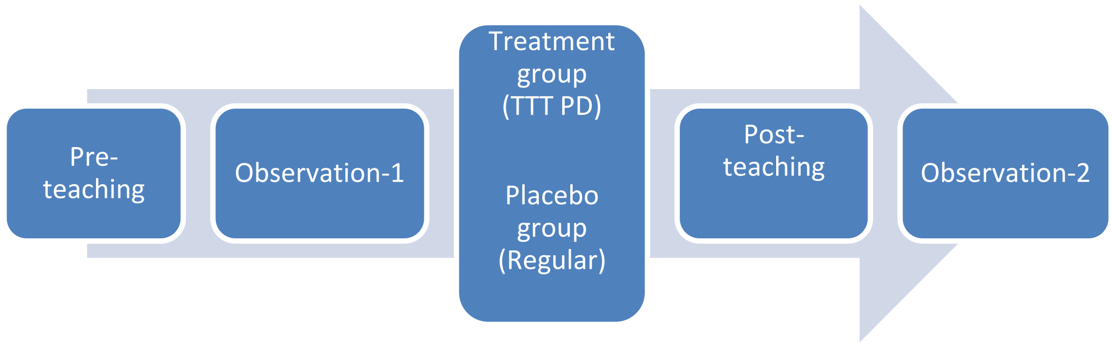

Figure 3.3 The design for the qualitative part of the study

Moreover, teacher participants were selected through combination of purposive and convenient procedures, their intact classes (students) were randomly assigned to the experimental and control groups. Some quantitative data, such as teacher achievement test and teachers' opinions about TTT PD was also collected from teachers. Table 3.9 is designed to represent the collection of quantitative data from teachers.

Table 3.9 Research design for the quantitative data of teacher participants

Group	Teaching -1	Pre-test	Sampling	Treatment	During treatment	Teaching -2	Post-test
Treatment	Pre teaching	MPUAT -T	Purposive/ convenient	TTT PD	COF	Post teaching	MPUAT -T TTTEF
Placebo	Pre teaching	MPUAT -T	Purposive/ convenient	Regular	COF	Post teaching	MPUAT -T

As seen from in Table 3.9 firstly, all groups taught the MPU to one of their classes as usual. Then, both treatment and placebo group teachers were given MPUAT-T as pre-tests. Afterwards, treatment group teachers participated to the TTT PD and placebo group teachers did not take any treatment. Then, both groups taught the MPU to their other classes. Finally, the treatment group teachers completed both MPUAT-T and TTTEF and placebo group teachers only completed the MPUAT-T.

3.4.2 Research Design for Student Participants

The design of this study concerning the student participants is similar to Solomon four-group design (Fraenkel & Wallen, 1996, p.275). The aim of Solomon four-group design is an attempt to eliminate the possible effect of pre-test. However, in this study the similar design was used to eliminate the effect of pre teaching. Table 3.10 includes six teachers and totally 12 classes. First two teachers are placebo group teachers and each has two classes. These intact classes were randomly assigned to placebo pre and placebo post groups. Similarly last four teachers are treatment group teachers and each also has two intact classes which were also randomly assigned to experimental and control groups. Thus, on the site of the students this is an experimental study. Table 3.10 is supplied to explain the structure of the design for student participants.

Table 3.10 The Solomon six-group design for student participants

Teacher	Group	Pre-test	Treatment	Post-test
Teacher-1	Placebo Pre Group	MPUAT-S	Regular teaching (pre-teaching)	MPUAT-S
	Placebo Post Group	MPUAT-S	Regular teaching (post-teaching)	MPUAT-S
Teacher-2	Placebo Pre Group	MPUAT-S	Regular teaching (pre-teaching)	MPUAT-S
	Placebo Post Group	MPUAT-S	Regular teaching (post-teaching)	MPUAT-S
Teacher-3	Experimental Group	MPUAT-S	TTT PD	MPUAT-S
	Control group	MPUAT-S	Regular teaching (pre-teaching)	MPUAT-S
Teacher-4	Experimental Group	MPUAT-S	TTT PD	MPUAT-S
	Control group	MPUAT-S	Regular teaching (pre-teaching)	MPUAT-S
Teacher-5	Experimental Group	MPUAT-S	TTT PD	MPUAT-S
	Control group	MPUAT-S	Regular teaching (pre-teaching)	MPUAT-S
Teacher-6	Experimental Group	MPUAT-S	TTT PD	MPUAT-S
	Control group	MPUAT-S	Regular teaching (pre-teaching)	MPUAT-S

Table 3.10 is not enough to represent the design of this study. That’s why supplementary Table 3.11 was developed for student participants.

Table 3.11 Research design for the quantitative data of student participants

Group	O (Pre-test)	Sampling	X (Treatment)	O (Post-test)
Experiment	MPUAT-S	convenient	Treatment group teachers taught to this class after participating to the TTT PD course	MPUAT-S
Control	MPUAT-S	convenient	Treatment group teachers taught to this class before participating to the TTT PD course	MPUAT-S
Placebo Pre	MPUAT-S	convenient	Placebo group teachers taught to this class earlier	MPUAT-S
Placebo Post	MPUAT-S	convenient	Placebo group teachers taught to this class after two months	MPUAT-S

As shown in Table 3.11 firstly, experimental, control, placebo pre and placebo post groups were given MPUAT-S as pre-tests. Then, except experimental group all other groups were taught MPU as regular. Then, teachers of students in the experimental groups (The while, they were also the teachers of control group students) taught after participating to the TTT PD and that of placebo groups taught with traditional teaching method. After treatments were completed, the post-tests were given to all groups.

On the other hand, seven research courses (two adaptation meetings are included) took place regularly throughout the program. The schedule for these courses is supplied in Appendix V. The distribution of the objectives to the weeks of main course is done according to the table of test specification (see Appendix F). Newton’s Laws of motion were taught during the adaptation meetings. This unit was chosen because this was the unit the teachers were teaching at their classes at that time.

The intentions of the courses were to conduct physics lessons, physics simulations, share ideas, critically examine and reflect upon teachers’ views and current practices, and to cooperatively and collaboratively reflect on the processes and products of the individual actions in the program. All dialogues from the courses were video recorded and later were used for analyses. The participant teachers and the researcher met once a week totally for seven weeks. Two of these weeks were adaptation phase and were conducted as a rehearsal of the main course by the researcher. The topic of the following week, which participants were going to teach in their classes, was the focus of that meeting. The aim of immediate application of the gained practices during the courses was to provide just in time teaching.

3.5. Procedure

The researcher decided to study on PD of physics teachers after he read and discussed the Hewson's (2007) chapter titled ''Teacher professional development in science'' in one of his PhD courses at Secondary School Science and Mathematics Education department at Middle East Technical University. He then prepared a proposal on teacher PD for another course at the same department. After determining the research problem, a four month literature review was conducted. Initially, the researcher specified search terms to be used in the literature review. The list of search terms is given in Appendix W. By the help of these keywords ERIC, Social Science Citation Index, JSTOR, Taylor & Francis, Wiley Inter Science, ProQuest (UMI) Dissertations & Theses, the electronic sources provided by the METU Library such as e-theses, e-journals, Academic Search Complete, EBSCO host, Education Research Complete, Dissertations and Theses, Turkish Higher Education Council National Dissertation Centre (YOK), and TUBITAK Ulakbilim databases were searched. Besides, some main journals in Turkey such as Hacettepe University Journal of Education, Journal of Education and Science, and Journal of Turkish Science Education were reviewed. Moreover, to know whether a needed article can be reached from the libraries of universities in Turkey, the libraries of Boğaziçi, Karadeniz Teknik, Gazi, and 9 Eylül universities were searched. Based on the results of the literature review the significance of this study was determined.

Once the literature review was momentarily finished, the population and the sample of the study were determined. In this step, because of the nature of the study the combination of both purposive and convenient sampling procedures were used for teachers and one of their classes was randomly assigned to control and another class was randomly assigned to experimental group. The researcher visited high schools in

Yenimahalle district of Ankara in order to find the candidates of the sample. Depending on the willingness of the interviewed teachers and depending on the criteria specified for selection of the teachers (see Section 3.1.1) the sample was determined. Furthermore, the minimum sample size was determined by following the procedure explained for power analysis by Cohen and Cohen (1983, p.155).

Needs analysis survey was developed and schools were visited to apply the needs analysis survey. The aim of the needs analysis was to decide about some parts of the content of the TTT PD course and the final design of the course. For instance, the time and the place of the meetings, and teachers' views on their SMK about each objective of the MPU were determined by needs analysis.

Moreover, depending on the design and context of the study, the required instruments were developed by the researcher. In order to triangulate data; forms, checklists, tests and surveys were developed. Triangulation of data requires the use of several data sources to produce multiple sets of data (Lincoln & Guba, 1985). One instrument was determined to measure students' achievement, two instruments were determined to measure teachers' progress on some variables, two instruments were developed for observation or treatment verification and finally one instrument was developed to ensure treatment fidelity. Briefly, the MPUAT-S, MPUAT-T, COF, TTTEF, TOC, and TFC were developed by the researcher. Pilot studies and expert views on these tests were conducted in 2012-2013 academic year before the study started. According to the results of pilot study and expert views, some changes were made on the instruments.

At the end of the first semester of the 2012-2013 school year the two week adaptation meetings and by the start of the second semester of the 2012-2013 school year, the main TTT PD course started over. The PD course lasted for seven weeks and five of these weeks were devoted to teaching the tenth grade MPU. Before starting the current study, necessary permissions to conduct this study were taken from the Ministry of Education. The permission document is presented in Appendix X. Then, by the start of the main study the pre-tests were administered to both placebo-pre group and control group students. Teachers in the implementation group taught the MPU earlier in one of their randomly determined classes. All these teachers' classes were observed in different percentages and the COF was filled out by the observer during the lessons and their all classes were post-tested after they finished teaching the MPU. After two months the main study started and teachers in the treatment group taught the MPU in parallel to the TTT PD courses. On the other hand, the placebo group teachers taught to their placebo-post groups without participating to the TTT PD courses. The classes of these teachers were pre-tested, once more teachers were observed in their classes and the COF was again filled out by the observer during the lessons. Once the TTT PD course finished and once all teachers finished teaching the MPU, students and teachers were once more given achievement post-tests. Moreover, the TTT PD course was evaluated by participating teachers by answering the items of TTTEF. Most of the lessons of both placebo and treatment group teachers were observed and video recorded both during pre-teaching and post-teaching. The time schedule of the study is given in Section 3.13.

Qualitative and quantitative data analysis techniques were used to interpret the results of the collected data. As data gathered through tests, forms, checklists and surveys, they were entered into the SPSS program and Microsoft Office Excel and they were analysed. In addition, by using document analysis method the data gathered from video records and COF were analysed. The last step was writing the dissertation.

3.6. Implementation of Treatments

The sections 3.6.1 and 3.6.2 includes the treatment given to the implementation group teachers. Treatment group teachers participated to both adaptation and main courses. Totally these teachers had an average of 21 hours of TTT PD course. However, placebo group teachers participated to only adaptation meetings which were about force and motion unit. Moreover, placebo group teachers taught to their two classes as usual. The details of both courses are given in the following sections.

Treatment group teachers taught to one of their classes during pre-teaching and taught to their other class during TTT PD course. Since during post-teaching treatment group teachers were taking an extra treatment, that is, TTT courses, to equate the amount of training during pre-teaching teachers were asked to prepare for their lessons. After each lesson, these teachers were interviewed about their preparations for lessons. Table 3.12 demonstrates the preparation of the treatment group teachers during pre-teaching.

Table 3.12 The amount of preparation of the treatment group teachers during pre-teaching

Teacher	Preparation	No of lessons observed	Preparation per lesson	No of weeks allocated to MPU	Average preparation per week
T3	7h* and 30min	5	1.50h	3	2.5h
T4	4h and 10 min	2	2.08h	3	1.39h
T5	8h and 30min	3	2.83h	3	2.83h
T6	6h and 35min	1	6.58h	1	6.58h
Average			3.25h		3.33h

h*: hour

As seen from Table 3.12, the average time of preparation of treatment group teachers during pre-teaching is 3.25 hours per lesson and 3.33h per week. During TTT PD they received 3 hour instruction per week, accordingly 1.5h per lesson. Thus, it seems that they have prepared more before pre-teaching both per lesson and per week. However, this is a little bit misleading. First, the sixth teacher taught the MPU in only one hour, second, since all lessons of teachers were not observed there were no way of knowing the amount of preparation for other lessons, third, they reported that they spend most of time of preparation for finding MPU related videos from internet. In any case as seen from table 3.12 the teachers have prepared considerably enough time for the lessons. This can be accepted as the amount of preparation that teachers made both before pre-teaching and post-teaching are equal. On the other hand, the treatment given to students is explained through the analysis of COF and the analysis of videos.

3.6.1. Adaptation Meeting

The aim of adaptation meetings was to ensure sincerity and familiarity and to have teachers to experience the nature of the study. The adaptation meetings took place in the first and second weeks of January at Friday evening between 6 PM and 9 PM, at a private school in Yenimahalle district of Ankara. 11 teachers promised to participate to the first meeting however; two of them explained excuse at the last moment. Thus, the first meeting began by eating dinner with 9 teachers. The dinner was eaten at a room in the dining hall of the same school. The dinner lasted for half an hour and during the dinner teachers introduced themselves and became acquainted with each other. Moreover, the change of the physics curriculum and the national project competition between high school students were two main topics that teachers argued on. After the meal the meeting started at the laboratory of the same school.

The researcher explained the aim and the structure of the TTT course that was going to take place within two months. The teachers were got clued in about the process of the study. Especially teachers were warned that they are free in participating to the course; moreover they were informed that they can abandon to participate to the PD course. Teachers asked several questions about the course and about their obligations. All questions were explained and then the researcher started teaching the topic of the week. First and third laws of motion were explained by the researcher and discussed by the teachers. Some counterintuitive questions were introduced and passionate discussions took place around these questions. Moreover, two animations were shown and two demonstrations were conducted. They also were discussed by the teachers. Furthermore, several misconceptions were discussed during the course. Although some teachers wanted to continue the discussions, the researcher finished the meeting at 9 PM. This was the first meeting that’s why to avoid the possibility of boring some teachers the meeting ended at that hour.

Except the content, the second adaptation meeting was similar to the first one in many aspects. The second course turned around the second law of motion including friction force. Once the two adaptation meetings finished participating teachers comprehend the nature of the courses that they were going to be subjected to. Additionally, the researcher understood that the course/study was continuing as planned.

3.6.2. Main Course (MC)

The MC course took place in the last three weeks of April and first two weeks of May at Friday evenings. The courses were conducted in the laboratory (Figure 3.4) of a private school in Yenimahalle district.

Figure 3.4 A scene from the main course

As in the case of AC, it continued between 6 PM and 9 PM, at the same school where the AC was executed. Teachers met every Friday evenings, meetings began by eating dinner and during the lessons tea was ready for drinking. If requested, teachers were going to be paid fees for transportation, however, none accepted. 17 teachers at different percentages participated to the main course. The participation rate of the data collection group teachers to the main course was given in the last column of Table 3.3. The design and the structure of the main course are listed below.

1. Each week one objective of MPU handled in the main course. Moreover, each week a different teacher prepared for teaching in the course where they were free in preparing the lessons. Since the aim of the study was to investigate the effectiveness of teachers teaching to each other, namely the collaboration of teachers, they were not forced to emphasize any method, teaching strategy or techniques during preparations and lecturing. However, tenth class curriculum (Appendix A) guided the teachers in determining the boundaries of the lessons that they prepared and presented.
2. The participating teachers were matched conveniently and five groups were formed. Before presenting the lesson, the lecturer worked on his notes with his partner and after the researcher checked the content of the prepared lesson and provided necessary feedback then the final form of the lesson was decided. During the preparation of the lessons the partners and the researcher communicated either through mail, phone or face to face meetings. The researcher generally provided educational materials such as books, animations, MPU related links, pen and pencils. Table 3.13 shows the teachers lectured during the main course and their partners.
3. The researcher tried to add his experiences all the time during the courses and he sometimes intervened and tried to explain the unclear points of the topics of interest. For example when teachers couldn’t end an argument or when the lecturer had trouble in answering questions he interfered and made necessary explanations.

Table 3.13 Teachers and their partners during main course

Course	Teacher	Partner	Date
C-1	Researcher	No partner	January-1st week
C-2	Researcher	No partner	January-2nd week
C-3	T-8	T-10	April- 2nd week
C-4	T-4	T-5	April- 3rd week
C-5	T-3	T-6	April- 4th week
C-6	T-9	T-5	May- 1st week
C-7	T-7	T-6	May- 2nd week

4. Except the first meeting of main course, all other meetings started with the summarization of the topic of the previous course by the researcher. The courses generally continued with the introduction of the topic by the lecturer, discussion of the main concepts, demonstration of the videos/animations and solving problems.
5. During the courses, teachers were free in asking questions, starting a discussion and making comments. However, any unrelated interventions were prevented by either lecturer or the researcher.
6. About 50% of the fifth lesson is supplied in Appendix Y. Although this document doesn’t completely reflect what took place during the TTT courses, it includes sufficient information for who want to have an idea about the treatment given to teachers.
7. The last activity of the course was to celebrate the TTT PD course with a cake (Figure 3.5).

Figure 3.5 The cake that was cut at the end of the course

3.7. Treatment Fidelity (TF)

Before administering a treatment it has to be verified that it adheres adequate power to produce a difference. The TF for this study was carefully satisfied: First of all, forms, checklists, tests and surveys were developed by the researcher. These were reviewed by some specialists to check whether they are consistent with the aim of the study or not. In addition, these materials were submitted to thesis monitoring committee periodically for checking. Moreover, periodic interviews were conducted with the supervisor of the study to ensure the appropriateness and adequateness of both the design of the study and the developed instruments. Since there is not a consensus on the design and procedure of experimental PD studies, in order to formalize the method of this study, sometimes more than tree hour discussions were conducted with the supervisor of the study. All these discussions were voice recorded and were once more listened to by the researcher in order not to miss any collimation or guidance of the supervisor. Furthermore, the TTT PD course is successfully used by many private schools and university preparation courses in Turkey. That's why it can be said that the effectiveness of this PD was proven informally. In other words, whether TTT PD course has a potential in making a difference was experienced heretofore. Finally, TFC was developed by the researcher. Whether the TTT PD possesses the general characteristics of effective PD courses were audited by this checklist. One professor, one associate professor and one research assistant at METU, an associate professor from Gaziantep University and one lecturer form Elazığ University declared their views on TTT PD through TFC. They were all experts in the field of "PD of teachers" and they all confirmed that TTT PD can make a difference in increasing teachers' knowledge. Based on their recommendations minor changes were made on the TFC. Table 3.14 represents the choices of four of five experts on the dimensions of the TFC. One of the experts (E-1 in Table 3.14) declared his views on the appropriateness of the TFC however he didn't scored the characteristics given in the checklist.

Table 3.14 The evaluation of the effectiveness of the TTT PD by the experts

	Completely include					**Partially include**					**Never include**				
Characteristics / Experts	E-1	E-2	E-3	E-4	E-5	E-1	E-2	E-3	E-4	E-5	E-1	E-2	E-3	E-4	E-5
Delivered in conducive settings	NA	√	√	√	√	NA					NA				
Collective participation	NA	√	√	√	√	NA					NA				
Active learning	NA	√	√	√	√	NA					NA				
Focused on the content of the subject that teachers teach	NA	√	√	√	√	NA					NA				
Coherence	NA	√	√	√	√	NA					NA				
Intensive	NA	√	√	√	√	NA					NA				
Sustained	NA	√	√	√		NA				√	NA				
Long duration	NA	√	√	√		NA				√	NA				
Just-in time teaching	NA	√	√			NA			√		NA				
Collaboration	NA	√	√	√	√	NA					NA				
Practice oriented	NA	√	√	√	√	NA					NA				
Needs analysis centred	NA	√	√	√	√	NA					NA				

As clearly seen from Table 3.14, nearly all experts expressed that TTT PD does possess the effective characteristics of a PD courses. On the other hand, job-embedded is one of the characteristics of effective PD that literature emphasis, however, TTT does not hold this characteristic. That’s why this characteristic was not added to TFC.

3.8 Researcher Role

In this study initially the researcher defined his main role as being a facilitator of the course, an active learner, listener and also a participant observer all the time. However, during the beginning of the main course he changed his role. During the third course (which was the first workshop of the main course) he observed the discussions of the teachers. Unfortunately teachers mostly had trouble in ending the discussions related to MPU and most of the questions remained unanswered. That's why during this course the researcher decided to become a coach or mentor. Thereby, the role of the researcher was a coach or a mentor in this study. He often interrupted the unnecessary discussions, sometimes he started some necessary discussion by asking questions, he always interfered and concluded when the teachers could not explain the concepts of MPU. Being a coach did not mean that the researcher would not gain any practices or experiences during the TTT PD. On the other hand, the researcher has twenty years of experience in teaching high school physics. Moreover, he is the head of physics department in a group of private schools. So far, he has participated and supervised many teacher courses/meetings in these schools. Thus, it can be said that he has experience in informal teacher PD. That's why he was sensitive in ethical issues, observations, guiding the discussions, data collection and communication. Furthermore, the researcher was actively teaching to tenth grades, to maximize the observations and coaching, he taught the MPU to his classes before the treatment phase.

3.9 Analysis of Data

The data that were obtained through application of the achievement tests were entered to a SPSS data file and data collected through application of forms and checklists were entered to an EXCEL data file. Then, depending on the structure of the instrument each teachers' and students' score were computed. Thus, some variables (i.e. pre- and post-variables) of the present study were constituted. Moreover, other variables which were students' previous physics course grade, and teacher experience, were also entered to SPSS file. Initially data cleaning was conducted and any data entered inadvertently was corrected. Fortunately, since achievement test data entering process was computerized no mistakes were detected. Then, missing data analysis which is discussed in Section 4.4 was conducted. Later, descriptive statistics was conducted for each variable and for both treatment and placebo groups' students. Following inferential statistics were used on the data: For inferential statistics ANCOVA was used on the data. Before conducting the ANCOVA, assumptions of this analysis were checked. The reason for choosing ANCOVA was that one group might be superior to the other group when they were assigned to control and experimental groups. Therefore, it was necessary to equate these groups at least on one independent variable by using covariate analysis. For qualitative analysis the video records and the data collected through COF was used. Videos were watched and forms were reviewed to analyse the data.

3. 10 Power Analysis

To have desired powerful results, power analysis was performed prior to the study. Since there were only four teachers who took the MPUT-T in the treatment group, inferential statistics were not conducted for them. The following power analysis was conducted for the treatment group students. To get results with the desired power, Cohen and Cohen (1983, p. 117) gave the following equation for estimating the required sample size.

$$n = \frac{L}{f^2} + k_A + k_B + k_C + 1$$

In the equation 'n' indicates the sample size, with respect to the alpha level (probability of Type I error). L value was determined by using the L values from the table presented in Cohen and Cohen. (1983, p. 527), f^2 is the effect size, k_A is the number of covariates, k_B is the number of group membership variables, and k_C is the number of interaction variables.

First of all, according to the literature, most of the effect sizes from the studies on the effect of PD on students' achievement are found to be modest (Blank & Alas, 2009). Therefore, it would be practical to set effect size to a medium value of 0.15 measured by f^2 (Cohen & Cohen, 1983, p. 179).

Second, the probability of rejecting true null hypothesis (probability of making Type I-error) was set to 0.05 which is usually accepted as a convention in educational research. The probability of failing to reject a false null hypothesis (probability of making Type II-error) was set to 0.20. Therefore, the power of the study, probability of rejecting a false null hypothesis, was set to 0.80.

Third, L value was determined as 10.90 by using the L values from the table presented in Cohen and Cohen (1983, p. 527). Number of covariates (k_A) is 4 (Pre-MPUAT-S, MPUAT-T, TE, and PCG), and the number of group membership variables (k_B) is 1 (TTT PD course). Thus, the number of interaction terms (k_C) is 4. After the required calculations, the minimum sample size for each group was resulted as 80.67. Since when the study was executed the exact number of student participants was appeared and the inferential statistics was conducted with a size of 213 subjects and power of the study was calculated once more as .98.

3.11 Assumptions and Limitations

1. The participant teachers have not been randomly selected but are self-selected by their willingness to participate this study. This is a general limitation in PD research since research shows that effective PD is associated with a volunteer population (Hewson, 2007; Jagielski, 1991). Because of the conditions and requirements stated in Section 3.1.1 it was almost impossible to select the teachers randomly.
2. The study was conducted at the tenth-grade level and the effects of the treatment on other grade levels were not studied. Except the data collection group (12 teachers which also include implementation group teachers and which only filled out TTTEF) the study only includes six teacher participants. This group of teachers may not represent the larger teacher population. The possibility exists that this group of participating teachers may be more motivated, bright, able, or talented than the general teaching population in Ankara.
3. Teacher's pedagogical beliefs, teaching philosophies, and abilities may vary and could affect the results of the study. These variables were not controlled in the study.
4. School characteristics such as school climate, teacher morale, administrative leadership, student discipline plan, classroom management, and parental involvement may have impacted student achievement. These were not controlled in the study.

3. 12 Ethical Issues

All of the teachers in this study were chosen on a volunteer basis. To protect participants from physically and psychologically harm, participant names, schools and other information are kept in secret. To ensure confidentially of research data, the data are not shared with others. The study participants and schools are protected by using pseudonyms. To prevent deception, purpose and the results of the study was shared with participants. Moreover, some of the results of the study were shared with those subjects who provided their e-mail addresses in order to be contacted when the study was completed. Briefly every effort was made to build trust, display empathy, maintain confidentiality among all participants and preserve all ethical responsibilities throughout the course of the study.

3.13 Budget and Time Schedule

Unfortunately the researcher could not found any financial support. The money needed for photocopy, for traveling and for investment during courses were provided by the researcher. All the activities that took place during the development of the dissertation are scheduled in Table 3.15.

Table 3.15 The time schedule

Activity	Time
Determination of research problem	April 2012
Determination of key words	May 2012
Literature review	May-August 2012
Development of materials	September 2012- April 2013
Determination of the participants	November- December 2012
First and second meetings before the main study	January 2013
Application of the pre-tests to pre-teaching group students	February 2013
Monitoring the pre-teaching group teachers at their classes	March 2013
Application of the post-tests to pre-teaching group students	March -2013
Application of the pre-tests to post-teaching group students	April 2013
Main study and monitoring the post-teaching group teachers at their classes	April-May 2013
Application of the post-tests to post-teaching groups	May – 2013
Data entering	May- June 2013
Analysis of data	June-July 2013
Writing the thesis	August 2013- February 2014

As seen from Table 3.15 this dissertation is prepared in about two years. Table shows that four months were used for literature review, the development of the instruments has lasted for eight months and writing the thesis has lasted for six months. Some of the activities were conducted concurrently. That is, for instance, while the TTTEF was developed, the researcher was observing the teachers during pre-teaching.

CHAPTER 4

RESULTS

The purpose of this chapter is to report the results of the analysis of the data collected in this study. This chapter begins with Sections 4.1 and Section 4.2 which include the results of the treatment verification and the results of the teachers' views about "teachers teaching teachers" (TTT) PD course, respectively. These two sections are followed by Section 4.3 which represents the results of class observation of both placebo and treatment group teachers one by one. The analysis of missing data is given in Section 4.4. Descriptive statistics is given in Section 4.5. Teachers' achievement test results are introduced in Section 4.6. The inferential statistics is given in section 4.7 which includes determination of covariates, assumptions of ANCOVA and result of ANCOVA for placebo and treatment groups. This chapter finalize with the summary of results in section 4.8.

4.1. Results of treatment verification

One of the primary determinants of successful intervention programs for teachers is the degree to which the courses are implemented with precision and consistency. Moreover, any success of a treatment may be due to an effective treatment or unknown contaminants added to treatment. Similarly any failure of a treatment may be due to an ineffective treatment or a treatment that was inadequately administered.

There were two phases of treatment of this study: The treatment given to the teachers, that is the TTT PD course and the treatment given to the students, that is the teaching of teachers in their classes after attending to TTT PD course. The treatment verification of the TTT PD course was provided with TOC. This checklist was filled out by the researcher all along the main course and was filled out by two different observer to carry out the inter scorer reliability. For each item of the TOC the observers scored one of "2, 1, 0 or NA", which stand for "yes, partially, no or not observed" respectively. For five main courses, the TOC was filled out eight times. All five courses were observed by the researcher, the third course was observed by the supervisor of the study and second and fifth courses were observed by an experienced teacher who was the head of physics department of a private school and was familiar with TTT courses. Moreover, once more he was informed about TTT PD course by the researcher. The inter scorer reliability for researcher and the supervisor of the study was found as .998 and for researcher and the other observer was found as .775. In calculating these values the researcher correlated the average of his five observations with that of the averages of other observers. Table 4.1 shows the results of the TOC observations. The average score for each dimensions of the TOC is the average of eight observations.

Table 4.1 The dimensions of the TOC and average score of each dimension

Characteristics	# of items	Av. Score
Delivered in conducive settings	5	1.72
Collective participation	4	1.38
Active learning	7	1.70
Focused on the content of the subject	9	1.83
Coherence	5	1.90
Intensive	1 (there were 3 more questions)	2
Sustained	1	2
Long duration	2 (there were 1 more question)	2
Just-in time teaching	1	2
Collaboration	6 (there were 6 more questions)	0.92
practice oriented	2	1.65
needs analysis centred	2	2
Lecturer	6	1.26
Teacher knowledge	4	1.41

The maximum possible score that can be taken on each dimension was 2. Referring to Table 4.1 the characteristics intensive, sustained, long duration, just-in time teaching and needs analysis centred had maximum possible scores. Collaboration was the dimension that got the least score from the observers. The average score of all dimensions is calculated as 1.70. In other words, it can be said that according to the observations the treatment given to teachers is 85% accomplished as planned.

As seen from Table 4.1 and TOC form in Appendix O, there were some items that were not Likert type. In "intensive" dimension there were three questions assessing "the duration of the course, the time allocated for the objective of the week and the time allocated for other professional development activities". The course was planned to last for 180 minutes and all observers were agreed that the course lasted for 3 hours. However, there were slight differences among the observers about time allocated for the objective of the week and for the professional development activities. In the "long duration" dimension one item was about the duration of the course. Since other observers did not participated to all courses this item was only observed by the researcher and the researcher observed and collected that throughout five weeks. In "collaboration" dimension there were six more items. The scoring process of these items was a little bit troublesome. In other words, the items were, for example, asking the number of participant teachers that asked questions during the course, the number of questions that the presenter asked and so on. Consequently the observers didn’t score these items and accordingly they were not interpreted.

The teachers were observed in their classes to verify the treatment given to the students. In other words, teachers were observed about their gained practices in their classrooms. For that purpose COF was used. The percentages of the observations done in the placebo group teachers’ classrooms are given in Table 4.2. When this table is designed, each 40 minute class hour is accepted as a full lesson. One of the placebo group teachers (T-1) finished the MPU in six class hours and the other teacher (T-2) finished it in four class hours both during pre-teaching and post teaching.

Table 4.2 Class observations of placebo group teachers during pre- and post-teachings

				Pre-teaching			
Teachers/ Lessons	L-1	L-2	L-3	L-4	L-5	L-6	% of lessons observed
T-1	O*+V**	O+V	V	V	X	X	100
T-2	O+V	O+V	O+V	O+V	O+V	V	100
				Post-teaching			
T-1	O+V	O+V	V	V	X	X	100
T-2	O+V		O+V		O+V		50

*O stand for lessons observed by the researcher

**V stands for lessons video recorded

Moreover, lessons that are dashed are not observed and that are crossed (X) were not conducted by the teacher. Furthermore, since later videos are watched by the researcher, they are also accepted as observed lessons and it affected the percentage of observed lessons.

Just as placebo group teachers, treatment group teachers also taught to one of their classes earlier and taught to their other classes in parallel to the intervention. Table 4.3 is designed to represent the observations done in the treatment group teachers' classes. Three of the four treatment group teachers (T-3, T-4 and T-5) finished MPU in their classes, which they taught earlier, in six class hours and the other one (T-6) finished the entire unit in only one class hour! On the other hand, during post teaching, that is teaching in parallel with TTT PD, the courses were under the control of the researcher. In other words, three of them taught MPU in eight class hours (four weeks) and one of them taught it in nine class hours (five weeks). Since he was the only teacher who had three weekly physics course hours in his school, the forth teacher (T-4) in Table 4.3 was the only teacher who taught the fifth objective of the MPU in his class. Meanwhile, even though he had three weekly physics course hours, each week he only used two of these hours for teaching MPU and he used the other hour for another unit.

Table 4.3 Class observations of treatment group teachers during pre- and post-teaching

Pre-teaching							
Teacher/ Lessons	L-1	L-2	L-3	L-4	L-5	L-6	% of lessons observed
T-3	O+V	O+V	O+V	O+V	O+V		100
T-4	O+V			O+V			33
T-5	O+V		O+V		O+V		50
T-6	O+V						100

Post-teaching (during/after treatment)											
	L-1	L-2	L-3	L-4	L-5	L-6	L-7	L-8	L-9	L-10	
T-3	O+V	O+V	O+V	O+V	O+V		O+V	V			88
T-4	O+V	O+V	O+V	O+V	V	V	V	V	V		100
T-5	O+V	O+V	O+V	O+V	O+V	V	V	V			100
T-6	O+V		S*		S		S				50

*This teacher further did not allowed to either observe or video record, the lessons were only voice (S) recorded.

As seen from Table 4.3 teachers' lessons were observed in different percentages. During pre-teaching teachers were free in allocating time for MPU, however, during the treatment, teachers had to obey the guidance of the researcher. Except the fourth teacher, all others taught MPU in their classes in eight class hours. Only the fourth teacher taught the fifth objective of MPU to his class, that is why he taught it in nine class hours. The researcher could not observe the teaching of this objective during pre-teaching, however, he watched the video record during the post-teaching and it was seen that the objective was taught as intended.

4.2. Results of the teachers’ views about TTT PD course

In order to see how the teachers perceive the designed course the views of the teachers who participated to TTT PD course were taken via a form (See Appendix U). In other words, the first research question was assessed through this instrument. The checklist was developed by the researcher. Its reliability and validity was discussed in Section 3.3.6. It was answered by 12 teachers. There were six dimensions and totally 85 items on the questionnaire. Each alternative in the checklist was coded as “1” for “strongly disagree”, “2” for “disagree”, “3” for “neutral’”, “4” for “agree’”, and “5” for “strongly agree”. Thus, the maximum possible score that can be taken for each item was 5 and minimum possible score was 1. The dimensions, the number of items in each dimension, and teachers’ averages on each dimension is given in Table 4.4.

Table 4.4 The dimensions and average score of each dimension of TTTEF

Dimension	# of items	Average scores
Attitude	10	4.33
Usefulness	16	4.26
Researcher	8	4.78
PCK	22	4.25
PK	15	4.04
SMK	14	4.38

Table 4.4 indicates that the maximum score is given to the ‘‘researcher’’ dimension and minimum score is given to ‘‘PK’’ dimension by the teachers. What is remarkable is that all dimension had scores over four. The average of each teacher on TTTEF and their average score on each dimension are given in Table 4.5.

Table 4.5 The results of TTTEF for each participating teacher

Teachers	Attitude	Usefulness	Researcher	PCK	PK	SMK	Av.[a]
1	4.80	5.00	5.00	5.00	4.93	5.00	**4.96**[b]
2	4.20	3.75	4.13	3.64	3.33	3.86	3.75
3	4.10	4.50	5.00	4.55	4.40	5.00	**4.58**
4	4.00	3.94	5.00	4.18	3.80	4.64	**4.20**
5	3.78	3.46	4.14	3.00	NA[c]	3.29	3.62
6	4.30	4.31	5.00	4.68	4.47	5.00	4.61
7	4.60	4.38	5.00	4.05	3.73	3.79	**4.16**
8	4.40	4.14	4.88	4.18	NA	4.14	4.28
9	4.40	4.00	5.00	3.45	3.53	3.57	3.85
10	4.20	4.25	4.75	4.36	3.93	4.71	4.34
11	4.80	4.69	4.88	4.68	4.33	4.50	4.62
12	4.33	4.47	4.50	4.00	3.93	4.43	4.23
Treatment group Av.	4.38	4.46	5.00	4.45	4.22	4.61	4.52
Rest average[d]	4.30	4.13	4.66	4.00	3.92	4.19	4.20
Implementation group Av.	4.33	4.26	4.78	4.25	4.04	4.38	4.34

[a]Average

[b]Bolds are the treatment group teachers

[c]This dimension was left blank by 5th and 8th teachers

[d]implementation group teachers without the treatment group teachers

Table 4.5 indicates that while the 1st teacher gave the highest score (4.96) to TTT PD course the 5th teacher gave the lowest score (3.62) to the course. Actually almost all scores of the 5th teacher on each dimension are the lowest. Moreover this was the teacher who didn’t filled out ‘‘PK’’ dimension of the TTTEF.

Teachers' evaluation of TTT PD is substantially reliable. Initially in order to help teachers to feel free during the application of the TTTEF, the researcher wanted them not to write their names. However, later after approximately two months through the orientation of the supervisor of the study the implementation group teachers were found and their papers were determined. The first (T6), third (T5), fourth (T3) and the seventh (T4) teachers in Table 4.5 were the treatment group teachers. The last part of Table 4.5 demonstrates the average scores of the treatment group (4.52), the implementation group without the treatment group (4.20), and the implementation group (4.34) on TTTEF. What is remarkable here is that the treatment group teachers have highest average score on TTTEF. Figure 4.1 is designed to represent average scores of the groups on the dimensions of TTTEF.

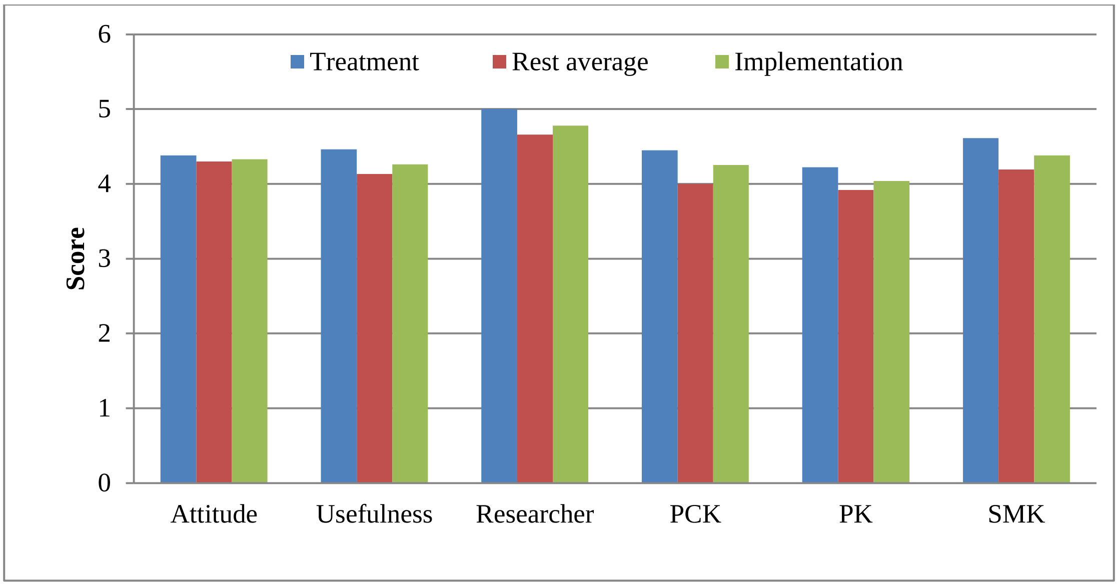

Figure 4.1 the average scores of the groups on TTTEF.

Figure 4.1 display that the treatment group has the higher scores on all dimensions. While the scores of the treatment group and the rest of the teachers who participated to the TTT PD course on the ''attitude'' dimension is more or less same, the treatment group teachers apparently has higher scores on the rest of the dimensions, especially it is more visible on ''SMK'' dimension.

4.3. Results of the class observations

In this study, total of six teachers' classes were observed. Two of these teachers were the placebo and four of them were treatment group teachers. During the observations, the classroom observation forms (COF) were filled out and the lessons, except several voice records, generally were video recorded. These records and the forms were used to analyse the class observations. For each teacher two tables and one figure were formed; the table of duration and frequency of activities, the comparison of pre- and post-teachings of teachers through figures, and the table of concepts of the modern physics unit (MPU) and the time allocated in teaching these concepts.

4.3. 1 Class observation results: Teacher T1

Teacher T1 has been actively teaching in an Anatolian High school. He has eighteen years of teaching experience. Up until present he has taught the MPU twice. He was a keen applicant for TTT PD. However, in order to equate the TE of placebo and treatment group teachers, he was purposely assigned to the placebo group. He allocated only three class hours to teach MPU to his placebo pre group and he spared only two class hours to teach the same unit to placebo post group. The researcher observed all his pre and post-groups' lessons. He was strict during the lessons and there were no disciplinary problems. Table 4.6 represents the frequency and duration of some activities that took place during pre and post-teaching in the classes of the said teacher. The change in these activities will be interpreted as the "signs of effects" of treatment given to these groups. The lessons presented in Table 4.6 (same tables are also used for other teachers) are not successive lessons; they are strictly observations on teachers' done by researchers. Videos were analysed to determine the frequency and duration of the activities conducted in the class. For some activities only frequency, and/or duration were purposeful. Duration of lecture, question frequency, plus the frequency and duration of discussions held, were taken into account to accomplish a greater understanding of the effect of TTT PD on the teachers' educational style.

Table 4.6 The frequency and the duration of the activities during teachings of teacher T1

Lessons/ Activities	Pre-teaching								Post-teaching					
	L-1 (27[a])		L-2 (12)		L-3 (30)		Per lesson		L-1 (38)		L-2 (38)		Per lesson	
	d[b]	f[c]	d	f	d	f	d	f	d	f	d	f	d	f
Lecturing	3		9		11		7.7		13		6		9.5	
Discussions/ Questioning	10	3	0	0	8	1	6	1.3	2	1	0	0	1	0.5
Questions asked to the teacher		0		0		3		1		0		0		0
Questions that teacher asked		4		0		1		1.7		3		0		1.5
Animation/ Simulation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Video	0	0	0	0	0	0	0	0	0	0	5	2	2.5	1.0
Solving problems	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PCK		0		0		0		0		0		0		0
PK		1		0		0		0.3		0		0		0
Note taking	0	0	0	0	0	0	0	0	0	0	3	1	1.5	0.5
Unrelated[d] teaching	14		3		11		9.3		19		13		16	

[a]Duration of the lesson in minutes, [b]Duration (min.), [c] Frequency, [d]unrelated teaching includes lecturing, discussions etc.

Table 4.6 indicates that Teacher T1 was not well organized during his lessons. For instance, while the time allocated for discussion was six minutes per lesson during pre-teaching, only one minute was allocated towards post-teaching. He spent 9.33 minutes per lesson during pre-teaching and 16 minutes per lesson during post-teaching, teaching topics that are not relative to the objectives of the MPU. His pre-teaching during the second lesson only consisted of 12 minutes, therefore the full forty minutes (one hour class) was incomplete. Hence, these may be the reasons as to why his placebo-post class was not as successful as his placebo-pre class. Moreover, besides for an explanation during pre-teaching at the beginning of the first lesson concerning the aim of the MPU, neither PCK nor PK activities were observed in the classes of this teacher. In order to visualize Table 4.6, Figure 4.2 was constructed.

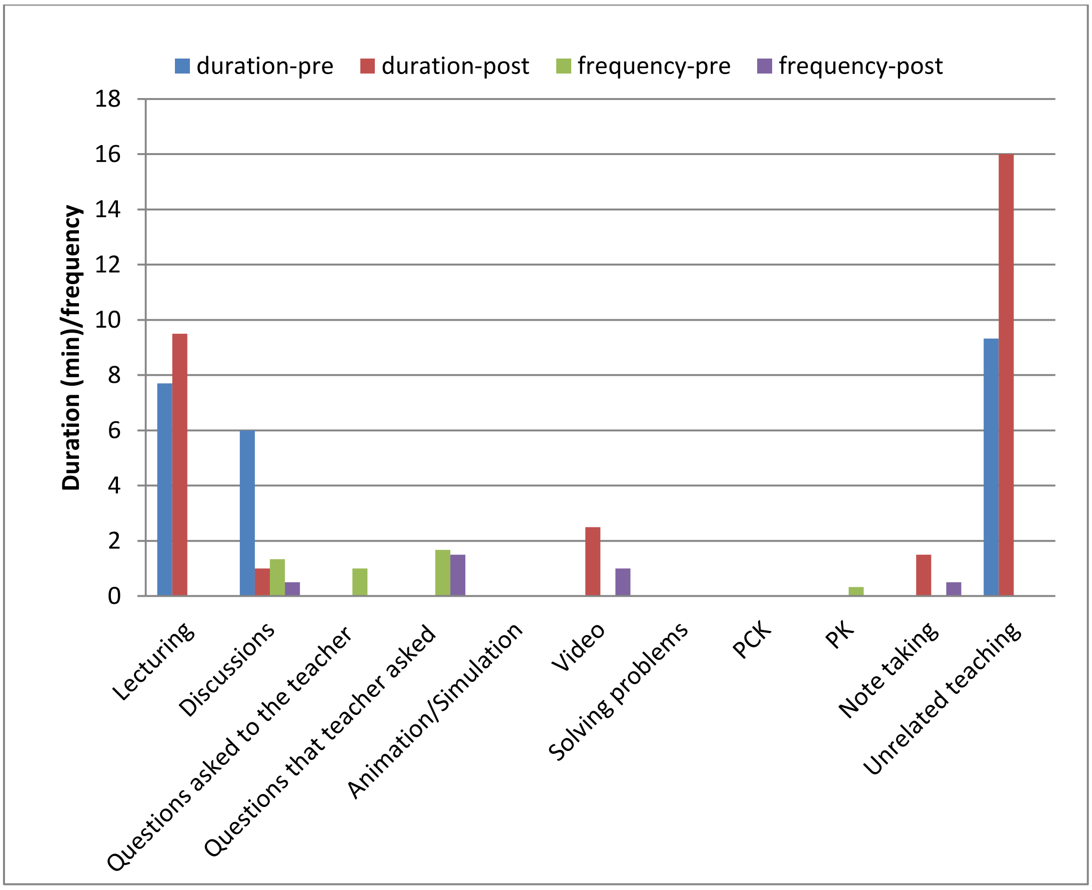

Figure 4.2 Comparison of pre- and post-teachings of Teacher T1

The obvious differences between the two lessons performed by Teacher T1 were the high amount of unrelated topics during post-teaching and the excessive amount of discussions in the class during pre-teaching. These two factors may explain the success of his students in his placebo-pre group. Moreover, Figure 4.2 shows that Teacher T1 mostly taught unrelated topics in his classes. In actual fact, the points he spoke about were not completely unrelated to the MPU, but they were not related to the objectives of the MPU. For example, he tried to explain the concepts of general relativity such as the precession in Mercury's orbit, he also spoke about time travel, he discussed time passing during dreaming, and students discussed teleportation, reincarnation and so forth. However, he never mentioned (for example) the Michelson–Morley (MM) experiment and sub-fields of modern physics. Moreover his teachings were full of mistakes! The worst of all was that most of his speech was incomprehensible. To give an example, the difference between classical and modern physics was explained as follows:

> The Science of Physics explains various things. For example, velocity is acceleration times time, meaning for example distance X= V.t etc. When we explain these, the part that we explain is called classical physics. The part that we cannot explain, by later investigating particles which are related what? Atom… the scientific investigations about atom, what is that part of physics is called? Modern physics…

The above passage fails to explain the correct difference (with a logical, complete meaning) between classical and modern physics. In other words it is vague and meaningless. Nevertheless, most of his speech was similar to the above passage. As another example, the speech below was neither correct nor related to the objectives of the MPU.

> The theory of special relativity investigates the systems that are moving constantly. The second part of the theory has enlarged the scope of the first part and the force between masses has been taken into account.

The percentage of unrelated teaching of this teacher was high, to gain more of an idea about the lessons referred to, the below passage is an example of "unrelated teaching".

> Similarly, all objects in the gravitational field of other objects move in a curved path. The minimum distance between two points in this field is not a straight line, it is curved. Einstein developed his general theory of relativity by reasoning, not by experiments. He bravely stated this and that his theory could be tested during a solar eclipse. So indeed during the solar eclipse of 1919 in May, the light from two stars that were behind the sun was affected by the gravitational field of the sun. They were even seen when they were behind the sun. Another test of the theory was the deflection in the orbit of Mercury….One of the results of the general theory of relativity was the finiteness of the universe; also that it's unlimited… Furthermore according to this theory, the universe was either expanding continuously or contracting…

Moreover, most of the concepts were taught incorrectly. For instance he explained that when objects move with high velocities, their lengths would contract. He also said that if one of the students had to go through the same scenario in space, he would accordingly return as a dwarf!

With all due consideration, the conclusion is that Teacher T1 is not well organized, doesn't abide by the curriculum, doesn't approach teaching correctly and doesn't convey meaningfulness. The achievements of his students, other than pre or post-teaching, may be attributed to some other factors.

4.3. 2 Class observation results: Teacher T2

This was a private school teacher with five years of teaching experience. So far he has participated in two PD programs similar to TTT PD. But none had taken the MPU into account. As in the case of Teacher T1, he was assigned purposely to the placebo group. It was the second time that he taught the MPU and in this academic year he taught the MPU to a total of five classes. The researcher observed all his lessons both during pre and post teaching. In order to teach the MPU he allocated six lessons during pre-teaching and four lessons during post-teaching. He did so because he was going to go abroad and he had to finish the MPU before the end of school year. Furthermore, he taught all his lessons with smart board and he had prepared PPT for his all lessons. Table 4.7 shows the activities that took place during the instructions of this teacher.

Table 4.7 The frequency and the duration of the activities during teachings of teacher T2

Lessons/ Activities	Pre-teaching														Post-teaching									
	L-1 (28)		L-2 (37)		L-3 (37)		L-4 (40)		L-5 (36)		L-6 (37)		Per lesson		L-1 (37)		L-2 (36)		L-3 (38)		L-4 (36)		Per lesson	
	d	F	d	f	d	f	d	f	d	f	d	f	d	f	d	f	d	f	d	f	d	f	d	f
Lecturing	9		10		7		4		13		7		5.67		26		18		6		17		16.75	
Discussion/ Questioning	8	3	11	5	20	4	12	4	6	2	4	2	6.10	3.33	5	1	4	1	4	2	0	0	3.25	1
Questions asked to the teacher		5		3		12		8		3		8		6.50		5		3		6		2		4
Questions that teacher asked		0		4		4		3		3		1		2.50		2		1		3		1		1.75
Animation/ Simulation	0	0	4	2	0	0	2	1	0	0	0	0	1	0.67	1	1	0	0	0	0	0	0	0.25	0.25
Video	7	1	10	3	5	2	11	4	0	0	10	3	7.17	1.71	0	0	11	2	10	4	0	0	5.25	1.50
Solving problems	0	0	0	0	0	0	0	0	9	2	8	2	2.83	0.67	0	0	0	0	11	3	17	3	7	1.50
PCK		1		0		1		1		0		0		0.5		0		1		0		0		0.25
PK		2		1		2		0		1		0		1		1		1		0		3		1.25
Note taking	0	0	0	0	0	0	0	0	3	1	4	1	1.17	0.67	0	0	0	0	0	0	0	0	0	0
Unrelated teaching	4		2		4		11		5		4		5.00		5		3		7		2		4.25	

As seen from Table 4.7 this teacher seems better during pre-teaching. For instance, while he lectured excessively more per lesson during post teaching, his students asked him more questions per lesson during pre-teaching. This means that his placebo-pre group students were more active than his placebo-post group students. This result is consistent with the reason he explained for the success of his placebo-pre group students in Section 4.5. Moreover, the table shows that while no note-taking activity took place and only one animation (1 min) was shown during post-teaching, these two activities were successfully conducted during pre-teaching. A clear comparison of all activities about pre- and post-teachings of Teacher T2 can be seen in Figure 4.3.

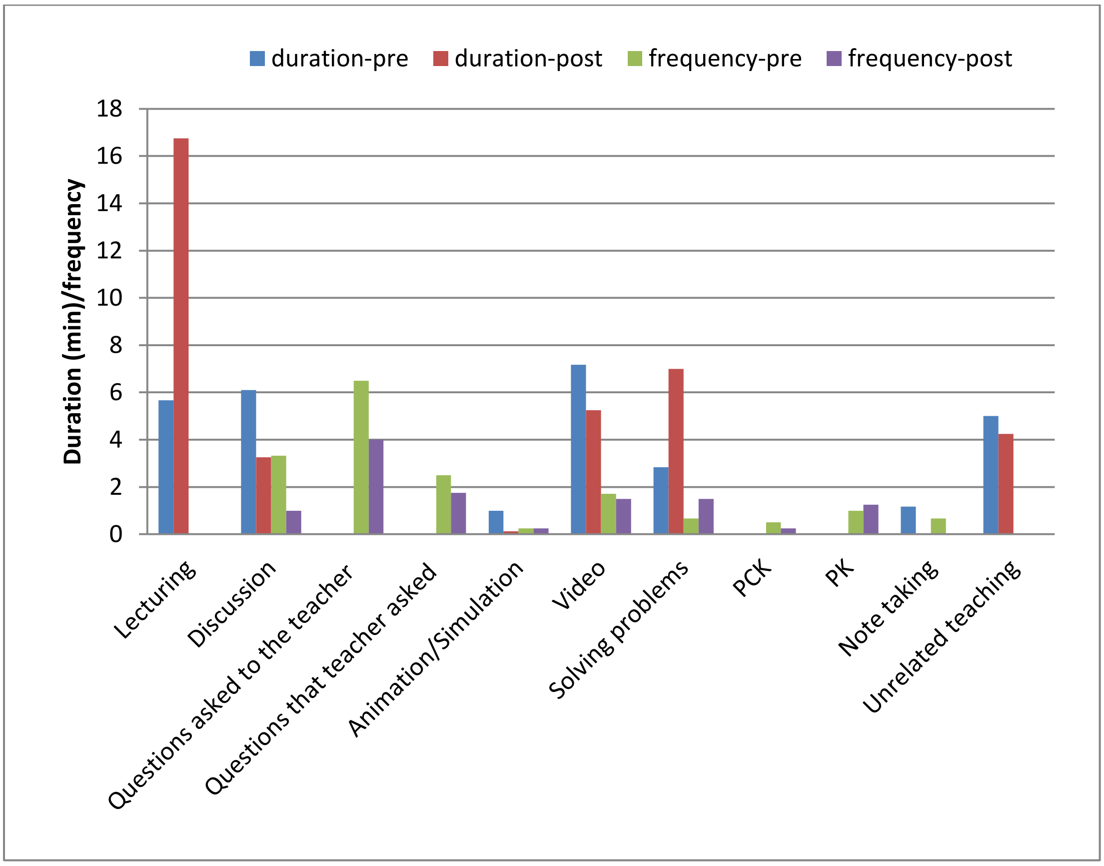

Figure 4.3 Comparison of pre- and post-teachings of Teacher T2

Figure 4.3 indicates that in terms of most of the activities that compare the pre- and post-teachings, Teacher T2 had done less during post-teaching. For instance, the amount of discussions and the number of the questions asked by the teacher were less during post teaching. However, the amount of lecturing was more in post-teaching. Moreover, the amount of problem solving and of unrelated teaching is in favour of post teaching. What is clear both in pre- and post-teachings is that PCK and PK activities were almost equal and vary very little. Since there were a considerable amount of discussions between teacher and students during pre-teaching, below is an example of a debate regarding the graph of wavelength and amount of radiation of blackbody.

> T: How can you deduce that the energy is not continuous or can you decide that it is quantized? Please think a little bit. How can you interpret this graph?
>
> S1: According to the graph the energy will increase up to infinity, but it does not happen so.
>
> T: This is the expected value, it radiates forever.
>
> S2: Do you mean it will increase to infinity?
>
> T2: Mehmet, what do you think? Mehmet has strange ideas. Do you have something different?
>
> (Mehmet did not answer)
>
> T: Halil İbrahim, what do you think now?
>
> S2: The energy will not increase to infinity…According to wavelength, as energy is added it must increase, it does not increase. After some time it gets to zero.
>
> T: Can you do something? Do you imagine something?
>
> S3: No, but I have difficulty in explaining.
>
> S4: Sir, I didn’t understand this blackbody radiation. I think that the light will move back from the place where it entered.
>
> T: Theoretically we think that it is confined, it does not leave, and it is absorbed by the blackbody after reflections.
>
> S4: Sir, I didn’t understand that, in any case actually there is no blackbody, how do we know that this happens or not? Maybe it doesn’t happen like that.
>
> T: They think that it happens like that.

The above discussion reveals that the debate between the teacher and students is vague; the teacher cannot reply clearly and cannot explain the radiation of blackbody. Furthermore, the teachers’ initial question reveals that he thinks that the idea of quantization was deduced from the interpretation of the wavelength- radiation graph. An example of PCK was that he guided students through questioning to have them to say that the "the speed of light in a vacuum has the same value, in all inertial frames, regardless of the velocity of the observer or the velocity of the source emitting the light". Another example was that in order to deduce the formula of time dilation, he used the method (a stationary and a moving observer observing the light reflection in a moving train) used in most of the physics books. Moreover, he used an analogy to explain the motion of the earth in hypothetical ether: The earth was a boat and the ether was water.

The usual PK he used in his teachings was to make a summary of previous lessons. Some other examples; he started one of the lessons by making an introduction, he examined the students' prior knowledge, he had one of the students solve the problem, he also requested the students to solve the problems by themselves.

An example of incorrect teaching was that he explained the proper time as the time measured by the observer who is in a moving reference frame. He also incorrectly taught the aim of the MM experiment. Furthermore, he stressed the variance of the mass with time many times. To conclude, the better performance of the placebo-pre group students of this teacher lead to the difference between the two classes. Table 4.8 shows the concepts of the MPU and the amount of time the placebo group teachers spared for teaching each concept. The values in the parenthesis are the minutes that teachers used to teach the concepts.

Table 4.8 The concepts of the MPU and teaching these concepts in placebo groups

Concepts	Correctly taught		Incorrectly taught		Inadequately taught [a]		Never mentioned	
	pre	post	pre	post	Pre	post	pre	post
The basic elements of modern physics					T2(18[b])	T1 (3[c]) T2 (19)	T1	
Distinction between classical and modern physics	T2 (4)				T1 (2)	T2 (3)		
Sub-fields of modern physics							T1,T2	
Inertial and non-inertial reference frames	T2(9)	T2(7)	T1 (3)					
Ether hypothesis					T2(5)	T2(3)	T1	
The Michelson–Morley Experiment	T2(11)	T2(8)			T1 (2)			
The postulates of the special theory of relativity	T2(5)		T1 (1)			T1 (4)		
Time Dilation					T1 (16) T2(30)	T1 (6) T2(19)		
The Twins Paradox					T1 (8) T2 (12)	T1 (6) T2 (9)		
Length Contraction	T2(21)	T2(13)				T1 (1)	T1(1)	
The invariant mass			T1 (3) T2(12)				T1(1)	
The speed of light is the ultimate speed	T1 (2) T2(10)	T1 (7) T2(8)						
Relativistic Energy		T2(21)						

[a]When around 50% of the concept was never mentioned it was accepted as inadequately taught.

[b]This is the total time used by Teacher T2 to teach this concept during pre-teaching. For example, this concept was taught in the first lesson and it was briefly repeated during the second lesson. 18 minutes is the sum of these two teachings.

[c]Teacher T1 has spent three minutes in teaching this concept during post-teaching

Table 4.8 presents that Teacher T1 had never mentioned the basic elements of the MPU during pre-teaching and had spared only three minutes to the same concept during post-teaching. Similarly, while he defined the inertial and non-inertial reference frames incorrectly during pre-teaching, he never mentioned it during post-teaching. Furthermore, while Teacher T2 had taught the inertial and non-inertial reference frames correctly and spent nine and seven minutes during pre- and post-teachings respectively, he taught the time dilation during both teachings inadequately, and allocated 30 and 19 minutes respectively. Moreover, while the inertial and non-inertial reference frames, the postulates of the special theory of relativity and the invariance of mass was incorrectly taught by Teacher T1 only the invariance of mass was incorrectly taught by Teacher T2.

As a result Teacher T2 did spare more time in teaching the MPU during pre-teaching when compared to post-teaching. Moreover, his placebo-pre group was more active and the activities took place more, when compared to post teaching. Furthermore, there has been no development in this teachers` teaching. In other words, if for example he taught a concept during pre-teaching inadequately, he did so in post-teaching also (see Table 4.8). Thus, some factors other than pre-teaching were effective in making a difference between his placebo pre and placebo post groups.

4.3. 3 Class observation results: Teacher T3

According to the experience index given in Table 3.4 this teacher was the one who had the most experience amongst all implementation group teachers and second most experienced teacher among TTT group teachers. He was teaching in a public Anatolian high school and he has 10 years of teaching experience. Moreover, he was a master student and he has written a physics book for high schools. Furthermore, he has a bureau where he gives private physics lessons. He had also been the head of the physics department in one of the provinces of Ankara for four years. Compared to all the implementation group teachers, he had participated in the PD programs conducted by the Ministry of Education the most. However, these programs were not about the MPU, they were mostly on curriculum or material development. Table 4.9 and follow up Figure 4.4 compare the pre- and post-teachings of this teacher.

Table 4.9 The frequency and the duration of the activities during teachings of Teacher T3

Lessons/ Activities	Pre-teaching												Post-teaching															
	L-1 (35)		L-2 (34)		L-3 (30)		L-4 (38)		L-5 (38)		Per lesson		L-1 (40)		L-2 (35)		L-3 (33)		L-4 (35)		L-5 (37)		L-6 (40)		L-7 (40)		Per lesson	
	d	f	d	f	d	f	d	f	d	f	d	f	d	f	d	f	d	f	d	f	d	f	d	f	d	f	d	f
Lecturing	17		18		23		24		18		20.0		20		17		21		5		16		26		19		17.71	
Discussion/ Questioning	15	3	12	3	4	2	9	3	9	4	9.80	3.00	18	5	9	3	7	2	7	3	16	4	8	3	5	2	10.00	3.14
Questions asked to the teacher		3		3		3		9		2		4.00		3		2		4		2		6		1		1		2.71
Questions that teacher asked		8		5		2		2		4		4.20		9		6		8		1		10		7		1		6.00
Animation/ Simulation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	2	1	0	0	0	0	0	0	0.57	0.29
Video	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0	0	0.43	0.14
Solving problems	0	0	0	0	0	0	0	0	7	3	1.4	0.6	0	0	0	0	0	0	15	6	3	1	0	0	16	8	4.86	2.14
PCK		1		0		0		0		0		0.2		3		1		1		0		0		1		1		1.00
PK		3		1		3		3		2		2.40		2		1		1		2		0		4		2		1.71
Note taking	0		0		0		0		0	0	0	0	0	0	6	2	0	0	3	1	0	0	0	0	0	0	1.29	0.43
Unrelated teaching	3		4		3		5		4		3.80		2		3		3		0		2		6		0		2.29	

Besides, for one of his post-teaching lessons, the researcher observed all his pre- and post-teachings. He taught the MPU in five lessons during pre-teaching and in eight lessons during post-teaching. Nevertheless, when compared to his "experience" his pre-teaching was not as good as expected and his acquirements from the TTT course were not as desired. Table 4.9 shows that while Teacher T3 hadn't shown an animation and a video during pre-teaching, he showed two animations and only one video during post teaching. Similarly, no note taking activities took place during pre-teaching. The usual instruction of this teacher during pre-teaching was that he had one of the students read from the book and afterwards when necessary he made comments. Figure 4.4 is the visualization of Table 4.9.

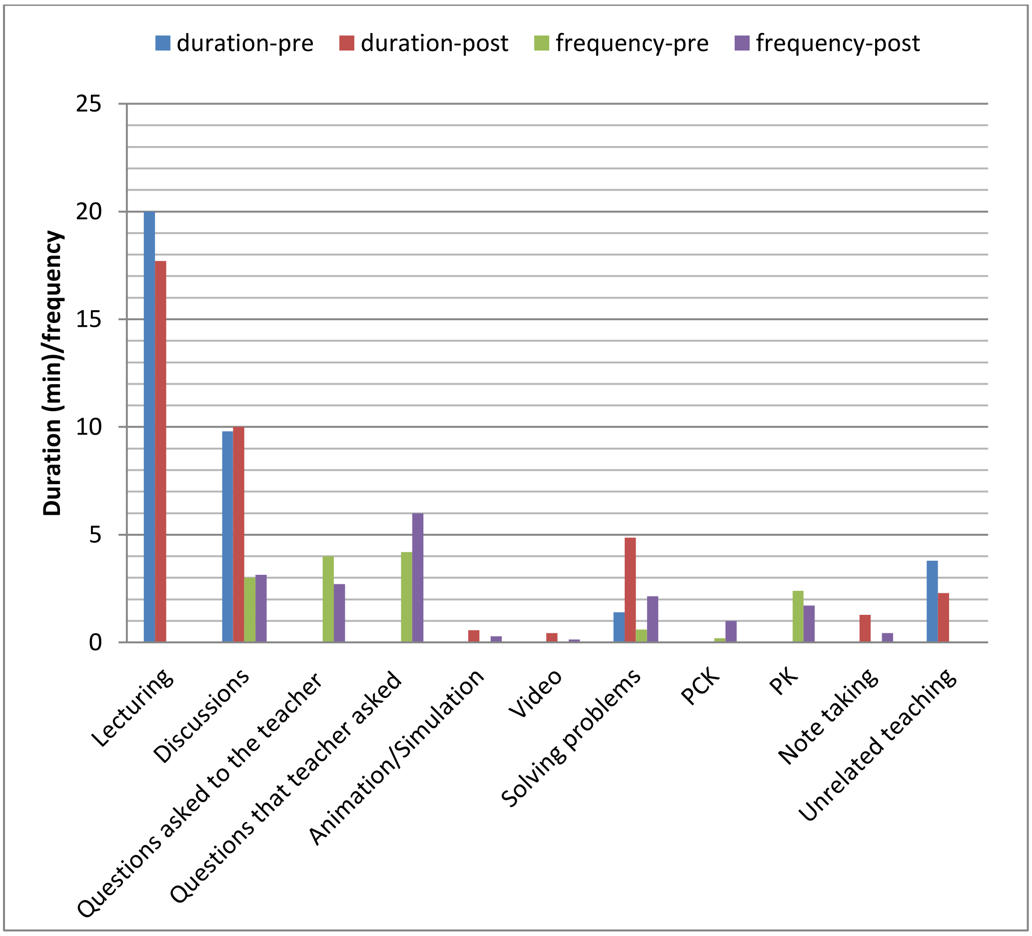

Figure 4.4 Comparison of pre- and post-teachings of teacher T3

Figure 4.4 indicates that lectures and discussions in the classes of this teacher are almost equal during both of his instructions. A slight decrease in the amount of lecturing and increase in the amount of discussions can be accepted as indicators of PD or in other words signs of success of the TTT course. However, the post-teaching class observations showed that the teacher forced himself to explain the concepts of the MPU and this lead to no decrease in lecturing and no increase in discussions. Therefore, not too many free discussions took place. As seen from Figure 4.4 the number of questions that the teacher asked increased considerably. The teacher was asking the meaning of core concepts such as twin paradox or reference frames, since he was receiving no answers; he then was trying to explain the concepts.

While the change in teacher's PK do not seem significant, his PCK relatively increased during post-teaching. The usual examples of PK during both instructions were repeating the important points or writing down the core concepts on the blackboard. Moreover, repeating the previous lessons, giving homework, encouraging students to think about the questions asked, not demoralizing students that give wrong answers, asking specific questions to students who are not interested in the discussions etc., were some other examples this teacher demonstrated during his teachings. Moreover, the only PCK observed during pre-teaching was that he mentioned two misconceptions about the relation between classical and modern physics: "Classical and modern physics laws are different" and "classical physics laws have been replaced by modern physics laws". On the other hand, he executed seven PCK activities during post-teaching. For instance, he made an analogy between the sub-fields of modern physics and medical, he derived the formula of time dilation in the same way that most physics books derive, and he likened the motion of the earth in the hypothetical ether to the motion of a ship in the ocean. Furthermore, in order to explain the relative motion, he simulated it by having two students walk at different speeds in the class etc.

Stating the aim of the MM experiment during pre-teaching was amongst the incorrect instructions of this teacher. Although the amount of unrelated instruction during pre-teaching was not too much, some unnecessary discussions such as, should a man wear a seatbelt while moving with the speed of light, where on the earth is a woman heavier, teleportation and Tesla's experiment, took place. Contrary to pre-teaching valuable discussions, such as, "can a car illuminate while moving with the speed of light, the trouble the scientists encountered in explaining the blackbody radiation and why the earth is accepted as an inertial reference frame", took place during post-teachings. Similarly time dilation was a challenging topic that students discussed during post-teaching. Table 4.10 includes the concepts of the MPU and the amount of time Teacher T3 used to explain these concepts.

Table 4.10 The concepts of the MPU and teaching these concepts in the classes of Teacher T3

Concepts	Correctly taught		Incorrectly taught		Inadequately taught **		Never mentioned	
	pre	post	pre	post	pre	post	pre	post
The basic elements of modern physics		T3(58)			T3(11)			
Distinction between classical and modern physics	T3(6)	T3(13)						
Sub-fields of modern physics	T3(3)	T3(8)						
Inertial and non-inertial reference frames		T3(17)			T3(18)			
Ether hypothesis	T3(3)	T3(6)						
The Michelson–Morley Experiment		T3(32)			T(5)			
The postulates of the special theory of relativity	T3(16)	T3(22)						
Time Dilation					T3(35)	T3(27)		
The Twins Paradox		T3(19)					T3	
Length Contraction		T3(16)			T3(23)			
The invariant mass	T3(9)				T3(2)			
The speed of light is the ultimate speed	T3(4)							T3
Relativistic Energy							T3	T3

Since relativistic energy is not taught in schools which has two hour weekly physics course, it is normal that this teacher has not taught relativistic energy. However, interestingly he never mentioned twin paradox during pre-teaching and never taught the intimateness of the speed of light during post-teaching. Table 4.10 says too many things, however, roughly it is clear that this teacher has correctly taught most of the concepts during post-teaching and has relatively allocated more time to each concept during post-teaching. For instance, he spared 11 and 58 minutes to instruct the basic elements of modern physics respectively during pre- and post-teachings. During pre-teaching he inadequately taught the inertial and non-inertial reference frames, because he only defined the reference frame but not inertial and non-inertial frames. Moreover, he inadequately taught the length contraction because he didn’t discuss length contraction according to stationary and moving observers. Similarly, the time dilation was inadequately taught both during pre- and post-teachings because as in the case of length contraction, he didn’t mentioned the time dilation according to different observers.

While he only tried to explain the meaning of radiation and photoelectric effect during pre-teaching, he tried to explain how the developments in these areas of physics triggered the development of modern physics during post-teaching. Moreover, he mentioned how the explanation of the blackbody radiation by the scientists leaded to the explanation of the photoelectric effect and atomic theories.

He taught the aim of the MM experiment incorrectly both during pre- and post-teachings. He merely stated the follow up results of the MM experiment during post-teaching. While he mostly lectured about reference frames during pre-teaching, he solved multiple choice questions about the same topics during post-teaching. Parenthetically, his teachings were not completely concurrent with what was discussed during the TTT course, for example, even though simultaneity was not discussed in the course this teacher taught it in his class.

As a summary, the TTT course relatively helped this teacher to instruct in accordance with the curriculum, it encouraged the teacher to teach in an organized manner, it slightly increased both the discussions he conducted with his students and his PCK, and it increased the amount of questions that he asked his students considerably. It also increased his students’ and his achievements on Post-MPUAT-

S. Moreover, when pre- and post-instructions are compared he was more confident during post-teaching.

4.3. 4 Class observation results: Teacher T4

This teacher has a total of 13 years of teaching experience. He taught science in elementary school for five years and he taught physics in high school for eight years. He additionally teaches physics on the weekends to 12th grade students who are preparing for their university entrance exams. According to the experience index given in Table 3.4, he was the second least experienced teacher. Still he was the one who got the highest score both in pre- and post-tests applied for the teachers. Moreover, the Anatolian high school he was teaching at was a pilot school and the Ministry of National Education was trying to establish the FATİH project there (Fatih, 2013). Furthermore, just as in the case of previous teachers he also participated in several PD programs designed by the Ministry of Education. Similarly, the PD programs he participated in were seminar like programs that did not include the MPU.

The researcher could observe only 33% of his pre-teaching and 100% of his post-teaching. In other words, the researcher missed four of pre-teaching and none of the post-teaching lessons. The following results and the descriptive statistics results indicated that he was the least exploited from the TTT course. In order to avoid any misunderstanding it should be stated that the class observations and the performance of this teacher during the course showed that he had substantial knowledge of the MPU concepts. Both his placebo pre- and placebo post-group students had gained satisfying scores (See Table 4.21).

He taught the MPU in six lessons during pre-teaching and in nine lessons during post-teaching. This teacher used questioning effectively and he introduced his entire lessons through PPT during his instructions. Moreover, he solved questions effectively almost after all lessons during both instructions and he generally started the lessons on time. Table 4.11 and follow up Figure 4.5 compare the pre- and post-teachings of this teacher.

Table 4.11 The frequency and the duration of the activities during teachings of Teacher T4

Lessons/ Activities	Pre-teaching						Post-teaching															
	L-1 (40)		L-4 (40)		Per lesson		L-1 (36)		L-2 (19)		L-3 (36)		L-4 (34)		L-5 (29)		L-6 (40)		L-7 (40)		Per lesson	
	d	F	d	f	d	f	d	f	d	f	d	f	D	F	d	f	d	f	d	f	d	f
Lecturing	23		17		20.0		18		6		16		7		22		19		10		14.0	
Discussion/ Questioning	7	3	4	2	5.50	2.50	9	3	5	3	10	4	5	2	6	3	6	4	4	2	6.43	3.00
Questions asked to the teacher		2		2		2.00		2		1		7		1		0		2		4		2.43
Questions that teacher asked		16		7		11.5		16		12		13		5		17		13		6		13.14
Animation/ Simulation	0	0	0	0	0	0	0	0	0	0	3	3	0	0	1	1	0	0	3	1	1	0.71
Video	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solving problems	5	2	17	11	11.0	6.50	0	0	8	6	0	0	22	13	0	0	11	7	19	6	8.57	4.57
PCK		2		1		1.5		1		2		1		1		2		3		2		1.71
PK		1		3		2.0		1		1		2		2		1		2		2		1.57
Note taking	0	0	0	0	0	0	6	2	0	0	5	1	0	0	0	0	0	0	2	1	1.86	0.57
Unrelated teaching	5		2		3.5		3		0		2		0		0		4		2		1.86	

Table 4.11 demonstrates that Teacher T4 never showed videos during his teachings. Moreover, the table shows that this teacher particularly solved many questions during his instructions. He was asking the questions through PPT and was solving them one by one with students and he was making comments about both questions and about each of the distractors. While no note-taking and animation/simulation activities took place during pre-teaching, some note-taking and animation/simulation activities (not considered to be sufficient) were seen during his post-teaching.

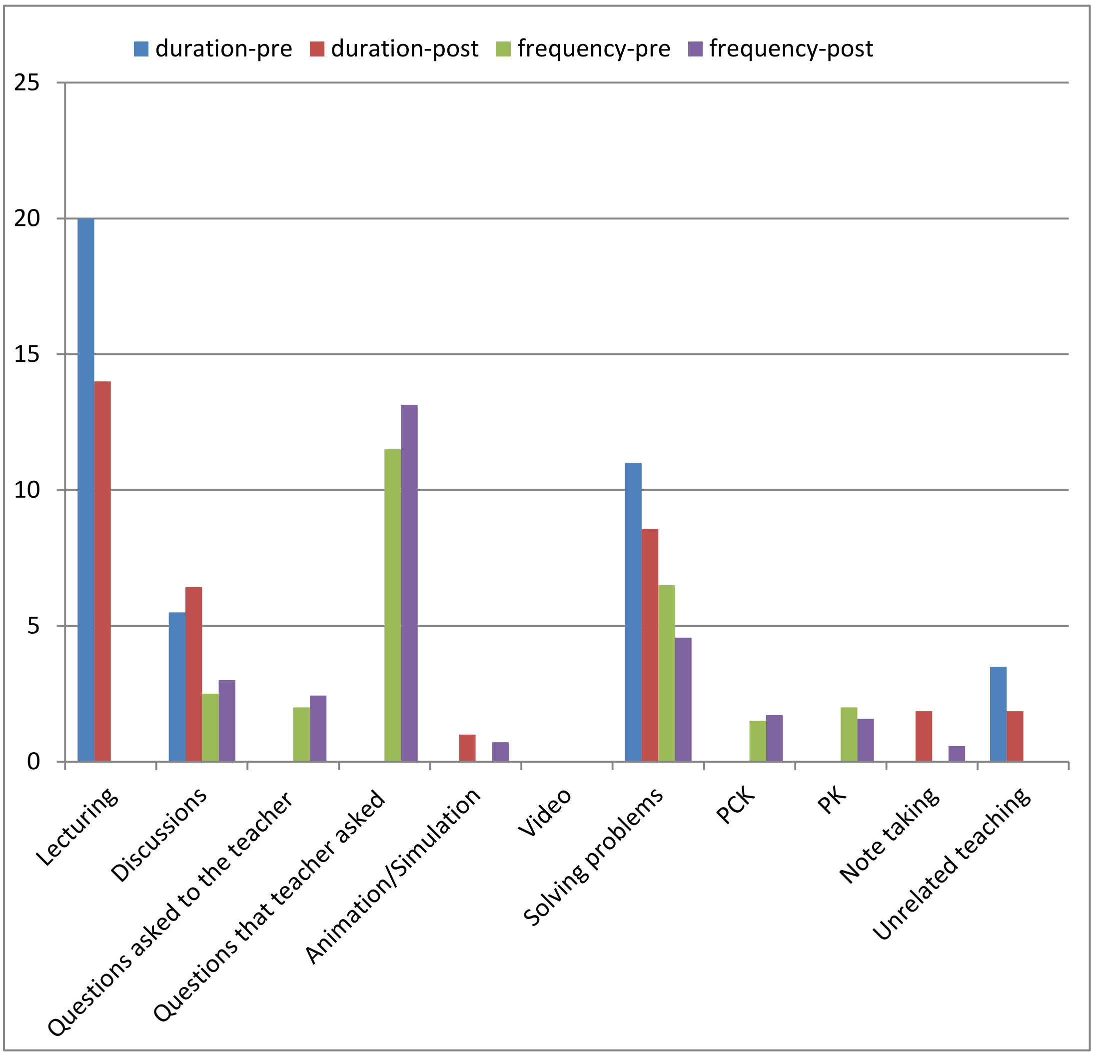

Figure 4.5 Comparison of pre- and post-teachings of Teacher T4

Since only 33% of pre-teaching of this teacher was observed, comparing his pre- and post-teaching is a little bit risky. Even so, mostly reporting post-teaching activities and making slight comparisons may be noteworthy. When comparing pre- and post-teachings, while the discussions and questions that the teacher and students asked increased, the amount of lecturing and unrelated teaching had decreased during post-teaching. Similarly, while PCK activities had increased slightly, the PK activities also decreased a fraction.

Discrepantly, some examples of PCK during post-teaching were; could not increase the speed of an electron to speed of light between two parallel plates, was given as an example about ultimate speed of the light, interpreted the mass in terms of both classical and modern physics, in order to teaching ‘‘paradox’’ used an analogy, guided students through questions to have them state that the speed of light has the same value in all inertial frames, stated the known examples of experiments about time dilation such as observation of muons, Hafele and Keating experiment and correcting the time in Global Positioning System (GPS). Moreover, during pre-teaching he exhibited some examples of PK differently, such as having students solve questions on the blackboard plus helping them, encouraging students come to conclusions with regards to what they had expressed, starting the MPU by giving examples from everyday life, motivating students in the case of correct answer and so on. As mentioned above this teacher used questioning too much. For example, in order to have students recall the previous lesson, the concepts of that lesson were discussed through questioning. Table 4.12 lists the teaching of concept of the MPU during the instructions of this teacher.

Table 4.12 The concepts of the MPU and teaching these concepts in the classes of Teacher T4

Concepts	Correctly taught		Incorrectly taught		Inadequately taught **		Never mentioned	
	pre	post	pre	post	pre	post	pre	post
The basic elements of modern physics	T4(7)	T4(38)						
Distinction between classical and modern physics	T4(3)	T4(4)						
Sub-fields of modern physics		T4(4)						
Inertial and non-inertial reference frames	T4(5)	T4(29)						
Ether hypothesis		T4(6)						
The Michelson–Morley Experiment	T4(8)	T4(20)						
The postulates of the special theory of relativity	T4(12) *	T(49)						
Time Dilation		T4(29)						
The Twins Paradox					T4(8)	T4(3)		
Length Contraction						T4(10)		
The invariant mass	T4(10)							
The speed of light is the ultimate speed	T4(3)	T4(8)						
Relativistic Energy	T4(17)							

As seen from Table 4.12 this teacher had correctly taught almost all concepts of the unit during both teachings. For instance, he taught time dilation according to both stationary and moving observers, he discussed the possibility of if we could see ourselves in a mirror if we had to move with the speed of light both in terms of classical and modern physics. Interestingly, while he taught the inertial and non-inertial reference frames' concepts and discussed the difference between the frames during pre-teaching he only defined and solved some questions about reference frames and didn't discuss the differences between them during post-teaching. Even though, twin paradox was an interesting concept and was sufficiently attractive to be discussed, in a different manner compared to the other teachers, this teacher did not handle it adequately enough during his instructions.

Although many activities were similar during both teachings, the quizzes were observed only during post-teaching. Moreover, he was the only teacher who discussed the fact that a reference frame moving without acceleration with respect to another inertial reference frame can also be accepted as an inertial reference frame during post-teaching. He was one of the teachers who discussed the possibility of if we could see ourselves in a mirror if we had to move with the speed of light during pre-teaching in the context of both classical and modern physics. Along with this fact, he discussed the facts that if we can speak with our mobile phone while we are moving with the speed of light, and can a car moving with the speed of light illuminate during post-teaching.

Moreover, even though it isn't included in the curriculum, he taught simultaneity during both instructions however, he didn't adequately teach length contraction during post-teaching. He explained the concept, gave the formula and started to solve problems without discussing thoroughly.

Consequently, even though this teacher seems relatively inexperienced, he was the one who mostly taught the MPU during both instructions correctly. Not much difference was observed between the two. Accordingly teacher achievement test scores and students' achievement gain scores were more or less similar for pre- and post-tests of this teacher. Moreover, this was the teacher among the treatment group who got the least score on TTTEF.

4.3. 5 Class observation results: Teacher T5

This teacher has 15 years of teaching experience, three of which he was head of the Physics Department in one of the provinces of Ankara. As in the case of preceding teachers, Teacher T5 was also instructing in an Anatolian high school. Before TTT he had participated in only one PD program which was about project preparation and designed by the Ministry of Education. It seems that according to the findings of this research that this was the teacher who most benefited from the TTT program. Class observation results and descriptive statistics results show that there is a significant development in this teacher and in his class (experimental group) in which he taught the MPU along with the TTT course.

So far he has taught the MPU three times. He taught the MPU during pre-teaching in six lessons and during post-teaching in eight lessons. The researcher observed 50% of his pre-teaching and 100% of post-teaching. A very significant difference was observed in the pre- and post-teachings of this teacher. Namely, there was a certain untidiness in the pre-teaching of this teacher. For instance, he used 30 minutes in the first lesson of pre-teaching and taught the difference between classical and modern physics, the sub-fields of modern physics, reference point, twin paradox, relativistic energy and he discussed the possibility of if we could see ourselves in a mirror if we had to move with the speed of light and also if teleportation is possible. However during post-teaching he taught all the objectives in accordance with the TTT course. Table 4.13 summarizes the pre-and post-teachings of Teacher T5.

Table 4.13 The frequency and the duration of the activities during teachings of Teacher T5

Teachers/ Activities	Pre-teaching								Post-teaching																	
	L-1 (30)		L-2 (33)		L-3 (35)		Per lesson		L-1 (31)		L-2 (32)		L-3 (35)		L-4 (27)		L-5 (36)		L-6 (40)		L-7 (36)		L-8 (26)		Per lesson	
	d	f	d	f	d	f	d	f	d	f	d	f	d	f	d	F	d	f	d	f	d	f	d	f	d	f
Lecturing	22		23		12		19.0		25		14		30		7		25		16		24		11		19.0	
Discussion/ Questioning	2	1	0		2	1	1.33	0.67	6	3	2	1	5	2	2	1	7	3	5	2	3	1	2	1	4.00	1.75
Questions asked to the teacher		5		1		3		3.00		0		0		1		2		2		2		2		1		1.25
Questions that teacher asked		0		0		2		0.67		3		3		8		2		7		4		5		3		4.38
Animation/ Simulation	0		0		0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0
Video	0		0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solving problems	0		3	1	19	4	3.14	1.67	0	0	14	9	0	0	18	27	0	0	19	21	6	2	13	6	8.75	8.13
PCK		1		1		0		0.67		4		2		1		0		1		2		1		1		1.50
PK		0		1		2		1.00		0		3		1		2		5		2		0		1		1.75
Note taking	0	0	0	0	2	1	0.67	0.33	0	0	0	0	0	0	0		4	2	0		3	1	0	0	0.88	0.38
Unrelated teaching	6		7		0		4.33		0		2		0		0		0		0		0		0		0.25	

Table 4.13 indicates that this teacher never used videos and animation/simulations during his teachings. Moreover, what is distinct is that he had solved many questions during his instructions. Furthermore, all pre-teaching class hours with the exception of one (sixth lesson), all post-teaching class hours were not fully used for teaching. In other words, lessons should last for 40 minutes however; this teacher on average used 35 minutes for each lesson. What makes this teacher different is that except for a duration of two minutes (second lesson) he did not teach unrelated topics during post-teaching. The comparison of pre- and post-teaching of this teacher is given in Figure 4.6.

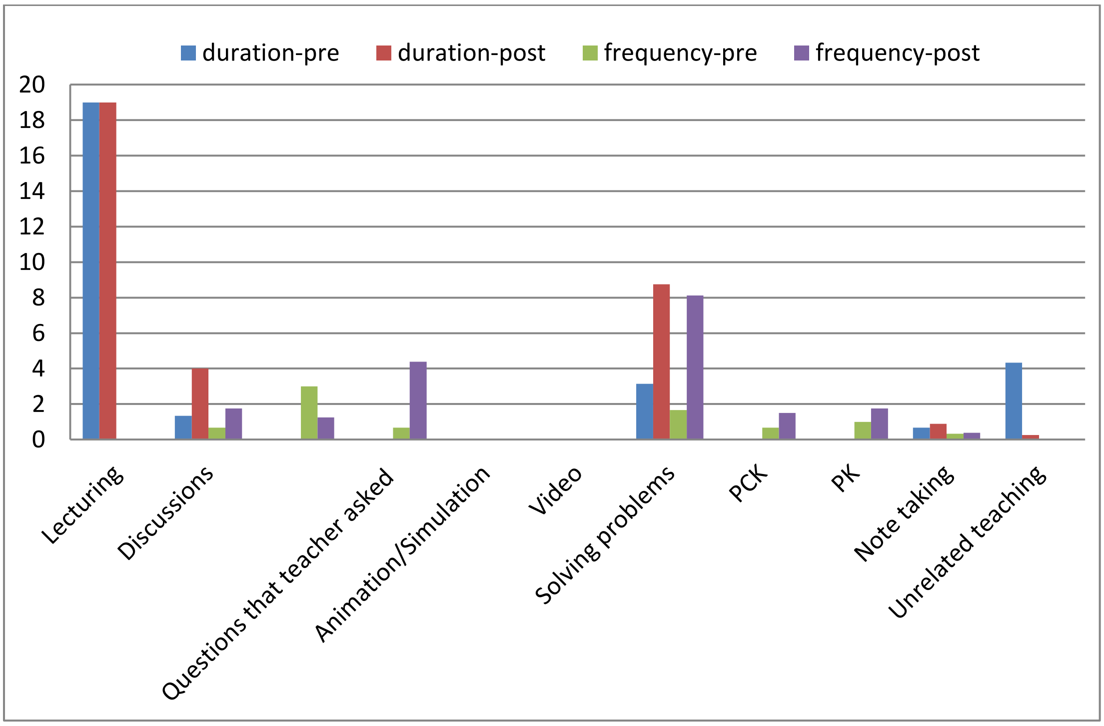

Figure 4.6 Comparison of pre- and post-teachings of Teacher T5

Figure 4.6 demonstrates that discussions and questions that this teacher had asked were considerably increased during post-teaching. Moreover, when this teacher is compared to the previous teachers he lectured too much. Actually his lecturing was a combination of speaking and questioning. Namely, he was having students complete his sentences. For instance, he was saying "the observer stationary with respect to the spaceship measures the length of the spaceship longer than …." and he was waiting for students to complete the sentence, and stating "the moving observer". Furthermore, while his unrelated teaching was more during pre-teaching, the number of questions he had solved related to the concepts of the MPU was more during post-teaching.

The Figure 4.6 shows that both PCK and PK behaviours detected had increased during post-teaching when compared to pre-teaching of teacher T5. During post-teaching he demonstrated some PK behaviours differently. For example he repeated the first and second postulates of special relativity several times to have students get familiar with the postulates, he had students state their opinion about time dilation at the beginning of the topic, he guided students through questions to have them identify the reference point and he had the answer of a question from different students without making any comments and so on. On the other hand, while 12 PCK's was observed totally during post-teaching only two were observed during pre-teaching. Along with stating the misconceptions, his PCK was mostly based on making analogies. For instance in order to draw attention to the difference between classical and modern physics he said: "every dog barks in his own yard", in order to clarify the dime dilation he said: "live fast stay young" and in order to explain the colour change of an object being heated he mentioned the colour change of an iron piece during forge.

During pre-teaching the number of questions were relatively high, however, some questions were either unrelated or meaningless. For instance one of the students asked the relation between the colours and the reflection of the light, another student asked if we are going to be refracted if we pass through a glass while moving with the speed of light. Furthermore, even though the curriculum does not recommend he unnecessarily spent too much time on the mathematical foundation of the time dilation. For instance, he dealt with the mathematical part of one problem for ten minutes; he especially allocated too much time in finding the gamma factor (γ) in that problem. As an example of unrelated teaching, he told the amount of time it takes the sun rays to travel to earth. Furthermore, sometimes not enough explanations were given when supplying answers to questions asked. For instance, one of the students asked the reason behind the length contraction while the object moves with relativistic speed, however the teacher slid over the question and continued lecturing.

On the other hand during post teaching he told of some core concepts that he didn't discuss during pre-teaching. For example, he explained why we could accept the earth as an inertial reference frame for an object on the earth, he correctly taught the aim and the results of the MM experiment, he discussed the time dilation and length contraction according to moving and stationary observers. Moreover, he was the only teacher who mentioned that all biological activities of an astronaut changes while he is moving with high speeds and he was the only teacher who taught a practical method (was explained by the researcher during the course) in solving special relativity problems. Furthermore, proving the formula of linear acceleration was the only example of unrelated teaching during post-teaching. The amount of time he spared for the concepts of the MPU during his teachings is displayed in Table 4.14.

Table 4.14 The concepts of the MPU and teaching these concepts in the classes of Teacher T5

Concepts	Correctly taught		Incorrectly taught		Inadequately taught **		Never mentioned	
	Pre	post	pre	post	pre	post	pre	post
The basic elements of modern physics		T5(37)			T5(4)			
Distinction between classical and modern physics		T5(11)			T5(6)			
Sub-fields of modern physics		T5(4)			T5(2)			
Inertial and non-inertial reference frames		T5(35)			T5(4)			
Ether hypothesis		T5(9)	T5(2)					
The Michelson–Morley Experiment	T5(9)	T5(34)						
The postulates of the special theory of relativity		T5(39)			T5(6)			
Time Dilation		T5(45)			T5(14)			
The Twins Paradox		T5(11)			T5(6)			
Length Contraction		T5(26)			T5(21)			
The invariant mass						T5	T5	
The speed of light is the ultimate speed	T5(4)	T5(6)						
Relativistic Energy	T5(12)						T5	

Table 4.14 clearly indicates that while Teacher T5 has inadequately taught most of the concepts of the MPU during pre-teaching he has taught most of them correctly during post-teaching. Moreover, the amount of time allocated for the post-teaching is considerably more than that of pre-teaching. For example while he spared only four

minutes to teach the basic elements of modern physics during pre-teaching he had allocated 37 minutes to the same concept during post-teaching which was approximately nine times more. The same table also indicates that he had never mentioned the invariant of mass during his instructions and although he shouldn't have taught the relativistic energy, he taught it during pre-teaching.

As a result, class observations showed that this teacher was more confident during post-teaching and his post-teaching was significantly different from his pre-teaching. Moreover, the fact that he mostly inadequately taught during pre-teaching and correctly taught during post-teaching may explain why his placebo-post group students were more successful.

4.3. 6 Class observation results: Teacher T6

This was a teacher who has 19 years of teaching experience and she was the only female among the treatment group teachers. So far she has taught the MPU only once and she was the only teacher who was teaching to Anatolian vocational high school students. Moreover, so far she has participated in four PD programs such as an English language course and Animation course. Furthermore, according to the experience index given in Table 3.4 she was the teacher who had the least experience.

This teacher was chosen for equating both the placebo and treatment groups and hence increasing the variety of collaborating teachers within the TTT course, because she was a female and was teaching at a vocational school. Since initially she didn't accept her lessons to be observed by the researcher, she was reinforced with donations. For instance, she was given a multifunctional radio, many physics course books and the researcher promised to be the supervisor of the physics project which was going to be prepared by her daughter. Nevertheless, once the class observations started she changed her idea and she limited the class observations and the researcher could only observe one of the two pre-teaching lessons and only two of the eight post-teaching lessons. Moreover, since it was the first time that her classes were being observed, instead of lecturing she slid over the lessons by showing videos during pre-teaching. The Table 4.15 indicates the activities this teacher conducted during her instructions.

Table 4.15 The frequency and the duration of the activities during teachings of Teacher T6

Teachers/ Activities	Pre-teaching				Post-teaching					
	L-1 (30)		Per lesson		L-1 (24)		L-2 (26)		Per lesson	
	d	f	d	f	d	f	d	F	d	f
Lecturing	5		5		7		16		11.50	
Discussion/ Questioning	2	1	2	1	2	1	3	2	2.50	1.50
Questions asked to the teacher		2		2		2		3		2.50
Questions that teacher asked		1		1		2		1		1.50
Animation/ Simulation	0	0	0	0	0	0	0	0	0	0
Video	20	4	20	4	9	2	0	0	4.50	1.00
Solving problems	0	0	0	0	6	4	0	0	3.00	2.00
PCK		1		1		1		2		1.50
PK		0		0		2		1		1.50
Note taking	0	0	0	0	0	0	7	2	3.50	1.00
Unrelated teaching	3		3		0		0		0	

As seen from Table 4.15 she never showed animations/simulations during her instructions. Moreover, while no note-taking, PK, and problem solving activity was observed during pre-teaching, no unrelated teaching was observed during post-teaching. There was no organization of lessons about the concepts of the MPU during pre-teaching. As in the case of pre-teaching of the Teacher T5, via videos, she explained many concepts of the MPU in a very short time interval. Namely, in one lesson she taught six concepts of the MPU. Moreover, most of the concepts were inadequately taught during pre-teaching, for example, she stressed the second postulate of special relativity, however, she never mentioned the first postulate. Further, she stated that mass increases with increasing speed. As an example of PCK during pre-teaching she mentioned one of the misconceptions about the distinction between classical and modern physics (classical physics laws have been replaced by modern physics laws). Three PCK behaviours observed during post-teaching were; mentioning one of the misconceptions about the difference between classical and modern physics, making an analogy between the MM experiment and the motion of a ship in the sea and teaching about the MM experiment the same way physics teachers generally teach. Moreover, the three PK behaviours during post-teaching were; stopping the video and making comments, summarizing the lesson and asking students to give examples of reference systems. Figure 4.7 is designed to compare the pre- and post-teachings of this teacher.

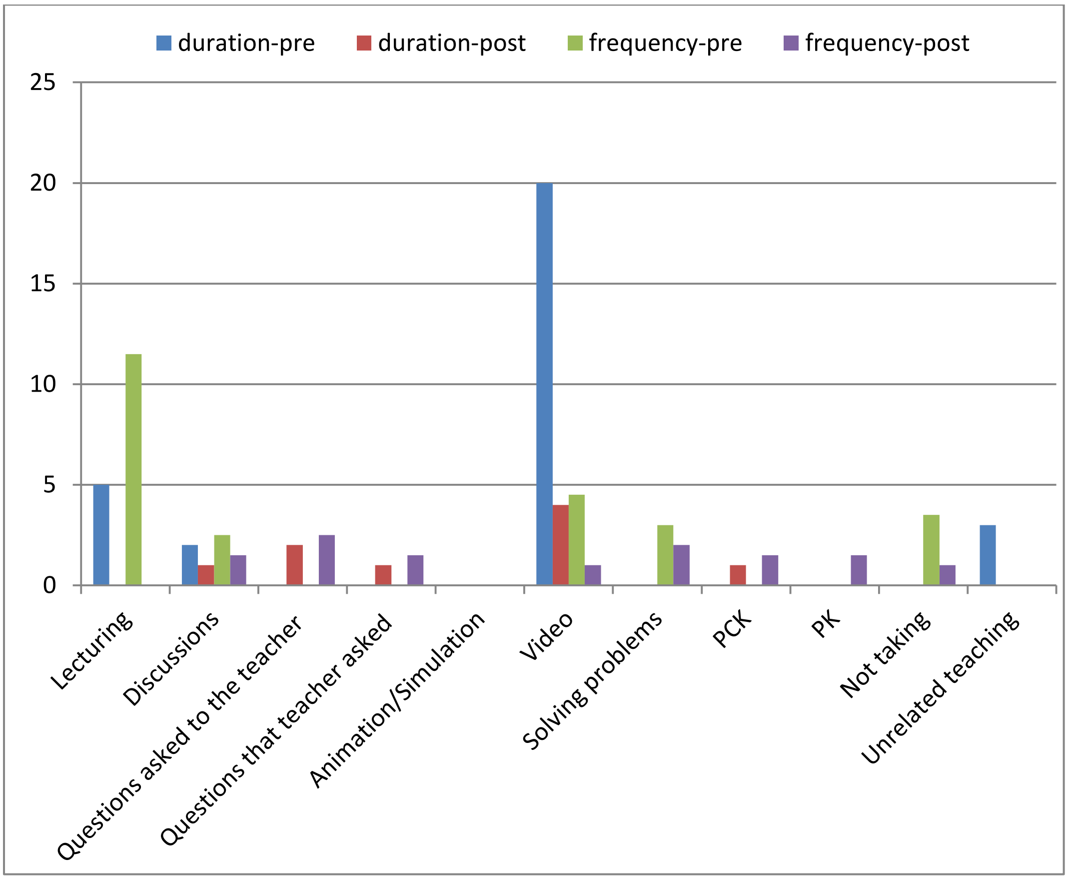

Figure 4.7 Comparison of pre- and post-teachings of Teacher T6

The excess of time allocated for videos during pre-teaching is clearly seen in Figure 4.7. The decrease in videos and increase in lecturing during post-teaching can be interpreted as an increase in self-efficacy of this teacher. Further, comparison of pre- and post-teachings of this teacher may not be valid. While observing 50% of pre-teaching could give healthy results 25% of observation of post-teaching could mislead. Table 4.16 was developed to display the instructions of the concepts of the MPU by this teacher.

Table 4.16 The concepts of the MPU and teaching these concepts in the classes of Teacher T6

Concepts	Correctly taught		Incorrectly taught		Inadequately taught **		Never mentioned	
	pre	post	pre	post	pre	post	pre	post
The basic elements of modern physics					T6(6)	T6(8)		
Distinction between classical and modern physics		T6(11)			T6(2)			
Sub-fields of modern physics		T6(5)						
Inertial and non-inertial reference frames		T6(13)						
Ether hypothesis		T6(3)						
The Michelson–Morley Experiment						T6(10)		
The postulates of the special theory of relativity					T6(5)			
Time Dilation					T6(3)			
The Twins Paradox					T6(5)			
Length Contraction					T6(2)			
The invariant mass								
The speed of light is the ultimate speed	T6(3)							
Relativistic Energy								

Table 4.16 indicates that except for one (the speed of light is the ultimate speed) she has taught all concepts of the MPU inadequately during pre-teaching. However during post-teaching she has correctly taught four concepts and inadequately taught two.

When everything is summarized for this teacher, it can be said that rather than class observation results, the achievement test (MPUAT-S and MPUAT-T) results are more valid concerning the development of this teacher.

4.3.7 Summary of class observations

To combine the results of the treatment group teachers Figure 4.8 was constructed. Since only 25% of the pre-teaching of Teacher T6 was observed, her results so as to prevent a misleading final figure were not included.

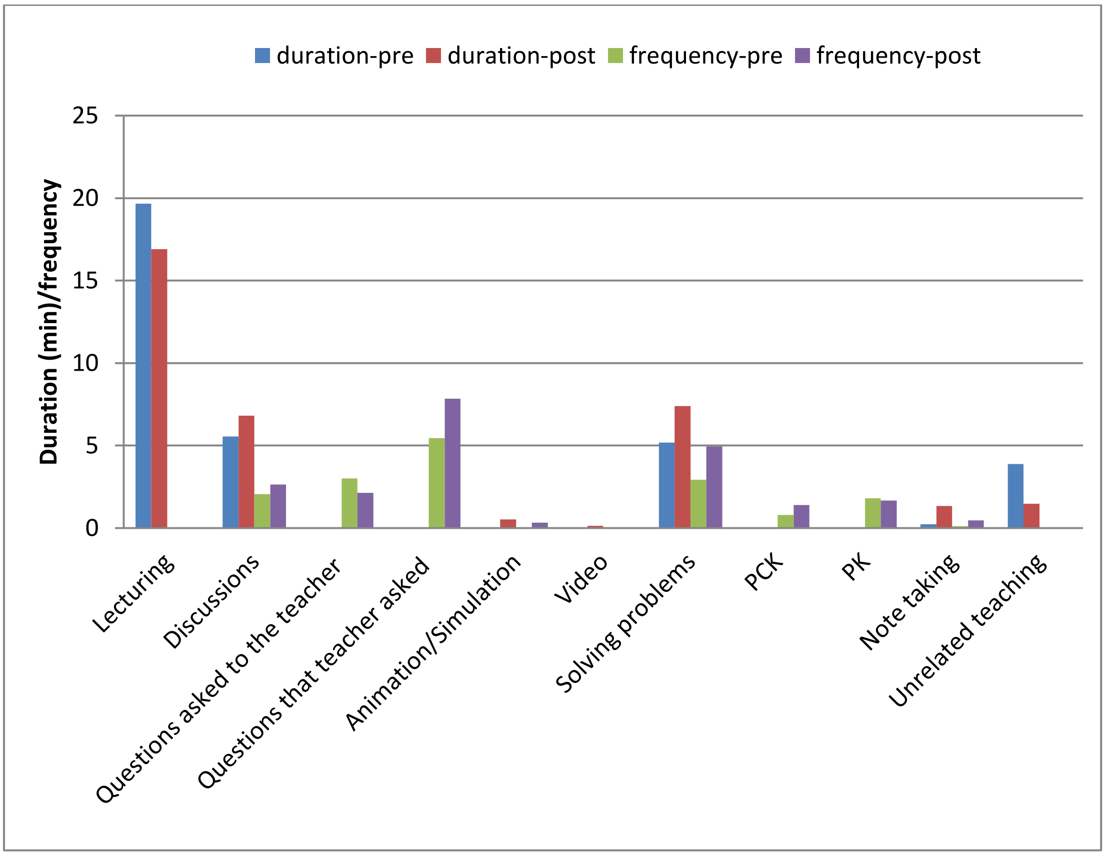

Figure 4.8 Comparison of pre and post-teachings of treatment group teachers

Figure 4.8 indicates that there are differences between the pre- and post-instructions of the treatment group teachers. When compared to pre-teaching the decrease in lecturing and unrelated teaching, and increase in discussions, in PCK and in the questions that the teachers asked during post teaching can be accepted as the success of the TTT course. The decrease in the number of the questions that the students asked during post-teaching can be interpreted as the increase in the self-efficacy of the teachers. In other words, the teachers were more confident during post-teaching and they were asking questions to start the discussions, focusing students' attention to the concepts and in the case of no reaction concerning answers, explaining the concepts. The figure shows that the PK of teachers has not changed. The remaining activities weren't observed much, therefore it is not noteworthy.

The TTT was designed to primarily increase three dimensions of teacher knowledge (SMK, PCK and PK) and indirectly to increase their students' achievement in the MPU. When class observation results are bonded it can be said that TTT is effective in increasing SMK and PCK of participant teachers, however, it did not affect the PK of participant teachers. Moreover, the following inferences are derived from class observations:

- When compared to pre-teaching the treatment group teachers spent more time during post-teaching in instructing the MPU.
- When compared to pre-teaching the treatment group teachers abide more by the curriculum during post-teaching in instructing the MPU.
- When compared to pre-teaching the treatment group teachers increased their PKC during post-teaching in instructing the MPU.
- When compared to pre-teaching the treatment group teachers' PK did not change during post-teaching in instructing the MPU.
- When compared to pre-teaching the treatment group teachers correctly taught most of the concepts of the MPU during post-teaching. They increased their SMK accordingly.
- When compared to pre-teaching the treatment group teachers asked questions that are more focused on the core concepts of the MPU.

- When compared to pre-teaching the duration and the frequency of most of the activities the treatment group teachers conducted in their classes increased during post-teaching.

4.4 Missing Data Analysis

Before starting to perform descriptive and inferential statistics, missing data analysis was performed. Total number of the students in the placebo group was 102 and that in the treatment group was 229. The MPUAT-S was administered to 99 students in the placebo group and 216 students in the treatment group as pre-test. However, 93 students in the placebo group and 213 students in the treatment group were post-tested for the MPUAT-S. Accordingly three and nine students in the placebo group, and 13 and 16 students in the treatment group were absent during the administration of the pre-tests and post-tests, respectively (See Table 4.17. and Table 4.18). In the case of missing values of the dependent variables, generally they are all excluded from all future analyses (Cohen & Cohen, 1983, p. 275). Therefore, nine students in the placebo group and 16 students in the treatment group were removed from the analyses and respectively 93 and 213 students were remained for the following analyses. Numbers of present and missing values associated with the variables used in the study for the placebo and the treatment group classes are presented in Table 4.17 and Table 4.18, respectively.

Table 4. 17 Missing values prior to the analysis for the placebo group

Class	Group	Variable	Present (N)	Missing (N)	Missing (%)
PreT1C1*	Placebo-pre	Pre-MPUAT-S	28	1	3.57
PostT1C1		Post-MPUAT-S	26	3	11.54
PreT1C2	Placebo-post	Pre-MPUAT-S	29	1	3.45
PostT1C2		Post-MPUAT-S	29	1	3.45
PreT2C1	Placebo-pre	Pre-MPUAT-S	21	1	4.76
PostT2C1		Post-MPUAT-S	18	4	22.22
PreT2C2	Placebo-post	Pre-MPUAT-S	21	0	0
PostT2C2**		Post-MPUAT-S	20	1	5.00
Total		Pre-MPUAT-S	99	3	2.94
		Post-MPUAT-S	93	9	8.82
		TE	102	0	0
		TTT PD	102	0	0
		PCG	102	0	0
		Post-MPUAT-T	102	0	0

*PreT1C1: The class of Teacher T1 in which MPU was taught earlier and pre-test was applied

**PostT2C2: The class of Teacher T2 in which MPU was taught in parallel with TTT PD course, and post-test was applied

Table 4. 18 Missing values prior to the analysis for the treatment group

Class	Group	Variable	Present (N)	Missing (N)	Missing (%)
PreT3C1	Control	Pre-MPUAT-S	16	2	12.50
PostT3C1		Post-MPUAT-S	18	0	0
PreT3C2	Experimental	Pre-MPUAT-S	28	2	7.14
PostT3C2		Post-MPUAT-S	28	2	7.14
PreT4C1	Control	Pre-MPUAT-S	29	1	3.45
PostT4C1		Post-MPUAT-S	27	3	11.11
PreT4C2	Experimental	Pre-MPUAT-S	28	1	3.57
PostT4C2		Post-MPUAT-S	27	2	7.41
PreT5C1	Control	Pre-MPUAT-S	31	0	0
PostT5C1		Post-MPUAT-S	30	1	3.33
PreT5C2	Experimental	Pre-MPUAT-S	29	2	6.90
PostT5C2		Post-MPUAT-S	27	4	14.81
PreT6C2	Control	Pre-MPUAT-S	24	1	4.17
PostT6C2		Post-MPUAT-S	23	2	8.69
PreT6C1	Experimental	Pre-MPUAT-S	31	4	12.90
PostT6C1		Post-MPUAT-S	33	2	6.06
Total		Pre-MPUAT-S	216	13	5.68
		Post-MPUAT-S	213	16	6.99
		TE	229	0	0
		TTT PD	229	0	0
		PCG	229	0	0
		Post-MPUAT-T	229	0	0

As seen from Table 4.17 and Table 4.18 in the each group, missing percentages are below 10% of the group sizes, and overall missing from the sample was 5.88 % for the placebo group and 6.33 % for the treatment group. Therefore, the number of missing values in each group was acceptable; and representativeness of the sample could not seriously be affected (Freankel & Wallen, 2003, p. 105). Moreover, loss of the sample was not systematic. The students did not know that they were being tested at those days. Thus, the missing was at random. In this case, loss of the data does not seriously affect the results (Kline, 2010, p. 55; Tabachnick & Fidell, 2007, p. 62). The missing subjects were from different schools, it was difficult to find these students, and thus the post-test was not applied to them.

Moreover, only one student in placebo group did not take both pre-test and post-test, however, three students in treatment group did not take both tests. On the other hand, two students in the placebo and 10 students in the treatment group, who completed the post-tests, did not complete the Pre-MPUAT-S. Missing values of all the variables are displayed in Table 4.19.

Table 4.19 Missing values of the data used in the analyses

Group	Variables	Present (N)	Missing (N)	Missing (%)
Placebo	Pre-MPUAT-S	91	2	2.15
	Post-MPUAT-S	93	0	0
	TE	93	0	0
	TTT PD	93	0	0
	PCG	93	0	0
	Post-MPUAT-T	93	0	0
Treatment (Experimental and control)	Pre-MPUAT-S	203	10	4.69
	Post-MPUAT-S	213	0	0
	TE	213	0	0
	TTT PD	213	0	0
	PCG	213	0	0
	Post-MPUAT-T	213	0	0

Since the missing data are random and less than 5% in both groups, the mean replacement procedure is employed (Tabachnick & Fidell, 2007). Therefore, these students' Pre-MPUAT-S scores were replaced with the group mean that is the mean of the Pre-MPUAT-S scores in this case. Afterwards, all the students who took post-tests were identified and retained for the analysis. Consequently, as seen in Table 4.19 in the placebo group 93 cases and in the treatment group 213 cases were used for performing separate ANCOVAs and their missing pre-test scores were replaced with the series means.

4.5. Descriptive Statistics

After missing data were replaced with series mean values, descriptive statistics of the Pre-MPUAT-S and Post-MPUAT-S were computed in Table 4.20 for both the placebo and the treatment groups. The upper part of Table 4.20 includes the descriptive statistics of each class, and bottom part of the table includes descriptive statistics of each group.

Table 4.20 indicates that there are two teachers in the placebo group and each has two classes, therefore there are totally four classes in the placebo group and the achievement test was administered to these classes as pre-tests and post-tests. As seen from Table 4.20, the means of all post-tests are higher than the means of all pre-tests. Similarly, there are four teachers in the treatment group and each also has two classes, therefore there are totally eight classes in this group and the achievement test was administered to these classes as pre-tests and post-tests. The means of post-tests in all classes are higher than that of pre-tests. Skewness and kurtosis values for all classes (including the classes of the placebo groups) are in range between -2 and +2. As a result, all distributions can be accepted as normal distribution.

Table 4.20 Descriptive statistics for the Pre-MPUAT-S and Post-MPUAT-S with respect to classes

Group	Class	N	Min.	Max.	Mean	SD	S[b]	K[c]
Placebo	PreT1C1[a]	26	4.00	12.00	7.32	2.11	0.98	0.32
	PostT1C1	26	2.00	15.00	9.42	2.82	-0.33	1.21
	PreT1C2	29	3.00	13.00	7.38	2.57	0.33	-0.43
	PostT1C2	29	3.00	14.00	8.45	3.07	0.04	-1.04
	PreT2C1	18	3.00	11.00	7.25	2.53	-0.07	-0.95
	PostT2C1	18	10.00	21.00	14.89	3.39	0.45	-0.89
	PreT2C2	20	4.00	12.00	7.68	2.25	0.45	-0.20
	PostT2C2	20	6.00	15.00	10.80	2.76	-0.60	-0.92
Treatment	PreT3C1	28	7.00	16.00	10.42	2.23	0.71	0.03
	PostT3C1	28	6.00	18.00	12.57	3.05	-0.34	-0.51
	PreT3C2	18	6.00	17.00	10.56	3.18	0.50	-0.67
	PostT3C2	18	8.00	19.00	14.17	2.73	-0.24	0.22
	PreT4C1	27	3.00	10.00	7.19	2.04	-0.14	-0.83
	PostT4C1	27	9.00	18.00	13.41	2.17	0.16	-0.16
	PreT4C2	27	.00	11.00	6.31	2.64	0.00	0.36
	PostT4C2	27	7.00	18.00	12.59	3.48	-0.15	-1.10
	PreT5C1	30	3.00	12.00	7.10	2.33	0.37	-0.68
	PostT5C1	30	6.00	15.00	10.50	2.43	-0.14	-0.63
	PreT5C2	27	3.00	11.00	6.64	2.06	0.56	-0.08
	PostT5C2	27	6.00	21.00	14.33	3.99	-0.21	-0.36
	PreT6C1	33	1.00	12.00	7.07	2.25	-0.36	0.82
	PostT6C1	33	4.00	15.00	8.33	2.77	0.46	-0.28
	PreT6C2	23	3.00	10.00	6.41	1.97	-0.05	-0.59
	PostT6C2	23	3.00	14.00	10.09	2.59	-0.77	0.94
Placebo-pre	preT1T2C1[d]	44	3.00	12.00	7.29	2.27	.40	-.38
	PostT1T2C1	44	2.00	21.00	11.66	4.07	.35	.27
Placebo-post	PreT1T2C2	49	3.00	13.00	7.50	2.42	.33	-.40
	postT1T2C2	49	3.00	15.00	9.41	3.11	-.20	-1.11

Table 4.20 (continued)

Group	Class	N	Min.	Max.	Mean	SD	S[b]	K[c]
Control	PreT3T4T5T6C1[e]	118	1.00	16.00	7.90	2.61	.29	.30
	PostT3T4T5T6C1	118	4.00	18.00	11.05	3.28	-.11	-.65
Experi-mental	PreT3T4T5T6C2	95	.00	17.00	7.23	2.91	.79	1.24
	PostT3T4T5T6C2	95	3.00	21.00	12.78	3.68	-.01	-.33

[a]First class of placebo group that teacher T1 taught during pre-teaching

[b]Skewness

[c]Kurtosis

[d]All (two) classes of placebo-pre group that placebo group teachers taught during pre-teaching

[e]All (four) classes of control group that treatment group teachers taught during pre-teaching

The maximum possible score that can be taken from MPUAT-S was 30. As seen from Table 4.20 among both the placebo and the treatment groups the maximum score taken was 21. When classes are compared in terms of the mean scores it is seen that in placebo group the post-test mean (14.89) of Class T2C1 and in treatment group the post-test mean (14.33) of Class T5C2 are the highest. The first is the class in which Teacher T2 taught the MPU earlier and the subjects in this class were listing carefully when compared to their counterpart class (as declared by the teacher himself), namely the class in which Teacher T2 taught the MPU later. The second is the class of Teacher 5 in which he taught the MPU after the TTT PD course. This was the teacher who most benefited from the TTT PD course (See Section 4.3) and whose students got highest gain scores (See Table 4.21). Moreover, the difference (5.50) between the means of pre- and post-test scores of the experimental classes is higher than the difference (3.15) between the pre- and post-test scores of the control group. Contrary, the difference (4.37) between the means of pre- and post-test scores of the placebo pre classes is higher than the difference (1.91) between the pre- and post-test scores of the placebo post classes. Thus, these mean differences show that TTT PD has increased students achievement and pre-teaching have a negative effect on the achievement of students.

A comparison of all pre-test and post-test results of the placebo group classes can be seen in Figure 4.9. In this figure; T1C1 and T2C1 are the placebo pre, and T1C2 and T2C2 are the placebo post group classes.

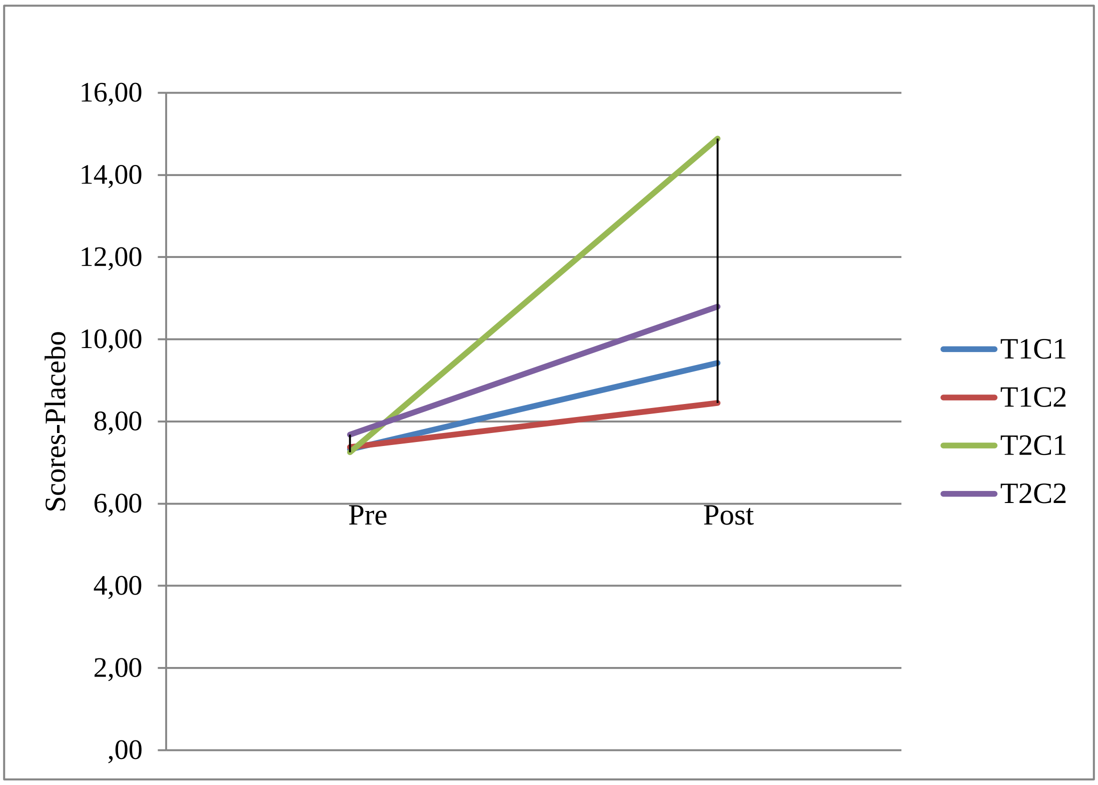

Figure 4.9 The comparison of pre-test and post-test results of the placebo group classes

Figure 4.9 indicates that the pre-test and post-test score difference of the placebo-pre group (T1C1 and T2C1) are higher than that of the pre-test and post-test score difference of the placebo-post group (T1C2 and T2C2). Initially teaching MPU to a class then teaching the same unit to another class after gaining some experience was expected to have positive results in favour of placebo-post group. In other words, the effect of pre-teaching, at least, was expected to have no effect. However, even though students in placebo pre and placebo post groups have equal achievement levels (in term of their PCG) the students of placebo-post group are less successful (in term of their achievement test results) than students of placebo-pre group. This contradiction was asked to the teachers. The first teacher said that while his placebo-pre class (T1C1) had the MPUAT-S after the physic midterm, accordingly the students had prepared for the midterm, his placebo-post class (T1C2) had the MPUAT-S before the midterm and accordingly they hadn't prepared for the midterm. On the other hand the second teacher said that in terms of listening lessons carefully and doing homework on time, his placebo-pre class (T2C1) was better than his placebo-post class. The explanations of these teachers, the class observation results that were given in Section 4.3 and the test results indicates that rather than the effect of pre-teaching the effect of some other factors such as having the test before the midterm or having students that have better habits of listening lesson and doing homework are more important in increasing students successes.

The comparison of pre-test and post-test results of the treatment group classes is given in Figure 4.10. In this figure; T3C1, T4C1, T5C1 and T6C1 are control, and T3C2, T4C2, T5C2 and T6C2 are experimental group classes.

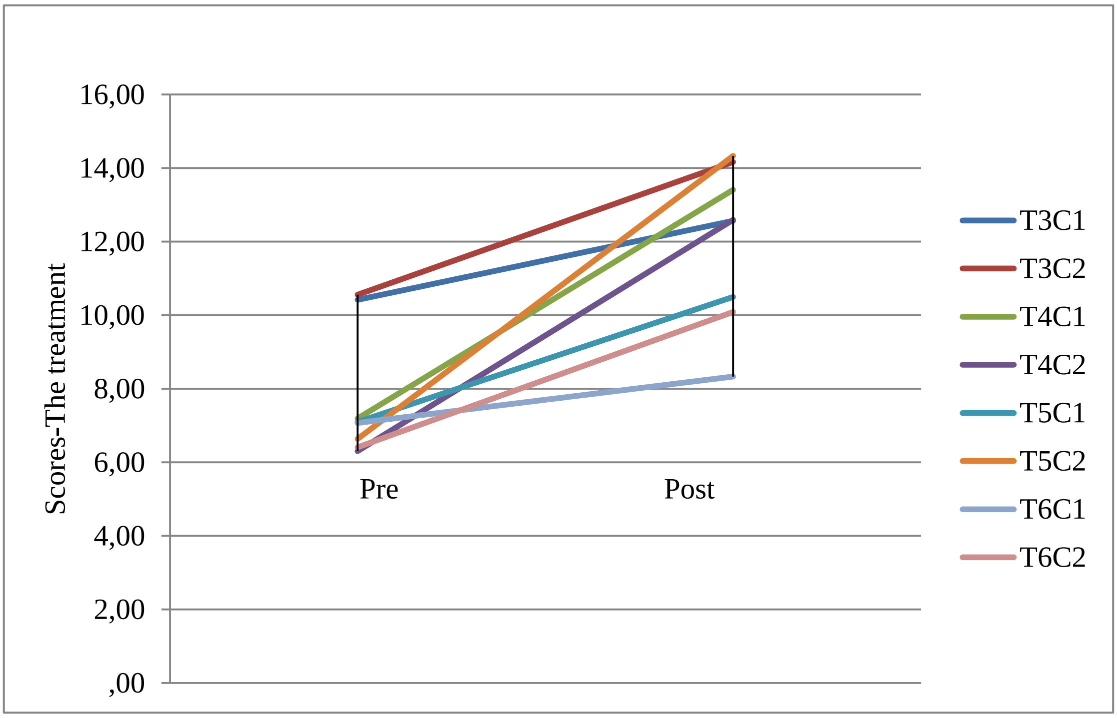

Figure 4.10 The comparison of pre-test and post-test results of the treatment group classes

Figure 4.9 and 4.10 indicate that while the pre-test scores of the placebo group classes are very close to each other that of the treatment group classes are varying in different amounts. Especially, pre-test and post-test scores of classes of Teacher T3 (T3C1 and T3C2) are obviously higher than that of other classes' scores. This obvious contradiction was asked to Teacher T3. He explained that before the application of pre-tests he had his both classes to read all MPU from their books. Since there were no computational questions on the MPUAT-S, it seems that reading from the book has increased the students' pre-test scores. The gain scores and effect size values with respect to group membership are given in Table 4.21.

Table 4.21 Gain scores and effect sizes of the placebo and the treatment classes.

	Teacher/Class	Group	Gain Score (Posttest-Pretest)	Effect Size (Gain score/SDpre)
Placebo	T1C1	Placebo-Pre	2.10	1.00
	T1C2	Placebo-Post	1.07	0.42
	T2C1	Placebo-Pre	7.64	3.02
	T2C2	Placebo-Post	3.12	1.39
Treatment	T3C1	Control	2.15	0.96
	T3C2	Experimental	3.60	1.13
	T4C1	Control	6.22	3.05
	T4C2	Experimental	6.28	2.38
	T5C1	Control	3.40	1.46
	T5C2	Experimental	7.69	3.73
	T6C1	Control	1.26	0.56
	T6C2	Experimental	3.68	1.87
Placebo	T1T2C1	Placebo-Pre	4.37	1.93
	T1T2C2	Placebo-Post	1.91	0.79
Treatment	T3T4T5T6C1	Control	3.15	1.21
	T3T4T5T6C2	Experimental	5.55	1.91

The most increase in mean scores with respect to the MPUAT-S is observed in the class of one of the treatment group teacher (T5C2). The students in the placebo pre groups have higher gain scores (2.10 and 7.64) than the placebo post group students' gain scores (1.07 and 3.12) with regard to the MPUAT-S. Consequently, the effect of pre-teaching is expected not to be significant in inferential statistics; however, the covariates (SCG, TE, Pre-MPUAT-S and Post-MPUAT-T) may change the situation. Moreover, in the treatment group the students of Teacher T4 have almost equal gain scores (6.22 and 6.28) in the control and experimental groups. Even though this teacher's experience was not as desired according to experience index given in Table 3.4, the pre- and post-class observations showed that he has a substantial knowledge of MPU. Thus, the TTT PD did not considerably affect this teacher and he was successful both before and after the TTT PD course.

Instead of interpreting the gain scores and effect sizes across classes, evaluating the gain score and the effect sizes of groups is more proper to the aim of this study. Thus, bottom part of Table 4.21 displays the gain scores and the effect sizes with respect to the groups. These effect size values indicate large effect sizes for all groups. The effect size of placebo pre group is higher than that of placebo post group. This unexpected result was explained after Figure 4.9. The effect size value of the experimental group is an early indication of success of TTT PD course.

Figure 4.11 and Figure 4.12 show the histograms with normal curves for both groups' dependent variables, that is, the post-tests of both groups. As an evidence of normal distribution, distributions of the scores are clearly seen in these histograms.

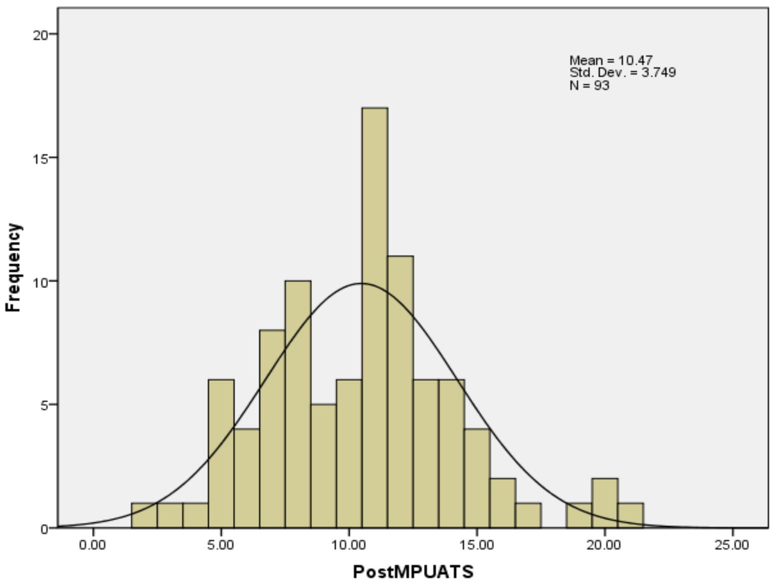

Figure 4.11 Histogram with normal curve for the dependent variable of placebo group.

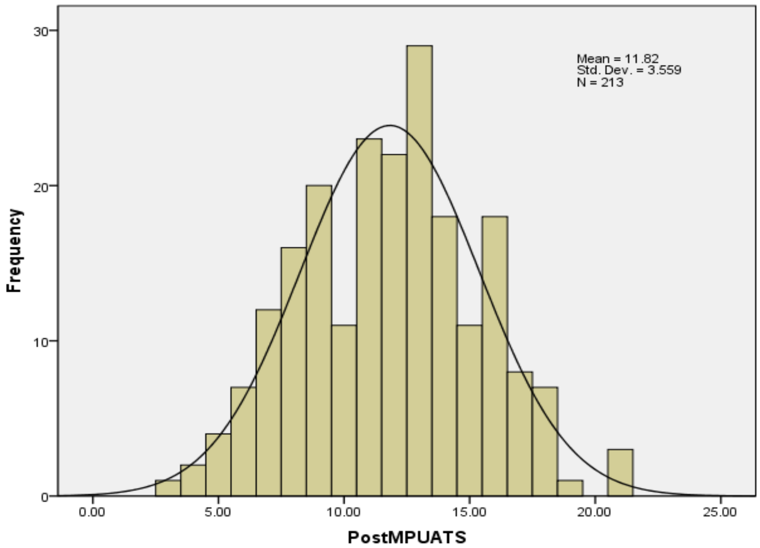

Figure 4.12 Histogram with normal curve for the dependent variable of treatment group.

4.6. Results of the teachers' achievement test

This was a test consisting of four open ended questions. All teachers of implementation group were subjected to this test. Teachers had this test as pre-test once they finished teaching to one of their classes (placebo pre and control groups). Afterwards, they had the same test as post-test once they finished teaching to their second class (placebo-post and experimental groups). The pre-test and post-test results of all six teachers are given in Figure 4.13.

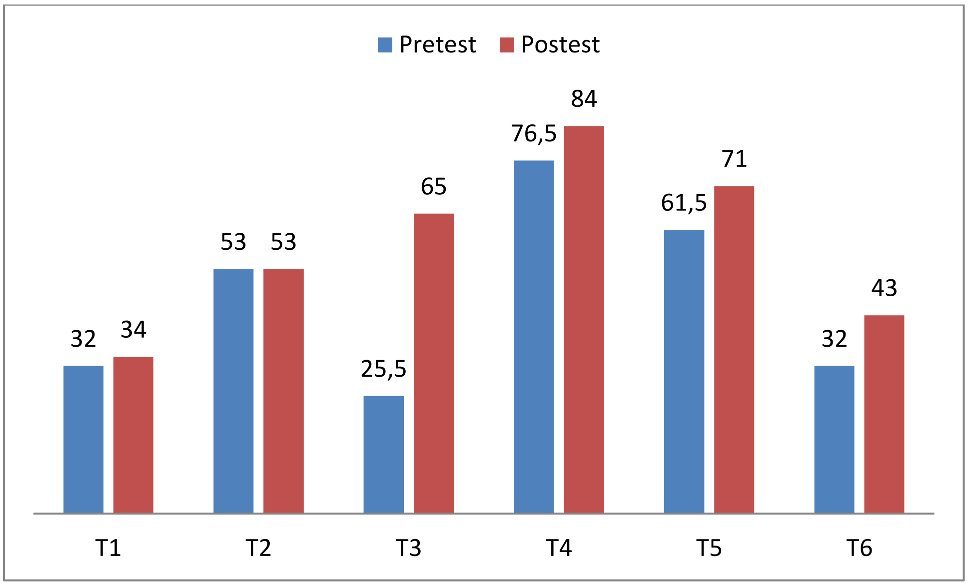

Figure 4.13 Pre-test and post-test scores of implementation group teachers

Figure 4.13 shows that the pre-test and post-test scores of one of the teachers (T2) of the placebo group has not changed. Moreover, the scores of one of them (T1) has increased slightly. Thus, the pre-teaching did not affect the achievement of these teachers. Regarding this result no achievement should be expected from the students of these teachers. However, the scores of the treatment group teachers have changed as desired.

The maximum possible score that could be taken on MPUAT-T was 100. The pre-test mean of the treatment group teachers was 48.88 and that of post-test was 65.75. Since pre-teaching did not effected the achievement of placebo group teachers the increase in treatment group teachers' scores can be attributed to TTT PD course. Moreover, the effect size (Cohen's d) calculated for treatment group teachers is 0.93 which accepted as 'large'.

4.7. Inferential Statistics

In this section, initially the covariates are determined, then assumptions of ANCOVA are checked, finally, ANCOVA is conducted and its results are displayed for both the placebo and the treatment groups. In this study, for placebo group no research questions were specified. However, a statistical analysis about the effect of pre-teaching can give reliable results.

4.7.1. Determination of Covariates

Correlations among possible covariates and the correlations of these covariates with the dependent variable are given in Table 4.22 and Table 4.23 for both groups. Since there are only two teachers in placebo group accordingly there are two values for TE and Post-MPUAT-T independent variables. Thus these two are dichotomous variables. Accordingly, Spearman correlations are calculated for these two variables. Independent variables that are uncorrelated with each other (or having correlations fewer than moderate) and significantly correlated with dependent variables (Tabachnick & Fidell, 2007, p. 212) can be used as covariates. In order to determine the covariates, the correlation coefficients among independent variables were calculated. Moreover, the correlation coefficients between each independent and dependent variable (post-MPUAT-S) were calculated. The results of the correlation analyses are given in Table 4.22 and 4.23 for placebo and treatment groups, respectively.

Table 4.22 Correlations among possible covariates and the dependent variable of placebo group

Variables	Pre-MPUAT-S	PCG	TE	Post-MPUAT-T
PCG	.005			
TE	-.044	-.770*		
Post-MPUAT-T	.044	.770*	-1.000*	
Post-MPUAT-S	.130	.500*	-.516*	.516*

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4.22 indicates that except Pre-MPUAT-S all other variables (PCG, TE and Post-MPUAT-T) had significant correlation with the dependent variable (Post-MPUAT-S). The maximum correlation between independent variables is -.770 (between TE and PCG) and .770 (between Post-MPUAT-T and PCG). Table 4.22 shows that the TE and Post-MPUAT-T have exactly same correlations with other variables. Moreover, the correlation between them is -1.000. Since there were only two values for both TE and Post-MPUAT-T and since the teacher who was more experienced got lower score on Post-MPUAT-T the correlation between them yield "-1" value. Since the process conducted to determine the TE was more reliable than scoring Post-MPUAT-T, the TE was preferred to be retained and the Post-MPUAT-T to be dropped from ANCOVA of placebo group. Thus, the results showed that the Pre-MPUAT-S, PCG and TE had significant correlation with the Post-MPUAT-S and did not have significant correlation between each other so they can be used as covariates in ANCOVA in placebo group. Even though Pre-MPUAT-S's correlation with the dependent variable is weak the researcher preferred to accept it as a covariate. On the other hand, all the variables of the treatment group were continuous, and Pearson correlations were calculated for them. Table 4.23 displays the correlations among possible covariates and the dependent variable of treatment group.

Table 4.23 Correlations among possible covariates and the dependent variable of treatment group

Variables	Pre-MPUAT-S	PCG	TE	Post-MPUAT-T
PCG	-.121			
TE	.448*	-.055		
Post-MPUAT-T	-.015	-.200*	.293*	
Post-MPUAT-S	.168*	.045	.328*	.419*

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4.23 indicates that except PCG all other variables (Pre-MPUAT-S, TE and Post-MPUAT-T) had significant correlation with the dependent variable (Post-

MPUAT-S). Interestingly students' first term PCG do not have a significant correlation (.045) with the dependent variable. Thus, PCG is excluded from the analysis, and it will not be used as a covariate in treatment group. Moreover, the maximum correlation between the remaining independent variables is .448 (between Pre-MPUAT-S and TE). Thus, the results showed that the Pre-MPUAT-S, TE and Post-MPUAT-T had significant correlation with the Post-MPUAT-S and did not have significant correlation between each other so they can be used as covariates in ANCOVA in treatment group.

4.7.2 Assumptions of ANCOVA

Along with assumptions of ANOVA, ANCOVA has some extra assumptions. The key assumptions of ANCOVA which also compromise that of ANOVA are: outliers, multicollinearity, normality, homogeneity of variance, linearity, homogeneity of regression and reliability of covariates. (Tabachnick & Fidell, 2007, p. 200). If any of these assumptions are not met the ANCOVA should not be conducted.

Outliers: ANCOVA is sensitive to outliers. The tails of distribution on histograms can give clues about outliers; however, box plots give visual and reliable results. When the tails of the distributions given in Figure 4.11 and in Figure 4.12 are checked, no data points are sitting on their own. Moreover, the box plot given in Figure 4.14 indicates some outliers for placebo group's dependent variable. These outliers were checked and they were within the range of possible scores for Post-MPUAT-S. In order to see how much of a problem these outlying cases are likely to be, the 5 % Trimmed Mean is checked (Pallant, 2007, p.63). If the trimmed mean and mean values are not very different than these outliers can be overlooked. In placebo group, the two mean values (10.34 and 10.47) are very similar. The fact that the outlier values are not too different from the remaining distribution, these cases was retained in the data file of placebo group. Furthermore, boxplot shown in Figure 4.15 indicates that there are no outliers in Post-MPUAT-S in treatment group.

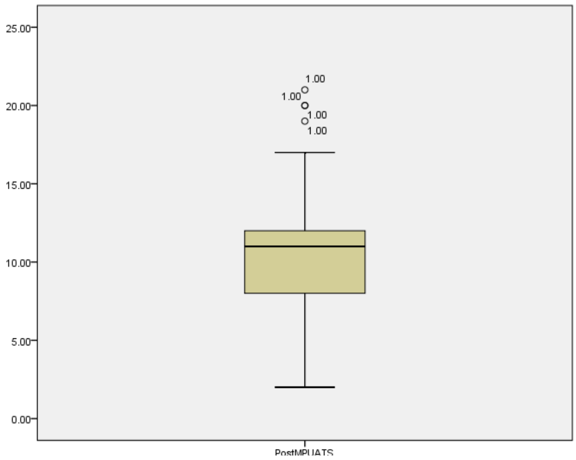

Figure 4.14 Box plot for dependent variable of placebo group

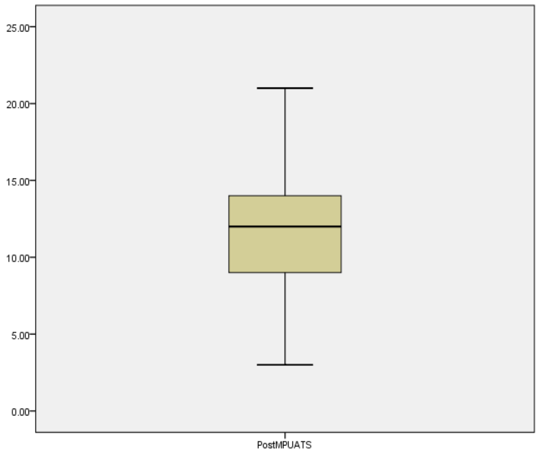

Figure 4.15 Box plot for dependent variable of treatment group

Reliability of covariates: Even though it is a rather unrealistic assumption in much social science research ANCOVA assumes that covariates are measured without error. There are four candidates of covariate for ANCOVA in this study. Pre-MPUAT-S is the data collected through MPUAT-S which was developed and conducted by the researcher. Its validity and reliability were discussed in Section 3.3.2 in Chapter three. TE was sensitively determined by the researcher through Table 3.4 in the third chapter. Post-MPUAT-T was developed by the researcher, its reliability and validity was ensured by collaborative work of the researcher and the supervisor of the study. Moreover, the researcher himself collected the data through this instrument and evaluated the results. PCG are usually determined by the teachers through open ended questions. Moreover, they are generally the average of three exams spread over a semester. Even though the reliability and the validity of the exams that teachers conduct in their classes are controversial, the combined scores usually reflect reliable results about students' academic achievements.

Correlations among covariates (multicollinearity): There should not be strong correlations among the variables that are chosen as covariates. In the case of strong (e.g. r=.80), correlations one or more of them should be removed (Stevens, 1996, p. 320). Overlapping covariates do not contribute to a reduction in error variance. To check this assumption, the correlations between covariates were examined. These values can be seen in Table 4. 22 and in Table 4. 23. Since all of the correlation coefficients are less than .80 in both groups, it is validated that the covariates do not strongly correlate. As a result, the assumption of multicollinearity was met.

Normality: The normality assumption can be checked through the skewness, kurtosis, and standard deviation values of dependent variable (Tabachnick & Fidell, 2007). Any distribution having skewness and kurtosis values between -2 and +2 can be accepted as normal distribution (George & Mallery, 2003, pp.98-99). When descriptive statistics section (Table 4.20) is examined, it can be said that normality assumption was verified. Moreover, the histograms given in Figure 4.11 and Figure 4.12 are evidences for normal distribution of the data of the dependent variables of groups.

Linear relationship between dependent variable and covariate: If ANCOVA is conducted it means that the relationship between the dependent variable and each of the covariates has a linear relationship rather than a curvilinear or any other relationship. Moreover, if there is more than one covariate, it also assumes a linear relationship between each of the pairs of the covariates. Scatterplots are used to test the linearity of covariates of both placebo and that of treatment group. In placebo group, three covariates were used, of which TE is dichotomous. That's why for placebo group scatterplot of only Post-MPUAT-S and PCG is given in Figure 4.16.

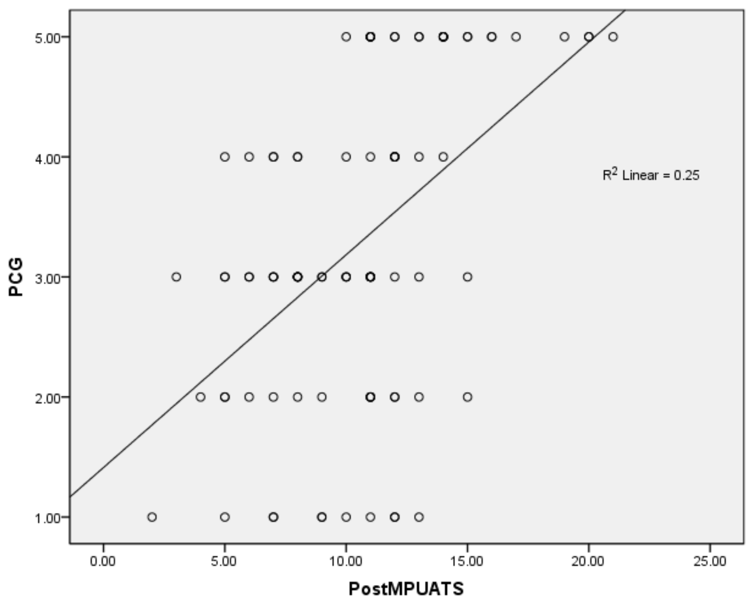

Figure 4.16 Relationship between PCG and dependent variable of placebo group

Figure 4.16 displays that the variation between PCG and Post-MPUAT-S is linear. In treatment group, also three covariates were used. To ensure the assumption of ANCOVA the relationship between the dependent variable and each of the covariates and the relationship between each pair of covariates are given in Figure 4.17.

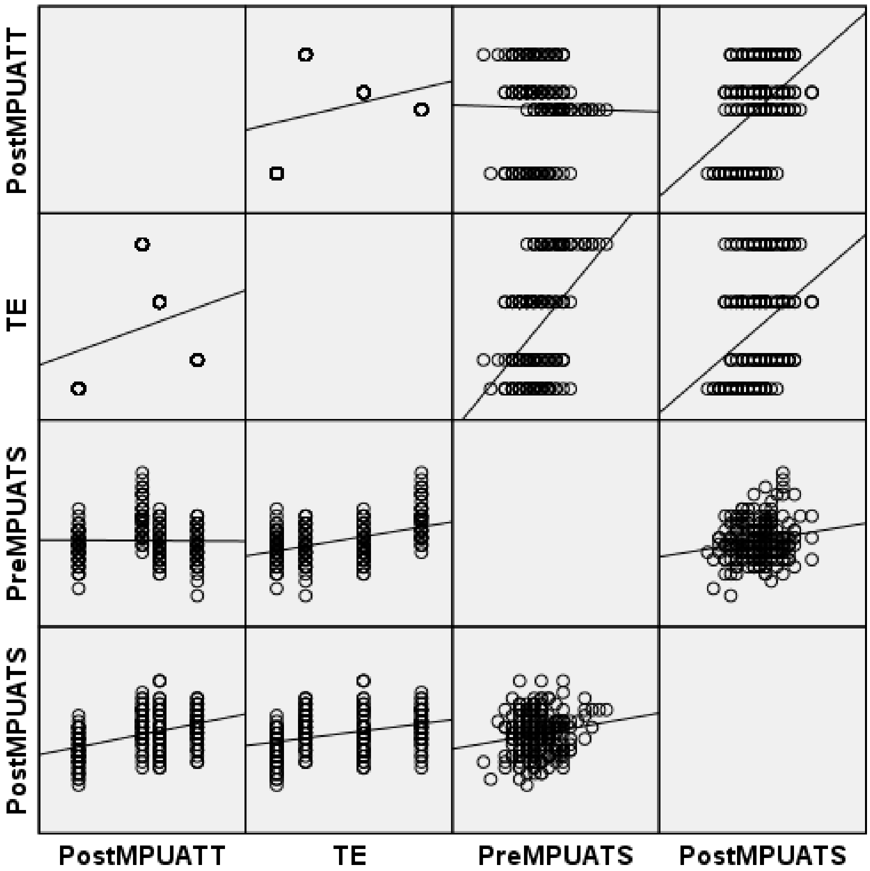

Figure 4.17 Relationship between each covariate and dependent variable of treatment group

The matrix scatterplot in Figures 4.17 reveals that the relationships between each covariate and the dependent variable of treatment group are linear.

Homogeneity of regression slopes: This assumption requires that the relationship between the covariate and dependent variable for each of groups (control and experimental) is the same. Similar slopes on the regression line for each group checks this relationship. Inequality of slops is the indication of an interaction between the covariate and the treatment. In the case of an interaction, then the results of ANCOVA will mislead, and therefore it should not be conducted (Stevens 1996, pp. 323, 331; Tabachnick & Fidell 2007, p. 202). Figure 4.18 indicates the relationship between the covariate (PCG) and dependent variable of placebo groups. Similarly, Figure 4.19, Figure 4.20, and Figure 4.21 indicate the relationship between the covariates (Pre-MPUAT-S, TE, and Post-MPUAT-T) and dependent variable of treatment groups.

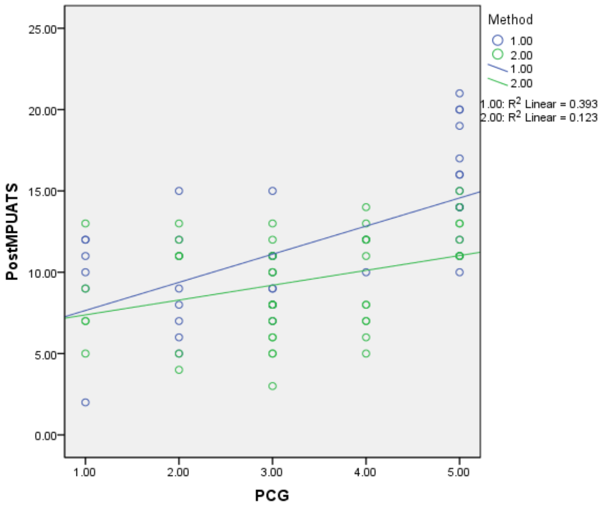

Figure 4.18 The relationship between the PCG and dependent variable of placebo groups

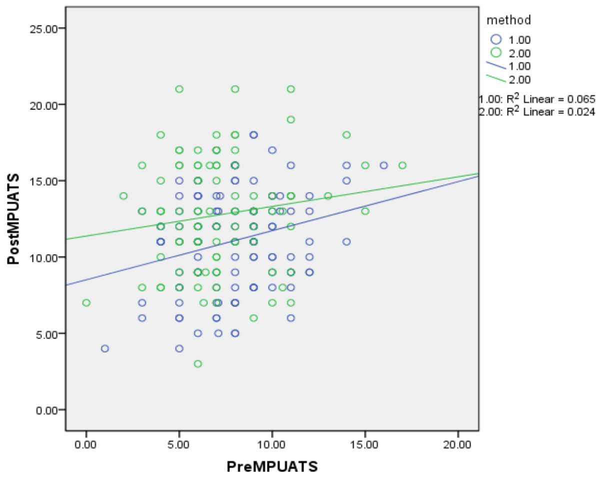

Figure 4.19 The relationship between the Pre-MPUAT-S and dependent variable of treatment groups

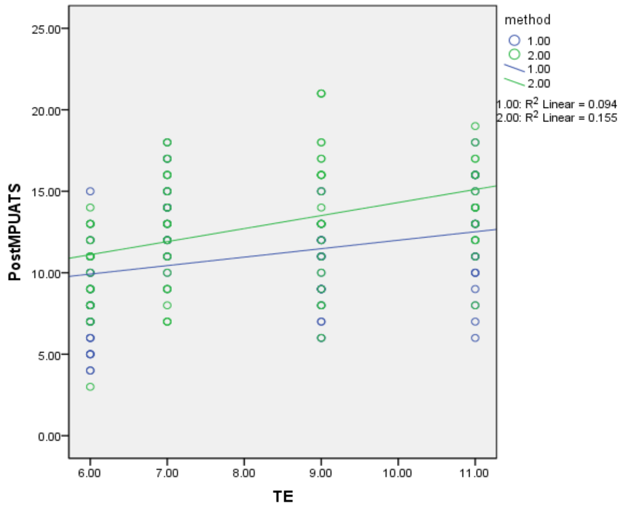

Figure 4.20 The relationship between the TE and dependent variable of treatment groups

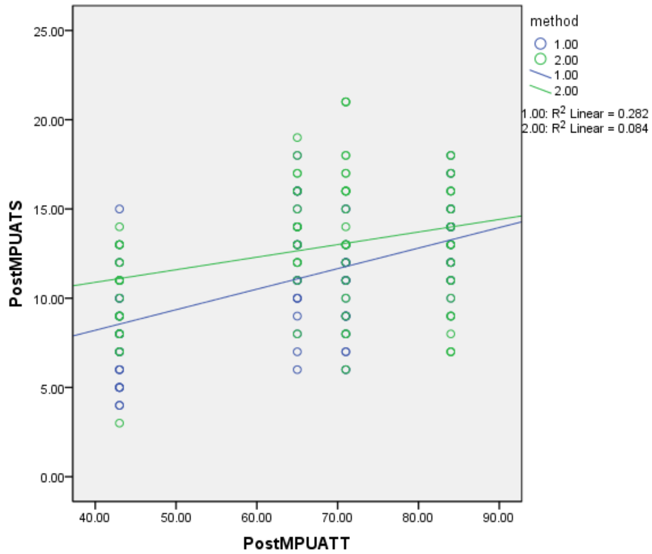

Figure 4.21 The relationship between the Post-MPUAT-T and dependent variable of treatment groups

Even though slopes on the regression line for each group are not same in Figures 4.18, 4.19 and 4.21, the slopes are somehow equal. Moreover, the lines do not cross. Thus, it can be said that there is no interaction between the covariates and the treatment. However, since the lines are not completely parallel one can inspect that there may be interaction between the covariate and the treatment. Thus rather than graphically, it is better to assess it statistically (Pallant, 2007). If the interaction is significant at an alpha level of .05, then we have violated the regression assumption. Table 4.24 was generated from the output obtained from SPSS for each of the covariates of placebo and treatment groups.

Table 4. 24 Homogeneity of regression slopes assumption

Source	Type III Sum of Squares	df	Mean Square	F	p
		Placebo group			
Method * PCG	.210	1	.210	.005	.941
Method * TE	.000	1	.000	.	.
Method * Pretest	18.659	1	18.659	.205	.652
		Treatment group			
Method * Pretest	6.460	1	6.460	.559	.456
Method * TE	14.222	1	14.222	1.343	.248
Method * Tpostest	23.770	1	23.770	2.404	.123

Table 4.24 shows that all Sig. values are greater than .05 and all are safely above the cut-off. This supports the earlier conclusion gained from inspections of the scatterplots shown in Figures 4.18, 4.19, 4.20 and 4.21 for each group. Since the TE in placebo group was a dichotomous variable, the interaction term (Method*TE) values in Table 4.24 are not generated.

Equality of variances: Levene's test was used to check equality of variances assumption. Table 4.25 indicates that while error variances of the Post-MPUAT-S across placebo groups were equal, the error variances of the Post-MPUAT-S across treatment groups were not equal. That means equality of variances assumption for the treatment group was not met. Since the violation of this assumption is not fatal to conduct ANCOVA and the calculated alpha value (.041) is very close to .05, the problem associated with this assumption was overlooked.

Table 4.25 Levene's Test of Equality of Error Variances

Group	F	df1	df2	P
Placebo	0.027	1	91	.871
Treatment	4.246	1	211	.041

The last assumption is independency of observations. The unit of analysis and experimental unit are expected to be same in ideal conditions. The independency of observations assumption can be met only if this situation was satisfied. Unit of analysis for this study is each individual. Experimental unit of the study is each class of placebo and treatment groups to which regular instruction and instruction after TTT PD was given. Thus, unit of analysis and experimental unit are not same in this study. Thus, nevertheless it is difficult to say that independence of observations was met during the treatment for this study. However, at least while data were being collected, the researcher himself applied all tests to all classes. It was observed that all of the participants completed their tests by their own. Thus, independence of observation may be assumed at least for the measurement processes.

4.7.3 Result of ANCOVA

Analysis of covariance (ANCOVA) was conducted to test both the effect of pre-teaching and that of TTT PD on the students' achievement. Teacher participating to TTT PD initially taught to one of their classes than they taught to their other class along with the PD proposed in this study. In order to distinguish the effect of TTT PD from that of pre-teaching a placebo group consisting of two teachers and four classes was formed.

4.7.3.1 The placebo group ANCOVA results

Since there was a strong correlation between TE and Post-MPUAT-T one of them (Post-MPUAT-T) was not included into ANCOVA. Blow pre-test and post-test results of the students of the placebo group teachers are compared through ANCOVA. Table 4.26 indicates the results of ANCOVA for the placebo group.

Table 4.26 ANCOVA results of the placebo group

Source	Type III Sum of Squares	df	Mean Square	F	p	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Corrected Model	504.52	4	126.13	14.07	.000	.390	56.29	1.00
Intercept	72.06	1	72.06	8.04	.006	.084	8.04	.80
TE	51.31	1	51.31	5.73	.019	.061	5.73	.66
Pre-MPUAT-S	23.07	1	23.07	2.57	.112	.028	2.57	.36
PCG	36.23	1	36.23	4.04	.047	.044	4.04	.51
Method	114.33	1	114.33	12.76	.001	.127	12.76	.94
Error	788.67	88	8.96					
Total	11494.00	93						
Corrected Total	1293.18	92						

Table 4.26 indicates that the placebo pre and placebo post groups' means are statistically different (F (1,88) = 12.76, p=0.001). Therefore, significant population mean difference was found between the students instructed during pre-teaching and instructed during post-teaching on the post-MPUAT-S scores of placebo group. When we look the mean scores of each group given in Table 4.20, we can see that the students instructed during pre-teaching got higher post-MPUAT-S scores than the students instructed during post-teaching. Moreover, the eta square value, 0.127 indicates a large effect size. Additionally, the observed power .94 is pretty good. The estimated means for the dependent variables are given in Table 4.27. These are the

means adjusted with the effect of covariates. The difference between both groups estimated means was 2.23 for the post- MPUAT-S. The difference before extracting the effects of the covariates was 2.25 (See Table 4.20 for unadjusted means).

Table 4.27 Estimated means for the post-MPUAT-S at each placebo groups

Dependent variable	Group	Mean
Post-MPUAT-S	Placebo-pre	11.65
	Placebo-post	9.42

The placebo group was constructed to investigate the effect of pre-teaching on teachers' performance during post-teaching. It was hypothesized that the pre-teaching would increase the achievement of placebo-post group students however the results of ANCOVA conducted for placebo group demonstrated that pre-teaching has negatively affected teachers' post-teaching. Placebo group teachers' implementations, which was explained in Section 4.5, during post-teaching leaded to this contradictory result. As a result due to unexpected threats, the effect of pre-teaching was not controlled as desired.

4.7.3.2 The treatment group ANCOVA results

The second null hypothesis of the study was "there is no significant effect of TTT PD course on the population means of tenth grade high school students' modern physics unit achievement post-test scores when students' modern physics unit achievement pre-test scores, students' first term physics course grades, their teachers' experiences, and their teachers' achievements are controlled". Since PCG had not significant correlation with the dependent variable (Post-MPUAT-S), it was not included into ANCOVA. Table 4.28 indicates the results of ANCOVA for the treatment group.

Table 4.28 ANCOVA results of the treatment group

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power
Corrected Model	762.21	4	190.55	20.61	.000	.284	82.44	1.00
Intercept	42.34	1	42.34	4.58	.034	.022	4.58	.57
Post-MPUAT-T	297.09	1	297.09	32.13	.000	.134	32.13	1.00
TE	58.59	1	58.59	6.34	.013	.030	6.34	.71
Pre-MPUAT-S	31.07	1	31.07	3.36	.068	.016	3.36	.45
Method	148.16	1	148.16	16.03	.000	.072	16.03	.98
Error	1923.02	208	9.25					
Total	32452.00	213						
Corrected Total	2685.22	212						

Table 4.28 indicates that the first null hypothesis was rejected ($F(1,208) = 16.03$, $p=.000$). Therefore, significant population mean difference was found between control group students (instructed during pre-teaching) and experimental group students (instructed during post-teaching) on the post-MPUAT-S scores of treatment group. When we look the mean scores of each group given in Table 4.20, we can see that the students instructed in parallel with TTT PD course got higher post-MPUAT-S scores than the control group students. Moreover, the eta square value, .072 indicates a moderate effect size. Additionally, the observed power of .98 was larger than the pre-calculated one. The estimated means for the dependent variables are given in Table 4.29. These are the means adjusted with the effect of covariates. The difference between both groups estimated means is 1.69 for the post-MPUAT-S. The difference before extracting the effects of the covariates was 1.73 (See Table 4.20 for unadjusted means). Thus, the Cohen's d value is calculated as .52 which similarly indicates a moderate effect size.

Table 4.29 Estimated means for the post-MPUAT-S at each treatment group

Dependent variable	Group	Mean
Post-MPUAT-S	Control	11.07
	Experimental	12.76

It was hypothesized that when compared to traditional teaching, instructing in parallel with TTT PD course would increase the students' achievement scores. The ANCOVA analysis for treatment group demonstrated the desired results such that participating to TTT PD course increased both teachers' performance (See teachers' achievement test and class observation results) and their students' achievements.

4.8 Summary of the results

In general this study determined there is a relationship between teacher PD, teacher knowledge and students' achievement in physics. Results obtained from the current study are summarized under each measuring tool or type of analysis as following:

According to the teachers' views about TTT PD course

- The TTTEF form results showed that the teachers participated to TTT PD course had positive attitudes against the course; they were of single mind about the usefulness of the course, and the effort and ethic of the researcher. They expressed that they had increased their teacher knowledge after participating to the course.
- The TTTEF results showed that in each dimensions the treatment group teachers had higher scores than the rest of the participating teachers.

According to the class observations of placebo group

- The first teacher of placebo group (T1) instructed all concepts of modern physics incorrectly, inadequately or never mentioned the concepts during both teachings. The activities he conducted during pre- and post-teaching were not consistent. His placebo-pre group was more successful.
- There was no difference between the two teachings of the second teacher of placebo group. He taught most of the topics of the MPU correctly during both

teachings. His placebo-pre group was also more successful because this group were more motivated than the others and he spent more hours in teaching to this group.

According to the class observations of treatment group

- The first teacher of the treatment group (T3) was the most experienced among all implementation group teachers, according to experience index. He was the teacher who had his students to read MPU before both instructions. That's why his students' pre-test scores were the highest among all treatment group classes. Moreover, the TTT PD course helped this teacher to instruct in accordance with the curriculum, it forced the teacher to teach in an organized manner, it slightly increased both the discussions he conducted with his students and his PCK. Furthermore, TTT PD considerably increased the amount of questions that he asked to his students and increased both his and his students' achievement on Post-MPUAT-S.
- As in the case of the second teacher of placebo group, there was no difference between the two teachings of the second teacher of treatment group (T4). He was the least experienced among all treatment group teachers. Still, it was observed that he had substantial background about MPU. Accordingly, teacher achievement test scores and students' achievement gain scores were more or less similar for pre- and post-tests of this teacher. Moreover, this was the teacher among the treatment group who got least score on TTTEF.
- The third teacher of the treatment group (T5) was the teacher who most benefited from the TTT PD course. His TTTEF score was the second highest among the treatment group teachers. Class observations showed that this teacher was more confident during post-teaching and his post-teaching was significantly different from his pre-teaching. Moreover, the fact that he mostly inadequately taught during pre-teaching and correctly taught during post-teaching may explain why his placebo-post group students were more successful. In other saying, his experimental class had the highest gain score.
- The fourth teacher in treatment group (T6) was the only female teacher. Her classes were not observed as intended. That's why, rather than class observation results, the achievement test results are more reliable about the development of this teacher. Even though her TTTEF score was the highest, restricted class

observations showed that she had not benefitted from the TTT PD as desired. The gain score of her experimental class was the second lowest and her achievement post-test result was the lowest.

- Teachers spent more time on the topics that they were familiar (such as relative motion or reference point) during pre-teaching.
  - Teachers were not well organized in instructing the concepts of MPU during pre-teaching. They usually taught many digressive concepts in the same lesson.
- Many sub-concepts of the MPU such as the results of the MM experiment were discussed during post teaching.
- The teachers were more eager and spent more effort in instructing the MPU during post teaching.
- There was not a relationship between teachers experience given in Table 3.4 and teachers performances in class and their students' achievement.
- When compared to pre-teaching, the treatment group teachers spent more time in instructing the MPU, abide more by the curriculum, increased their PKC, did not changed their PK, correctly taught most of the concepts of the MPU, increased their SMK, asked questions that are more focused on the core concepts of the MPU, increased the duration and the frequency of the most of the activities during post-teaching.

According to missing data analysis

- Missing data analysis conducted for both placebo and treatment groups showed that missing percentages for each group were at acceptable rates.

According to descriptive statistics

- The maximum score that can be taken on achievement test was 30. However, all groups, that is; placebo pre, placebo post, control and experimental groups had means lower than 15 (See Table 4.20). It can be said that MPUAT was a difficult test for students.
- The descriptive statistics showed that the distribution of the data at each dependent variable was approximately normal.

- The post-test scores of the placebo pre group were higher than the post-test scores placebo post group. In other words, a negative effect of pre-teaching was detected. Some other factors such as the motivation of the students or the time of application of the tests were more effective than pre-teaching.
- In the treatment group, the gain scores of the experimental group was higher than that of the control group, whereas in placebo group the gain score of placebo pre group was higher than that of placebo post group.

According to the teachers' achievement test

- According to pre- and post-test scores of teachers' achievement test results, while the pre- and post-test results of placebo group teachers were approximately same, the post-test scores of treatment group teachers were higher than the pre-test scores. In other words, the treatment group teachers' achievement has increased.

According to inferential statistics

- In the placebo group the independent variables; students pre-test scores (Pre-MPUAT-S), students first term physics grades (PCG) and teacher experience (TE) had significant correlation with the dependent variable (Post-MPUAT-S) and they were used as covariates in ANCOVA.
- In the treatment group the independent variables; students pre-test scores (Pre-MPUAT-S), teacher experience (TE) and post-test scores of teachers' achievement test (Post-MPUAT-T) had significant correlation with the dependent variable (Post-MPUAT-S) and they were used as covariates in ANCOVA.
- Normality, absence of outliers, homogeneity of regression, equality of variances, multicollinearity, reliability of covariates and independency of observations assumptions for ANCOVA were checked and except equality of variances assumption of treatment group all of the others were met.
- The results of ANCOVA for placebo group showed that there is no effect of pre-teaching on the placebo group students' post-MPUAT-S scores. Instead, the students instructed earlier got significantly higher scores than the students instructed later.

- The results of ANCOVA for treatment group showed that there is a significant effect of the TTT PD on the treatment group students' post-MPUAT-S scores. That means the TTT PD has an effect on changing students' achievement.

CHAPTER 5

DISCUSSION, CONCLUSION AND IMPLICATIONS

This chapter consists of seven sections. The first section starts with a discussion of the results and is followed by an internal and external validity of the study. The fourth and fifth sections comprise the conclusions and the suggested best practices of TTT development and implementation, respectively. The chapter ends with the implications of the study and recommendations for further research.

5.1. Discussion of the Results

In the previous chapter the results of the data collected via treatment verification form, course evaluation form, class observation form and separate achievement tests applied to teachers and students were presented. In this section, initially, the class observation and course evaluation results are merged, and the effect of TTT course on teacher knowledge is discussed. Secondly, as extra outcome physics teachers' problems in understanding and teaching the MPU are presented. Thirdly, the comparison of results of this study with that of other experimental studies is displayed. Finally, the possible reasons behind the moderate or small effect sizes that experimental PD studies usually result in are discussed.

5.1.1 The effect of TTT course on SMK, PCK and PK

The basic premise of the PD course designed for this study was primarily aimed to increase the teachers' SMK and dependently aimed to increase PCK and PK of teachers. This was done because as Ball, Thames and Phelps (2008) state, "Teachers who do not know a subject well are not likely to have the knowledge they need to help students learn the content, and just knowing a subject well may not be sufficient for teaching." Therefore, primarily this study aimed to increase teachers' SMK and subsequently aimed to change teachers' PK and PCK. Classroom observation results and participating teachers' own statements on the course evaluation form showed an increase in both their SMK and PCK. This result implies that there is a substantial relation between SMK and PCK. Concurrently, Tobin, Tippins, and Gallard (1994) state, "SMK functions as a source to be transformed for teaching." Moreover, Borko (2004) and Van Driel et al. (2002) support this result and they see a substantial and coherent understanding of subject matter as a prerequisite for the improvement of PCK.

Similarly, relationships between SMK and the components of the PCK of science teachers were investigated by Halim and Meerah (2002). They examined 12 Malaysian science teachers' PCK on some selected physics concepts. The trainee teachers attending a one-year postgraduate teacher-training course were interviewed on selected basic concepts in physics at the lower secondary level. They showed that the participants were unable to employ the appropriate teaching strategies required to explain the scientific ideas. Thus, as current studies claim, they recommend including SMK in science teacher training coursework.

Additionally, the findings of the study conducted by Käpylä, Heikkinen and Asunta (2009) support the current research. They designed a study to investigate the effect of the amount and quality of content knowledge on PCK. They used photosynthesis and plant growth as an example. They used questionnaires, lesson preparation tasks and interviews to collect data over ten primary and ten secondary (biology) student teachers. They found that determining students' conceptual difficulties and choosing the most important content for students were problematic tasks for teachers. Further, their results emphasised that good SMK had a positive influence on student-teachers' PCK and thus on effective teaching. Specifically, they showed that teachers who knew the content better became conscious of students' conceptual difficulties and recognised students' misconceptions better.

Furthermore, Kaya (2009) tried to explore the relationships among the components of pre-service science teachers' PCK involving the topic of 'ozone layer depletion'.

His results corroborate the results of current study and showed that there was a significant inter-relationship between the SMK and the PCK of the pre-service science teachers.

However, this study could not find a relation between SMK and PK. The class observations and TTTEF results showed that TTT PD was not effective in increasing teachers' PK. Changing teachers' PK relatively may require longer time. In other words, TTT PD was conducted for five weeks. This amount of time may not be sufficient to change teachers' PK. For instance, Choy, Wong, Lim and Chong (2013) reported that while the teachers' self-perceived PK for classroom management increased significantly at the end of first year of teaching, their self-perceived PK for lesson planning and instructional strategies remained unchanged at the end of first year of teaching. However, they found significant increases in all three factors in teachers' self-perceived PK from the end of first year to the end of third year of teaching. Thus, referring to this result, in this study, expecting a change in teachers' PK in due course of two months is extremely optimistic.

5.1.2 Teachers' MPU related knowledge

Studies that had taken MPU into consideration in teacher PD programs could not be found in the literature. Studies regarding the MPU in the literature were not related to teacher PD; they were separate studies associated with the students' and pre-service teachers' understanding of the special theory of relativity. The brief discussion of teachers' problems in understanding the MPU is reported here for the benefit of future researchers. Teachers' discussions during TTT courses (as an example see Appendix Y) and the class observation results (see section 4.3) of the present study revealed that physics teachers had several problems in understanding and teaching the MPU. The typical problems of these teachers were:

- Fragmented knowledge, e.g.: developments that contributed the birth of modern physics.
- Insufficient knowledge, e.g.: the discrepancy between the theoretical and experimental results of blackbody radiation.
- Incorrect knowledge, e.g.: the aim of the Michelson-Morley experiment.

- Misconceptions, e.g.: changes in mass as objects reach high speeds, and classical laws of physics that have been replaced by modern laws of physics.
- Difficulties understanding some concepts, e.g.: the first postulate of special relativity; the laws of physics are the same in any inertial frame of reference.
- Difficulties in understanding the connections between different concepts, e.g.: the relation between the Michelson-Morley experiment and the second postulate of the special theory of relativity (the speed of light is independent of the motion of the source).
- Unnecessary discussions, e.g.: teleportation and Tesla's experiments.
- Disregarding the national curriculum, e.g.: even though the national curriculum doesn't include simultaneity and relative motion at high speeds, participant teachers tried to teach these topics.

Similar results were found by Selçuk (2010) who investigated the pre-service teachers' understanding of and difficulties with some core concepts in the special theory of relativity. She deduced that pre-service teachers have some specific and considerable difficulties even after instruction in the special theory of relativity. For instance, she found that some pre-service teachers regard mass as a speed-dependent concept, many of them do not accurately comprehend the time dilation phenomenon, and some of them see time dilation as unilateral. In addition, she reported that pre-service teachers had misconceptions when identifying 'proper time' and 'proper length', they had difficulties in comprehending the relativity of reference systems, and they also thought the ground system was an absolute system.

Even though they didn't analyse the prospective teachers' understanding of special relativity theory, Yıldız (2012) and, Hosson, Kermen and Parizot (2010) found in common that prospective physics teachers have a deep lack of understanding of concepts associated with special relativity. Since four of the five objectives of the MPU taught at tenth grade level in Turkey are about special relativity, their results can be accepted as concurrent with the results of the current study.

5.1.3 Comparisons with the other experimental studies related to PD

In this section, to begin with, the effect size of this study is compared to the Meta-analysis conducted by Blank and Alas (2009) and then compared to the review conducted by Yoon et al. (2007). Secondly, the effect size is discussed with the experimental studies that have higher and lower effect sizes than that of the current study. Finally, the intensity of the current study and that of 23 experimental studies are discussed in terms of effect size.

Firstly, a moderate effect size of 0.52 (Cohen's d) was calculated for this study. Similarly, in their Meta-analysis Blank and Alas (2009) reviewed 16 studies and they found that most of the effect sizes from these studies were also modest. The average effect size (Cohen's d) for 16 studies was 0.31. As in the case of this study their analysis showed that all of the studies reported did show positive effects on student achievement. Moreover, they reported that the average effect size for science teacher PD studies was small and was not significantly different from zero (0.05 for pre-post design and 0.18 for post only design). This study was about physics teachers' PD but contrary to their result showed moderate effect size. Furthermore, among the 16 studies they worked on, ten used quasi-experimental designs. Of the ten studies, two resulted in negative, six small, one moderate and one large effect size. Thus, on the average, the effect size resulted in the current quasi-experimental study does not concur with similar studies analysed by Blank and Alas. Another different result; the design of the current study was preliminarily based on collaboration of teachers, the PD programs analysed by Blank and Alas that offer collaboration networking for participating teachers show marginal (ES= .01) or near zero impact.

When regarding the effect size, the result of this study concurs with Yoon et al.'s (2007) review. While the effect size was 0.52 (Cohen's d) for this study, the average effect size across the nine studies they reviewed was 0.54. They found that the effect size was fairly consistent across the three content areas. The effect size calculated in this study regards physics and it was 0.52. Similarly, Yoon et al. found 0.51, 0.57 and 0.53 for science, mathematics, and reading and English/language arts, respectively. Further, among the nine studies reviewed by Yoon et al. (2007) three (Carpenter et al., 1989; Saxe et al., 2001 & McCutchen et al., 2002) were focusing on deepening teachers' content knowledge and understanding of how students learn.

The average effect size was 0.614 for these three studies, which is more or less close to the calculated effect size (0.52) of the current study. Furthermore, quasi-experimental design was used for this study and a moderate effect size was calculated. Concurrently, both the randomized controlled trials and quasi-experimental designs reviewed by Yoon et al. resulted in moderate effect sizes. They found that while the average effect size for the randomized controlled trials was 0.51, the average effect size of quasi-experimental designs was 0.61.The comparison of this study with the Meta-analysis of Blank and Alas (2009), and review of Yoon et al (2007) on some parameters is given in Table 5.1.

Table 5.1 Comparison of this study with Yoon et al. (2007), and Blank and Alas (2009)

Studies	Contact hours	duration	Sample		Effect Size
			Teacher	Students	
This study, 2014	15 hours	About two months	6	306	0.52
Yoon et al. 2007	5-100 hours Average 49 hours	1-12 months Average 5 months	5-44 teachers Average 22 teachers	98 -779 students Average 337 students	–0.53 - 2.39 Average 0.54
Blank and Alas, 2009	2-540 hours Average 91 hours	1 day- 16 months Average	6-198 teachers Average 45 teachers	70-7813 students Average 1116 students	–0.19 - 1.63. Average 0.31

Table 5.1 shows that both the average duration and the average contact hours of the review (Yoon et al., 2007) and that of the Meta-analysis (Blank & Alas, 2009) are greater than both the duration and the contact hours of this study. A similar interpretation is also valid for the average number of students and teachers

participating in the studies. However, the effect size calculated for the present study is slightly less than the average of that of Yoon et al., and it is considerably more than the average of that of Blank and Alas. When these conclusions are assessed in the general context of professional development it is too early to build a link between the duration-effect size and contact hours- effect size.

Additionally, Yoon et al. (2007) pointed out that while the studies that had more than 14 hours of PD showed a positive and significant effect on student achievement from PD, the studies that involved the least amount of PD (5–14 hours total) showed no statistically significant effects on student achievement. Concurrently the present study applied 15 hours (the adaptation meetings are not included) of PD and showed a statistically significant effect on student achievement. Thus, while Yoon et al. reports 14 hours as the critical amount of PD that might lead to student achievement, Blank and Alas raise this amount to 100 hours. It seems that more and more research is needed in the area of experimental PD to speak with greater certainty.

Secondly, the effect size (Cohen's d) calculated for the effect of treatment (TTT course) of this study was 0.52. The 42 reported effect sizes of 23 studies on the relation between PD and student achievement ranges between -0.59 and 2.39. Except for 11 effect sizes in eight studies, the remaining 31 effect sizes of known PD studies were less than 0.52. What was clear was that each of these eight studies have longer duration than the duration of current study. While 15 hours of PD activities was conducted for the current study an average of 36 hours were spent for these eight studies. However, these 36 hours of PD activities were conducted over the course of 6.25 months (on average). Therefore an average of six hours was used per month (1.5 hours per week) for PD in these studies. The teachers participating in the current study received 15 hours of PD in the course of five weeks and they were subjected to three hours of PD per week. Consequently, the studies which have higher effect sizes have longer average duration than the current study but also have less average intensity.

On the other hand, the studies that have fewer effect sizes on average have conducted 72 hours of PD activities. Moreover, the average time span for these studies was 5.40 months. Therefore, the intensity for these studies was approximately 3.33 hours per week. Thus, the studies which have fewer effect sizes have longer average duration and higher average intensity than the current study. As a result, when the PD studies are compared in terms of only duration or only intensity, no meaningful inferences are derived. For instance, the study conducted by Carpenter et al. (1989) has an intervention of intensity of approximately 5 hours per week (83 hours over four months) and its effect size is 0.41. However, that of Cole (1992) reported an effect size of 0.82 for reading and has an intensity of 0.8 hours per week (40 hours over a year). Further, among the 23 experimental studies, the most intensive study (Marek & Methven, 1991) which was designed to give 100 hours of PD in only one month has less effect size (0.39) than the least intensive study (Heller et al., 2007) which gave 10 hours of PD in the course of eight months (ES=0.69). Similar contradictory results were found in other studies (see Table 2.2 and Table 2.3). Furthermore, in their Meta-analysis, Blank and Alas (2009) saw that there was an inconsistent pattern in the relationship of 'time' and 'duration' to effects. Thus, rather than duration, the PD studies should be compared in terms of some other parameters.

Thirdly, when regarding intensity, that is the number of contact hours per week, that of this study is just below the average of the 23 known experimental studies. While 15 hours of PD activities were conducted for the current study, an average of 49 and 91 hours were spent for Yoon et al.’s (2007) review and Blank and Alas’s (2009) Meta-analysis, respectively. However, these 49 and 91 hours of PD activities were conducted in the course of five and six months (on average), respectively. Therefore, an average of 9.8 hours was used per month (2.5 hours per week) for PD in the review of Yoon et al. Similarly, an average of 15.2 hours was used per month (3.8 hours per week) for PD in the Meta-analysis of Blank and Alas. However, teachers participating in current study received 15 hours of PD in the course of five weeks and they were subjected to three hours of PD per week. Consequently, while the average intensity of PD in the Meta-analysis was higher, the average intensity of reviewed experimental PD studies was less than the intensity of this study. Astonishingly, in terms of the effect sizes the reverse is true!

5.1.4 Why do experimental PD studies usually result in moderate or small effect sizes?

Since this question was not discussed within the context of experimental PD in the literature, the personal opinions of the researchers may be useful for future studies.

Probably or logically the PD designs are faced with three consecutive losses. First of all, the participating teachers cannot construct adequate knowledge from the collaborating teachers' collective knowledge or from the mentor/coach. Second, teachers cannot utilize all the constructed or acquired knowledge in their classes. Third, students can not reflect all this knowledge in their test results. It may be because of all these losses that the effect of the PD decreases so much. The results of MPUAT-T and that of MUAT-S support these losses. While the effect size calculated for the teachers' achievement test was large (.93), for students it was medium (.52). (The effect size for teacher data was calculated through descriptive statistics and that of student data was calculated through inferential statistics). Now, an important question arises: How can we minimize these losses? Or which characteristics of PD decrease these losses the most? It seems that content focus, active learning, coherence, collective participation, long duration, intensive, sustained and delivered in conductive settings characteristics minimize the first loss. Just-in time teaching doubtlessly minimizes the second loss. Nevertheless, there are no features associated with effective PD that can minimize the third loss. In order to decrease this loss, some other factors (such as students' motivation, good testing conditions and so on) have to be considered with PD designs. Figure 5.1 is designed to represent these losses.

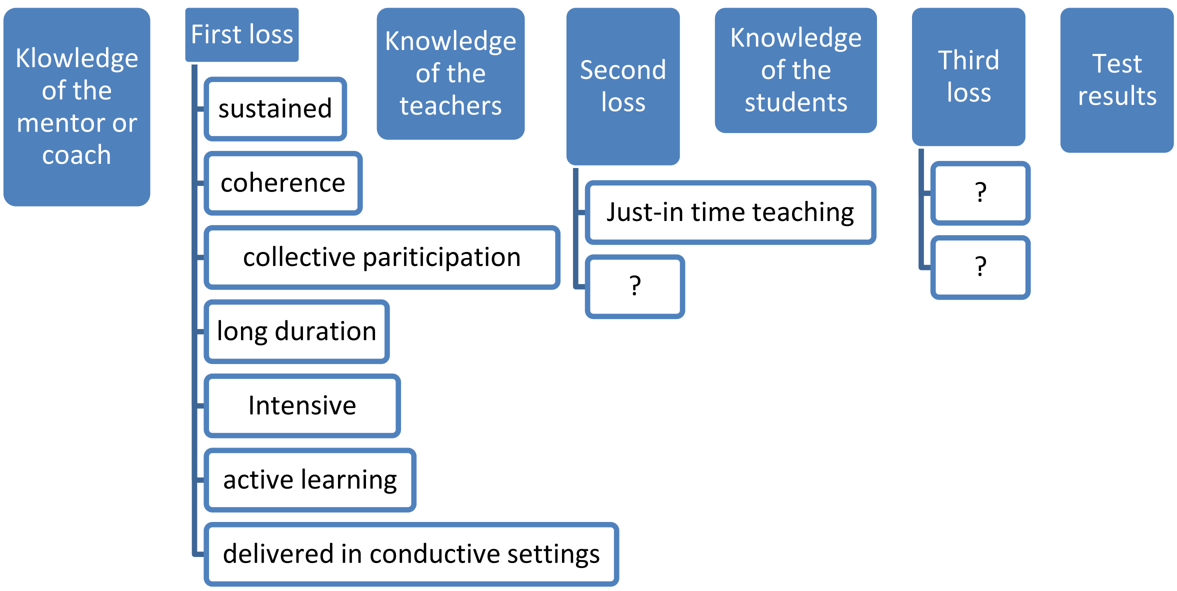

Figure 5.1 A model representing the decrease in the effect of PD interventions

5.2. Internal Validity of the Study

The internal validity of the study refers to the degree to which extraneous variables may influence the results of research. A study that claims it has internal validity must provide that the "observed difference on the dependent variable is directly related to the independent variable(s), and not due to some other unintended variables" (Fraenkel & Wallen, 1996, p.242). There are various possible threats that most of the studies are vulnerable to. Because of the complexity of this study there were many possible threats that may affect its validity. Possible treats to internal validity and the methods used to cope with them are discussed in this section.

Subject characteristics, mortality, location, instrumentation (instrument decay, data collector characteristics, and data collector bias), testing, history, maturation, attitude of subjects (Hawthorn effect, John Henry effect, and demoralization effect), regression, and implementer threats are the threats that most of the experimental studies suffer from. Below are the threats to the internal validity of this study and the proof of their control.

According to the missing data analysis, the percentage of students who missed the tests and students who performed the tests were within the acceptable range. Thus, in order to limit the mortality threat, the missing values were replaced with the series mean. Subject characteristics were not a serious threat because each teacher had two classes, of which one was the control group and the other was the experimental group class. The teachers randomly assigned their equal (in terms of physics achievement) classes to the groups. Moreover, one of the covariates analyses was used as statistical analysis to match the subjects of groups on some variables which were the Pre-MPUAT-S, Post-MPUAT-T, SCG, and TE. Therefore, potential pre-existing differences on students' academic achievement, their teachers' academic achievement, their first term physics course grades and their teachers' experience were adjusted through ANCOVA. This analysis was expected to reduce the potential effect of subject characteristics threat.

There was a possibility of both teachers and their students changing their behaviour due to the attention they were receiving by participating in the study, known as Hawthorne effect. The possibility also existed that the treatment group teachers could teach harder in their control group classes in an attempt to show that they could teach better without participating in a service training course. This is known as the John Henry effect. In order to eliminate any possible influences of both the Hawthorne effect and John Henry effect, both teachers and students were informed about the study. They were told that the treatment was just a regular part of instruction. Moreover, the teachers didn't teach to their control and experimental classes at the same time. That's why there was no possibility of control and experimental group students affecting each other. For instance, the control groups could not take a rivalry position because initially they were taught the MPU, then subsequently the experimental groups were taught MPU. Furthermore, since teachers willingly participated in this study there was no reason to change their behaviour due to becoming part of this special study. Moreover, in terms of students, since groups were instructed at different times (bimonthly) a potential interaction between them was not observed.

Four teachers initially taught the MPU to one of their classes (control group) then they taught to experimental group classes. The gained experiences in teaching the MPU beforehand might interfere with the practices gained during the treatment. There were two factors that could avoid this threat. First, teachers taught the same unit bimonthly. There was a sufficient span of time between the two teaching sessions not to influence each other. Second, of the 6 teachers, 2 of them constituted a placebo group; they did not participate in the TTT PD course; that is, they taught both of their classes as usual. In other words, a design like Solomon four-group design was used to control the effect of pre-teaching. The results of placebo groups and those of treatment groups were analysed for any interaction effect and no interaction was observed. Moreover, the success or failure of the placebo group students might be because of the competencies of their teachers. To avoid this threat during the determination of the treatment and the placebo groups, attention was paid to their equality. Table 3.5 guided the researcher in equating the groups according to their experiences. Further, in order to equate the groups of students, their teachers' experiences were used as a covariate. Furthermore, the case of teachers and students having the same achievement test brings with it the possibility of teachers 'teaching to the test'. That's why separate achievement tests were prepared for students and teachers on the tenth grade MPU. Additionally, to avoid the possibility of the researcher distinguishing the teachers according to their academic achievements during the TTT PD course, the researcher did not calculate the pre-test scores of the teachers until the post-test was applied.

Since all data were collected by the conductor of the current study and the collection procedure was standardized, the data collector characteristics threat was prevented. That is, no extra time was given to any classes, all classes were tested one week after the end of the main course and the researcher was careful in all classes to avoid any cheating. Data collector bias is also an important threat to the internal validity. All data were collected by the researcher and data collection procedure was standardized.

One control and one experimental group were selected from each school, during class observations it was seen that each pair of classes was in a similar setting. Therefore, there were no factors to cause a location threat. The treatment given to students was given by the original teachers of the students. In order to minimize the implementation threat, treatment verification was conducted as discussed in Section 4.1.

Students' levels in academic achievement were measured through multiple choice test items and the evaluation process was computerized. That's how an instrument decay threat was prevented. Moreover, there were two data collection instruments applied to the teachers. One of them was only applied to four (MPUAT-T) and the other one was applied to the 12 teachers (TTTEF). Thus scoring the results of these two instruments was an easy process for the researcher.

Pre-tests were used in this study, which is why students' improvement may be caused by practice on the pre-test. First of all, the test was about the MPU and students were not familiar with the concepts of this unit. Therefore, it was difficult for students to remember the pre-test questions and practice them. Second, since pre-tests were conducted in both groups, any possible threat is valid for both groups. Third, there were two months between the pre-tests and post-tests. This could also help to minimize a testing threat. Fourth, to avoid or minimize this threat the aim of the pre-test was not explained to the students. Fifth, students didn't know that they were going to have the same test once more. Finally, teachers never saw the test items until the post tests were applied.

This study is free from the history threat because neither the researcher nor the teachers reported any unexpected or unplanned events that might have affected students' performance. Since this study was conducted during the course of two months the maturation threat is not a serious problem in this study. The groups of students participating in the current study were intact groups from high schools. Since students were not selected based on extreme features such as 'high achievers' or 'low achievers,' the regression threat was also eliminated.

Furthermore, the researcher claims that there was one more instrumentation threat which does not appear in the literature. Some researchers because of economic reasons use a test booklet several times, which spoils the booklet. When a test booklet has been used several times some of its questions are erroneously answered by students, which usually confuses the next examinee, or at times the booklets are written on and again it disturbs the next examinee. This threat will be called 'instrument spoil' and in order to avoid this treat, for each examiner a unique booklet was used. Moreover, in the case of reuse of the same booklet it was checked by the researcher for any excessive wear.

As described above possible threats to this study were controlled up to a desired level. Thus, any development in teachers and their students can safely be attributed to the PD applied to them. That is, the observed differences in teachers' knowledge and the achievement of their students are due to TTT PD.

5.3 External Validity of the Study

According to the ANCOVA, there is a statistically significant mean difference between instruction after TTT PD course and traditional instruction with respect to academic achievement. The accessible population is all tenth grade students from Anatolia high schools located in the city centres of three central districts of Ankara. Subjects from six schools out of 24 in these districts have almost the same characteristic in terms of prior achievement and socioeconomic status.

The number of students (n=306) who participated in the study exceeds 10% of the accessible population. However, since the participants of the current study were not randomly selected, the results of this study cannot be generalized to the accessible population of the study. The socioeconomic status of families of the students included in the sample was usually medium. Consequently, the results of this study can be generalized to other populations if they have similar characteristics as those in the current study. Moreover, a low rate of loss of subjects in the post-tests cannot be considered as a limitation in generalization of the results.

The current study was carried out in the second semester of the school year. The treatments were carried out in teachers' regular classes. The number of students in each class ranged from 18 to 35. The tests were administered during school days. The tests were administered in classes within one lecture hour. Results of the study are valid under these conditions. Therefore, the results of the study can be generalized to other Anatolian high schools which have similar ecological conditions described above.

5.4 Conclusions

This research has several limitations regarding the characteristics of the current study. First of all, qualitative data was gathered from the class observations of only six teachers; these were volunteer teachers and, moreover, they were purposively selected (see section 3.1.1). Secondly, even though an extensive literature review was conducted, only 23 experimental studies were found. There may be more experimental PD studies and this study does not include experimental studies published after year 2009. Thirdly, because of the nature of this study, teachers were free during pre-teaching (control group). However, during post teaching (experimental group) they were compelled to teach one of the objectives of the MPU each week. Consequently, since during pre-teaching teachers taught the MPU haphazardly, control and experimental groups were not taught the MPU in equal amounts. This study's conclusions may have been impacted or influenced by the above limitations.

One of the purposes of this study was to investigate the influence of the TTT PD program on teachers' knowledge of the MPU. First, the results of class observations showed that TTT PD has increased teachers' MPU specific subject matter knowledge (SMK), pedagogical content knowledge (PCK) and has not affected the teachers' pedagogical knowledge (PK). The details of this conclusion were given in Section 4.3 (the COF results). Second, the class observation results showed that the TTT PD increased teachers' self-confidence and participating teachers gained better knowledge and skills in teaching MPU. Further, participating in the TTT PD course caused teachers to teach the MPU in accordance with the requirements of the curriculum. Third, as perceived by the participating teachers, the TTT PD is an effective program in increasing teachers' knowledge. Moreover, teachers affirmed that the TTT PD is a useful program for teachers in PD, and their attitudes toward the TTT PD were positive. The details were given in Section 4.2 (the TTTEF results).

The second purpose of this study was to find a link between PD and student achievement. The results of ANCOVA showed that TTT PD had a significant effect on the students' post-MPUAT scores. In other words, the students who were instructed after their teachers participated in the PD course attained significantly higher achievement scores in MPU than the students who were instructed before their teachers participated in the PD course. The data collected through the achievement test applied to the treatment group students strongly support that the TTT PD is an effective program to increase teachers knowledge and indirectly students' achievement in MPU, and there is statistically ($p<.05$) and practically (dCohen=.52) significant mean difference between the TTT PD and traditional instruction in favour of the TTT PD. This means that the students who are instructed after their teachers participated in the TTT PD have better achievement scores than the students who are instructed before their teachers participated in TTT PD.

Furthermore, the effect of pre-teaching on students' achievement was also investigated. The separate ANCOVA results showed that a significant negative effect of pre-teaching was observed. The possible reasons behind the negative effect of pre-teaching were discussed in the previous chapter (see Sections 4.5 and 4.7.3.1). The data collected through achievement test applied to placebo group students indicate that gaining an experience through pre-teaching is not effective in increasing students' achievement scores. On the contrary, a statistically ($p<.05$) significant mean difference between the pre- and post-teachings was observed in favour of the pre-teaching sessions.

On the other hand, it was thought that any increase in students' achievement should be strongly related to an increase in achievement of teachers' who participated in the TTT PD course. The study was designed to explore this reasoning. In order to see any change in participating teachers' success, an achievement test was applied to them. While the teachers who participated in the TTT PD course (treatment group teachers) increased their own post-MPUAT-T scores, the teachers who did not participate in the course (placebo group teachers) could not increase their post-MPUAT-T scores. A large effect size (dCohen=.93) was calculated for the effect of TTT PD on teachers' achievement.

Furthermore, it was again reasoned that without knowing the change in teachers' knowledge, reporting any change in students' achievement alone would be problematic. Accordingly, rather than investigate the teachers' knowledge (Shulman, 1987) through interviews and surveys, this study followed the strategy of investigating the development of teachers' knowledge through classroom observations. Classroom observations were made to directly see the change in teachers' knowledge and validate the change in students' achievement. Thus, this strategy successfully related the effect of the TTT PD course on teachers' knowledge to its effect on student achievement.

Moreover, in this study a PD program used by some private schools to enhance their teachers' teaching skills was utilized to change the participating teachers' knowledge and their students' achievement. The class observation and teachers course evaluation results showed that TTT PD is effective in increasing teachers' knowledge. Similarly, the achievement test results showed that TTT PD possesses the adequate potential to increase both teachers' and students' success. Thus, it can be concluded that the results of this study support the effectiveness of TTT PD. Namely, TTT PD can be offered to policy makers who seek models supported by research evidence. Moreover, the effective PD features specified for this study were successfully incorporated in the TTT PD. In other words, the effective characteristics - content focus, active learning, coherence, collective participation, sustained and intensive, delivered in conductive settings and just-in time teaching - were successfully carried out within the structure of the TTT PD course.

Additionally, as mentioned in the first and second chapters, there is little research performed on the relation between PD and student achievement. Further, the known experimental PD studies all have different types of interventions and different designs. Among the 23 experimental studies discussed in the first and second chapters few were purely experimental and most of them were quasi-experimental designs. Moreover, most of them were post-test only designs. In this study separate designs were used for teachers and students. Regarding students, this was a quasi-experimental design. However, the design developed for the teachers, matches with none of the designs of the known 23 experimental studies. That is to say, in this study the design used for teachers eases experimental studies in the area of teacher PD, which is very rare. Rather than composing control and experimental group teachers (actually it seems difficult to equate them), having some teachers initially teaching to one class, then giving teachers a PD treatment and finally having them teach the same 'unit' to another class, it is easier to conduct an experimental study. The conduction of this study indicated that when such a design is utilized probably it will be easy to compare the pre- and post-teaching of teachers and accordingly investigate the effect of PD programs.

Consequently, in this study, the effects of the TTT PD course on teachers' knowledge and their students' achievement were investigated. In doing so, this study provided the physics education community with specific data regarding the link between professional development and student achievement in the area of the tenth grade modern physics unit.

5.5 Implications

The implications derived from this study can be compiled for in-service trainers and for researchers.

For in-service trainers

- The TTT PD course has been used by some private schools in Turkey for more than 20 years. It is now empirically validated that this PD model has empowered teachers to take an active role in the programs and has enabled teachers to collaborate in increasing students' achievement. Thus, this model is suggested to be used in teacher PD.
- Staff developers should design and implement PD programs similar to TTT PD to help teachers abide by the curriculum. None of the participants in this

study conducted their lessons in accordance with the requirements of the national curriculum prior to their participation in TTT PD.

- This study was conducted on the MPU which was newly added to the Turkish tenth grade national physics curriculum. When new topics are added to the curriculum teachers usually need help in teaching them. Accordingly, these results suggest that staff developers should consider including such topics to in-service programs (a) to help teachers to practice teaching the new topics (b) to increase the participation rate.

- Even though the intervention utilized in this study possessed most of the effective characteristics of PD, it resulted in moderate effect size. From this conclusion the researcher takes the liberty to state that any in-service training course that does not possess most of the characteristics of the effective PD should not be conducted.

- Teachers were eager to understand and discuss the concepts of the MPU during the TTT course. This unit was newly added to the national curriculum and a needs analyses survey indicated that teachers need help in teaching this unit. Based on this fact it can be said that in-service training courses should be comprised of topics that are attractive to teachers. Accordingly, programs should especially focus on teachers' knowledge of the subject (that is SMK).

- The evidence from the conduction of the current study suggests that teachers should receive in-service trainings that they will immediately be able to incorporate into their daily instructional planning. There should not be long duration between receiving PD and the application of this PD. In other words, just-in time teaching of teachers should be preferred.

- For the placebo group, the placebo pre-group students were more successful than placebo post-group students. One of the classes (T1C1) of this group had the post-test after the physics exam, regarding the MPU during pre-teaching. This was the reason behind the success of that class (see Table 4.20). Thus, when conducting the tests, they should not be applied after the students' exam regarding the same topic. This is a serious threat to the internal validity.

- During the conduction of the TTT courses it was observed that teachers could not end some discussions and could not explain some concepts (see Appendix Y). It is now clear that teachers need support especially when discussing counterintuitive concepts such as modern physics concepts. For this reason it is recommended that content focused PD programs should be conducted at the helm of a scholarly coach.

For researchers

- This study primarily aimed to increase teachers' SMK during the TTT course and a positive effect was detected on students' achievement. Thus, it can be said that one way to improve physics teachers' quality and subsequently increase student achievement, is to design the research to increase teachers' SMK.

- This study suggests that instead of investigating the effect of PD on student achievement alone, the effect of PD on teachers, also should be investigated. Because without knowing with certainty of any change in teachers knowledge, claiming any change in students' achievement is controversial.

- The researcher donated many physics course books, notebooks, pens, pencils and flash disks and it was observed that teachers were motivated with these donations. Thus, this study suggests that both before and during the conduction of studies that take teachers into account, the participating teachers should be motivated with gifts.

- While determining which teachers should participate, it was seen that when teachers were told explicitly they generally chose to participate in the TTT course. Thus, researchers should intrinsically motivate teachers through explaining the importance and the necessity of the course while composing the sample of the study.

- There are 23 PD studies that tried to find a link between PD and student achievement. However, almost all have different designs. Since the nature of research on teacher PD in science is complicated and difficult, the design of this study can be used to conduct feasible experimental studies. In other words, finding teachers of similar experience or achievement levels and then composing control and experimental groups is very difficult. Instead, as employed in this study, the effect of a treatment can be investigated by looking at pre- and post- teachings of the same 'unit' by the same teachers. In other words, teachers should first teach the unit (such as MPU) to one of their classes (control group) and after having a treatment then they should teach the same unit to the equivalent counterpart class (experimental group). Thus, once both groups are pre- and post-tested the effect of the intervention can be revealed.

- In experimental PD studies teachers are mostly equated in terms of experience. The evidence from achievement test results and class observations of this study showed that along with experience, academic achievement also should be taken into account when equating teachers. The researcher strongly suggests that before equating teachers, their performances in the classroom should be observed.

- When the results of this study are compared with the similar studies from the literature it revealed that comparing the effect sizes of PD studies with duration and contact hours or intensity does not give meaningful results. For this reason more and more studies are needed to make safe inferences.

5.6 Suggested best practices of TTT development and implementation

- It was observed by the researcher that the TTT PD process could take a great deal of time and could become tiring. Those who wish to conduct the TTT PD should plan each step carefully and be ready for a tiring process. Motivating teachers throughout the course, being careful not to disturb teachers during class observations, planning to observe as many lessons as possible, urging teachers to finish the previous unit and start the current unit on time, possessing satisfactory knowledge of the unit to actively guide teachers during the discussions, and being patient while preparing of the various instruments required to collect and triangulate the data - all of these are especially tiring processes.

- During the teacher selection process, researchers should start with as many teachers as possible. Some teachers initially may promise to participate but once the course starts they may make excuses and drop out.

- The TTT PD was held on evenings in this study. The teachers usually participated in the TTT PD after school work. Therefore, ordering dinner was a must! Coffee and tea during the course was also good. Figure 5.2 is a view of one of the meals eaten together. The one without the rose is the researcher.

Figure 5.2 A scene from the dinner with participating teachers

- During the course of this study six teachers were observed during both pre- and post-teaching. The teachers were from different schools. Course hours of some of the teachers overlapped. The researcher asked the principals of the schools to change the course's place on the time table. Gifts and sincerity eased the work of the researcher.

- Teachers are usually annoyed when they are observed. Thus, in order not to annoy them, both before and during class observations researchers should help the teachers feel relaxed. For example, giving a gift (book, notebook, diary, pen, pencil, flash disk), speaking about the topic that the teacher will present and not looking directly at teacher during instruction helps him/her to feel unburdened.

- Researchers who may use this design should carefully decide on the unit which they will take into account. Since the participant teachers will change the sequence of this unit in one of their classes, there shouldn't be high relation between this unit and the pre- and post-units. In this study, the MPU was taken into account and the concepts in this unit are not closely related to other high school physics units.

- The unit that will be taught during the PD course should increase the participation rate and draw teachers' attention to the course.
- This researcher understands why there is so little study on the effect of PD programs on student achievement. Fullan (1990, pg. 7) describes the situation the best.

In short, staff development, implementation of innovation, and student outcomes are closely interrelated, but because they require such a sophisticated, persistent effort to coordinate, they are unlikely to succeed in many situations. Any success that does occur is unlikely to be sustained beyond the tenure or energy of the main initiators of the project.

Thus, supervisors should encourage researchers and substantial economical help should be provided for starting an experimental PD study.

5.7 Recommendations for Further Researches

This study provided insights into how tenth grade high school students' physics achievement could be improved through a PD program focused on enhancing teachers' knowledge of physics content. The PD program used in this study not only yielded a positive effect on student achievement but also increased teachers' SMK and PCK. Moreover, it was relatively easy to conduct. With these in mind, the following recommendations are made for future researchers.

- In this study, the effect of the TTT course on the three dimensions (SMK, PCK and PK) of Shulman's (1987) teacher knowledge was investigated. Future research should consider improving all dimensions of teacher knowledge through the TTT course.
- The TTT course, in this study, was designed for physics teachers. Future researchers should consider its effects in other subject areas such as mathematics, chemistry or biology. Moreover, MPU was engaged during the

TTT course; studies including other units should be conducted to determine if the results are similar or different from the findings in this study.

- A literature review indicated that the number of studies fully addressing PD's direct effect on teachers and its indirect effect on students' achievement is notably less. Replicating this study will increase the number of desired studies that directly examine this link.

- The current study preliminarily was designed to increase the SMK of teachers; the same design can be used to increase other teacher knowledge (Shulman, 1987) areas.

- Additional investigations using this PD model should consider comprising two or more units. Such a study may be able to indicate more reliable statistically significant results on the effect of the TTT PD program over the course of several units.

- Although a five week implementation period was sufficient to register significant change in teachers' knowledge and students' achievement, longer periods may produce more reliable changes. Time and practice may be necessary factors to help teachers to increase their knowledge.

- It was seen that the TTT PD had a direct positive effect on teachers' PD and an indirect effect on the students' achievement. A similar study can be conducted at different grade levels to determine if a PD using TTT would have effects in other grades.

- Along with the literature, this study implies that future studies conducted on the link between PD and student achievement can make it possible to determine whether PD programs designed for teachers have positive impact on students' achievement.

- Research that compares PD studies in terms of design and the quality of intervention may be noteworthy. For example, the common points of the interventions of the experimental PD studies that have low, moderate and large effect sizes can be studied.

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APPENDIX A

TENTH GRADE MODERN PHYSICS UNIT CURRICULUM

ONUNCU SINIF MODERN FİZİK ÖĞRETİM PROGRAMI

KAZANIMLAR	AÇIKLAMALAR
1 Modern fizik ile ilgili olarak öğrenciler; 1.1 Modern fiziğin doğuşuna katkıda bulunan gelişmeleri açıklar. **FTTÇ 1. Fizik ve teknolojinin doğasını anlar.** **FTTÇ 2. Fizik ve teknolojinin birbirini nasıl etkilediğini analiz eder.**	⇤⇥ **1.1** Modern fiziği oluşturan temel unsurlardan biri olan görelilik açıklanır, diğerlerinden (ışığın yapısı, atomun yapısı ve elektromanyetik ışıma enerjisinin kesikli olması) ise kısaca bahsedilerek ayrıntıları ilerleyen yıllarda verilir. **[!] 1.1** Yirminci yüzyılın başlarına kadar fiziğin daha çok - görece kütlesi büyük ve hızı küçük olan - makro evrendeki olayları açıklamaya çalıştığı ve bu alanın “Klasik Fizik” olarak adlandırılabileceği; günümüzde ise mikro evrendeki (atom ve atom altı parçacıklar) ve ışık hızına yakın hızlarda hareket eden cisimlerin hareketini açıklamaya odaklandığı ve bu alanın ise “Modern Fizik” olarak adlandırılabileceği vurgulanır. **[!] 1.1** Modern fiziğin; kuantum, atom ve çekirdek fiziği, katıhal/yoğun madde fiziği gibi alt isimler altında da incelenebildiği belirtilir. **??? 1.1 “**Modern fizik ve klasik fizik yasaları farklıdır.”, “Klasik fizik yasalarının yerini modern fizik yasaları almıştır.” FTTÇ 1b. Fizik biliminin sınanabilir, sorgulanabilir, doğrulanabilir, yanlışlanabilir ve delillere dayandırılabilir bir yapısı olduğunu anlar. FTTÇ 1h. Anahtar fizik kavramlarının farkına varır (değişim, etkileşim, kuvvet, alan, korunum, ölçme, olasılık, kesinlik, ölçek, denge, madde-enerji ilişkisi, uzay-zaman yapısı, rezonans, entropi vb.). FTTÇ 1n. Fizik ve teknolojiye farklı kültürlerden birçok kadın ve erkeğin katkıda bulunduğunu farkına varır. FTTÇ 1o. Fiziğin ve teknolojinin ilerlemesinde sürekli sınamanın, gözden geçirmenin ve eleştirmenin rolünü değerlendirir.

FTTÇ 3. Fizik ve teknolojinin birey, toplum ve çevre ile etkileşimini analiz eder.	FTTÇ 2a. Fizik ve teknoloji arasındaki etkileşimin tarihsel gelişimini inceler. FTTÇ 2b. Teknolojik bir yeniliğin, fizik bilimindeki bilimsel bilgilerin gelişmesine yaptığı katkıyı örneklerle belirler ve açıklar. FTTÇ 2c. Fizikteki, bilimsel bir bilginin teknolojinin gelişmesine yaptığı katkıyı örneklerle belirler ve açıklar. FTTÇ 3n. Fizik ve teknolojideki önemli bir buluş veya uygulamanın, bilim dünyasını ve toplumu nasıl değiştirdiğini açıklar.
BİB 1. Bilgiyi arar, bulur ve uygun olanı seçer.	BİB 1a. Farklı bilgi kaynaklarını kullanır. BİB 1b. Bilgi kaynaklarının güvenilir ve geçerli olup olmadığını kontrol eder. BİB 1c. Çoklu arama kriterleri kullanır. BİB 1d. Amacına uygun bilgiyi arar, bulur ve seçer.
TD 2. Fiziğe ve dünyaya karşı olumlu tutum ve değerler geliştirir.	TD 2a. Fizikteki gelişmeleri izler ve değerini bilir. TD 2b. Fiziğin ve teknolojinin bugünkü sınırlılıklarını bilir ve ona göre davranır. TD 2d. Fizikteki gelişmelerin günlük yaşamımızdaki uygulamalarından dolayı bu gelişmelerin çevresel, ekonomik ve sosyal sonuçlarından haberdar olur. TD 2e. Birçok meslek dalının fizik bilgisi içerdiği gerçeğinden yola çıkarak fiziğe önem verir.
2 Özel görelilik ile ilgili olarak öğrenciler; 2.1 Işık hızının eylemsiz referans sisteminden bağımsız olduğunun ileri sürülmesine neden olan araştırmaları açıklar.	**[!] 2.1** İvmesiz (duran veya sabit hızla) hareket eden gözlem çerçevesine eylemsiz referans sistemi denildiği belirtilir. Evrende mutlak eylemsiz bir referans sisteminin olmadığı ve dünyanın eylemsiz referans sistemi olarak kabul edilebileceği vurgulanır. Eylemsiz bir referans sistemine göre ivmesiz hareket eden gözlem çerçevesinin de eylemsiz referans sistemi kabul edildiği ifade edilir. **2.1** 9. ve 10. sınıflar, Kuvvet ve Hareket Üniteleri. **2.1** Michelson ve Michelson-Morley deneylerinden formüllere girilmeden kavramsal olarak bahsedilir. **??? 2.1** "Evren esir denilen bir madde ile doludur."

FTTÇ 1. Fizik ve teknolojinin doğasını anlar.	FTTÇ 1b. Fizik biliminin sınanabilir, sorgulanabilir, doğrulanabilir, yanlışlanabilir ve delillere dayandırılabilir bir yapısı olduğunu anlar. FTTÇ 1h. Anahtar fizik kavramlarının farkına varır (değişim, etkileşim, kuvvet, alan, korunum, ölçme, olasılık, kesinlik, ölçek, denge, madde-enerji ilişkisi, uzay-zaman yapısı, rezonans, entropi vb.). FTTÇ 1n. Fizik ve teknolojiye farklı kültürlerden birçok kadın ve erkeğin katkıda bulunduğunu farkına varır. FTTÇ 1o. Fiziğin ve teknolojinin ilerlemesinde sürekli sınamanın, gözden geçirmenin ve eleştirmenin rolünü değerlendirir.
FTTÇ 2. Fizik ve teknolojinin birbirini nasıl etkilediğini analiz eder.	FTTÇ 2a. Fizik ve teknoloji arasındaki etkileşimin tarihsel gelişimini inceler. FTTÇ 2b. Teknolojik bir yeniliğin, fizik bilimindeki bilimsel bilgilerin gelişmesine yaptığı katkıyı örneklerle belirler ve açıklar. FTTÇ 2c. Fizikteki, bilimsel bir bilginin teknolojinin gelişmesine yaptığı katkıyı örneklerle belirler ve açıklar.
FTTÇ 3. Fizik ve teknolojinin birey, toplum ve çevre ile etkileşimini analiz eder.	FTTÇ 3n. Fizik ve teknolojideki önemli bir buluş veya uygulamanın, bilim dünyasını ve toplumu nasıl değiştirdiğini açıklar.
BİB 1. Bilgiyi arar, bulur ve uygun olanı seçer.	BİB 1a. Farklı bilgi kaynaklarını kullanır. BİB 1b. Bilgi kaynaklarının güvenilir ve geçerli olup olmadığını kontrol eder. BİB 1c. Çoklu arama kriterleri kullanır. BİB 1d. Amacına uygun bilgiyi arar, bulur ve seçer.
TD 2. Fiziğe ve dünyaya karşı olumlu tutum ve değerler geliştirir.	TD 2a. Fizikteki gelişmeleri izler ve değerini bilir. TD 2b. Fiziğin ve teknolojinin bugünkü sınırlılıklarını bilir ve ona göre davranır. TD 2d. Fizikteki gelişmelerin günlük yaşamımızdaki uygulamalarından dolayı bu gelişmelerin çevresel, ekonomik ve sosyal sonuçlarından haberdar olur. TD 2e. Birçok meslek dalının fizik bilgisi içerdiği gerçeğinden yola çıkarak fiziğe önem verir.
2.2 Özel görelilik kuramının temel kabullerini açıklar.	**[!] 2.2** Bu kabuller "Fizik yasaları tüm eylemsiz referans sistemlerinde aynıdır" ve "Işık hızı, eylemsiz referans sisteminde, ışık kaynağının ve gözlemcinin hareketinden bağımsızdır (Örneğin, ışığın boşluktaki hızı her durumda 3.10^8 m/s olarak ölçülür ve bu hızın elektriksel ve manyetik kuvvetlerin ifadelerindeki sabitlerle belirlendiği)" şeklinde açıklanır. ⇤⇥**2.2** Galileo ve Lorentz dönüşümlerine girilmez.

	[N] 2.2 Einstein - 1921 **[!] 2.2** Işık hızında hareket edildiğinde bu kabullerin gözlemleri nasıl değiştirdiği örneklerle açıklanır. “Işık hızında hareket ederken elimizdeki aynaya baktığımızda kendimizi görüp göremeyeceğimiz” ve “arabayla ışık hızında giderken farları açtığımızda önümüzün aydınlanıp aydınlanmayacağı” temel kabullerin varlığında ve yokluğunda (klasik mekanikle) tartışılır.
BİB 1. Bilgiyi arar, bulur ve uygun olanı seçer.	BİB 1a. Farklı bilgi kaynaklarını kullanır. BİB 1b. Bilgi kaynaklarının güvenilir ve geçerli olup olmadığını kontrol eder. BİB 1c. Çoklu arama kriterleri kullanır. BİB 1d. Amacına uygun bilgiyi arar, bulur ve seçer.
4. İletişim becerileri geliştirir.	BİB 4a. Fizikle ilgili konuşmaları dikkatli bir şekilde ve ilgiyle dinler. BİB 4b. Fizik kavram, terim ve yasalarını içeren makale veya diğer yazılı materyalleri okur ve anlar.
2.3 Işık hızına yakın hızlardaki hareketli için uzunluk ve zaman değişimlerini yorumlar.	**[!] 2.3** Cismin hareketi doğrultusundaki uzunluk kısalması ve zaman genişlemesi denklemlerle ve grafiklerle verilir. Denklemlerin karmaşık problemlere uygulanmasına girilmez, ancak grafikler değişkenler arasındaki ilişkiyi yorumlamak için kullanılır. Haftada iki saatlik fizik dersini seçen öğrenciler için uzunluk kısalması ve zaman genişlemesi formüllerine girilmeden grafiklerle kavramsal düzeyde verilir. **[!] 2.3** Bir cismin kütlesinin hıza bağlı olmasının çelişkilere götürdüğü ve anlamlı olmadığı, dolayısıyla durgunluk kütlesi kavramının gereksiz olacağı; cisimler için tek bir kütleden söz edilebileceği vurgulanır. Durgunluk kütlesi yani sadece kütle cismin madde miktarı ve iç enerjisinin (atom altı parçacıklar hariç) bir ölçüsüdür. Yani bir cismin iç enerjisi değişirse kütlesi de değişir (doğal olarak bunun tersi de doğrudur), ancak iç enerjiye bağlı kütle değişimi makroskopik boyutta ölçülemeyecek kadar küçüktür. **[!] 2.3** Özel görelilik kuramına göre; kütleli bir parçacığı ışık hızına ulaştırmak için sonsuz enerji vermek gerektiği, bunun için evrendeki enerjinin yetmeyeceği ve bundan dolayı da ışık hızına ulaşılamayacağı vurgulanır.
BİB 1. Bilgiyi arar, bulur ve uygun olanı seçer.	BİB 1a. Farklı bilgi kaynaklarını kullanır. BİB 1b. Bilgi kaynaklarının güvenilir ve geçerli olup olmadığını kontrol eder. BİB 1c. Çoklu arama kriterleri kullanır. BİB 1d. Amacına uygun bilgiyi arar, bulur ve seçer.

2.4 *Işık hızına yakın hızlar için yeniden yorumlanması gereken bazı temel kavramları örnekler vererek açıklar.	⇤⇥ ***2.4** Bir parçacığın kütlesi hızla değişmezken, kinetik enerji (Ek) ve (Potansiyel enerji dikkate alınmazsa) dolayısı ile toplam enerji (E) hıza bağlıdır. Bu nedenle kütle tüm eylemsiz referans sisteminde aynı kalırken, kinetik enerji değeri ölçüldükleri gözlem çerçevesine bağlı olarak değişir (kuvvet, ağırlık ve ivme gibi kavramların değişimine girilmez). Hız değişimine bağlı olarak kinetik enerji değişimi üzerinde durulur ve kütle-enerji eşdeğerliği açıklanır.
FTTÇ 1. Fizik ve teknolojinin doğasını anlar.	FTTÇ 1b. Fizik biliminin sınanabilir, sorgulanabilir, doğrulanabilir, yanlışlanabilir ve delillere dayandırılabilir bir yapısı olduğunu anlar. FTTÇ 1h. Anahtar fizik kavramlarının farkına varır (değişim, etkileşim, kuvvet, alan, korunum, ölçme, olasılık, kesinlik, ölçek, denge, madde-enerji ilişkisi, uzay-zaman yapısı, rezonans, entropi vb.). FTTÇ 1n. Fizik ve teknolojiye farklı kültürlerden birçok kadın ve erkeğin katkıda bulunduğunu farkına varır. FTTÇ 1o. Fiziğin ve teknolojinin ilerlemesinde sürekli sınamanın, gözden geçirmenin ve eleştirmenin rolünü değerlendirir.
BİB 1. Bilgiyi arar, bulur ve uygun olanı seçer.	BİB 1a. Farklı bilgi kaynaklarını kullanır. BİB 1b. Bilgi kaynaklarının güvenilir ve geçerli olup olmadığını kontrol eder. BİB 1c. Çoklu arama kriterleri kullanır. BİB 1d. Amacına uygun bilgiyi arar, bulur ve seçer.

Sabitler:
c :Işığın boşluktaki hızı: $\cong 3.10^8 \ {}^{m}/_{s}$
Formüller:

* $\gamma = \dfrac{1}{\sqrt{1-\dfrac{v^2}{c^2}}}, \qquad \gamma > 1$

γ: Gözlem çerçeveleri arasındaki dönüşüm katsayısı
v: Hareketlinin hızı
c: Işık hızı

* $L = L_0\sqrt{1-\frac{v^2}{c^2}} = \frac{L_0}{\gamma}$

L: Cisme göre v hızı ile hareket eden bir gözlem çerçevesinde gözlenen uzunluk
L_0: Cisme göre durgun olan bir gözlem çerçevesinde gözlenen uzunluk

* $\Delta t = \frac{\Delta t_0}{\sqrt{1-\frac{v^2}{c^2}}} = \gamma \Delta t_0$

Δt :Cisme göre v hızı ile hareket eden bir gözlem çerçevesinde gözlenen zaman aralığı
Δt_0:Cisme göre durgun olan bir gözlem çerçevesinde gözlenen zaman aralığı

$E = \frac{mc^2}{\sqrt{1-\frac{v^2}{c^2}}}, \quad E = \gamma E_0, \quad E_0 = mc^2$

E: Toplam enerji
m: Cismin kütlesi
E_0: Durgunluk enerjisi

* $E_k = E - E_0 = \frac{mc^2}{\sqrt{1-\frac{v^2}{c^2}}} - mc^2 = mc^2(\gamma - 1)$

E_k: Kinetik enerji

* $\Delta E = \Delta m.c^2$

ΔE:Kütle değişiminin enerji eşdeğeri
Δm :Kütle değişimi

Birimler:
L: metre (m)

t: saniye (s)

E: joule (J)

APPENDIX B

SCHOOL VISITS

OKUL ZİYARETLERİ

Okul	Tarih (yıl 2012)	Okuldaki öğret-men #	Görüşülen öğretmen #	Kabul eden öğretmen #	Görüşme şekli
M. Azmi Doğan A. L.	22.10, 20.12	2	2	1	Ziyaret, Tel.*
M. R. Uzel Kimya A.T. L	22.10	4	2	0	Ziyaret
Mehmet Akif Ersoy L.	22.10, 20.12	3	2	0	Ziyaret, Ziyaret
Demetevler A.İ. Hatip L.	22.10, 20.12	3	3	3	Ziyaret, Ziyaret
Halide Edip L.	23.10	3	1	0	Ziyaret
Mustafa Kemal L.	23.10	4	1	0	Ziyaret
Prof. Dr.Sevket Raşit H. L.	23.10	5	1	0	Ziyaret
Yahya Kemal Beyatlı A. L.	23.10	4	2	0	Ziyaret
Yenimahalle A.Teknik L.	01.11	3	1	1	Ziyaret
Tevfik İleri İmam Hatip L.	01.11	4	2	0	Ziyaret

Y.Mahalle Ticaret A. M. L.	1.11, 20.12	4	1	1	Tel., Tel.
Yunus Emre A. Kız M.. L.	1.11	2	2	0	Ziyaret
Faruk Nafız Çamlıbel A. L.	13.11	4	1	0	Ziyaret
N. Mehmet Çekiç A.L.	13.11	4	1	0	Ziyaret
Mobil A.L.	13.11, 24.12	6	1	0	Ziyaret,
			1	1	Ziyaret
Demetevler M. Sinan L.	13.11	4	2	0	Ziyaret
Celal Yardımcı L.	15.11	4	2	1	Ziyaret
Batıkent L.	15.11	3	3	0	Ziyaret
Atatürk A.L.	22.11	5	1	1	Tel.
Alparslan A.L.	22.11, 10.12	5	2	0	Ziyaret
			2	1	Ziyaret
Batıkent A. Teknik ve EML	22.11, 26.12	4	2	0	Ziyaret, Tel.
Özel Serhat Samanyolu L.	29.11	5	2	1	Ziyaret
Özel Serhat Samanyolu FL.	29.11	2	2	1	Ziyaret
Özel Çağlayan Lisesi	29.11	1	1	0	Ziyaret
Özel Ankara Aziziye A.L.	6.12	2	1	0	Ziyaret
Şentepe L.	27.12	1	1	0	Ziyaret

APPENDIX C

NEEDS ANALYSIS SURVEY - FIRST VERSION

İHTİYAÇ ANALİZİ ANKETİ - İLK SÜRÜM

Kıymetli Öğretmenim,

Bu anket etkili ve faydalı bir hizmet içi eğitim kursunda öğretmenlerin ihtiyaçlarını ortaya çıkartmak için geliştirilmiştir. Cevaplarınız önümüzdeki yıllarda yapılacak hizmet içi eğitim kurslarının sizin görüşleriniz ve beklentileriniz doğrultusunda şekillenmesine katkıda bulunabileceğinden önem taşımaktadır. Lütfen bütün soruları yanıtlayınız. Bu araştırmada toplanılan tüm bilgiler kesinlikle gizli tutulacaktır.

İletişim: Nuri Balta, ODTU Eğitim Fakültesi, nuribalta@yahoo.com

A) KİŞİSEL BİLGİLER

Aşağıdaki sorular, hazırlanacak eğitim programı hakkındaki görüşlerinizin kişisel bilgilerinizle ilişkisini tespit etmek amacıyla sorulmuştur.

A1. Cinsiyetiniz:

( ) Kadın ( ) Erkek

A2. Okulunuzun bulunduğu ilçe:

…………..……………………………

A3. Okulunuzun adı:

…………..……………………………

A4. Evinizin bulunduğu ilçe/semt:

…………..……………………………

A5. Şu anki görevleriniz dâhil olmak üzere bu güne kadar yaptığınız görevleri ve ortalama sürelerini (yıl olarak) yazınız?

Görev	Yıl
Öğretmen	
Müdür Yrd.	
Zümre Başkanlığı	
Formatörlük	
Müdür	
Diğer (Lütfen yazınız):	

A6. Şu anki eğitim durumunuz (fizik eğitiminden farklı ise yazınız):

( ) Lisans mezunu

( ) Tezsiz yüksek lisans mezunu

( ) Yüksek lisans öğrencisi …………..

( ) Tezli yüksek lisans mezunu…….

( ) Doktora öğrencisi ……………...

( ) Doktora mezunu …………….

A7. Mezun olduğunuz fakülte:

( ) Eğitim Fakültesi
( ) Fen-Edebiyat Fakültesi

Diğer (Lütfen yazınız):
…………..……………………………

A8. Çalıştığınız okul türü:

( ) Anadolu Lisesi

( ) Genel Lise

( ) Anadolu Öğretmen Lisesi

( ) Meslek Lisesi

( ) Fen Lisesi

Diğer (Lütfen yazınız):

…………..……………………………

A9. Bu sene derslerine girdiğiniz 10'ncu sınıfların şubeleri, her sınıftaki öğrenci sayısı ve her sınıftaki toplam haftalık ders saatlerinizi yazınız.

Şube	Öğrenci sayısı	Haftalık ders saati sayısı

B) MESLEKİ TECRÜBELER

B1. Daha önce herhangi bir hizmet-içi eğitime katıldıysanız aşağıdaki tabloyu doldurunuz.

Yı-lı	Eğitimin süresi (gün)	Eğitimin türü (çalıştay, seminer, konferans, vb.)	Eğitimin Uygulama-sı*	Eğitimin konusu (aynı eğitimde birden fazla ise hepsini yazınız.)	Eğitimin Düzenle-yicisi (M.E.B, TÜBİTAK, vb.)	Eğitimin düzenlendi-ği Yer (okul, hizmet-içi enstitüleri, üniversite, vb.)	Eğitimde-ki rolünüz (sunum yapmak, materyal geliştirmek, sadece dinleyici olmak, vb.)	Eğitimin verim-liliği**
								(5) (4) (3) (2) (1) (0)
								(5) (4) (3) (2) (1) (0)
								(5) (4) (3) (2) (1) (0)
								(5) (4) (3) (2) (1) (0)

* Katıldığınız eğitimin türüne bağlı olarak size en uygun seçeneğin harfini tabloya yazınız.

a) teori ağırlıklı b) uygulama ağırlıklı c) hem teori hem de uygulama ağırlıklı

** Katıldığınız eğitimlerin verimliliğini; 5 (çok verimli), 4 (verimli), 3 (orta verimli), 2 (az verimli), 1 (verimsiz), 0 (kararsızım) olacak şekilde derecelendiriniz.

B2. Aşağıda verilen öğretim yöntem ve tekniklerini genel olarak derslerinizde ve modern fizik ünitesinde kullanma sıklığını belirtir misiniz?

	Daima		Genellikle		Çoğunlukla		Çok az		Hiç	
	Genel olarak	Modern fizik	Genel olarak	Modern fizik	Genel olarak	Modern fizik	Genel olarak	Modern fizik	Genel olarak	Modern fizik
Yazılı-sözlü anlatım										
Soru-cevap										
Problem çözme										
Bilimsel Gösteri										
Gözlem gezisi										
Etkinlik										
Rol oynama										
Grup tartışması										
Bilgisayar destekli öğretim										

B3. Şu ana kadar 10. sınıflarda modern fizik ünitesini kaç yıl anlattınız? Toplam kaç sınıfa anlattınız?

……………………………………………………………………………………

B4. Eğer anlattıysanız, bu ünite için yıllık planda ne kadar süre ayırdınız? (Her yıl için ayrı yazınız)

……………………………………………………………………………………

B5. Onuncu sınıf modern fizik ünitesinin öğretiminde karşılaşılması muhtemel bazı sorunlar aşağıda sıralanmıştır. Siz de bu sorun/sorunlardan hangileri ile karşılaştınız?

( ) Ünite için gerekli kaynakların azlığı

( ) Ünitenin öğretim programındaki yeri (sırası)

( ) Diğer ünitelerle karşılaştırıldığında yeni öğretiliyor olması

( ) Bu konudaki bilginizi yetersiz/eksik görmeniz

( ) Gereksiz bir konu olarak görmeniz

( ) Zaman yetersizliği

( ) Konun, öğrenciler tarafından anlaşılması zor kavramlar içermesi

( ) Konun, günlük hayatla ilişkisinin kurulmasının zor olması

Diğer..………………………………………………………………………
…………….................….………………………………………………………………
…………………….................…………………….

B6. Onuncu sınıf ünitelerinin zorluk derecesi <u>size göre ve öğrencilerinize</u> göre nedir?

Üniteler	Çok kolay		Kolay		Ne kolay, ne de zor		Zor		Çok Zor	
	Size gör	Öğrenciye	Size göre	Öğrenciye göre	Size göre	Öğrenciye göre	Size göre	Öğrenciye göre	Size göre	Öğrenciye göre
Madde ve										
Kuvvet ve										
Elektrik										
Modern										
Dalgalar										

B7. Öğrettiğiniz fizik konuları ile ilgili bir sorun yaşadığınızda (bir problemin çözümünde, bir kavramın açıklanmasında vb.) üstesinden gelmek için neler yaparsınız?

	Daima	Genellikle	Çoğunlukla	Çok az	Hiç
Okuldaki arkadaşımdan yardım alırım					
Okul dışındaki tanıdık arkadaşlarımdan yardım alırım					
Akademik çevreden yardım alırım					
Fizik kitaplarına bakarım					
İnternette araştırırım					
İnternette üye olduğum sosyal medya gruplarına sorarım					
Diğer (Lütfen yazınız)					

B8. Onuncu sınıf modern fizik ünitesinin kazanımları ile ilgili aşağıdaki tabloyu doldurunuz.

B8.1. Bu ünitedeki kazanımlar hakkındaki fizik bilginizin seviyesi nedir?
*Durum: Görüşlerinizi; 5 (çok iyi), 4 (iyi), 3 (Normal), 2 (az), 1 (Çok az) olacak şekilde derecelendiriniz.

B8.2. Bu ünitedeki kazanımlara öğrencilerinizin ilgisi nedir?
**İlgi: Görüşlerinizi; 5 (çok iyi), 4 (iyi), 3 (Normal), 2 (az), 1 (Çok az) olacak şekilde derecelendiriniz.

Kazanımlar	*Durumunuz	**Öğrenci ilgisi
1. 1 Modern fiziğin doğuşuna katkıda bulunan gelişmeleri açıklar • Işığın yapısı, atomun yapısı ve elektromanyetik ışıma enerjisinin kesikli olmasından kısaca bahsedilerek • Klasik ve modern fizik arasındaki fark açıklanarak		
2.1 Işık hızının eylemsiz referans sisteminden bağımsız olduğunun ileri sürülmesine neden olan araştırmaları açıklar • Eylemsiz referans sistemi örneklendirilerek • Michelson-Morley deneyi açıklanarak		
2.2 Özel görelilik kuramının temel kabullerini açıklar		
2.3 Işık hızına yakın hızlardaki hareketli için uzunluk ve zaman değişimlerini yorumlar		
2.4 Işık hızına yakın hızlar için yeniden yorumlanması gereken bazı temel kavramları örnekler vererek açıklar • Hız değişimine bağlı olarak kinetik enerji değişimi üzerinde durularak • Kütle-enerji eşdeğerliği açıklanarak		

B9. Modern fizik ünitesi ile ilgili tecrübelerinizi daha iyi anlamak için sizin eklemek istediğiniz hususlar var ise aşağıda belirtiniz.

…………………………………………………………………………………………………
…………………………………………………………………………………………………

C) HAZIRLANACAK OLAN "10. SINIF MODERN FİZİK" KONULU EĞİTİME YÖNELİK SORULAR

C1. Hizmet içi eğitim kursunda anlatılacak olan modern fizik (özel görelilik) ünitesinin kazanımları ile ilgili tabloyu lütfen doldurunuz.

*(istek): Tablonun altında verilen, yapılmasını istediğiniz çalışmanın harfini ilgili kazanımın karşısına yazınız. Bir kazanım için birden fazla çalışma önerilebilir.
**(önem). Modern fizik ünitesinde 5 kazanım vardır. Kursun verimli olması için kursta kazanımlara verilmesi gereken önem sırasını yazınız. 1'den 5'e kadar sıralayınız.

Kazanımlar	istek*	önem**
1. Modern fiziğin doğuşuna katkıda bulunan gelişmeleri açıklar • Işığın yapısı, atomun yapısı ve elektromanyetik ışıma enerjisinin kesikli olmasından kısaca bahsedilerek • Klasik ve modern fizik arasındaki fark açıklanarak		
2. Işık hızının eylemsiz referans sisteminden bağımsız olduğunun ileri sürülmesine neden olan araştırmaları açıklar		

• Eylemsiz referans sistemi örneklendirilerek • Michelson-Morley deneyi açıklanarak		
3. Özel görelilik kuramının temel kabullerini açıklar		
4. Işık hızına yakın hızlardaki hareketli için uzunluk ve zaman değişimlerini yorumlar		
5. Işık hızına yakın hızlar için yeniden yorumlanması gereken bazı temel kavramları örnekler vererek açıklar • Hız değişimine bağlı olarak kinetik enerji değişimi üzerinde durularak • Kütle-enerji eşdeğerliği açıklanarak		

a. Etkinlik yapılmasını isterim
b. Deney yapılmasını isterim
c. İyi bilen birinin konuyu anlatmasını isterim
d. Ünitenin zor kavramlarını birileri ile tartışarak öğrenmek isterim
e. Animasyon ve simülasyon gösterimi isterim
f. Konu ile ilgili problem çözülmesini isterim
g. Konunun öğretiminde çağdaş öğretim yöntemleri
h. Konu ile ilgili öğrencilerde var olan kavram yanılgıları ve düzeltme yöntemlerini isterim
i. Bu konun öğretimindeki sorunlar ile ilgili tartışma yapmak isterim

Diğer(Lütfen yazınız)……………………………………………………………………………………

C2. Onuncu sınıf modern fizik ünitesi ile ilgi düzenlenecek kurs ikinci dönemin başında yapılacak ve öğretim programında bu ünite için önerilen süre gereği 6 hafta olacaktır. Her hafta yapılacak çalışmalara bağlı olarak kurs 2-3 saat sürecektir. Böyle bir hizmet içi eğitim kursunun etkili olabilmesi için kursun zamanı size göre hangisi olmalıdır?

( ) Cuma akşamları ( ) Cumartesi akşamları ( ) Pazar akşamları ( ) Hafta içi bir akşam ( ) Diğer (lütfen yazınız)…………………………….……………………………………………

Sorular	Evet	Hayır
C3. Böyle bir hizmet içi eğitim kursuna ihtiyaç duyuyor musunuz?		
C4. Kursa 6 hafta katılmanız durumunda Demetevler civarına ulaşımınız sizi maddi olarak etkiler mi?		
C5. Kursun yemek faslı ile başlamasını ister misiniz?		
C6. Onuncu sınıf modern fizik ünitesi ile ilgi düzenlenecek kurstan önce (Aralık ya da Ocak ayında) iki tane hazırlık (adaptasyon) kursu düzenlenecektir. Bu kurslara katılmak ister misiniz?		
C7. Araştırmanın yapısından dolayı kursa katılacak öğretmenlerin		

modern fizik ünitesini bir sınıflarında elektrik ünitesinden önce anlatmaları gerekmektedir. Bu değişikliği yapmak sizin için problem olur mu?		
C8. Kursta katılımcı öğretmenlerden bazıları sırası ile hazırlanıp ders anlatacaklar. Bu kursta bir konuyu hazırlanıp anlatmak ister misiniz?		

C9. C8 sorusuna cevabınız evet ise, C1 sorusunun altında verilen tablodaki kazanımlardan hangisini bu kursta anlatmak istersiniz?

……………………………………………………………………………………

C10. Bu sene girdiğiniz 10. sınıflardan kaç tanesinin akademik başarı açısından hangi seviyede (düşük, orta, iyi) eşit olduğunu düşünüyorsunuz? (Örneğin üç sınıfım iyi derecede, iki sınıfım orta derecede eşit seviyededir gibi)

……………………………………………………………………………………

C11. Bu sene okulunuzda kaç öğretmen 10. sınıflara fizik dersi anlatmaktadır?

……………………………………………………………………………………

D12. Bu çalışmanın başlayabilmesi için birinci dönem ünitelerinin zamanında bitirilmesi gerekmektedir. İkinci dönemin başlaması ile birlikte bu dönemin konularına başlayabilecek misiniz?
( ) Evet ( ) Hayır

D11. M.E.B.'dan gerekli izinler alındıktan sonra, 2012-2013 bahar döneminde uygulanması planlanan "modern fizik (özel görelilik)" konulu eğitim programına katılmak ister misiniz?

( ) Evet ( ) Hayır

D13. Size ulaşabileceğimiz telefon ve elektronik posta adresinizi yazar mısınız?

……………………………………………………………………………………

D14. Öğrencilere bu üniteyi daha iyi anlatabilmek için neler yapılabileceği ile ilgili ve hazırlanan kursun etkinliğini artırmak için sizin eklemek istediğiniz hususlar var ise aşağıda belirtiniz.

……………………………………………………………………………………

D15. Hazırlayacağımız eğitimle ilgili olarak yukarıda bahsi geçmeyen ancak sizin eklemek istediğiniz hususlar var ise aşağıda belirtiniz.

……………………………………………………………………………………

APPENDIX D

NEEDS ANALYSIS SURVEY EXPERT CHECKLIST FORM

İHTİYAÇ ANALİZİ ANKETİ UZMAN GÖRÜŞÜ KONTROL LİSTESİ

Bu anket; lise 10'ncu sınıflara derse giren öğretmenlerin katılacakları bir hizmet içi eğitim kursu (a) adaylarını belirlemek, (b) kursun organizasyonunu düzenlemek ve (c) kursta anlatılacak konu ile ilgili görüş almak için düzenlenmiştir.

Kursta, katılımcı öğretmenler ve araştırmacı zümre yapacaklardır. Zümre faaliyetleri çerçevesinde öğretmenler sırasıyla birbirlerine ders anlatacaklar. Bu dersler 10. sınıf modern fizik ünitesini kapsayacaktır. Bu ankette üç ana bölüm bulunmaktadır.

- **Birinci bölümde** öğretmenlerin cinsiyet ve çalıştığı okul gibi kişisel bilgiler sorulmaktadır. Bu sorular, yapılacak hizmet içi eğitim programının sonuçları ile katılımcı öğretmenlerin kişisel bilgileri arasındaki ilişkiyi tespit etmek amacıyla sorulmuştur.
- **İkinci bölümdeki** sorularla öğretmenlerin şu ana kadarki katıldıkları hizmet içi eğitim kursları hakkında bilgi toplanacaktır.
- **Üçüncü bölümde** hazırlanacak olan "10. sınıf modern fizik" konulu eğitime yönelik sorular bulunmaktadır. Bu sorular, yapılacak kursta hem ünitenin içeriğinde üzerinde durulması gereken noktaları belirlemek hem de kursun organizasyonu verimli hale getirmek için sorulmuştur.

Anket maddeleri ile ilgili görüşlerinizi bildirirken:

1. Anlaşılmadığını düşündüğünüz maddeler varsa bunları numaralarını yazarak belirtiniz. Varsa nasıl daha anlaşılır hale getirilebilecekleri ile ilgili görüşlerinizi aşağıdaki tabloya ekleyiniz.

Madde no	Önerileriniz

2. Maddeleri daha kısa ve öz bir şekilde düzenlemek için önerileriniz varsa bunları numaralarını yazarak aşağıdaki tabloya ekleyiniz.

Madde no	Önerileriniz

3. Anketten çıkmasını önerdiğiniz soruları numaralarını yazarak ve çıkartma sebebini belirterek aşağıdaki tabloya ekleyiniz.

Madde no	Sebep

4. Ankete eklenmesini önerdiğiniz soruları bölümünü de belirterek aşağıdaki tabloya ekleyiniz.

Bölüm	Eklenecek madde

5. Bazı sorular bulundukları bölümün amacına hizmet etmiyor olabilir. Bulunduğu bölümün amaçlarına uygun olmadığını düşündüğünüz madde/ maddelerin gitmesi gereken bölümü aşağıdaki tabloya ekleyiniz.

Madde no	Gitmesi gereken bölüm	Sebep

6. Sizce bu anket bu çalışma için yeterli midir?
( ) Evet ( ) Hayır

7. Varsa eklenmesini uygun gördüğünüz alt bölümler nelerdir? Lütfen aşağıdaki tabloya ekleyiniz.

Diğer öneri ve görüşleriniz:

APPENDIX E

NEEDS ANALYSIS SURVEY - FINAL VERSION

İHTİYAÇ ANALİZİ ANKETİ - SON SÜRÜM

Kıymetli Öğretmenim,

Bu anket etkili ve faydalı bir hizmet içi eğitim kursunda öğretmenlerin (sizlerin) ihtiyaçlarını ortaya çıkartmak için geliştirilmiştir. Cevaplarınız önümüzdeki yıllarda yapılacak hizmet içi eğitim kurslarının sizin görüşleriniz ve beklentileriniz doğrultusunda şekillenmesine katkıda bulunabileceğinden önem taşımaktadır. Lütfen bütün soruları yanıtlayınız. Bu araştırmada toplanılan tüm bilgiler kesinlikle gizli tutulacaktır.

İletişim: Nuri Balta, ODTU Eğitim Fakültesi, nuribalta@yahoo.com

A) KİŞİSEL BİLGİLER

Aşağıdaki sorular, hazırlanacak eğitim programı hakkındaki görüşlerinizin kişisel bilgilerinizle ilişkisini tespit etmek amacıyla sorulmuştur.

A1. Cinsiyetiniz:
( ) Kadın ( ) Erkek

A2. Okulunuzun bulunduğu ilçe:
…………..……………………………

A3. Okulunuzun adı:
…………..……………………………

A4. Evinizin bulunduğu ilçe/semt:
…………..……………………………

A5. Şu anki görevleriniz dâhil olmak üzere bu güne kadar yaptığınız görevleri ve ortalama sürelerini (yıl olarak) yazınız?

Görev	Yıl
Öğretmen	
Zümre Başkanlığı	
Formatörlük	
Müdür Yrd.	
Müdür	
Diğer (Lütfen yazınız):	

A6. Şu anki eğitim durumunuz:
( ) Lisans mezunu
( ) Tezsiz yüksek lisans mezunu
( ) Yüksek lisans öğrencisi
…………..
( ) Tezli yüksek lisans mezunu…….
( ) Doktora öğrencisi………………...
( ) Doktora mezunu………………….

A7. Mezun olduğunuz fakülte:

( ) Eğitim Fakültesi

( ) Fen-Edebiyat Fakültesi

Diğer (Lütfen yazınız):
…………..……………………

A8. Şu an çalıştığınız okul türü:

( ) Anadolu Lisesi

( ) Genel Lise

( ) Anadolu Öğretmen Lisesi

( ) Meslek Lisesi

( ) Fen Lisesi

Diğer (Lütfen yazınız):
…………..……………………………

A9. Bu sene derslerine girdiğiniz 10'ncu sınıfların şubeleri, her sınıftaki öğrenci sayısı ve her sınıftaki toplam haftalık ders saatlerinizi yazınız.

Şube	Öğrenci sayısı	Haftalık ders saati sayısı

B) MESLEKİ TECRÜBELER

B1. Daha önce herhangi bir hizmet-içi eğitime katıldıysanız aşağıdaki tabloyu doldurunuz.

Yılı	Eğitimin süresi (gün)	Eğitimin türü (çalıştay seminer, konferans, vb.)	Eğitimin uygulaması*	Eğitimin konusu (aynı eğitimde birden fazla ise hepsini yazınız.)	Eğitimin düzenleyicisi (M.E.B, TÜBİTAK, vb.)	Eğitimin düzenlendiği yer (okul, hizmet-içi enstitüleri, üniversite, vb.)	Eğitimdeki rolünüz (sunum yapmak, materyal geliştirmek, sadece dinleyici olmak, vb.)	Eğitimin verimliliği **
								(5) (4) (3) (2) (1) (0)
								(5) (4) (3) (2) (1) (0)
								(5) (4) (3) (2) (1) (0)
								(5) (4) (3) (2) (1) (0)
								(5) (4) (3) (2) (1) (0)
								(5) (4) (3) (2) (1) (0)

* Katıldığınız eğitimin türüne bağlı olarak size en uygun seçeneğin harfini tabloya yazınız.

a) teori ağırlıklı b) uygulama ağırlıklı c) hem teori hem de uygulama ağırlıklı

** Katıldığınız eğitimlerin verimliliğini; 5 (çok verimli), 4 (verimli), 3 (orta verimli), 2 (az verimli), 1 (verimsiz), 0 (kararsızım) olacak şekilde derecelendiriniz.

B2. Şu ana kadar 10. sınıflarda modern fizik ünitesini kaç yıl(kez) anlattınız? Toplam kaç sınıfa anlattınız?

……………………………………………………………………………………………

B3. Eğer anlattıysanız, bu ünite için yıllık planda ne kadar süre ayırdınız? (Her yıl için ayrı yazınız)……………………….…………………………………………........................

B4. Aşağıda verilen öğretim yöntem ve tekniklerini genel olarak derslerinizde ve modern fizik ünitesinde kullanma sıklığını belirtiniz?

	Daima		Genellikle		Çoğunluk la		Çok az		Hiç	
	Genel olarak	Modern fizik	Genel olarak	Modern fizik	Genel olarak	Modern fizik	Genel olarak	Modern fizik	Genel olarak	Modern fizik
Yazılı-sözlü anlatım										
Soru-cevap										
Problem çözme										
Bilimsel Gösteri										
Gözlem gezisi										
Etkinlik										
Rol oynama										
Grup tartışması										
Bilgisayar destekli öğretim										

B5. Onuncu sınıf modern fizik ünitesinin öğretiminde karşılaşılması muhtemel bazı sorunlar aşağıda sıralanmıştır. Bu soruları önem sırasına göre 1'den 8'e kadar sıralayınız.

( ) Ünite için gerekli kaynakların azlığı

( ) Ünitenin öğretim programındaki yeri (sırası)

( ) Diğer ünitelerle karşılaştırıldığında yeni öğretiliyor olması

( ) Bu konudaki bilginizi yetersiz/eksik görmeniz

( ) Gereksiz bir konu olarak görmeniz

( ) Zaman yetersizliği

( ) Konunun, öğrenciler tarafından anlaşılması zor kavramlar içermesi

( ) Konunun, günlük hayatla ilişkisinin kurulmasının zor olması

Diğer……………………………………………………………………………………
…...................……………………………………………………………………………

B6. Size ve öğrencilerinize göre 10. sınıf ünitelerinin zorluk derecesi(anlatma ve anlama zorluğu) nedir?

Üniteler	Çok kolay		Kolay		Ne kolay, ne de zor		Zor		Çok Zor	
	Size göre	Öğrenci ve göre	Size göre	Öğrenci ve göre	Size göre	Öğrenci ve göre	Size göre	Öğrenci ve göre	Size göre	Öğrenci ve göre
Madde ve										
Kuvvet										
Elektrik										
Modern										
Dalgalar										

B7. Öğrettiğiniz fizik konuları ile ilgili bir sorun yaşadığınızda (bir problemin çözümünde, bir kavramın açıklanmasında vb.) üstesinden gelmek için neler yaparsınız?

	Daima	Genellikle	Çoğunlukla	Çok az	Hiç
Okuldaki öğretmen arkadaşlarıma danışırım.					
Okul dışındaki arkadaşlarıma danışırım					
Akademisyenlere danışırım					
Fizik kaynak kitaplarına bakarım					
İnternette araştırma yaparım					
Üyesi olduğum mail gruplarına ve sosyal paylaşım sitelerinde paylaşarak çözüm ararım					
Diğer (Lütfen yazınız)					

B8. Onuncu sınıf modern fizik ünitesinin kazanımları ile ilgili aşağıdaki tabloyu doldurunuz.

B8.1. Bu ünitedeki kazanımlar hakkındaki fizik bilginizin seviyesi nedir?
*Bilgi: Görüşlerinizi; 5 (çok iyi), 4 (iyi), 3 (Normal), 2 (az), 1 (Çok az) olacak şekilde derecelendiriniz.
B8.2. Bu ünitedeki kazanımlara öğrencilerinizin ilgisi ne idi?
**İlgi: Görüşlerinizi; 5 (çok iyi), 4 (iyi), 3 (Normal), 2 (az), 1 (Çok az) olacak şekilde derecelendiriniz.

Kazanımlar	*Bilgi	**Öğrenci ilgisi
1. 1 Modern fiziğin doğuşuna katkıda bulunan gelişmeleri açıklar • Işığın yapısı, atomun yapısı ve elektromanyetik ışıma enerjisinin kesikli olmasından kısaca bahsedilerek • Klasik ve modern fizik arasındaki fark açıklanarak		
2.1 Işık hızının eylemsiz referans sisteminden bağımsız olduğunun ileri sürülmesine neden olan araştırmaları açıklar • Eylemsiz referans sistemi örneklendirilerek • Michelson-Morley deneyi açıklanarak		
2.2 Özel görelilik kuramının temel kabullerini açıklar		
2.3 Işık hızına yakın hızlardaki hareketli için uzunluk ve zaman değişimlerini yorumlar		
2.4 Işık hızına yakın hızlar için yeniden yorumlanması gereken bazı temel kavramları örnekler vererek açıklar • Hız değişimine bağlı olarak kinetik enerji değişimi üzerinde durularak • Kütle-enerji eşdeğerliği açıklanarak		

B9. Modern fizik ünitesi ile ilgili tecrübelerinizi daha iyi anlamamız için eklemek istediğiniz hususlar var ise aşağıda belirtiniz.

………………………………………………………………………………………

C) HAZIRLANACAK OLAN "10. SINIF MODERN FİZİK" KONULU EĞİTİME YÖNELİK SORULAR

C1. Hizmet içi eğitim kursunda ele alınacak olan modern fizik (özel görelilik) ünitesinin kazanımları ile ilgili tabloyu lütfen doldurunuz.

*(istek): Tablonun altında verilen, yapılmasını istediğiniz çalışmanın harfini ilgili kazanımın karşısına yazınız. Bir kazanım için birden fazla çalışma önerilebilir.
**(önem). Modern fizik ünitesinde 5 kazanım vardır. Kursun verimli olması için kursta kazanımlara verilmesi gereken önem sırasını yazınız. 1'den 5'e kadar sıralayınız.

j. Etkinlik yapılmasını isterim
k. Deney yapılmasını isterim
l. İyi bilen birinin konuyu anlatmasını isterim
m. Ünitenin zor kavramlarını birileri ile tartışarak öğrenmek isterim
n. Animasyon ve simülasyon gösterimi isterim
o. Konu ile ilgili problem çözülmesini isterim
p. Konunun öğretiminde çağdaş öğretim yöntemlerinin kullanılmasını isterim
q. Konu ile ilgili öğrencilerde var olan kavram yanılgıları ve düzeltme yöntemlerinin anlatılmasını isterim
r. Bu konun öğretimindeki sorunlar ile ilgili tartışma yapmak isterim
s. Konuya özgü ölçme-değerlendirme yöntemlerinin anlatılmasını isterim

Diğer(Lütfen yazınız)……………………………………………………………………

Kazanımlar	istek*	önem**
1. Modern fiziğin doğuşuna katkıda bulunan gelişmeleri açıklar • Işığın yapısı, atomun yapısı ve elektromanyetik ışıma enerjisinin kesikli olmasından kısaca bahsedilerek • Klasik ve modern fizik arasındaki fark açıklanarak		
2. Işık hızının eylemsiz referans sisteminden bağımsız olduğunun ileri sürülmesine neden olan araştırmaları açıklar • Eylemsiz referans sistemi örneklendirilerek • Michelson-Morley deneyi açıklanarak		
3. Özel görelilik kuramının temel kabullerini açıklar		
4. Işık hızına yakın hızlardaki hareketli için uzunluk ve zaman değişimlerini yorumlar		
5. Işık hızına yakın hızlar için yeniden yorumlanması gereken bazı temel kavramları örnekler vererek açıklar • Hız değişimine bağlı olarak kinetik enerji değişimi üzerinde durularak • Kütle-enerji eşdeğerliği açıklanarak		

C2. Onuncu sınıf modern fizik ünitesi ile ilgi düzenlenecek kurs ikinci dönemin başında yapılacak ve öğretim programında bu ünite için önerilen süre gereği 6 hafta olacaktır. Her hafta yapılacak çalışmalara bağlı olarak kurs 2-3 saat sürecektir. Böyle bir hizmet içi eğitim kursunun etkili olabilmesi için kursun zamanı size göre hangisi olmalıdır?

( ) Cuma akşamları ( ) Cumartesi akşamları ( ) Pazar akşamları ( ) Hafta içi bir akşam ( ) Diğer (lütfen yazınız)……………………………………………………………………………

Sorular	Evet	Hayır
C3. Böyle bir hizmet içi eğitim kursuna ihtiyaç duyuyor musunuz?		
C4. Kursa 6 hafta katılmanız durumunda Demetevler civarına ulaşımınız sizi maddi olarak etkiler mi?		
C5. Kursun yemek faslı ile başlamasını ister misiniz?		
C6. Kursun sizin okulunuzda düzenlenmesini ister misiniz?		
C7. Onuncu sınıf modern fizik ünitesi ile ilgi düzenlenecek kurstan önce (Aralık ya da Ocak ayında), haftada iki saatten iki haftalık hazırlık (adaptasyon) kursu düzenlenecektir. Bu kurslara katılmak ister misiniz?		
C8. Araştırmanın yapısından dolayı kursa katılacak öğretmenlerin modern fizik ünitesini bir sınıflarında elektrik		

ünitesinden önce anlatmaları gerekmektedir. Bu değişikliği yapmak sizin için problem olur mu?		
C9. Kursta katılımcı öğretmenlerden bazıları sırası ile hazırlanıp ders anlatacaklar. Bu kursta bir konuyu hazırlanıp anlatmak ister misiniz?		

C10. Yukarıdaki soruya (C8) cevabınız evet ise, C1 sorusunun altında verilen tablodaki kazanımlardan hangisini bu kursta anlatmak istersiniz?

……………………………………………………………………………………….

C10. Bu sene girdiğiniz 10. sınıflardan kaç tanesinin akademik başarı açısından hangi seviyede (düşük, orta, iyi) eşit olduğunu düşünüyorsunuz? (Örneğin üç sınıfım iyi derecede, iki sınıfım orta derecede eşit seviyededir gibi)

………………………………………………………………………………………

C11. Bu sene okulunuzda kaç öğretmen 10. sınıflara fizik dersi anlatmaktadır?

……………………………………………………………………………………..

D12. Bu çalışmanın başlayabilmesi için birinci dönem ünitelerinin zamanında bitirilmesi gerekmektedir. İkinci dönemin başlaması ile birlikte bu dönemin konularına başlayabilecek misiniz?

( ) Evet ( ) Hayır

D11. M.E.B.'dan gerekli izinler alındıktan sonra, 2012-2013 bahar döneminde uygulanması planlanan "modern fizik (özel görelilik)" konulu eğitim programına katılmak ister misiniz?

( ) Evet ( ) Hayır

D13. Size ulaşabileceğimiz telefon ve elektronik posta adresinizi yazar mısınız?

Elektronik posta:.. Cep tel:...

D14. Öğrencilere bu üniteyi daha iyi anlatabilmek için neler yapılabileceği ile ilgili ve hazırlanan kursun etkinliğini artırmak için sizin eklemek istediğiniz hususlar var ise aşağıda belirtiniz.

………………………………………………………………………………………
………………………………………………………………………………………

D15. Hazırlayacağımız eğitimle ilgili olarak yukarıda bahsi geçmeyen ancak sizin eklemek istediğiniz hususlar var ise aşağıda belirtiniz.

………………………………………………………………………………………
………………………………………………………………………………………

APPENDIX F

TABLE OF TEST SPECIFICATION FOR MPUAT-S AND FOR MPUAT-T

MPUAT-S VE MPUAT-T İÇİN BELİRTKE TABLOSU

Kazanımlar	Kazanımların açıklamaları	Revize edilmiş Bloom Taksonomisinin bilişsel süreç boyutları				
		Hatırlamak	Anlamak	Uygulamak Analiz etmek Değerlendir-mek Yaratmak	[1]Süre (%)	Soru sayısı (%)
1.1 Modern fiziğin doğuşuna katkıda bulunan gelişmeleri açıklar.	⇤⇥ **1.1-a** Modern fiziği oluşturan temel unsurlardan biri olan görelilik **açıklanır**, diğerlerinden (ışığın yapısı, satomun yapısı ve elektromanyetik ışıma enerjisinin kesikli olması) ise kısaca **bahsedilerek** ayrıntıları ilerleyen yıllarda verilir. **[!] 1.1-b** Yirminci yüzyılın başlarına kadar fiziğin daha çok - görece kütlesi büyük ve hızı küçük olan - makro evrendeki olayları açıklamaya çalıştığı ve bu alanın “Klasik Fizik” olarak adlandırılabileceği; günümüzde ise mikro evrendeki (atom ve atom altı parçacıklar) ve ışık hızına yakın hızlarda hareket eden cisimlerin hareketini	-2-[2] 7 (1.1-d)[3] 8 (1.1-d) 9 (1.1-d) 10 (1.1-d) 11 (1.1-d) 12 (1.1-d) 14 (1.1-b) 14 (1.1-c) 18 (1.1) ~~31 (1.1)~~	-0,5- ~~32 (1.1)~~[4]		2,5 (31,3)	9 (34.6)

	açıklamaya odaklandığı ve bu alanın ise “Modern Fizik” olarak adlandırılabileceği **vurgulanır**. **??? 1.1-c “**Modern fizik ve klasik fizik yasaları farklıdır.”, “Klasik fizik yasalarının yerini modern fizik yasaları almıştır.” **[!] 1.1-d** Modern fiziğin; kuantum, atom ve çekirdek fiziği, katıhal/yoğun madde fiziği gibi alt isimler altında da incelenebildiği **belirtilir**.					
2.1 Işık hızının eylemsiz referans sisteminden bağımsız olduğunun ileri sürülmesine neden olan araştırmaları açıklar.	**[!] 2.1-a** İvmesiz (duran veya sabit hızla) hareket eden gözlem çerçevesine eylemsiz referans sistemi denildiği belirtilir. Evrende mutlak eylemsiz bir referans sisteminin olmadığı ve dünyanın eylemsiz referans sistemi olarak kabul edilebileceği vurgulanır. Eylemsiz bir referans sistemine göre ivmesiz hareket eden gözlem çerçevesinin de eylemsiz referans sistemi kabul edildiği **ifade edilir.** **2.1-b** 9. ve 10. sınıflar, Kuvvet ve Hareket Üniteleri. **2.1-c** Michelson ve Michelson-Morley deneylerinden formüllere girilmeden kavramsal olarak bahsedilir. **??? 2.1-d** “Evren esir denilen bir madde ile doludur.”	-0,8- 3 (2.1-d) 29 (2.1-c)	-0,4- 6 (2.1-a) ~~19 (2.1-a)~~		1.2 (15)	3 (11.5)

2.2 Özel görelilik kuramının temel kabullerini açıklar.	**[!] 2.2-a** Bu kabuller "Fizik yasaları tüm eylemsiz referans sistemlerinde aynıdır" ve "Işık hızı, eylemsiz referans sisteminde, ışık kaynağının ve gözlemcinin hareketinden bağımsızdır (Örneğin, ışığın boşluktaki hızı her durumda 3.10^8 m/s olarak ölçülür ve bu hızın elektriksel ve manyetik kuvvetlerin ifadelerindeki sabitlerle belirlendiği)" şeklinde açıklanır. ⇤⇥**2.2-b** Galileo ve Lorentz dönüşümlerine girilmez. **[N] 2.2-c** Einstein – 1921 **[!] 2.2-d** Işık hızında hareket edildiğinde bu kabullerin gözlemleri nasıl değiştirdiği örneklerle açıklanır. "Işık hızında hareket ederken elimizdeki aynaya baktığımızda kendimizi görüp göremeyeceğimiz" ve "arabayla ışık hızında giderken farları açtığımızda önümüzün aydınlanıp aydınlanmayacağı" temel kabullerin varlığında ve yokluğunda (klasik mekanikle) tartışılır.	-0,7- ~~2 (2.2-c)~~ 4 (2.2) 13 (2.2-d)	-0,6- 20(2.2-a) 1 (2.2-a)		1.3 (16.3)	4 (15.4)
2.3 Işık hızına yakın hızlardaki hareketli için uzunluk ve zaman değişimlerini yorumlar.	**[!] 2.3-a** Cismin hareketi doğrultusundaki uzunluk kısalması ve zaman genişlemesi denklemlerle ve grafiklerle verilir. Denklemlerin karmaşık problemlere uygulanmasına girilmez, ancak grafikler değişkenler	-0.5- 5 (2.3-b) ~~28 (2.3-b)~~	-2,5- 13 (2.3-c) 15 (2.3-a) 16 (2.3) 17 (2.3) ~~21 (2.3)~~ 22 (2.3) ~~23 (2.3)~~ ~~24 (2.3)~~ 25 (2.3) 26 (2.3) 26(2.3-b)		3 (37.5)	10 (38.5)

	arasındaki ilişkiyi yorumlamak için kullanılır. Haftada iki saatlik fizik dersini seçen öğrenciler için uzunluk kısalması ve zaman genişlemesi formüllerine girilmeden grafiklerle kavramsal düzeyde verilir. **[!] 2.3-b** Bir cismin kütlesinin hıza bağlı olmasının çelişkilere götürdüğü ve anlamlı olmadığı, dolayısıyla durgunluk kütlesi kavramının gereksiz olacağı; cisimler için tek bir kütleden söz edilebileceği vurgulanır. Durgunluk kütlesi yani sadece kütle cismin madde miktarı ve iç enerjisinin (atom altı parçacıklar hariç) bir ölçüsüdür. Yani bir cismin iç enerjisi değişirse kütlesi de değişir (doğal olarak bunun tersi de doğrudur), ancak iç enerjiye bağlı kütle değişimi makroskopik boyutta ölçülemeyecek kadar küçüktür. **[!] 2.3-c** Özel görelilik kuramına göre; kütleli bir parçacığı ışık hızına ulaştırmak için sonsuz enerji vermek gerektiği, bunun için evrendeki enerjinin yetmeyeceği ve bundan dolayı da ışık hızına ulaşılamayacağı vurgulanır.		27 (2.3) ~~30 (2.3)~~			
2.4 Işık hızına yakın hızlar için yeniden yorumlanması gereken	⇤⇥**2.4-a** Bir parçacığın kütlesi hızla değişmezken, kinetik enerji (Ek) ve (Potansiyel enerji dikkate alınmazsa)	Çekirdek fizik programında yoktur				

bazı temel kavramları örnekler vererek açıklar.	dolayısı ile toplam enerji (E) hıza bağlıdır. Bu nedenle kütle tüm eylemsiz referans sisteminde aynı kalırken, kinetik enerji değeri ölçüldükleri gözlem çerçevesine bağlı olarak değişir (kuvvet, ağırlık ve ivme gibi kavramların değişimine girilmez). Hız değişimine bağlı olarak kinetik enerji değişimi üzerinde durulur ve kütle-enerji eşdeğerliği açıklanır.					
*Süre (%)		4 (50)	4 (50)	0 0 0 0	8 (100)	
Soru sayısı (%)		14 (53.8)[6]	12 (46.2)	0 0 0 0		26[5] (100)

[1]Haftada iki saat fizik dersi olan okullarda bu üniteye öğretim programında 8 saat süre verilmiştir. Bu kolonda verilen değerler her kazanım için ayrılan süreyi saat cinsinden göstermektedir. Her kazanım ile ilgi hazırlanan soru sayısı bu süre ile orantılıdır.

[2]Bloom taksonominin bilişsel boyutu için ayrılan süre iki çizgi "-1-"arasında ders saati olarak verilmiştir.

[3]Parantez dışındaki değer soru numarasını (Parantez içindeki değer ise Kazanım veya Açıklama numarasını göstermektedir)

[4]Madde analizi sonucunda testten çıkartılan sorulardır.

[5]Başarı testinden toplam 9 soru çıkartılmıştır. Kalan 23 sorudan bazıları birden fazla kazanımı ölçtüğünden soru sayısı bu tabloda 26 olarak görünmektedir.

[6]Soru sayıları ve yüzdelikler 9 soru çıkartıldıktan sonra kalan 23 soruya göre yazılmıştır.

Cevap Anahtarı:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	B	B	B	A	A	A	A	B	B	B	A	B	C	A
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
A	D	B	C	E	D	D	E	E	A	D	A	C	E	D

APPENDIX G

TENTH GRADE MODERN PHYSICS ACHIEVEMENT TEST-STUDENT-ROUGH VERSION:1

ONUNCU SINIF MODERN FİZİK BAŞARI TESTİ- ÖĞRENCİ-KABA SÜRÜM:1

1. Fatma, Ayşe ve Zehra Ankara-Eskişehir hızlı treninin kalkışını bekliyorlar. Fatma, elindeki kalemini yere düşürüyor, Ayşe, ipe bağladığı silgisine salınım hareketi yaptırıyor ve Zehra, elindeki lazerin ışığını duvardaki aynadan yansıtıyor.

Bu kişiler aynı olayları tren hareketli iken aynı şekilde yapsalardı hangileri trenin durgun halindeki ile aynı olurdu?

I. Kalemin düşmesi

II. silginin salınımı

III. ışığın yansıması

A) Yalnız I B) Yalnız III C) I ve II D) I ve III E) I, II ve III

2. Fizik öğretmeni Osman Bey özel göreliliğin temel kurallarını anlattıktan sonra aşağıdaki gibi hareketler yapan referans sistemlerini sıralıyor.

Sizce bu referans sistemlerinden hangisinde fizik kuralları hep aynıdır?

A) İvmeli
B) Sabit hızlı
C) Salınım hareketli
D) Çembersel hareketli
E) Artan ya da azalan hızlı

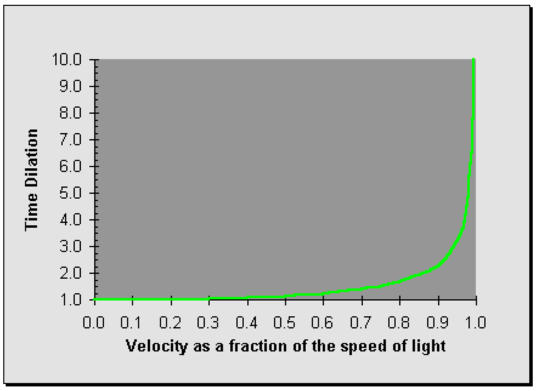
3. Einstein'ın gençlik yıllarında kendisine şu soruyu sorduğu söylenir: Işık hızında hareket ederken elimdeki aynada kendime bakarsam ne görürüm?

   Modern fiziğe göre Einstein'a ne cevap verirsiniz?

   A) Aynayı siyah görürsünüz
   B) Aynaya baktığınız halde görüntünüz oluşmaz
   C) Durgun halde aynada ne görürsen aynısını görürsün
   D) Görüntünüz bozuk görünür
   E) Görüntünüzü olduğundan daha küçük görürsünüz

4. Bir aracın hızı arttıkça, durgun gözlemciye göre arabadaki zaman genişlemesi aşağıdaki grafikte gösterildiği gibi olmaktadır.

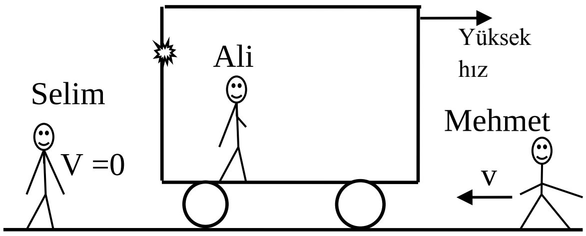
   Size göre aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi açıklamaktadır?



   A) Hız arttıkça zaman genişlemesi düzgün azaltmaktadır
   B) Hız arttıkça zaman genişlemesi sabittir
   C) Hız arttıkça zaman genişlemesi düzgün artmaktadır
   D) Işık hızına yaklaşıldıkça zaman aşırı genişlemektedir
   E) Işık hızına yaklaşıldıkça zaman durmaktadır

5. İleride ışık hızına yakın hızla hareket eden trenler yapıldığını varsayalım. Bu trenlerden biri hareket halindeyken vagonunun arka duvarındaki lamba birden yanıyor. Lambanın ışığının ön duvara ulaşma süresi vagonda duran Ali için t_a, yerde duran Selim için t_s ve vagona doğru yüksek hızla yaklaşan Mehmet için t_m dir.

   Buna göre t_a, t_s ve t_m arasındaki ilişki nedir?

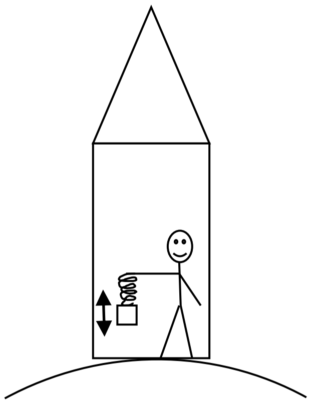


A) $t_a > t_s > t_m$
B) $t_m = t_a = t_s$
C) $t_m > t_s > t_a$
D) ???$t_m = t_s > t_a$
E) $t_s > t_a > t_m$

6. Modern ve klasik fizik ile ilgili olarak;
   I. Modern fizik ve klasik fizik yasaları farklıdır
   II. Klasik fizik yasalarının yerini modern fizik yasaları almıştır
   III. Modern ve klasik fiziğin gelişimi halen devam etmektedir

Yargılarından hangileri doğrudur?

A) Yalnız I B) Yalnız III C) I ve II D) I ve III E) II ve III



7. Yerde duran bir uzay aracındaki astronot, bir yaya bir cisim asıyor ve cisim yukarı aşağı salınım hareketi yapıyor. Uzay aracı dünyaya göre ışık hızına yakın bir sabit hızla harekete başlıyor.

   Buna göre yerdeki gözlemciye ve uzay aracındaki astronota göre cismin bir defa yukarı-aşağı hareketi(periyodu) için geçen süre nasıl değişir?

	Yerdeki gözlemci	Astronot
A)	Artar	Değişmez
B)	Azalır	Değişmez
C)	Değişmez	Azalır
D)	Değişmez	Artar
E)	Azalır	Artar

8. ODTU fizik bölümünde birçok çalışma yapılmaktadır. Aşağıdaki bölümler de bunlardan birkaç tanesidir.
   I. Nükleer fizik
   II. Atom fiziği
   III. Teorik fizik

   Buna göre ODTU fizikteki bu bölümlerden hangileri modern fiziğin alt alanlarıdır?

   A) Yalnız I   B) Yalnız III   C) I ve II   D) I ve III   E) II ve III

9. Her birinin hızı 0,8c olan iki uzay aracı birbirlerine doğru hareket ediyorlar. Araçların birbirlerine göre hızlarının büyüklüğü aşağıdakilerden hangisi olabilir? (c, ışık hızıdır)

   A) 0 – 0,8c arasında bir değer
   B) 0,8c – c arasında bir değer
   C) c
   D) 1,6c
   E) c- 1,6c arasında bir değer

10. Aşağıdakilerden hangileri dünyaya göre eylemsiz referans sistemi olabilir?

   I. Konya ovasındaki bir ağaç
   II. Sabit hızla giden Ankara Eskişehir treni
   III. Sabit hızla çembersel bir yörüngede gösteri yapan motosikletli

   A) Yalnız I   B) Yalnız III   C) I ve II   D) I ve III   E) II ve III

11. Astronotlara uzayda seyahat ettikleri süre ile orantılı olarak ücret ödendiğini farz edin. Siz bir astronot olsaydınız yaptığınız bir uzay yolculuğundan sonra şirketinizin size aşağıdaki saatlerden hangisine göre ödeme yapmasını isterdiniz
    A) Şirketin duvarındaki saat
    B) Uzay aracınızdaki saat
    C) Seyahatiniz sırasında kolunuzda bulunan saat
    D) Sizinle aynı hızda aynı sürede fakat zıt yönde uzaya gidip gelen arkadaşınızın kolundaki saat
    E) Sizinden daha hızlı sizinle aynı yönde ve sürede gidip gelen arkadaşınızın aracındaki saat

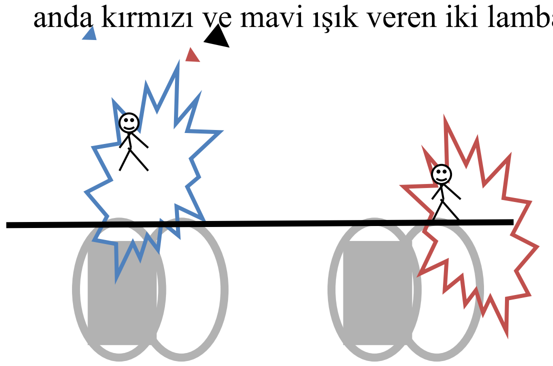
12. Zambak 10. Sınıf sayfa 312

K, L ve M gözlemcilerinin bulunduğu uzay araçları ile, bunlarla aynı doğrultuda hareket eden X, Y ve Z uzay araçları şekildeki hızlara sahiptir. X, Y ve Z araçları, kendi hareket yönlerinde ışık veren farlarını açıyorlar.

Farlardan yayılan ışığın K, L ve M gözlemcileri tarafından algılanan hızları v_K, v_L, v_M, klasik ve modern fiziğe göre aşağıdakilerden hangisindeki gibi olur? (c: ışık hızı)

	Klasik Fiziğe Göre			Modern Fiziğe Göre		
	v_K	v_L	v_M	v_K	v_L	v_M
A)	2,6c	c	0,5c	2,6c	c	0,5c
B)	2,6c	c	0,5c	c	c	c
C)	c	c	c	2,6c	c	0,5c
D)	0,5c	c	2,6c	0,5c	c	2,6c
E)	c	c	c	c	c	c

13. Yüksek hızla hareket eden bir trenin vagonlarından birinde şekildeki gibi aynı anda kırmızı ve mavi ışık veren iki lamba yanıyor.



Buna göre yerdeki ve vagondaki gözlemcilere göre hangi ışık önce duvara ulaşır?

	Yerdeki	Vagondaki
A)	Mavi	Kırmızı
B)	Kırmızı	Mavi
C)	Mavi	Aynı anda
D)	Kırmızı	Aynı anda
E)	Aynı anda	Aynı anda

14. Aşağıdakilerden hangilerini klasik fizik açıklar?

I. Elektromanyetik ışıma
II. Elektromanyetizma
III. Atomun yapısı

A) Yalnız II B) Yalnız III C) I ve II D) I ve III E) II ve III

15. Fuat ışık hızına yakın hızlarla hareket edildiği zaman bir cismin boyunun nasıl değişeceğini merak etmektedir. Fuat'ın sorusuna karşılık fizik öğretmeni Osman Bey öğrencilerinden konu ile ilgili hipotezler kurulmasını ister.

Aşağıdakilerden hangisi bu araştırmada sınanmaya uygun bir hipotez değildir?

A) Hız ne kadar fazla olursa boy o kadar fazla kısalır
B) Hız ne kadar fazla olursa boy o kadar fazla uzar
C) Hız ne olursa olsun boy değişmez
D) Hızla boyun değişmesini gözlemlemek için her yöntem denemelidir
E) Boyun kısalması cismin hızlandığı yere bağlıdır

16. Michelson-Morley deneyi aşağıdakilerden hangisini ölçmek için tasarlanmıştı?

A) Dünyanın çekim ivmesini hesaplamak
B) Elektronların göreli hızlarını hesaplamak
C) Dünyanın esire göre hızını hesaplamak
D) Işığın hızı ile esirin hızını karşılaştırmak
E) Işığın dalga boyunu hesaplamak

17. NASA'daki bilim adamları ışık hızına yakın bir hızla yıldızlar arası bir yolculuğa çıkacak astronot için hazırlık yapmaktadırlar. Bilim adamlarına yardımcı olabilir misiniz? Sizce astronotun;

I. Yatağının boyu,
II. Tüketeceği yiyecek ve içeceğin miktarı
III. Kolundaki saate yetecek pilin ömrü

hangileri astronotun hareketli olmasına göre göz önüne alınıp gerekli hesapların yapılması lazımdır?

A) Yalnız I B) I ve II C) II ve III D) I ve III E) I, II ve III

18. Yanınızdan geçip sizden uzaklaşan bir uzay aracını gözlemliyorsunuz. Uzay aracı geri dönüp size doğru hareket ederse, aracın ilk durumu ile karşılaştırdığımızda, aşağıdakilerden hangisi gözlemlenir?

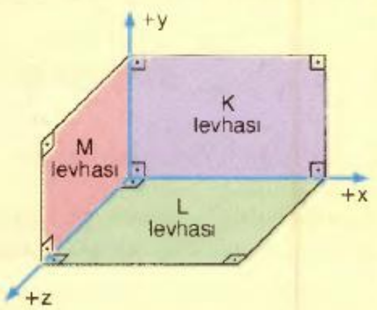
A) Aracın boyu uzar ve içindeki saat daha hızlı ilerler
B) Aracın boyu uzar ve içindeki saat daha yavaş ilerler
C) Aracın boyu kısalır ve içindeki saat daha hızlı ilerler
D) Aracın boyu da içindeki saatin ilerlemesi de değişmez
E) Aracın boyu kısalır ve içindeki saat daha yavaş ilerler

19. Silindirik bir uzay aracı sizin bakış doğrultunuzdan uzaklaşmaktadır. Buna göre uzay aracının uzunluğu ve çapı size göre nasıl değişir?

	Uzunluğu	Çapı
A)	Artar	Artar
B)	Azalır	Azalır
C)	Değişmez	Artar
D)	Değişmez	Değişmez
E)	Kısalır	Değişmez

20.

Yüzey alanları eşit K, L ve M levhaları X, Y, Z koordinat ekseni üzerine şekildeki gibi yerleştirilmiştir.



Bu levhalar, ışık hızına yakın bir hızla +x yönünde hareket eden uzay aracı içinde olsaydı, Dünyadaki gözlemciye göre, hangilerinin yüzey alanı değişir?

A) Yalnız K levhasının
B) Yalnız L levhasının
C) Yalnız M levhasının
D) K ve L
E) L ve M

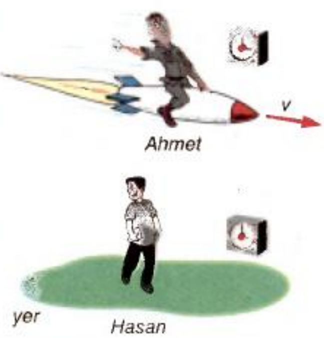
21. Hareketli ve hareketsiz iki araçtaki aşağıdaki olaylarla ilgili;
    I. Hareketsiz bir araçta serbest düşen bir bilyenin toplam enerjisi sabit, hareketli olan araçta değişkendir
    II. Hareketsiz bir araçta ölçülen suyun güzey gerilimi, hareketli olan araçta farklı olur.
    III. Hareketli bir aracın farlarından çıkan ışığın hızı hareketsiz arabanınki ile aynı olur

    Yargılarından hangileri doğrudur?

    A) Yalnız III B) I ve II C) II ve III D) I ve III E) I, II ve III

22. Çoşku 10. Sınıf. Sayfa:243

Ahmet ve Hasan saatlerini aynı anda ayarlıyor ve Ahmet ışık hızına yakın bir v hızıyla harekete başlıyor. Her ikisi içinde yelkovan bir tur atıyor.



Buna göre, aşağıdaki yorumlardan hangisi kesinlikle yanlıştır?

A) Ahmet bir dakikalık zaman geçtiğini gözlemler.
B) Hasan bir dakikalık zaman geçtiğini gözlemler.
C) Ahmet için geçen bir dakika Hasan için geçen bir dakikaya eşittir.
D) Ahmet için geçen bir dakika Hasan için geçen bir dakikadan uzundur.
E) Ahmet'in organizmasının çalışma hızı yavaşlar.

23. Kemal ve Cemal'in atom saatleri özdeştir. Kemal, saatini Uluslararası uzay istasyonuna giden Sayuz Uzay aracının içine koyuyor. Sayuz'un görevi bittikten sonra dünyaya dönüyor.

    Kemal ve Cemal saatlerini yan yana koyduklarında;

    I. İkisi de aynı saati gösterir
    II. Kemal'in saati önde olur
    III. Kamil'in saati daha yavaş tıklar

    Yargılarından hangileri doğrudur?

    A) Yalnız II B) Yalnız III C) II ve III D) I ve III E) I, II ve III

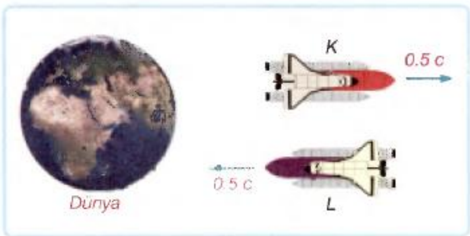
24. Çoşku 10. Sınıf. Sayfa:245

Can, Sadık ve Ahmet'in özdeş üç yay sarkacı vardır. Can ve Sadık yüksek hızla giden bir uzay aracında iken yay sarkaçlarının periyotlarını sırasıyla t_1 ve t_2 olarak, yerde durgun olan Ahmet ise sarkacının periyodunu t_3 olarak ölçüyor.

Buna göre, t_1, t_2, t_3 arasındaki ilişki aşağıdakilerden hangisidir?

A) $t_1 = t_2 = t_3$
B) $t_1 = t_2 > t_3$
C) $t_3 > t_1 = t_2$
D) $t_1 > t_2 > t_3$
E) $t_2 = t_3 > t_1$

25. Çoşku 10. Sınıf. Sayfa:245

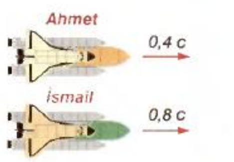


Eşik büyüklükte hızlarla zıt yönde hareket eden uzay araçlarında K Dünya'dan uzaklaşırken L Dünya'ya doğru hareket ediyor. Araçlar Dünya'dan eşit uzaklıkta iken flaş ışığı yakıyor.

Aynı anda yakılan bu flaşlardan çıkan ışığın Dünya'ya ulaşması ile ilgili ne söylenebilir?

A) L den gelen ışık önce ulaşır.
B) K den gelen ışık önce ulaşır.
C) Aynı anda ulaşır.
D) Belirlenemez.
E) Gözlemciye göre değişir.

26. Çoşku 10. Sınıf. Sayfa:249.



Aynı yaştaki üç arkadaştan ikisi şekilde belirtilen hızlarla aynı anda uzay yolculuğuna çıkıp bir süre sonra aynı anda Dünya'ya dönüyor.

Dünya'daki gözlemcilere göre, bu arkadaşların en gençten en yaşlıya sıralanışı nasıl olur?

A) İsmail, Ahmet, Ali
B) Ali, Ahmet, İsmail
C) Hepsinin eşit olur
D) İsmail, Ali, Ahmet
E) Ahmet, İsmail, Ali

APPENDIX H

TENTH GRADE MODERN PHYSICS ACHIEVEMENT TEST- STUDENT-ROUGH VERSION:2

ONUNCU SINIF MODERN FİZİK BAŞARI TESTİ- ÖĞRENCİ-KABA SÜRÜM:2

Yönergeler

1. Testte her biri beş seçenekli 30 soru yer almaktadır. Lütfen bütün sorulara cevap vermek için gayret gösteriniz.
2. Sınavı tamamlamak için önerilen süre yaklaşık 40 dakikadır.
3. Bu testin sonuçları Ortadoğu Teknik Üniversitesi'nde Ortaöğretim Fen ve Matematik Alanları Eğitimi Bölümü'nde doktora yapan araştırmacının tezinde veri olarak kullanılacaktır. Bu bir bilimsel çalışmadır. Bu soruları cevaplandırdığınız için siz de bilimsel bir çalışmanın parçasısınız. Gerekli ilgiyi gösterdiğiniz için teşekkür ederiz.

---

1. Modern fiziğin doğuşuna;

   I. Işığın yapısı
   II. Atomun yapısı
   III. Görelilik

   konularında elde edilen gelişmelerden hangileri katkıda bulunmuştur?

   A) Yalnız I B) Yalnız II
   C) Yalnız III D) I ve III
   E) I, II ve III

2. Fatma, Ayşe ve Zehra Ankara-Eskişehir hızlı treninin içinde trenin kalkışını bekliyorlar. Fatma, elindeki kalemini yere düşürüyor, Ayşe, ipe bağladığı silgisine salınım hareketi yaptırıyor ve Zehra, elindeki lazerin ışığını duvardaki aynadan yansıtıyor.

   Bu kişiler aynı olayları, tren doğrusal bir yolda sabit hızla hareket ederken aynı şekilde yapsalardı hangileri için aynı fizik kuralları yine geçerli olurdu?

I. Kalemin düşmesi süresi

II. silginin salınım periyodu

III. ışığın yansıma açısı

A) Yalnız I B) Yalnız III
C) I ve II D) I ve III
E) I, II ve III

3. Fizik öğretmeni Osman Bey özel göreliliğin temel kurallarını anlattıktan sonra aşağıdaki gibi hareketlere sahip referans sistemlerini sıralıyor.

Sizce bu referans sistemlerinden hangisinde fizik kanunları geçerlidir?

A) Hızlanan bir otomobil
B) Sabit hızla giden bir gemi
C) Salınım hareketi yapan bir salıncak
D) Çembersel yörüngede gösteri yapan bir motosikletli
E) Eğimli bir vadide aşağı hızlanan bir kayakçı

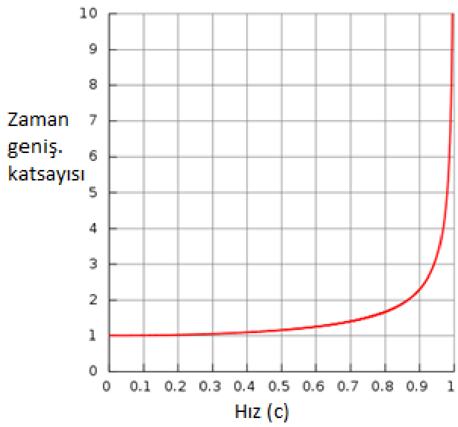
4. Einstein'ın gençlik yıllarında kendisine şu soruyu sorduğu söylenir: Işık hızında hareket ederken elimdeki düzlem aynada kendime bakarsam ne görürüm?

Modern fiziğe göre Einstein'a aşağıdaki cevaplardan hangisini verirsiniz?

A) Aynaya baktığınız halde hiçbir görüntü göremezsiniz
B) Durgun halde aynada ne görürseniz aynısını görürsünüz
C) Görüntünüzü bozuk görürsünüz
D) Görüntünüzü olduğundan daha büyük görürsünüz
E) Görüntünüzü olduğundan daha küçük görürsünüz

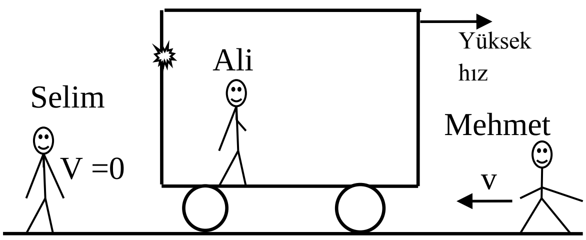
5. Bir aracın hızı arttıkça, durgun gözlemciye göre arabadaki zaman genişlemesi aşağıdaki grafikte gösterildiği gibidir.

Size göre aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi açıklar?



A) Hız arttıkça zaman genişlemesi düzgün azaltmaktadır
B) Hız arttıkça zaman genişlemesi sabittir
C) Hız arttıkça zaman genişlemesi düzgün artmaktadır
D) Işık hızına yaklaşıldıkça zaman aşırı genişlemektedir
E) 0.9c hızında zaman durmaktadır

6. Gelecekte ışık hızına yakın hızla hareket eden trenler yapıldığını varsayalım. Bu trenlerden biri hareket halindeyken vagonunun arka duvarındaki lamba birden yanıyor. Lambanın ışığının ön duvara ulaşma süresi vagonda duran Ali için t_a, yerde duran Selim



için t_s ve vagona doğru yüksek hızla yaklaşan Mehmet için t_m dir.

Buna göre t_a, t_s ve t_m arasındaki ilişki nedir?

A) $t_a > t_s > t_m$
B) $t_m = t_a = t_s$
C) $t_m > t_s > t_a$
D) $t_m = t_s > t_a$
E) $t_s > t_a > t_m$

7. Modern ve klasik fizik ile ilgili olarak;

I. Modern fizik ve klasik fizik yasaları farklıdır
II. Klasik fizik yasalarının yerini modern fizik yasaları almıştır
III. Modern ve klasik fiziğin gelişimi halen devam etmektedir

yargılarından hangileri doğrudur?

A) Yalnız I B) Yalnız III
C) I ve II D) I ve III
E) II ve III

8. Astronotlara uzayda seyahat ettikleri süre ile orantılı olarak ücret ödendiğini farz edin. Siz bir astronot olsaydınız yaptığınız bir uzay yolculuğundan sonra, şirketiniz size aşağıdaki saatlerden hangisine göre ödeme yapsaydı kazancınız daha fazla olurdu?

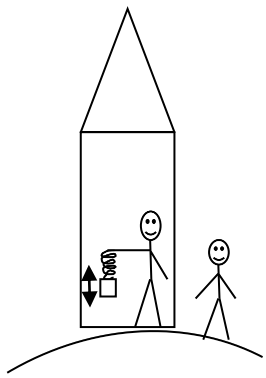
A) Şirketin duvarındaki saat
B) Uzay aracınızdaki saat
C) Seyahatiniz sırasında kolunuzda bulunan saat
D) Sizinle aynı hızda aynı sürede fakat zıt yönde uzaya gidip gelen arkadaşınızın kolundaki saat
E) Sizden daha hızlı sizinle aynı yönde ve sürede gidip gelen arkadaşınızın aracındaki saat

9. Dokuzuncu sınıfta fiziğin doğası ünitesinde fiziğin alt alanlarını öğrenmiştik. Bunlar; Mekanik, Elektrik, Manyetizma, Optik, Termodinamik, Atom fiziği, Nükleer fizik ve Katıhal fiziği idi.

Buna göre fiziğin alt alanlarından kaç tanesi modern fiziğin de alt alanları kapsamındadır?

A) 1 B) 2 C) 3 D) 4 E) 5

10. Yerde duran bir uzay aracındaki astronot, esnek bir yayın ucuna astığı cisme yukarı aşağı salınım hareketi yapıyor. Daha sonra uzay aracı Dünya'ya göre ışık hızına yakın sabit bir hızla hareket ediyor.



Buna göre uzay aracı sabit hızla hareket ederken yerdeki gözlemciye ve astronota göre cismin bir defa yukarı-aşağı hareketi(periyodu) için geçen süre araç durgunken ölçülen periyoda göre nasıl değişir?

	Yerdeki gözlemci	Astronot
A)	Artar	Değişmez
B)	Azalır	Değişmez
C)	Değişmez	Azalır
D)	Değişmez	Artar
E)	Azalır	Artar

11. Fuat ışık hızına yakın hızlarla hareket edildiği zaman bir cismin gözlenen boyunun nasıl değişeceğini merak etmektedir. Fuat'ın sorusuna karşılık fizik öğretmeni Osman Bey öğrencilerinden konu ile ilgili hipotez kurmalarını ister.

    Aşağıdakilerden hangisi bu araştırmada sınanmaya uygun bir hipotez değildir?

    A) Hız ne kadar fazla olursa cismin boyu o kadar fazla kısalır
    B) Hız ne kadar fazla olursa cismin boyu o kadar fazla uzar
    C) Hız ne olursa olsun cismin boyu değişmez
    D) Cismin hızı iki katına çıktığında boyu yarıya iner
    E) Cismin boyunun kısalması cismin bulunduğu yere bağlıdır

12. Modern fizikte ışığın yapısı ile ilgili bazı gelişmeler,

    I. Işığın foton denilen taneciklerden oluşması
    II. Işığın renklere ayrılması
    III. Işığın hem dalga hem de tanecik gibi davranması

    verilenlerden hangileri olabilir?

    A) Yalnız I B) Yalnız II
    C) Yalnız III D) I ve III
    E) I, II ve III

13. Yıldız savaşları filminde her birinin hızı 0,8c olan iki uzay aracı birbirlerine doğru hareket ediyorlar.

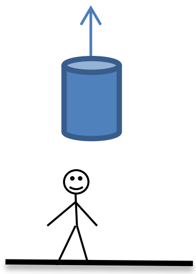
    Buna göre, araçların birbirlerine göre hızlarının büyüklüğü aşağıdakilerden hangisi olabilir? (c, ışık hızıdır)

    A) 0 – 0,8c arasında bir değer
    B) 0,8c – c arasında bir değer
    C) c
    D) 1,6c
    E) c- 1,6c arasında bir değer

14. Aşağıdakilerden hangileri dünyadaki bir hareketi incelemek için bir eylemsiz referans sistemi olabilir?

    I. Konya ovasındaki bir ağaç
    II. Sabit hızla doğrusal bir yolda giden Ankara Eskişehir treni
    III. Sabit süratle çembersel bir yörüngede gösteri yapan motosikletli

15. Aşağıdakilerden hangilerini modern fizik açıklar?



I. Kara cisim ışıması
II. Elektroman yetizma
III. Atom çekirdeğinin yapısı

A) Yalnız II B) Yalnız III

C) I ve II D) I ve III

E) I, II ve III

16. Michelson-Morley deneyi aşağıdakilerden hangisini ölçmek için tasarlanmıştı?

A) Dünyanın çekim ivmesini hesaplamak
B) Elektronların göreli hızlarını hesaplamak
C) Esirin var olup olmadığını araştırmak
D) Işığın hızı ile esirin hızını karşılaştırmak
E) Işığın dalga boyunu hesaplamak

17. NASA'daki bilim insanları ışık hızına yakın bir hızla yıldızlar arası bir yolculuğa çıkacak astronot için hazırlık yapmaktadırlar. Bilim adamlarına yardımcı olabilir misiniz?
Sizce astronotun;

I. Yatağının boyu,
II. Tüketeceği yiyecek ve içeceğin miktarı
III. Kolundaki saate yetecek pilin ömrü

verilenlerden hangileri astronotun hareketli olmasına göre göz önüne alınıp gerekli hesapların yapılması gerekmektedir?

A) Yalnız I B) I ve II
C) II ve III D) I ve III
E) I, II ve III

18. Yanınızdan geçip sizden uzaklaşan bir uzay aracını gözlemliyorsunuz. Uzay aracı geri dönüp size doğru hareket ederse, aracın ilk durumu ile karşılaştırdığınızda, aşağıdakilerden hangisi gözlemlenir?

A) Aracın boyu uzar ve içindeki saat daha hızlı ilerler
B) Aracın boyu uzar ve içindeki saat daha yavaş ilerler
C) Aracın boyu kısalır ve içindeki saat daha hızlı ilerler
D) Aracın boyu kısalır ve içindeki saat daha yavaş ilerler
E) Aracın boyu da içindeki saatin ilerlemesi de değişmez

19. Silindirik bir uzay aracı sizin bakış doğrultunuzdan ışık hızına yakın bir hızla uzaklaşmaktadır. Buna göre uzay aracının uzunluğu ve çapı size göre nasıl değişir?

	Uzunluğu	Çapı
A)	Artar	Artar
B)	Azalır	Azalır
C)	Değişmez	Artar
D)	Değişmez	Değişmez
E)	Kısalır	Değişmez

20. Kemal ve Cemal'in atom saatleri aynı zamanı göstermektedir. Cemal'in saati dünyada dururken, Kemal saatini, NASA tarafından yeni geliştirilen uzay aracının içine koyuyor. Uzay aracı Mars yolculuğunu yaptıktan sonra dünyaya dönüyor. Kemal ve Cemal saatlerini yan yana koyduklarında;

I. İkisi de aynı saati gösterir
II. Kemal'in saati geride olur
III. Cemal'in saati daha yavaş tıklar

Yargılarından hangileri doğrudur?

A) Yalnız II B) Yalnız III
C) II ve III D) I ve III
E) I, II ve III

21. ODTÜ'de (Orta Doğu Teknik Üniversitesi) fizik bölümünde birçok branş vardır. Aşağıdaki branşlar da bunlardan birkaç tanesidir.

I. Nükleer fizik
II. Atom fiziği
III. Teorik fizik

Buna göre ODTÜ fizik bölümünde okutulan bu branşlardan hangileri modern fiziği oluşturan temel unsurlardandır?

A) Yalnız I B) Yalnız III
C) I ve II D) I ve III
E) II ve III

22. Yıldızlar arası yolculuğa çıkan Ahmet, Alfa Centauri'deki ziyaretini bitirdikten sonra yıldızdan 0,5c hızı ile ayrılıyor. Buna göre yıldızın ışığı Ahmet'e göre Ahmet'i hangi hızla geçer?

A) 0,5c
B) 0,5c-c arası bir hızla
C) c-1,5c arası bir hızla
D) 1,5c hızı ile
E) c hızı ile

23. Dünya'ya göre 0,6c hızı ile yola çıktığınızı düşünün, size ve dünyadakilere göre;

I. Dakikadaki kalp atış sayınız

II. Boyunuz

III. Kütleniz

niceliklerinden hangileri farklı ölçülebilir?

	Size göre	Dünyadakilere göre
A)	I, II ve III	II ve III
B)	II ve III	I, II ve III
C)	I ve III	I, II ve III
D)	Hiç biri	I ve II
E)	II ve III	Hiç biri

24. Modern fiziğin doğuşu ile ilgili olarak;

I. Sadece Einstein tarafından geliştirilmiştir
II. 19. yüzyıl sonları ile 20. yüzyıl başlarında doğmuştur
III. Max Plank'n modern fiziğin doğuşuna katkısı büyüktür

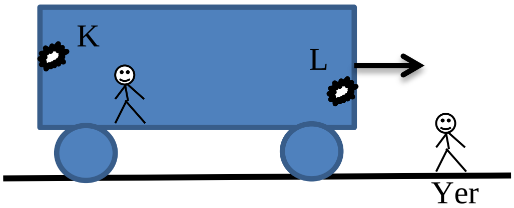
yargılarından hangileri doğrudur?

A) Yalnız I B) Yalnız II

C) Yalnız III D) II ve III

E) I, II ve III

25. Işık hızına yakın bir hızla hareket eden bir trenin vagonlarından birinde şekildeki gibi aynı anda K ve L lambaları ışık vermeye başlıyorlar.



Buna göre yerdeki ve vagondaki gözlemcilere göre hangi lambanın ışığı önce karşısındaki duvara ulaşır?

	Yerdeki	Vagondaki
A)	K	L
B)	L	K
C)	K	Aynı anda
D)	L	Aynı anda
E)	Aynı anda	Aynı anda

26.

Can, Sadık ve Ahmet'in özdeş üç yay sarkacı vardır. Can ve Sadık yüksek hızla giden bir uzay aracında iken yay sarkaçlarının periyotlarını sırasıyla t_1 ve t_2 olarak, yerde durgun olan Ahmet ise sarkacının periyodunu t_3 olarak ölçüyor.

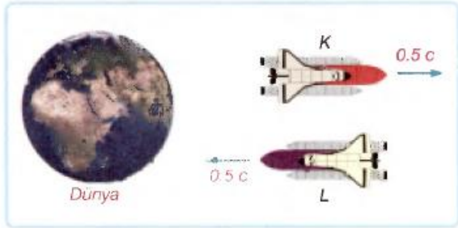
Buna göre, t_1, t_2, t_3 arasındaki ilişki aşağıdakilerden hangisidir?

A) $t_1 = t_2 = t_3$ B) $t_1 = t_2 > t_3$

C) $t_3 > t_1 = t_2$ D) $t_1 > t_2 > t_3$

E) $t_2 = t_3 > t_1$

27.



Eşik büyüklükte hızlarla zıt yönde hareket eden uzay araçlarında K Dünya'dan uzaklaşırken L Dünya'ya doğru hareket ediyor. Araçlar Dünya'dan eşit uzaklıkta iken flaş ışığı yakıyor.

Aynı anda yakılan bu flaşlardan çıkan ışığın Dünya'ya ulaşması ile ilgili ne söylenebilir?

A) L den gelen ışık önce ulaşır.

B) K den gelen ışık önce ulaşır.

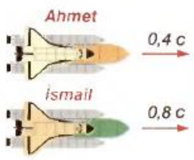
C) Aynı anda ulaşır.

D) Belirlenemez.

E) Gözlemciye göre değişir.

28.

Aynı yaştaki üç arkadaştan ikisi şekilde belirtilen hızlarla aynı anda uzay yolculuğuna çıkıp bir süre sonra aynı anda Dünya'ya dönüyor.



Dünya'daki gözlemcilere göre, bu arkadaşların en gençten en yaşlıya sıralanışı nasıl olur?

A) İsmail, Ahmet, Ali B) Ali, Ahmet, İsmail

C) Hepsinin eşit olur D) İsmail, Ali, Ahmet

E) Ahmet, İsmail, Ali

29. Yıldızlar arası bir yolculuk yapacak bir uzay aracı için şöyle bir fikir ortaya atılmıştır: Güneşin yakınlarına fırlatılan bir uzay aracı güneşin ışığının itmesi ile hızlandırılabilir. Başlangıçta yavaş olan uzay aracı uzun sürede çok yüksek hızlara ulaştırılabilir. Böyle bir aracın yapıldığını farz edin. Bu araç için;

I. Hızlandıkça kütlesi değişmez
II. Işık hızına ulaştırmak için sonsuz enerjiye ihtiyaç vardır.
III. Uzun sürede ışık hızına ulaşır

yargılarından hangileri doğrudur?

A) Yalnız I B) I ve II
B) C) I ve III D) II ve III
C) E) I, II ve III

30. Aşağıdaki fiziksel olayların hangileri ile ilgili gelişmeler modern fiziğin doğuşuna katkıda bulunmuştur.

I. Fotoelektrik olayı
II. Işığın girişimi
III. Kara cisim ışıması

A) Yalnız I B) Yalnız II
C) I ve III D) II ve III E) I, II ve III

APPENDIX I

TENTH GRADE MODERN PHYSICS ACHIEVEMENT TEST- STUDENT- FIRST VERSION

ONUNCU SINIF MODERN FİZİK BAŞARI TESTİ- ÖĞRENCİ-İLK SÜRÜM

Adınız Soyadınız: …………………………………………………..

Cinsiyetiniz: □ Kız □ Erkek

Sınıfınız: …………………………………………………..

Okulunuzun adı: …………………………………………………..

Yönergeler

1. Sınava başlamadan önce yukarıda verilen kısmı eksiksiz doldurunuz.
2. Bu testin amacı sizlerin modern fizik ünitesini öğrenmeden önceki bilgilerinizi değerlendirmektir. Lütfen bütün sorulara cevap vermek için gayret gösteriniz.
3. Testte her biri beş seçenekli 34 soru yer almaktadır. Dört yanlış bir doğru soruyu götürmektedir.
4. Size göre doğru cevap yoksa ‘‘f’’ şıkkını işaretleyiniz.
5. Soruyu cevaplamaya çalıştıktan sonra anlayamadıysanız ‘‘g’’ şıkkını işaretleyiniz.
6. Sınavı tamamlamak için önerilen süre yaklaşık 40 dakikadır.
7. Bu testin sonuçları Ortadoğu Teknik Üniversitesi’nde Ortaöğretim Fen ve Matematik Alanları Eğitimi Bölümü’nde doktora yapan araştırmacının tezinde veri olarak kullanılacaktır. Bu soruları cevaplandırdığınız için siz de bu bilimsel bir çalışmanın parçasısınız. Gerekli ilgiyi gösterdiğiniz için teşekkür ederiz.

1. Modern fiziğin doğuşuna;

   I. Işığın yapısı
   II. Atomun yapısı
   III. Görelilik

   konularında elde edilen gelişmelerden hangileri katkıda bulunmuştur?

A) Yalnız I B) Yalnız II C) Yalnız III D) I ve III E) I, II ve III

2. Fatma, Ayşe ve Zehra Ankara-Eskişehir hızlı treninin içinde trenin kalkışını bekliyorlar.

   I. Fatma, elindeki kalemin yere düşme süresini,
   II. Ayşe, ipe bağladığı silgisinin salınım periyodunu ve
   III. Zehra, elindeki lazerin ışığını duvardaki aynadan yansıma açısını ölçüyor.

   Bu kişiler aynı ölçümleri, tren doğrusal bir yolda sabit hızla hareket ederken tekrarlasalar hangileri ilk kullandıkları fizik kuralları yine kullanabilirler?

   B) Yalnız Fatma B) Yalnız Ayşe C) Fatma ve Ayşe
   D) Ayşe ve Zehra E) Fatma, Ayşe ve Zehra

3. Fizik öğretmeni Osman Bey özel göreliliğin temel kurallarını anlattıktan sonra aşağıdaki gibi hareketlere sahip referans sistemlerini sıralıyor.

   I. Hızlanan bir otomobil
   II. Hızlanan otomobili sürekli aynı mesafede takip eden motosikletli
   III. v hızı ile giden bir kayık
   IV. v hızı ile giden kayığa göre 2v hızı ile giden gemi
   V. Salınım hareketi yapan bir salıncak
   VI. Eğimli bir vadide aşağı hızlanan bir kayakçı

4. Dünyaya göre hangileri eylemli, hangileri eylemsiz referans sitemi olarak kabul edilebilir?

	Eylemli	Eylemsiz
A)	I, II, V ve VI	III ve VI
B)	I, IV ve V	II, III, VI
C)	II, V ve VI	I, III ve VI
D)	IV ve VI	I, II, III ve V
E)	II, III, IV ve V	I ve VI

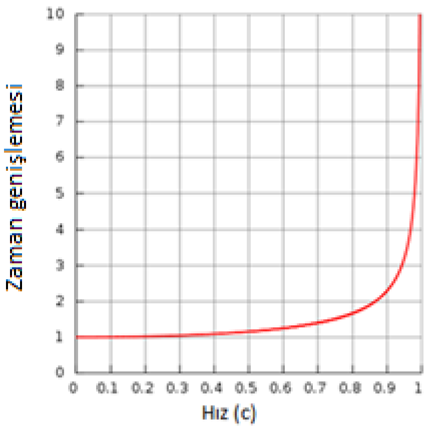
5. Işık hızında hareket ederken düzlem aynada kendimizi görmemiz özel göreliliğin;

   I. Işık hızı, eylemsiz referans sisteminde, ışık kaynağının ve gözlemcinin hareketinden bağımsızdır
   II. Fizik yasaları tüm eylemsiz referans sistemlerinde aynıdır
   III. Işık hızı aşılamaz

   kabullerinden hangilerinden dolayıdır?

A) Yalnız I B) Yalnız II C) I ve II D) I ve III E) II ve III

6. Farklı sabit hızlarda hareket eden referans sistemlerindeki zaman genişlemesinin hıza bağlı değişimi aşağıdaki grafikte gösterildiği gibi olmaktadır.



   Buna göre zaman genişlemesi;

   I. Sabit hızla giden bir araba
   II. Sabit hızla giden bir jet uçağı
   III. Işık hızına yakın bir hızla giden bir uzay aracı

   Hangileri için ihmal edilemez?

   A) Yalnız I B) Yalnız III C) I ve II D) I ve III E) I, II ve III

7. Modern ve klasik fizik ilişkisi ile ilgili olarak;

   I. Modern fizik ve klasik fizik yasaları farklıdır
   II. Klasik fizik yasalarının yerini modern fizik yasaları almıştır
   III. Klasik Fizik, görece kütlesi büyük, hızı küçük; modern fizik ise görece kütlesi küçük ve hızı büyük olan cisimler için geçerlidir.

   yargılarından hangileri doğrudur?

   A) Yalnız I B) Yalnız III C) I ve II D) I ve III E) II ve III

8. Yıldızlar arası kargo taşımacılığı yapan bir şirketin sahibi olduğunuzu düşünün. İşe alacağınız bir astronota;

I. Şirketin duvarındaki
II. Uzay aracındaki
III. Seyahat esnasında astronotun kolundaki

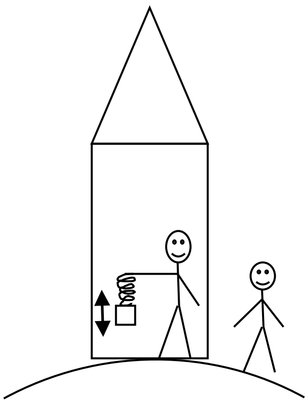
saatlerden hangisine göre ödeme yapsanız daha kazançlı olurdunuz?

9. Dokuzuncu sınıfta fiziğin doğası ünitesinde fiziğin alt alanlarını öğrenmiştik. Bunlar; Mekanik, Elektrik, Manyetizma, Optik, Termodinamik, Atom fiziği, Nükleer fizik ve Katıhal fiziği idi.

Buna göre, fiziğin alt alanlarından kaç tanesi modern fiziğin de alt alanları kapsamındadır?

A) 1 B) 2 C) 3 D) 4 E) 5

10. Yerde duran bir uzay aracındaki astronot, esnek bir yayın ucuna astığı cismin salınım periyodunu ölçüyor. Daha sonra uzay aracı hızlanarak ışık hızına yakın sabit bir hız kazanıyor ve yoluna bu hız ile devam ediyor. Uzay aracı sabit hızla hareket ederken astronot, aynı yay ile cismin periyodunu tekrar ölçüyor.



Yerdeki gözlemciye ve astronota göre cismin bu yeni periyodu araç durgunken ölçülen periyoda göre nasıl değişir?

<u>Yerdeki gözlemci</u>	<u>Astronot</u>
A) Artar	Değişmez
B) Azalır	Değişmez
C) Değişmez	Azalır
D) Değişmez	Artar
E) Azalır	Artar

11. Işık ile ilgili aşağıdaki bulgulardan hangileri modern fiziğin doğuşuna katkıda bulunmuştur?

I. Foton denilen taneciklerden oluştuğunun anlaşılması
II. Renklere ayrılmasının keşfedilmesi
III. Dalga gibi davrandığının ispatlanması

A) Yalnız I B) Yalnız II C) Yalnız III D) I ve III E) I, II ve III

12. Yıldız savaşları filminde her birinin hızı 0,8c olan iki uzay aracı birbirlerine doğru sabit hızla hareket ediyorlar.

Buna göre, araçların birbirlerine göre hızlarının büyüklüğü aşağıdakilerden hangisi olabilir? (c, ışık hızıdır)

A) 0 – 0,8c arasında bir değer
B) 0,8c – c arasında bir değer
C) c
D) 1,6c
E) c- 1,6c arasında bir değer

13. Bir binanın tepesinden serbest bırakılan bir cismin hareketini incelemek için aşağıdakilerden hangisi eylemsiz bir referans sistemi olabilir?

I. Kız kulesi
II. Sabit hızla giden Ankara Eskişehir treni
III. Sabit süratle çembersel bir yörüngede gösteri yapan motosikletli

A) Yalnız I B) Yalnız III C) I ve II D) I ve III E) II ve III

14. Aşağıdakilerden hangilerini modern fizik kapsamında doğru açıklanır?

I. Kara cisim ışıması
II. Elektromanyetizma
III. Atom çekirdeğinin yapısı
A) Yalnız II B) Yalnız III C) I ve II D) I ve III E) I, II ve III

15. Michelson ve Michelson-Morley deneylerinde;

I. Işığın girişimi
II. Dünyanın hızı
III. Esir

kavramlarından hangileri kullanılmıştır?

A) Yalnız I B) I ve II C) II ve III D) I ve III E) I, II ve III

16. NASA'daki bilim insanları ışık hızına yakın bir hızla yıldızlar arası bir yolculuğa çıkacak astronot için hazırlık yapmaktadırlar. Bilim adamlarına yardımcı olabilir misiniz?

    Sizce astronotun;

I. Yatağının boyu,
II. Tüketeceği yiyecek ve içeceğin miktarı
III. Kolundaki saate yetecek pilin ömrü

verilenlerden hangileri astronotun hareketli olmasına göre göz önüne alınıp gerekli hesapların yapılması gerekmektedir?

A) Yalnız I B) I ve II C) II ve III D) I ve III E) I, II ve III

17. Sabit bir hızla sizden uzaklaşan bir uzay aracını gözlemliyorsunuz. Uzay aracı geri dönüp aynı büyüklükteki hızla size doğru hareket ederse, aracın ilk durumu ile karşılaştırdığınızda;

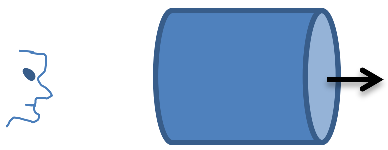
I. boyu kısalır
II. boyu değişmez
III. içindeki saat daha yavaş ilerler
IV. içindeki saatin ilerlemesi değişmez

yargılarından hangileri doğrudur?

A) Yalnız I B) I ve III C) I ve IV D) II ve III E) II ve IV

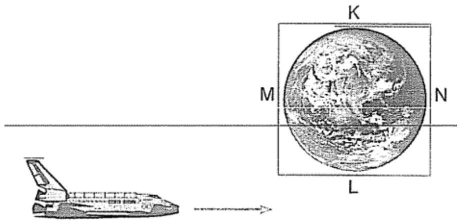
18. Silindirik bir uzay aracının şekildeki gibi bakış doğrultunuzdan ışık hızına yakın bir hızla uzaklaştığını düşünün.
    Buna göre uzay aracının uzunluğu ve çapı size göre nasıl değişir?

	Uzunluğu	Çapı
A)	Artar	Artar
B)	Azalır	Azalır
C)	Değişmez	Artar
D)	Değişmez	Değişmez
E)	Kısalır	Değişmez

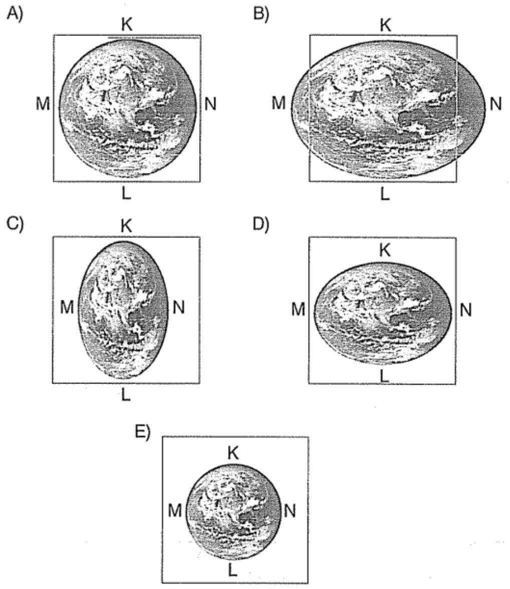


19. Zambak 313 sayfa... 10.soru

Işık hızına yakın yüksek hızla hareket eden bir uzay aracı şekildeki gibi Dünya'nın M ve N noktalarından geçen doğruya paralel bir yörünge izliyor.



Buna göre, uzay aracındaki bir gözlemci Dünya'yı aşağıdakilerden hangisindeki gibi görür?



20. Kemal ve Cemal'in atom saatleri (çok küçük zaman farklarını bile ölçebilen) aynı zamanı göstermektedir. Cemal'in saati dünyada dururken, Kemal saatini, NASA tarafından yeni geliştirilen uzay aracının içine koyuyor. Uzay aracı Mars yolculuğunu yaptıktan sonra dünyaya dönüyor.

Kemal ve Cemal saatlerini yan yana koyduklarında;

I. İkisi de aynı saati gösterir
II. Kemal'in saati geride olur
III. Cemal'in saati daha yavaş tıklar

Yargılarından hangileri doğrudur?

A) Yalnız II B) Yalnız III C) II ve III D) I ve III E) I, II ve III

21. ODTÜ'de (Orta Doğu Teknik Üniversitesi) fizik bölümünde birçok branş vardır. Aşağıdaki branşlar da bunlardan birkaç tanesidir.

I. Nükleer fizik
II. Atom fiziği
III. Teorik fizik

Buna göre ODTÜ fizik bölümünde okutulan bu branşlardan hangileri modern fiziğin altında incelenebilir?

A) Yalnız I B) Yalnız III C) I ve II D) I ve III E) II ve III

22. Yıldızlar arası yolculuğa çıkan Ahmet, bize en yakın yıldız olan Alfa Centauri'deki ziyaretini bitirdikten sonra yıldızdan 0,5c hızı ile ayrılıyor.

Buna göre yıldızın ışığı Ahmet'e göre Ahmet'i hangi hızla geçer?

A) 0,5c
B) 0,5c-c arası bir hızla
C) c-1,5c arası bir hızla
D) 1,5c hızı ile
E) c hızı ile

23. Yıldızlararası yolculuğa hazırlanan Mustafa, yolculuğun hemen öncesi birçok kontrolden geçiyor. Bunlardan bazıları Mustafa'nın;

I. dakikadaki kalp atış sayısı

II. boyu ve

III. kütlesidir

Mustafa, ışık hızına yakın bir hız ile yola çıktığında, hareketli olmasından dolayı kendisine ve dünyadakilere göre yukarıdaki niceliklerinden hangileri değişebilir?

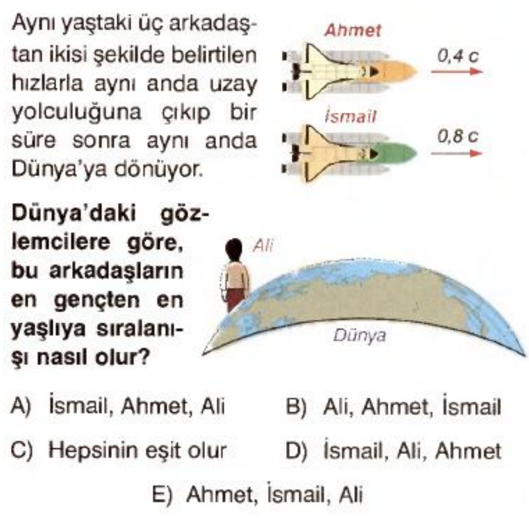
	Kendisine göre	Dünyadakilere göre
A)	I, II ve III	II ve III
B)	II ve III	I, II ve III
C)	I ve III	I, II ve III
D)	Hiç biri	I ve II
E)	II ve III	Hiç biri

24. Can, Sadık ve Ahmet'in özdeş üç yay sarkacı vardır. Can ve Sadık yüksek hızla giden bir uzay aracında iken yay sarkaçlarının periyotlarını sırasıyla t1 ve t2 olarak, yerde durgun olan Ahmet ise sarkacının periyodunu t3 olarak ölçüyor.

Buna göre, t_1, t_2 ve t_3 arasındaki ilişki aşağıdakilerden hangisidir?

A) $t_1=t_2=t_3$ B) $t_1=t_2>t_3$ C) $t_3>t_1=t_2$ D) $t_1>t_2>t_3$ E) $t_2=t_3>t_1$

25. Çoşku 10. Sınıf. Sayfa:249


Aynı yaştaki üç arkadaştan ikisi şekilde belirtilen hızlarla aynı anda uzay yolculuğuna çıkıp bir süre sonra aynı anda Dünya'ya dönüyor.

Dünya'daki gözlemcilere göre, bu arkadaşların en gençten en yaşlıya sıralanışı nasıl olur?

A) İsmail, Ahmet, Ali B) Ali, Ahmet, İsmail

C) Hepsinin eşit olur D) İsmail, Ali, Ahmet

E) Ahmet, İsmail, Ali

26. Aşağıdaki fiziksel olayların hangileri ile ilgili gelişmeler modern fiziğin doğuşuna katkıda bulunmuştur.

I. Fotoelektrik olayı
II. Işığın girişimi
III. Kara cisim ışıması

Yalnız I B) Yalnız II C) I ve III D) II ve III E) I, II ve III

27. Bir cismin kütlesi ile ilgili olarak;

I. İç enerjisi değişirse kütlesi de değişir
II. Hızı değişirse kütlesi de değişir
III. Işık hızına ulaştırmak için sonsuz enerji vermek gerekir

Yargılarından hangileri doğrudur?

A) Yalnız I B) Yalnız II C) I ve III D) II ve III E) I, II ve III

28, 29, 30, 31, 32, 33 ve 34. sorular doğru yanlış sorularıdır. Bu sorularda verilen cümleler doğru ise A, yanlış ise B şıkkını işaretleyiniz

28. Newton'un F=ma olarak bilinen kanunu ışık hızına yakın hız ile hareket eden cisimlerde de geçerlidir.
    A) B)
29. Modern fiziğe göre araba ile ışık hızında giderken farları açtığımızda önümüz aydınlanır.
    A) B)
30. Klasik fiziğe göre ışık hızında hareket ederken elimdeki düzlem aynada kendime bakarsam kendimi göremem.
    A) B)
31. Esir evrendeki tek mutlak eylemsiz referans sistemidir
    A) B)
32. Michelson-Morley deneylerinde var olduğu söylenen esir maddesinin varlığı ispatlanmaya çalışılmıştır.
    A) B)
33. katıhal/yoğun madde fiziği kuantum fiziğinin alt alanlarından biridir
    A) B)
34. Işık hızı, her durumda, ışık kaynağının ve gözlemcinin hareketinden bağımsızdır.
    A) B)
35. Aşağıda, üstte kavramlar, altta ise ilişkili oldukları açıklamaları/tanımları verilmiştir. Alttaki açıklamalar üstteki birden fazla kavram ile ilişkili olabilir.

Buna göre kavramlar ile açıklamaları/tanımları hangi şıkta doğru eşleştirilmiştir?

Kavramlar

1. Modern fizik
2. Atom ve çekirdek fiziği
3. Görelilik
4. Kuantum

Açıklamalar/Tanımlar

a. Modern fiziğin alt alanıdır
b. Modern fiziği oluşturan temel unsurlardan birdir
c. Mikro evrendeki ve ışık hızına yakın hızlarda hareket eden cisimlerin hareketini açıklamaya odaklanır.
   A) 1..b; 2..b-c; 3,4..c
   B) 1..c; 2,4..a; 3..b
   C) 1..a; 2..c; 3..a; 4..b
   D) 1,3..c; 2..b; 4..a
   E) 1..c; 2..a; 4..b

APPENDIX J

TENTH GRADE MODERN PHYSICS ACHIEVEMENT TEST- STUDENT-SECOND VERSION

ONUNCU SINIF MODERN FİZİK BAŞARI TESTİ- ÖĞRENCİ-İKİNCİ SÜRÜM

Yönergeler

1. Bu testin amacı sizlerin 10. sınıf modern fizik ünitesindeki konularla ilgili bilgilerinizi ölçmektir. Lütfen bütün sorulara cevap vermek için gayret gösteriniz.
2. Testte 6 tane doğru-yanlış, 6 tane eşleştirme, 18 tane çoktan seçmeli ve 2 tane açık uçlu soru yer almaktadır. Her sorunun sadece bir doğru cevabı vardır. Bir soru için birden çok cevap yeri işaretlenmişse o soru yanlış cevaplanmış sayılacaktır.
3. Bu test puanlanırken doğru cevaplarınızın sayısından yanlış cevaplarınızın sayısının dörtte biri düşülecek ve kalan sayı net puanınız olacaktır.
4. Cevaplarınızı optik forma işaretleyiniz. Bu kitapçık üzerinde karalama yapabilirsiniz.
5. Soruları okuduktan sonra cevabını bilmiyorsanız, lütfen ‘‘**f**’’ şıkkını işaretleyiniz.
6. Soruların seçeneklerinde size göre doğru cevap yoksa sizce doğru olan cevabı optik formda ilgili soru numarasında şıklardan sonraki boşluğa yazınız.
7. Testin bütünü için verilen cevaplama süresi toplam 40 dakikadır.
8. Bu testin sonuçları Ortadoğu Teknik Üniversitesi’nde Ortaöğretim Fen ve Matematik Alanları Eğitimi Bölümü’nde doktora yapan araştırmacının tezinde veri olarak kullanılacaktır. Bu soruları cevaplandırdığınız için siz de bu bilimsel çalışmanın bir parçasısınız. Gerekli ilgiyi gösterdiğiniz için teşekkür ederiz.
9. Sınavda gerekli olabilecek formüller en son sayfada mevcuttur.
10. Sınav sonuçlarını sizinle paylaşabilmemiz için sınava başlamadan önce optik formdaki ‘‘Ad Soyad’’ kısmını doldurunuz.

DOĞRU YANLIŞ SORULARI

	Doğru	Yanlış	Bilmiyorum
1. Modern fiziğe göre, boşlukta 0,5c hızında giden bir aynaya gelen ve yansıyan ışınların hız büyüklükleri eşit olur.	(a)	(b)	(f)
2. Einstein özel görelilik teorisinden dolayı Nobel ödülü almıştır.	(a)	(b)	(f)
3. Evren esir denilen bir madde ile doludur.	(a)	(b)	(f)
4. Özel görelilik ikizler paradoksuna açıklama getirememiştir.	(a)	(b)	(f)
5. Özel görelilik kuramına göre enerji vererek kütleli bir cismi ışık hızına ulaştırma mümkün değildir.	(a)	(b)	(f)
6. Eylemsiz referans sistemi olarak kabul edilen v hızlı kayığa göre, 2v hızı ile giden bir gemi de eylemsiz referans sistemi olarak kabul edilebilir.	(a)	(b)	(f)

A. EŞLEŞTİRME SORULARI

- Solda fiziğin alt alanları, sağda ise bunların fizik ile ilişkileri belirtilmiştir. Solda, her bir maddenin önün deki boşluğa, sağda bu madde ile en iyi eşleşen ilişkinin harfini optik forma işaretleyiniz. Sağdaki her bir ilişki birer defa, birden çok ya da hiç kullanılmayabilir.

Fiziğin alt alanları	*Fizik ile ilişkileri*
7. ____ Katıhal fiziği	a. Modern fiziğin alt alanları kapsamındadır
8. _____ Atom fiziği	b. modern fiziğin alt alanları kapsamında değildir
9. _____ Optik	f. Cevabını bilmiyorum
10. _____ Manyetizma	
11. _____ Termodinamik	
12. _____ Nükleer fizik	

B. ÇOKTAN SEÇMELİ SORULAR

13. Modern fiziğe göre ışık hızında hareket ederken düzlem aynada kendimizi görebilmemiz özel göreliliğin;

I. Fizik yasaları tüm eylemsiz referans sistemlerinde aynıdır
II. Işık hızı aşılamaz
III. Işık hızı, eylemsiz referans sisteminde, ışık kaynağının ve gözlemcinin hareketinden bağımsızdır

kabullerinden hangilerinden dolayıdır?

a) Yalnız I b) Yalnız II

c) Yalnız III d) I ve III

e) II ve III

f) Cevabını bilmiyorum

14. Modern ve klasik fizik ilişkisi ile ilgili olarak;

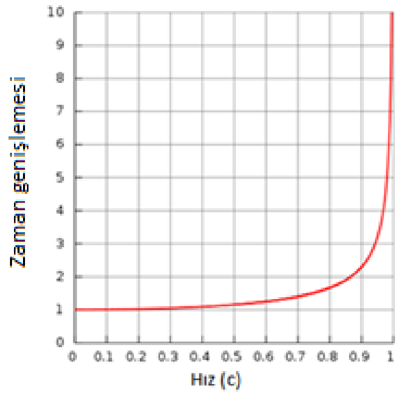
IV. Modern fizik ve klasik fizik yasaları tamamen farklıdır
V. Klasik fizik yasalarının yerini modern fizik yasaları almıştır
VI. Klasik fizik, görece kütlesi büyük ve hızı küçük; modern fizik ise görece kütlesi küçük ve hızı büyük olan cisimlerin hareketlerini açıklamaya odaklanır.

yargılarından hangileri doğrudur?

a) Yalnız I b) Yalnız III
c) I ve II d) I ve III e) II ve III

f) Cevabını bilmiyorum

15. Farklı sabit hızlarda hareket eden referans sistemlerindeki zaman genişlemesinin hıza bağlı değişimi aşağıdaki grafikte gösterildiği gibi olmaktadır.



Buna göre zaman genişlemesi;
I. sabit hızla giden bir araba
II. sabit hızla giden bir jet uçağı
III. ışık hızına yakın bir hızla giden bir uzay aracı

hangileri için ihmal edilemez?

a) Yalnız I b) Yalnız III

c) I ve II d) I ve III e) I, II ve III

f) Cevabını bilmiyorum

16. Yıldızlar arası kargo taşımacılığı yapan bir şirketin sahibi olduğunuzu düşünün. İşi daha ucuza getirmek için işe alacağınız bir astronota;
I. Şirketinizin duvarındaki saate
II. Uzay aracınızdaki saate
III. Seyahat esnasında astronotun kolundaki saate

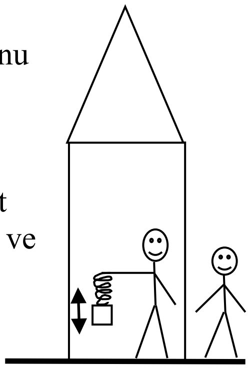
göre ödeme yapmak <u>istemezsiniz</u>?

a) Yalnız I b) Yalnız III c) I ve II

d) II ve III e) I, II ve III

f) Cevabını bilmiyorum

17. Yerde duran bir uzay aracındaki astronot, esnek bir yayın ucuna astığı cismin salınım periyodunu ölçüyor. Daha sonra uzay aracı hızlanarak ışık hızına yakın sabit bir hız kazanıyor ve yoluna bu hız ile devam ediyor. Uzay aracı sabit hızla hareket ederken astronot, aynı yay ile cismin periyodunu tekrar ölçüyor.



Yerdeki gözlemciye ve astronota göre cismin bu yeni periyodu araç durgunken ölçülen periyoda göre nasıl değişir?

Yerdeki gözlemci	Astronot
A) Azalır	Değişmez
B) Değişmez	Azalır
C) Değişmez	Artar
D) Artar	Değişmez
E) Artar	Azalır
F) Cevabını bilmiyorum	

18. Işık ile ilgili;

I. Renklere ayrılmasının keşfedilmesi
II. Dalga gibi davrandığının ispatlanması
III. Foton denilen taneciklerden oluştuğunun anlaşılması

bulgulardan hangileri modern fiziğin doğuşuna katkıda bulunmuştur?

a) alnız I b) Yalnız II c) Yalnız III

d) I ve III e) I, II ve III

f) Cevabını bilmiyorum

19. Bir binanın tepesinden serbest bırakılan bir cismin hareketini incelemek için aşağıdakilerden hangisi eylemsiz bir referans sistemi kabul edilebilir?

I. Kız kulesi
II. Sabit hızla giden Ankara Eskişehir treni
III. Sabit süratle çembersel bir yörüngede gösteri yapan motosikletli

a) Yalnız I b) Yalnız III
b) I ve II d) I ve III e) II ve III
f) Cevabını bilmiyorum

20. Yıldızlar arası yolculuğa çıkan Ahmet, bize en yakın yıldız olan Alfa Centauri'deki ziyaretini bitirdikten sonra yıldızdan 0,5c hızı ile ayrılıyor.
Buna göre yıldızın ışığı Ahmet'e göre Ahmet'i hangi hızla geçer?

a) 0,5c b) 0,5c-c arası bir hızla

c) c-1,5c arası bir hızla

d) 1,5c hızı ile e) c hızı ile

f) Cevabını bilmiyorum

21. NASA'daki bilim insanları yıldızlar arası bir yolculuğa çıkacak astronot için hazırlık yapmaktadırlar. Aşağıdakilerin gerektiğinden ne fazla ne de az olması istenmemektedir.

Sizce astronotun;

I. Yatağının boyu,
II. Tüketeceği yiyecek ve içeceğin miktarı
III. Kolundaki saate yetecek pilin ömrü

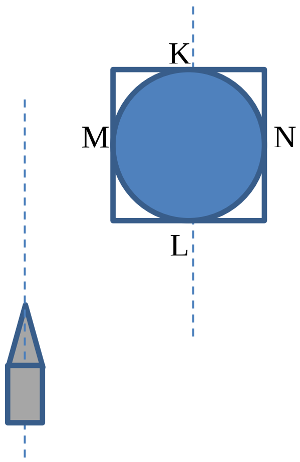
verilenlerden hangileri astronotun ışık hızına yakın bir hızla yolculuğunu yapması göz önüne alınıp gerekli hesapların yapılması gerekmektedir?

a) Yalnız I b) I ve II c) I ve III

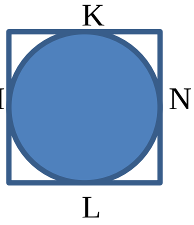
d) II ve III e) I, II ve III

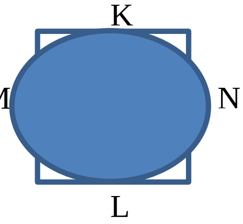
f) Cevabını bilmiyorum

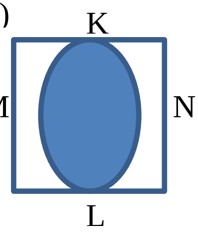
22. Işık hızına yakın yüksek hızla hareket eden bir uzay aracı şekildeki gibi Dünya'nın K ve L noktalarından geçen doğruya paralel bir yörünge izliyor.

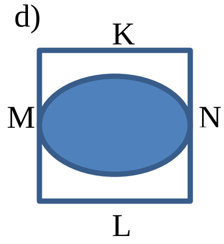


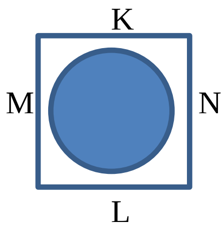
Buna göre, uzay aracındaki bir gözlemci Dünya'yı aşağıdakilerden hangisi gibi görür? (Dünya etrafındaki kare çerçeve, soruda ve şıklarda aynı büyüklüktedir)

a)


b


c)


d)


e)


f) Cevabını bilmiyorum

23. Can, Sadık ve Ahmet'in özdeş üç yay sarkacı vardır. Dünyaya göre, Can 0.5c hızla ve Sadık 0.8c hızla giden bir uzay aracında iken yay sarkaçlarının periyotlarını sırasıyla t_1 ve t_2 olarak, yerde durgun olan Ahmet ise sarkacının periyodunu t_3 olarak ölçüyor.

Buna göre, t_1, t_2 ve t_3 arasındaki ilişki aşağıdakilerden hangisidir?

a) $t_2>t_1>t_3$ b) $t_1=t_2>t_3$ c) $t_3>t_1=t_2$

d) $t_3>t_1>t_2$ e) $t_1=t_2=t_3$

f) Cevabını bilmiyorum

24. Sabit bir hızla sizden uzaklaşan bir uzay aracını gözlemliyorsunuz. Uzay aracı geri dönüp aynı büyüklükteki hızla size doğru hareket ederken ki

durumu ile ilk durumunu karşılaştırdığınızda;

A) boyu kısalır
B) boyu değişmez
C) içindeki saat daha yavaş ilerler
D) içindeki saatin ilerlemesi değişmez

yargılarından hangileri doğrudur?

a) Yalnız I b) I ve III c) I ve IV

d) II ve III e) II ve IV

f) Cevabını bilmiyorum

25. Kemal ve Cemal'in (çok küçük zaman farklarını bile ölçebilen) atom saatleri aynı zamanı göstermektedir. Cemal'in saati dünyada dururken, Kemal saatini, NASA tarafından yeni geliştirilen uzay aracının içine koyuyor. Uzay aracı Mars yolculuğunu yaptıktan sonra dünyaya dönüyor.

Kemal ve Cemal saatlerini yan yana koyduklarında;

I. İkisi de aynı saati gösterir
II. Kemal'in saati geride olur
III. Cemal'in saati, Kemal'inkine göre daha uzun aralıklarla tıklar

yargılarından hangileri doğrudur?

a) Yalnız II b) Yalnız III

c) II ve III d) I ve III e) I, II ve III

f) Cevabını bilmiyorum

26. Yıldızlararası yolculuğa hazırlanan Mustafa, yolculuğun hemen öncesi birçok kontrolden geçiyor. Bunlardan bazıları Mustafa'nın;

I. dakikadaki kalp atış sayısı

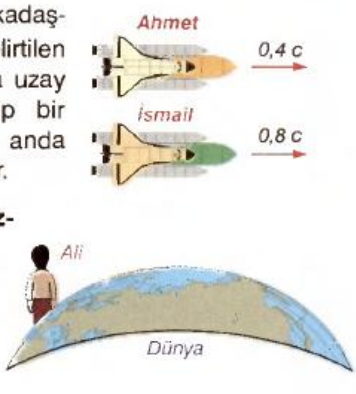
II. boyu ve

III. kütlesidir

Mustafa'ya ve dünyadakilere göre yukarıdaki niceliklerinden hangileri <u>yalnızca ışık hızına yakın bir hız ile yolculuk yapacağından dolayı</u> yolculuk öncesi değerlerine göre değişebilir?

	<u>Kendisine göre</u>	<u>Dünyadakilere göre</u>
A)	I, II ve III	II ve III
B)	Hiç biri	I, II ve III
C)	I ve III	I, II ve III
D)	Hiç biri	I ve II
E)	II ve III	Hiç biri
F)	Cevabını bilmiyorum	

27.


Aynı yaştaki üç arkadaştan ikisi şekilde belirtilen hızlarla aynı anda uzay yolculuğuna çıkıp bir süre sonra aynı anda Dünya'ya dönüyor.

Dünya'daki gözlemcilere göre, bu arkadaşların en gençten en yaşlıya sıralanışı nasıl olur?

A) İsmail, Ahmet, Ali B) Ali, Ahmet, İsmail

C) Hepsinin eşit olur D) İsmail, Ali, Ahmet

E) Ahmet, İsmail, Ali

f) Cevabını bilmiyorum

28. Bir cismin kütlesi ile ilgili olarak;

I. İç enerjisi değişirse ölçülemeyecek kadar bile olsa kütlesi de değişir
II. Sabit gözlemciye göre farklı hızda hareket etmeye başlarsa kütlesi de değişir
III. Sabit gözlemciye göre farklı hızda hareket etmeye başlarsa yoğunluğu da değişir

yargılarından hangileri doğrudur?

a) Yalnız I b) Yalnız II c) I ve III

d) II ve III e) I, II ve III

f) Cevabını bilmiyorum

29. Michelson-Morley deneyi;

I. Deneyin hatalı olduğuna karar verilmesi
II. Esir kavramına gerek olmadığına karar verilmesi
III. Işık hızının eylemsiz referans siteminden bağımsız olduğunun anlaşılması

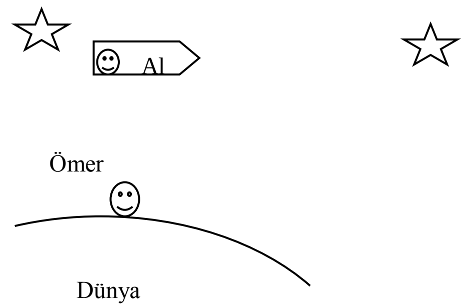
hangileri ile sonuçlanmıştır?

a) Yalnız I b) Yalnız II c)Yalnız III

d) I ve II e) II ve III

f) Cevabını bilmiyorum

30. Ali, iki yıldız arasında ışık hızına yakın sabit bir hız ile seyahate çıkıyor. Dünyadaki Ömer ise Ali'nin yolculuğunu gözlemliyor.



Ömer ve Ali'ye göre iki yıldız arasındaki uzaklık ve seyahat süresi ile ilgili;

I. Uzaklık Ali'ye göre daha kısadır
II. Süre Ömer'e göre daha fazladır
III. Uzaklık da süre de ikisine göre eşittir.

yargılarından hangileri doğrudur?

a) Yalnız I b) Yalnız II

c) I ve II d) II ve III e) I, II ve III

f) Cevabını bilmiyorum

C. AÇIK UÇLU SORULAR

- 31 ve 32. soruların cevaplarını optik formun arkasına yazınız.

31. Modern fiziğin doğuşunu katkıda bulunan gelişmeleri yazınız

32. Modern fiziğin doğuşuna katkıda bulunan gelişmeleri birer cümle ile açıklayınız

APPENDIX K

TENTH GRADE MODERN PHYSICS ACHIEVEMENT TEST- STUDENT-FINAL VERSION

ONUNCU SINIF MODERN FİZİK BAŞARI TESTİ-ÖĞRENCİ-SON SÜRÜM

Yönergeler

1. Bu testin amacı sizlerin 10. sınıf modern fizik ünitesindeki konularla ilgili bilgilerinizi ölçmektir. Lütfen bütün sorulara cevap vermek için gayret gösteriniz.
2. Testte 6 tane doğru-yanlış, 6 tane eşleştirme, 18 tane çoktan seçmeli ve 2 tane açık uçlu soru yer almaktadır. Her sorunun sadece bir doğru cevabı vardır. Bir soru için birden çok cevap yeri işaretlenmişse o soru yanlış cevaplanmış sayılacaktır.
3. Bu test puanlanırken doğru cevaplarınızın sayısından yanlış cevaplarınızın sayısının dörtte biri düşülecek ve kalan sayı net puanınız olacaktır.
4. Cevaplarınızı optik forma işaretleyiniz. Bu kitapçık üzerinde karalama yapabilirsiniz.
5. Soruları okuduktan sonra cevabını bilmiyorsanız, lütfen ‘‘**f**’’ şıkkını işaretleyiniz.
6. Soruların seçeneklerinde size göre doğru cevap yoksa sizce doğru olan cevabı optik formda ilgili soru numarasında şıklardan sonraki boşluğa yazınız.
7. Testin bütünü için verilen cevaplama süresi toplam 40 dakikadır.
8. Bu testin sonuçları Ortadoğu Teknik Üniversitesi’nde Ortaöğretim Fen ve Matematik Alanları Eğitimi Bölümü’nde doktora yapan araştırmacının tezinde veri olarak kullanılacaktır. Bu soruları cevaplandırdığınız için siz de bu bilimsel çalışmanın bir parçasısınız. Gerekli ilgiyi gösterdiğiniz için teşekkür ederiz.
9. Sınav sonuçlarını sizinle paylaşabilmemiz için sınava başlamadan önce optik formdaki ‘‘Ad Soyad’’ kısmını doldurunuz.

DOĞRU YANLIŞ SORULARI

	Doğru	Yanlış	Bilmiyorum
1. Modern fiziğe göre, boşlukta 0,5c hızında giden bir aynaya gelen ve yansıyan ışınların hız büyüklükleri eşit olur.	(a)	(b)	(f)
2. Einstein özel görelilik teorisinden dolayı Nobel ödülü almıştır.	(a)	(b)	(f)
3. Evren esir denilen bir madde ile doludur.	(a)	(b)	(f)
4. Özel görelilik ikizler paradoksuna açıklama <u>getirememiştir</u>.	(a)	(b)	(f)
5. Özel görelilik kuramına göre enerji vererek kütleli bir cismi ışık hızına ulaştırma mümkün değildir.	(a)	(b)	(f)
6. Eylemsiz referans sistemi olarak kabul edilen v hızlı kayığa göre, 2v hızı ile giden bir gemi de eylemsiz referans sistemi olarak kabul edilebilir.	(a)	(b)	(f)

D. EŞLEŞTİRME SORULARI

- Solda fiziğin alt alanları, sağda ise bunların fizik ile ilişkileri belirtilmiştir. Solda, her bir maddenin önündeki boşluğa, sağda bu madde ile en iyi eşleşen ilişkinin harfini optik forma işaretleyiniz. Sağdaki her bir ilişki birer defa, birden çok ya da hiç kullanılmayabilir.

Fiziğin alt alanları	***Fizik ile ilişkileri***
7. ____ Katıhal fiziği	a. Modern fiziğin alt alanları kapsamındadır
8. _____ Atom fiziği	b. modern fiziğin alt alanları kapsamında <u>değildir</u>
9. _____ Optik	f. Cevabını bilmiyorum
10. _____ Manyetizma	
11. _____ Termodinamik	
12. _____ Nükleer fizik	

E. ÇOKTAN SEÇMELİ SORULAR

13. Modern fiziğe göre ışık hızında hareket ederken düzlem aynada kendimizi görebilmemiz özel göreliliğin;

I. Fizik yasaları tüm eylemsiz referans sistemlerinde aynıdır
II. Işık hızı aşılamaz
III. Işık hızı, eylemsiz referans sisteminde, ışık kaynağının ve gözlemcinin hareketinden bağımsızdır

kabullerinden hangilerinden dolayıdır?

b) Yalnız I b) Yalnız III c) I ve II

d) I ve III e) II ve III

f) Cevabını bilmiyorum

14. Modern ve klasik fizik ilişkisi ile ilgili olarak;

I. Modern fizik ve klasik fizik yasaları tamamen farklıdır
II. Klasik fizik yasalarının yerini modern fizik yasaları almıştır
III. Klasik fizik, görece kütlesi büyük ve hızı küçük; modern fizik ise görece kütlesi küçük ve hızı büyük olan cisimlerin hareketlerini açıklamaya odaklanır.

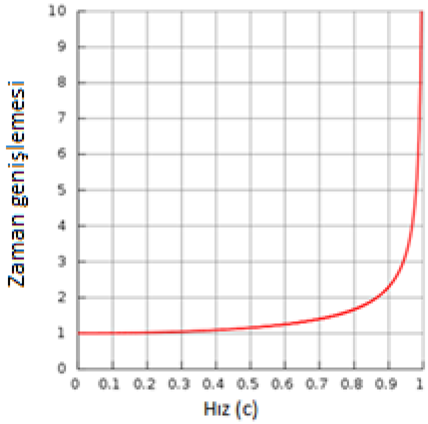
yargılarından hangileri doğrudur?

a) Yalnız I b) Yalnız II

c) Yalnız III d) I ve II e) II ve III

f) Cevabını bilmiyorum

15. Farklı sabit hızlarda hareket eden referans sistemlerindeki zaman genişlemesinin hıza bağlı değişimi aşağıdaki grafikte gösterildiği gibi olmaktadır.



Buna göre zaman genişlemesi;
I. sabit hızla giden bir araba
II. sabit hızla giden bir jet uçağı
III. ışık hızına yakın bir hızla giden bir uzay aracı

hangileri için ihmal edilemez?

b) Yalnız III b) I ve II c) I ve III

d) II ve III e) I, II ve III

f) Cevabını bilmiyorum

16. Yıldızlar arası kargo taşımacılığı yapan bir şirketin sahibi olduğunuzu düşünün. İşi daha ucuza getirmek için işe alacağınız bir astronota;

I. Şirketinizin duvarındaki saate
II. Uzay aracınızdaki saate
III. Seyahat esnasında astronotun kolundaki saate

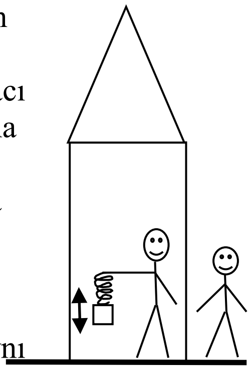
göre ödeme yapmak <u>istemezsiniz</u>?

b) Yalnız I b) Yalnız II c) Yalnız III

d) II ve III e) I, II ve III

f) Cevabını bilmiyorum

17. Yerde duran bir uzay aracındaki astronot, esnek bir yayın ucuna astığı cismin salınım periyodunu ölçüyor. Daha sonra uzay aracı hızlanarak ışık hızına yakın sabit bir hız kazanıyor ve yoluna bu hız ile devam ediyor. Uzay aracı sabit hızla hareket ederken astronot, aynı yay ile cismin periyodunu tekrar ölçüyor.



Yerdeki gözlemciye ve astronota göre cismin bu yeni periyodu araç durgunken ölçülen periyoda göre nasıl değişir?

	Yerdeki gözlemci	Astronot
A)	Azalır	Değişmez
B)	Değişmez	Azalır
C)	Değişmez	Değişmez
D)	Artar	Değişmez
E)	Artar	Azalır

F) Cevabını bilmiyorum

18. Işık ile ilgili;

I. Renklere ayrılmasının keşfedilmesi
II. Dalga gibi davrandığının ispatlanması
III. Foton denilen taneciklerden oluştuğunun anlaşılması

bulgulardan hangileri modern fiziğin doğuşuna katkıda bulunmuştur?

b) Yalnız I b) Yalnız III c) I ve II

d) I ve III e) I, II ve III

f) Cevabını bilmiyorum

19. Bir binanın tepesinden serbest bırakılan bir cismin hareketini incelemek için aşağıdakilerden hangisi eylemsiz bir referans sistemi kabul edilebilir?

I. Kız kulesi
II. Sabit hızla giden Ankara Eskişehir treni
III. Sabit süratle çembersel bir yörüngede gösteri yapan motosikletli

a) Yalnız I b) Yalnız III c) I ve II
d) II ve III e) I, II ve III
f) Cevabını bilmiyorum

20. Yıldızlar arası yolculuğa çıkan Ahmet, bize en yakın yıldız olan Alfa Centauri'deki ziyaretini bitirdikten sonra, yıldızdan 0,5c hızı ile ayrılıyor. Buna göre yıldızın ışığı Ahmet'e göre Ahmet'i hangi hızla geçer?

a) 0,5c b) 0,5c-c arası bir hızla

c) c-1,5c arası bir hızla

d) 1,5c hızı ile

e) c hızı ile

f) Cevabını bilmiyorum

21. NASA'daki bilim insanları yıldızlar arası bir yolculuğa çıkacak astronot için hazırlık yapmaktadırlar. Aşağıdakilerin gerektiğinden ne fazla ne de az olması istenmemektedir.

Sizce astronotun;

I. Yatağının boyu,
II. Tüketeceği yiyecek ve içeceğin miktarı
III. Kolundaki saate yetecek pilin ömrü

verilenlerden hangileri <u>astronotun ışık hızına yakın bir hızla yolculuğunu yapması</u> <u>göz önüne</u> alınıp gerekli hesapların yapılması gerekmektedir?

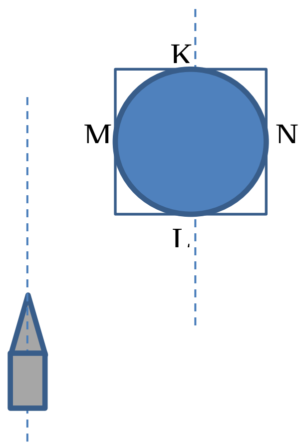
a) Yalnız I b) Yalnız II c) I ve II

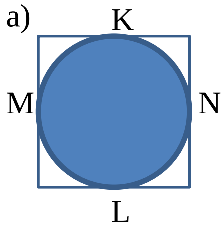
d) II ve III e) I, II ve III

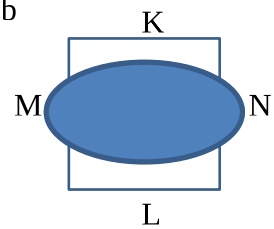
f) Cevabını bilmiyorum

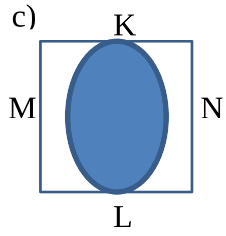
22. Işık hızına yakın yüksek hızla hareket eden bir uzay aracı şekildeki gibi Dünya'nın K ve L noktalarından geçen doğruya paralel bir yörünge izliyor.

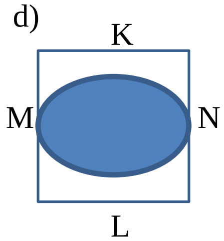
Buna göre, uzay aracındaki bir gözlemci Dünya'yı aşağıdakilerden hangisi gibi görür? (Dünya etrafındaki kare çerçeve, soruda ve şıklarda aynı büyüklüktedir)

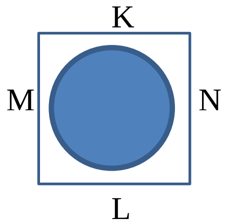


a)


b


c)


d)


e)


f) Cevabını bilmiyorum

23. Can, Sadık ve Ahmet'in özdeş üç yay sarkacı vardır. Dünyaya göre, Can 0.5c hızla ve Sadık 0.8c hızla giden bir uzay aracında iken yay sarkaçlarının periyotlarını sırasıyla t_1 ve t_2 olarak, yerde durgun olan Ahmet ise sarkacının periyodunu t_3 olarak ölçüyor.
Buna göre, t_1, t_2 ve t_3 arasındaki ilişki aşağıdakilerden hangisidir?

a) $t_2>t_1>t_3$ b) $t_1>t_2>t_3$ c) $t_3>t_1=t_2$

d) $t_3>t_1>t_2$ e) $t_1=t_2=t_3$

f) Cevabını bilmiyorum

24. Sabit bir hızla sizden uzaklaşan bir uzay aracını gözlemliyorsunuz. Uzay aracı geri dönüp aynı büyüklükteki hızla size doğru hareket ederken ki durumu ile ilk durumunu karşılaştırdığınızda;

I. boyu kısalır
II. boyu değişmez
III. içindeki saat daha yavaş ilerler
IV. içindeki saatin ilerlemesi değişmez

yargılarından hangileri doğrudur?

b) Yalnız I b) I ve III c) I ve IV

d) II ve III e) II ve IV

f) Cevabını bilmiyorum

25. Kemal ve Cemal'in (çok küçük zaman farklarını bile ölçebilen) atom saatleri aynı zamanı göstermektedir. Cemal'in saati dünyada dururken, Kemal saatini, NASA tarafından yeni geliştirilen uzay aracının içine koyuyor. Uzay aracı Mars yolculuğunu yaptıktan sonra dünyaya dönüyor.
Kemal ve Cemal saatlerini yan yana koyduklarında;

I. İkisi de aynı saati gösterir
II. Kemal'in saati geride olur
III. Cemal'in saati, Kemal'inkine göre daha uzun aralıklarla tıklar

yargılarından hangileri doğrudur?

b) Yalnız II b)Yalnız III c) II ve III

d) I ve II e) I, II ve III

f) Cevabını bilmiyorum

26. Yıldızlararası yolculuğa hazırlanan Mustafa, yolculuğun hemen öncesi birçok kontrolden geçiyor. Bunlardan bazıları Mustafa'nın;

I. dakikadaki kalp atış sayısı

II. boyu ve

III. kütlesidir

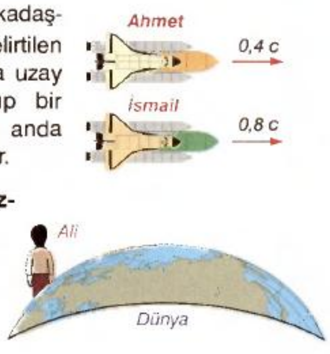
Mustafa'ya ve dünyadakilere göre yukarıdaki niceliklerinden hangileri <u>yalnızca ışık hızına yakın bir hız ile yolculuk yapacağından dolayı</u> yolculuk öncesi değerlerine göre değişebilir?

<u>Kendisine göre</u>	<u>Dünyadakilere göre</u>
A) I, II ve III	II ve III
B) Hiç biri	I, II ve III
C) I ve III	Hiç biri
D) Hiç biri	I ve II
E) Hiç biri	Hiç biri

F) Cevabını bilmiyorum

27.

Aynı yaştaki üç arkadaştan ikisi şekilde belirtilen hızlarla aynı anda uzay yolculuğuna çıkıp bir süre sonra aynı anda Dünya'ya dönüyor.



Dünya'daki gözlemcilere göre, bu arkadaşların en gençten en yaşlıya sıralanışı nasıl olur?

A) İsmail, Ahmet, Ali B) Ali, Ahmet, İsmail

C) Hepsinin eşit olur D) İsmail, Ali, Ahmet

E) Ahmet, İsmail, Ali

f) Cevabını bilmiyorum

28. Bir cismin kütlesi ile ilgili olarak;

I. İç enerjisi değişirse ölçülemeyecek kadar bile olsa kütlesi de değişir
II. Sabit gözlemciye göre farklı hızda hareket etmeye başlarsa kütlesi de değişir
III. Sabit gözlemciye göre farklı hızda hareket etmeye başlarsa yoğunluğu da değişir

yargılarından hangileri doğrudur?

b) Yalnız I b) Yalnız III c) I ve III

d) II ve III e) I, II ve III

f) Cevabını bilmiyorum

29. Michelson-Morley deneyi;

I. Deneyin hatalı olduğuna karar verilmesi
II. Esir kavramına gerek olmadığına karar verilmesi
III. Işık hızının eylemsiz referans siteminden bağımsız olduğunun anlaşılması

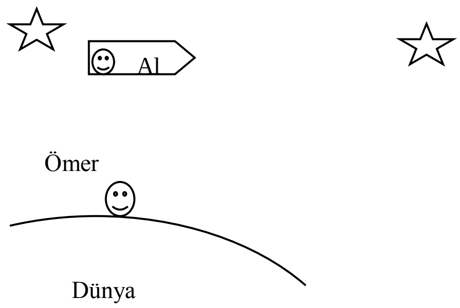
hangileri ile sonuçlanmıştır?

a) Yalnız I b) Yalnız II

c)Yalnız III d) I ve II e) II ve III

f) Cevabını bilmiyorum

30. Ali, iki yıldız arasında ışık hızına yakın sabit bir hız ile seyahate çıkıyor. Dünyadaki Ömer ise Ali'nin yolculuğunu gözlemliyor.



Ömer ve Ali'ye göre iki yıldız arasındaki uzaklık ve seyahat süresi ile ilgili;

I. Uzaklık Ali'ye göre daha kısadır
II. Süre Ömer'e göre daha fazladır
III. Uzaklık ikisine göre eşittir, süre Ali'ye göre daha kısadır.

yargılarından hangileri doğrudur?

a) Yalnız I b) Yalnız II

c) Yalnız III d) I ve II e) II ve III

f) Cevabını bilmiyorum

F. AÇIK UÇLU SORULAR

➢ 31 ve 32. soruların cevaplarını optik formun arkasına yazınız.

31. Modern fiziğin doğuşunu katkıda bulunan gelişmeleri yazınız

32. Modern fiziğin doğuşuna katkıda bulunan gelişmeleri birer cümle ile açıklayınız

APPENDIX L

EXPERT OPINION FORM FOR THE FIRTS AND SECOND VERSIONS OF THE MPUAT-S

MPUAT-S'NİN BİRİNCİ VE İKİNCİ SÜRÜMLERİ İÇİN UZMAN GÖRÜŞÜ FORMU

Sayın Uzman,

Bu test 10. sınıf öğrencilerinin modern fizik ünitesindeki başarılarını ölçmek için geliştirilmiştir. Testte şimdilik 37 soru görünmektedir. Uzman görüşü ve pilot uygulamadan sonra soru sayısı 32'ye düşürülecektir. Lütfen bu test ile ilgili aşağıdaki ifadeleri okuyup bununla ilgili düşüncelerinizi en iyi açıklayan seçeneği işaretleyiniz. Eklemek istediğiniz önerilerinizi ifadelerin yanında yer alan boşluğa yazabilirsiniz.

İlginize teşekkür ederim.

İFADELER		**Az ⟷ Çok**					**ÖNERİLER İNİZ**
		1	**2**	**3**	**4**	**5**	
1.	Testin yönergeleri sizce açık ve takip edilebilir mi?						
2.	Testteki sorular hedef öğrencilerin bilişsel seviyelerine uygun mu?						
3.	32 soru sizce bu ünite için yeterli midir?						
4.	32 soruluk testin tamamlanması için ayrılan süre sizce uygun mu?						
5.	Testin dili hedef öğrenciler için sizce uygun mu?						
6.	Testte kullanılan yazı boyutunun okunabilirliği sizce uygun mu?						
7.	Testin maddelerinde kullanılan şekiller sizce anlaşılabilir mi?						
8.	Test maddeleri (soru kökü veya çeldiriciler) doğru cevap ya da diğer maddeler için ipucu içeriyor mu?						

9.	Modern fizik ünitesinin ilk dört kazanımı haftada 2 saat fizik dersi alan öğrencilere 8 saatte anlatılmaktadır. Yukarıdaki Belirtke Tablosunda her kazanım için ayrılan soru sayısı sizce uygun mu?						
11.	Kazanıma uygun olmayan soru/sorular varsa, numarasını yandaki boşluğa yazabilir misiniz?						
12.	Bloom taksonominin bilişsel süreç boyutlarından uygun olmayan soru/sorular varsa, numarasını yandaki boşluğa yazabilir misiniz?						
13.	İçerik bakımından hatalı olduğunu düşündüğünüz sorular var mı? Varsa gerekli açıklamaları soru üzerinde gösterebilir misiniz?						
14.	Soruların doğru cevabı olan şıkkı soru üzerinde kırmızı font yaparak gösterebilir misiniz?						

APPENDIX M

TENTH GRADE MODERN PHYSICS ACHIEVEMENT TEST-TEACHER

ONUNCU SINIF MODERN FİZİK BAŞARI TESTİ-ÖĞRETMEN

1. A. Sadece öğretim programında verilenleri göz önünde bulundurarak modern fiziğin doğuşuna katkıda bulunan gelişmeleri sıralayınız.
   B. Bu gelişmelerin bazılarında ortak olan bir özellik var mıdır? Varsa bu özelliği kısaca açıklayınız.
2. A. Işık hızının eylemsiz referans sisteminden bağımsız olduğunun ileri sürülmesine neden olan araştırmalar hangileridir?
   B. Bu araştırmalardaki hangi durum ışık hızının eylemsiz referans sisteminden bağımsız olduğunun ileri sürülmesine neden olmuştur?

3. Özel göreliliğin kabullerinden biri ‘‘’Fizik yasaları tüm eylemsiz referans sistemlerinde aynıdır” şeklindedir. Bu kabulü örneklerle açıklar mısınız?

4. Işık hızına yakın hızla hareket eden Ali’nin elinde bir 1m uzunluğunda bir çubuk vardır. Yerde duran Ömer ise elindeki silgisini yere 0,3 saniyede düşürdüğünü hesaplıyor.
   A. Ömer, Ali’nin elindeki çubuğun uzunluğunu 0,8 m olarak hesaplıyor. Sizce kim çubuğun uzunluğu doğru hesaplıyor?
   B. Ali silginin düşme süresini 0,24 saniye olarak ölçüyor. Sizce kim silginin düşme süresini doğru hesaplıyor?

APPENDIX N

TREATMENT FIDELITY EXPERT VIEW FORM

KURS YETERLİLİĞİ UZMAN GÖRÜŞÜ FORMU

Açıklama: Bu form, tez çalışmam için düzenlediğim kursun yeterliliğini (treatment fidelity) sorgulamak için düzenlenmiştir. Diğer bir değişle bu form, düzenlenen profesyonel gelişim (PG) kursunu geliştirmek için alan yazınından seçilen kriterlerin yeterli olup olmadığını ve bu kriterlerin kursun içerisine sistematik olarak entegre edilip edilmediğini sorgulamaktadır.

Alan yazını, (a) kolay yürütülebilir, (b) toplu katılımın olduğu, (c) aktif öğrenmenin olduğu, (d) konu bilgisini artırıcı, (e) içeriği uyumlu, (f) yoğun (alan yazına göre toplamda 14 saattin altındaki kurslar etkisizdir) , (g) sürekli, (h) uzun süreli ve (ı) iş başında olan PG programlarını etkili göstermektedir. (Loucks-Horsley,1995; Darling-Hammond,1996; Hawley & Valli, 1998; Birman, Desimone, & Porter, 2000; Joyce & Showers, 2002; Guskey, 2003; Corcoran, 2007; Yoon et al., 2007; Desimone, 2008; Wei et al., 2009; Tanrıverdi & Günel, 2012).

Bunların yanında bu çalışma, (a) işbirliğine uygun ve (b) edinilen bilgileri hemen kullanabilmeyi de etkili PG kurslarının özelliklerine dâhil etmiştir. Dahası, uzman görüşleri alındıktan sonra (a) uygulama odaklı ve (b) ihtiyaç analizi merkezli olmayı da etkili PG kurslarının özelliklerine dâhil etmiştir.

Soru A1: Sizin eklemek istediğiniz başka etkili PG kurs özellikleri var mı? Varsa bu özellikleri açıklar mısınız?

Soru A2: Yukarıda 'açıklama' kısmında alan yazın tarafından etkili oldukları

Soru B1: Aşağıdaki tablonun birinci sütununda alan yazınından derlenen etkili PG kurs özellikleri, ikinci sütunda bu kursun ilgili etkili PG özelliği ile ilgili yapısı ve sonraki sütunlarda ise bu çalışmanın kurs yapısının etkili PG kurs özelliklerini ne kadar içerdiğini kodlayabileceğiniz üç seçenek verilmiştir. Her özelliğin karşısındaki üç seçenekten birine ''X'' işareti koyunuz.

Etkili PG kurs özellikleri	**Bu kursun ilgili yapısı**	**Tamamen içermektedi**	**Kısmen içermektedi**	**Hiç içermiyor**
Kolay yürütülebilir (Delivered in conductive settings)	a. Kursa katılan öğretmenler Ankara'nın Yenimahalle ve Mamak ilçelerindeki okullarda görev yapmakta olan farklı tecrübelere sahip, 10. sınıflara derse giren öğretmenlerdir. b. Kurs, Yenimahalle'deki teknolojik imkânlara (akılı tahta vb.) sahip özel bir okulun laboratuvarında gerçekleştirilecektir. c. Kursa yaklaşık 10 öğretmen katılacaktır d. Kurs Cuma akşamları saat 18:00 ile 21:00 arasında yapılacaktır. e. Kurs birlikte yemek yemek ile başlayacak sonra laboratuvarda ders ile devam edecektir. f. Araştırmacı kursun her adımını planlayan, gözlemci ve kendisine soru sorulduğunda cevap veren rolündedir. g. Kurs, yemek dâhil haftada üç saat olarak planlanmıştır. h. Kursa katılan öğretmenler adaptasyon süreci dâhil toplam 21 saatlik bir eğitim alacaklardır. Bu eğitim sadece, öğretim programına göre 8 (haftada 2 saat fizik dersi olanlar) ya da 12 (haftada 3 saat			

	fizik dersi olanlar) saatte anlatılan 10. sınıf modern fizik ünitesini kapsayacaktır. i. Kursun başlama saati, yeri vb. özellikler, yapılan ihtiyaç analizi anketi ve öğretmenlerle yapılan yüz yüze görüşmelerle belirlenmiştir. j. Öğretmenler kursa özel araçları ile ikişer ve üçer gruplar halinde gelip gideceklerdir. (Öğretmenlerin kursa gelip gitme yol ücretleri ödenmek istenmiş fakat öğretmeler kabul etmemiştir). k. Kursta ele alınan 10. sınıf modern fizik ünitesine, birincisi ünitenin öğretim programına yeni dâhil olması nedeniyle öğretmenlerin ihtiyaçlarının olabileceği düşüncesi, ikincisi kursa katılan öğretmenlerin belirlenmesi aşamasında yapılan görüşmeler ve üçüncüsü yapılan ihtiyaç analizi anketi sonuçlarına göre karar verilmiştir.			
Toplu katılım (Collective participation)	a. Kursa katılan öğretmenlerin hepsi fizik öğretmeni olacaktır. b. Kursa, hepsi 10.ncu sınıflara derse giren ve sınıflarında 10. sınıf modern fizik ünitesini anlatan öğretmenler olacaktır.			
Aktif öğrenme (Active learning)	a. Kurs esnasında öğretmenler konunun önemli yerlerini tartışacak, sorular soracak, konu ile ilgili soruları çözecek, düşünce deneylerini ve animasyon/simülasyonları tartışarak yorumlayacaklar.			
Konu bilgisine odaklanmış (Focused on the content of the subject that teachers teach)	c. Her hafta bir öğretmen kurstan önce konuya hazırlanacak ve konuyu sınıfta anlatacak sonra tartışmaya açacaktır. d. Kursta yapılacak aktivitelerin tamamı öğretmenlerin konu bilgilerini artırmaya yönelik olacaktır.			
Uyum (Coherence)	a. Kursta sadece 10.sınıf modern fizik ünitesi işlenecek. b. Kursta planlanan bütün aktiviteler bu üniteye yönelik olacaktır. c. Öğretmenlerin konu dışı tartışmaları ve planlanan çalışmaların dışına çıkmaları araştırmacı tarafından engellenecektir.			
Yoğun (Intensive)	a. Altı saatlik adaptasyon kursunu ve her toplantının bir saatini (yemek ve vb. durumlarla geçirilen süre) çıkarttığımızda, haftada 2 saat fizik dersi olan			

	öğretmenler sınıflarında anlatacakları her bir saat ders için 1.5, haftada 3 saat fizik dersi olan öğretmenler her bir saat ders için 1 saat kurs alacaklardır (Bu değerler hesaplanırken okullarda haftalık ders saatinin 40 dakika olduğu göz önüne alınmış ve öğretmenlerin bu 40 dakikanın tamamında ders anlattıkları varsayılmıştır).			
Sürekli (Sustained)	a. Kurs, ikisi adaptasyon olmak üzere toplam yedi hafta sürecektir. Adaptasyon kursu peş peşe 2 hafta ve asıl kurs peş peşe 5 hafta sürecektir. (Bu kursun etkinliği şimdilik modern fizik ünitesi üzerinden araştırılmaktadır. Yıl boyu diğer üniteler için de aynı kursun düzenlenmesi bu çalışmamın sonunda öneri olarak verilecektir).			
Uzun süreli (Long duration)	a. Bu kurs toplam 7 hafta sürecektir.			
İş başında (Job-embedded)	*Bu kurs, öğretmenlere iş başında bir öğretim olanağı sunamamaktadır.*			
Edinilen bilgileri hemen kullanabilme (Just-in time teaching)	a. Kurs, öğretmenlerin 10. sınıf modern fizik ünitesini anlatmaya başlayacakları döneme denk getirilecek ve öğretmenler her hafta kursta ele aldıkları kazanımı bir sonraki hafta sınıflarında anlatacaklardır.			
İşbirliği (Collaboration)	a. Öğretmenler kurs esnasında anlaşılması zor kavramları birlikte ele alacaklar ve çözemedikleri soruları birlikte çözecekler. b. Öğretmenler mail ve telefon paylaşımı yapacak, hafta içi ihtiyaç duydukları anda birbirleri ile anlık iletişim kurarak işbirliklerine devam edecekler. c. Yemek esnasında, kurs esnasında veya kurstan hemen sonra öğretmenlerin doküman paylaşımı yapmaları ve birebir görüşmeleri sağlanacaktır. d. Kurs esnasında öğretmenlerin gruplar halinde soru veya sorunları belirleyip çözmeleri sağlanacaktır. e. Kurstan önce dersi anlatan öğretmen kendi partneri ile işbirliği yaparak dersi hazırlayacaktır. f. Kurs esnasında kurulan yakın ilişkilerle ve paylaşılan iletişim bilgileri ile öğretmenlerin kurs sonunda da diğer ünitelerde işbirliklerine devam etmeleri sağlanacaktır.			

Uygulama odaklı	g. Öğretmenler kursta kendilerine sorulan soruları cevaplamaya çalışacaklar. h. Cevabını bilmedikleri soruları, açıklayamadıkları kavramları gerektiğinde kitaplardan veya internet ortamında araştıracaklar.			
İhtiyaç analizi merkezli	a. Kurstan önce ihtiyaç analizi çalışması yapılacaktır. b. İhtiyaç analizi çalışması ile kursa katılmaya istekli öğretmenler belirlenecek ve bu öğretmenler ile ilgili çeşitli demografik bilgiler toplanacaktır. c. İhtiyaç analizi çalışması ile kursta öğretilecek üniteye (10.sınıf modern fizik ünitesi) öğretmenlerin ne derecede ihtiyaç duydukları, kurs esnasında bu ünite ile ilgili yapılacak aktivitelere vb. karar verilecektir.			

Soru B2: ‘‘Hiç içermiyor’’ ya da ‘‘kısmen içermektedir’’ olarak işaretlediğiniz etkili PG özelliklerin bu kursa nasıl (mümkünse) daha iyi entegre edilebileceğini lütfen

Soru B3: Soru A’ya cevap olarak yazdığınız etkili PG kurs özellikleri bu kursa uyarlanabilir mi? Cevabınız evet ise nasıl uyarlanabileceğini lütfen yazınız.

APPENDIX O

TREATMENT OBSERVATION CHECKLIST

KURSU GÖZLEM KONTROL LİSTESİ Gözlem No: Gözlemci: Tarih: Kurs başlama saati: Kurs bitiş saati: Sayın gözlemci, Bu form, şu an gözlemlediğiniz kursun etkili profesyonel gelişim kurslarının özelliklerini ne derecede taşıdığını sorgulamaktadır. Lütfen her maddenin karşısındaki bir seçeneğe ''X'' işareti koyunuz. Bazı maddelerde sıklık veya süre sorulduğuna dikkat ediniz.		Evet	Kısmen	Hayır	Gözlemlenmedi
	Yürütülebilirlik (Delivered in conducive settings)				
1	Kurs ortamı düzenli ve çalışmaya elverişli mi?				
2	Kurs planlandığı gibi yürütülüyor mu?				
3	Kurs zamanında başlıyor mu?				
4	Kurs zamanı öğretmenlerin toplanmasına uygun mu?				
5	Kurs yerine ulaşım kolay mı?				
	Toplu katılım (Collective participation)				
6	Öğretmenlerin hepsi fizik öğretmeni mi?				
7	Öğretmenlerin hepsi 10. sınıflara derse giriyor mu?				
8	Öğretmenler aynı okuldan mı?				
9	Öğretmenlerin hepsi aynı ilçeden mi?				
	Aktif öğrenme (Active learning)				
10	Öğretmenler, kursta fiziksel olarak sürekli aktif mi?				
11	Öğretmenler, anlatan kişiye soru soruyorlar mı?				
12	Kursta konu ve kavramlar üzerine aktif tartışmalar yapılıyor mu?				
13	Öğretmenler kurstan etkin bir şekilde faydalanmak için çaba/gayret gösteriyorlar mı?				

14	Öğretmenler not alıyorlar mı?				
15	Öğretmenler dersi dinliyorlar mı?				
16	Öğretmenler öğrenme konusunda istekli mi?				
	Konu alan bilgisi odaklı (Focused on the content of the subject that teachers teach)				
17	Öğretmenler birbirlerine fizik konularını anlatıyorlar mı?				
18	Yapılan aktiviteler konu alan bilgisi odaklı mı?				
19	Konunun önemli yerlerini tartışılıyorlar mı?				
20	Konuya ait, düşünce deneyleri yapılıyor ve animasyon/simülasyon gösteriliyor mu?				
21	Konuya ait örnek sorular çözüyorlar mı?				
22	Konunun içerdiği ana fikirlere vurgu yapılıyor mu?				
23	Kavramsal boyutu ön plana çıkaran tartışmalar oluyor mu?				
24	Yapılan aktiviteler konunun içerdiği kavramlara yönelik mi?				
25	Yapılan aktiviteler konunun içerdiği kavramları pekiştirme işlevini görüyor mu?				
	Uyum (Coherence)				
26	Kursta 10. sınıf modern fizik ünitesi mi işleniyor?				
27	Kursta yapılanlar 10. sınıf modern fizik ünitesi etrafında birleşiyor mu?				
28	Kursta yapılanlar 10.sınıf öğrencilerinin seviyesine uygun mu?				
29	Kursta yapılanlar 10. sınıf öğretim programına uygun mu?				
30	Yapılan çalışmalar öğretmenlerin bilgilerini artırmaya yönelik mi?				
	Yoğun (Intensive)				
31	Kurs alan yazının belirttiği yoğunlukta mı?				
32	Kursta işlenen kazanım için harcanan süre ne kadardır?	……..dakika			
33	Kursta harcanan toplam süre ne kadardır?	……..dakika			
34	Kursta profesyonel gelişim (yemek, siyasi konular vb.) dışında harcanan süre ne kadardır?	……..dakika			
	Süreklilik (Sustained)				
35	Kurs her hafta devam ediyor mu?				
	Uzun süreli (Long duration)				
36	Kurs alan yazının öngördüğü minimum uzunluktan fazla mı?				
37	Adaptasyon kursu toplam kaç hafta sürmüştür?	…….hafta			
38	Asıl kurs toplam kaç hafta sürmüştür	…….hafta			
	Edinilen bilgileri hemen kullanma (Just in time teaching)				
39	Öğretmenler, işlenen konuyu kurstan sonraki hafta sınıflarında anlatıyorlar mı?				
41	**İşbirliği**				
42	Kursta öğretmenler birlikte çalışmalar yapıyorlar mı?				

43	Öğretmenler bilmedikleri/anlamadıkları konuları diğerlerine soruyorlar mı? a. Kaç öğretmen anlamadığı yeri sordu? b. Kaç öğretmen bilmediği yeri sordu? c. Kursta kaç defa soru soruldu? *Bu maddeler kurstan sonra videolar seyredilerek doldurulacaktır*	………kişi ………kişi ……… defa			
44	Öğretmenler ders materyali alış verişi yapıyorlar mı? a. Kaç öğretmen ders materyali alış verişi yaptı? b. Kaç farklı materyal paylaşıldı? c. Kaç defa materyal alış verişi yapıldı? *Bu maddeler kurs sonunda öğretmenlere sorularak doldurulacaktır.*	 …… kişi ……. materyal …….. defa			
45	Öğretmenler soruları birlikte çözüyorlar mı?				
46	Öğretmenler iletişim bilgilerini paylaşıyorlar mı?				
47	Derse hazırlanan öğretmen ortağı ile işbirliği yapmış mı?				
48	Öğretmenler geçmiş deneyimlerinden söz ederek örnekler sunuyorlar mı?				
	Uygulama odak				
49	Öğretmenlere çözmeleri için soru soruluyor mu?				
50	Öğretmenler ihtiyaç duyduklarında kitap ve internet kullanıyorlar mı?				
	İhtiyaç analizi merkezli				
51	Kurstan önce ihtiyaç analizi yapılmış mı?				
52	Kursta yapılanlar ihtiyaç analizi sonuçları ile uyumlu mu?				
	Dersi anlatan				
53	Konuya önceden hazırlanmış mı?				
54	Konuyu önceden ortağı ile çalışmış mı?				
55	Dersi coşkulu anlatıyor mu?				
56	Eğitim öğretim stratejilerini kullanıyor mu?				
57	Konuyu animasyon, grafik, tablo, video vb. ile destekliyor mu?				
58	Gelen sorulara ikna edici cevaplar verebiliyor mu?				
	Öğretmen bilgisi				
59	Pedagojik alan bilgisine yönelik çalışmalar oluyor mu?				
60	Pedagojik bilgiye yönelik çalışmalar oluyor mu?				
61	Öğretim programına yönelik çalışmalar oluyor mu?				
62	Konu alan bilgisine yönelik çalışmalar oluyor mu?				

Kursta başka gözlemleriniz varsa lütfen yazınız:

APPENDIX P

CLASSROOM OBSERVATION FROM-INITIAL VERSION

SINIF GÖZLEM FORMU-İLK SÜRÜM

Bu form ‘‘öğretmenin öğretmene öğretmesi’’ profesyonel gelişim kursuna katılan öğretmenlerin, kursta edindikleri kazanımların sınıflarına yansımasını gözlemlemek amacıyla düzenlenmiştir. Formdaki alt boyutlar Shulman'ın (1987) öğretmen bilgisi boyutlarından **pedagojik alan bilgisi** (kavramlar ve kavram yanılgıları, öğretim stratejisi, öğrenci bilgisi), **pedagojik bilgisi** (ders organizasyonu, dersin sunumu, sınıfla etkileşim, sınıf ortamı), **konu bilgisi** ve **öğretim programı bilgisini** kapsamaktadır.

Okul:

Sınıf:

Sınıftaki öğrenci sayısı:

Öğretmen:

Gözlemci:

Tarih:

Kazanım:

Lütfen değerlendirmenizi şöyle yapınız;
4=İyi: Davranış eksiksiz gözlemlendi
3-2-1=Orta: Davranış eksik gözlemlendi
0=Zayıf: Davranış sergilenmeli idi fakat gözlemlenmedi
Boş= Davranış gözlemlenmedi

		İyi	**Orta**	**Zayıf**	**Boş**
1	Öğrencilerin öğrenme farklılıkları göz önüne alınarak ders anlatıldı				
2	Dersin girişinde yapılacaklardan bahsedildi				
3	Kavram yanılgılarını ortaya çıkartacak sorular soruldu				
4	Öğrenci sorularına anlaşılır cevaplar verildi				
5	Kavram yanılgıları açıklandı				
6	Konunun ana kavramları anlatıldı				
7	Konu ve kavramlar uygun sıra ile işlendi				
8	Konu günlük yaşam ile ilişkilendirildi				
9	Çözülen sorular kazanımlara uygundu				
10	Derste, verilecek kazanımlardan bahsedildi				
11	Öğrenciler konuyu anlamadığında aynı şey farklı bir yol (tanım, formül, grafik etc.) ile yeniden anlatıldı				
12	Konun anlaşılması için farklı stratejiler kullanıldı				
13	Zor kavramlar benzetme, şekil, grafik, animasyon/simülasyon, düşünce deneyleri ile anlatıldı				
14	Konunun anlaşılıp anlaşılmadığı sorularla kontrol edildi				
15	Sorulan soruların cevabı öğrencilere bulduruldu				

16	Öğrencilerin seviyesine uygun tartışmalar yapıldı				
17	Sınıfın seviyesine uygun bilimsel dil kullanıldı				
18	Öğrencilerin konuyu anlamadığının farkına varıldı				
19	Öğrencilerin anlamakta zorlandıkları yerler belirlendi				
20	Öğrencilerin önbilgileri yoklandı				
21	Öğrencilerin anlayabileceği sorular soruldu				
22	Dersin amacı açıkça belirtildi				
23	Ders gelecekteki derslere bağlandı				
24	Zaman verimli kullanıldı				
25	Kavramlar açıkça anlatıldı				
26	Bilinmeyen kavramlar bilinenler üzerinden anlatıldı				
27	Sınıfta bir dağınıklık vardı				
28	Ders esprili anlatıldı				
29	Dersin önemli yerleri özetlendi				
30	Konunun anlaşılıp anlaşılmadığı kontrol edildi				
31	Konunun önemli yerleri vurgulandı				
32	Konunun zor kısımları üzerinde duruldu				
33	Ders özetlenerek bitirildi				
34	Ders coşkulu bir şekilde anlatıldı				
35	Kazanımlar yanlış verildi				
36	Öğrencilere düşünmeleri için zaman tanındı				
37	Öğrenciler soru sormaya teşvik edildi				
38	Öğrencilerin soruları ve fikirleri dinlendi				
39	Öğrenciler tartışmaya teşvik edildi				
40	Öğrencilerin konuyu anlamaları için gerekli olan önbilgiler anlatıldı				
41	Derste çözülen sorular öğrencilerin anlamasını kolaylaştırdı				
42	Öğrencilerin dikkatleri toplandı				
43	Öğrencilerin not almalarına zaman tanındı				
44	Öğrenci cevapları tam olmadığında yardımcı olundu				
45	Sorular ve cevaplar gerektiğinde tekrarlandı				
46	Öğrencilerle bireysel olarak ilgilenildi				
47	Öğrenci motivasyonu sağlandı				
48	Ders rahat tavırlar içinde anlatıldı				
49	Ders öğrencilerin katılımı ile geçti				
50	Derste çoğunlukla öğretmen konuştu				
51	Konu ile ilgili temel ilke ve kavramlar doğru anlatıldı				
52	Örnek sorular doğru çözüldü				
53	Öğrenci sorularına doğru cevaplar verildi				
54	Konu etraflıca anlatıldı				
55	Formüller doğru kullanıldı				
56	Öğrencilerin konuyu anlamadıklarını anladı				
57	Birimler doğru kullanıldı				
58	Bilimsel olarak doğru dil kullanıldı				
59	Kavramlar arası ilişikler kuruldu				
60	Öğrencilerden söylediklerini destekleyen veriler bulmaları istendi				
61	Söylediği ifadelerin, şekillerin ve grafiklerin anlamını doğru açıkladı				
62	Kazanımların dışına çıkıldı				
63	Derse dikkat çekici giriş yapıldı				

64	Kazanımlar eksik verildi				
65	Dersin önceki dersler ile ilişkisine değinildi				
66	Ders uygun hızda anlatıldı				
67	Verilen ödevler kazanımlara uygundu				
68	Öğrencilerin bireysel farklılıkları dikkate alındı				
69	Kavram yanılgıları uygun stratejiler kullanılarak giderilmeye çalışıldı				
70	Fizik-Teknoloji-Toplum-Çevre kazanımları işlendi				
71	Bilişim ve İletişim Becerileri kazanımları işlendi				
72	Tutum ve Değerler kazanımları işlendi				
73	Ders yaşam temelli yaklaşımla anlatıldı				

Varsa eklemek istediğiniz diğer görüşlerinizi yazınız:

APPENDIX R

CLASSROOM OBSERVATION FROM-FINAL VERSION

SINIF GÖZLEM FORMU-SON SÜRÜM

Bu form, ‘‘Öğretmenin Öğretmene Öğretmesi’’ profesyonel gelişim kursuna katılan öğretmenlerin sınıflarında kursa katılmadan önce ve kurs sonunda yapılacak gözlemler için hazırlanmıştır.

Formdaki alt boyutlar Shulman’ın (1987) tanımladığı “öğretmen bilgisi”’nin, **alan bilgisi, pedagojik alan bilgisi** (kavram yanılgıları, öğretim stratejisi, öğretim programı) ve **pedagojik bilgisi** (ders organizasyonu, dersin sunumu, sınıfla etkileşim) boyutlarını kapsamaktadır.

Öğretmenlerin her bir boyutta sergilediği davranışlar gözlemci tarafından ilgili tablolara yazılacaktır. Gözlemci gözlemlediği her davranışı numara vererek açıklayacaktır. Alan bilgisi boyutunda, davranış numarasının baş tarafındaki boşluğa ‘‘Nerede’’ sütununda verilen, (davranışın sergilendiği yerin) harfini yazacaktır.

Gözlemlerin tablolara nasıl not edileceğini daha iyi görebilmek için, örnek olarak, alan bilgisi ile ilgili gözlemlenen iki davranışın yazımı, alan bilgisi tablosunda gösterilmiştir.

Gözlem No:

Okul Adı:

Sınıf-Şube:

Sınıftaki öğrenci sayısı:

Öğretmen Adı:

Gözlemci Adı:

Tarih:

Kazanım(lar)ın numarası:

Ders saati:

Tablolar şu alt boyutlardan oluşmaktadır:
Tablo 1: Öğretmenlerin alan bilgilerindeki <u>a-hataları</u> ve <u>b-eksikleri</u> içermektedir.

Tablo 2: Öğretmenlerin kavram yanılgıları, öğretim stratejileri ve öğretim programı bilgisi alt boyutlarında sergiledikleri davranışlarını içermektedir.

Tablo 3: Öğretmenlerin dersin organizasyonu, dersin sunumu ve sınıfla etkileşim alt boyutlarında sergiledikleri davranışlarını içermektedir.

TABLO 1: ALAN BİLGİSİ	
a. Hata	Nerede
1. …c… Optiğin modern fiziğin bir alt alanı olduğunu söyledi. 2. …a…Zaman genişlemesi formülünde Δt_o’ı olaya göre hareketli olan kişinin ölçtüğü zaman olarak tanımladı. 3. … 4. …	a. Tanım b. Birim c. Açıklama d. Öğrenci sorusu e. Günlük yaşam f. Kazanım g. Formül h. İlişki i. Yorum j. Örnek soru çözümü k. Benzetme l. … m. …
b. Eksik	
1. … 2. … 3. … 4. …	
TABLO 2: PEDAGOJİK ALAN BİLGİSİ	
a. Kavram yanılgıları boyutunda sergilenen davranışlar	
1. … 2. … 3. …	
b. Öğretim stratejileri boyutunda sergilenen davranışlar	
1. …	

2. … 3. …
c. Öğretim programı bilgisi boyutunda sergilenen davranışlar
1. … 2. … 3. …
TABLO 3: PEDAGOJİK BİLGİSİ
a. Ders organizasyonu boyutunda sergilenen davranışlar
1. … 2. … 3. …
b. Dersin sunumu boyutunda sergilenen davranışlar
1. … 2. … 3. …

c. Sınıfla etkileşim boyutunda sergilenen davranışlar
1. … 2. … 3. …
Yukarıdaki boyutlarda öğretmenlerin performanslarını olumlu veya olumsuz etkileyen faktörleri etkileri ile birlikte açıklayınız:

APPENDIX S

COURSE EVALUATION EXPERT VIEW FORM

KURS DEĞERLENDİRME UZMAN GÖRÜŞÜ FORMU

A. Bu form, yedi hafta sürecek olan ‘‘öğretmenin öğretmene öğretmesi’’ profesyonel gelişim kursuna katılacak öğretmenlerin kurstaki kazanımlarını sorgulamaktadır. Kursta, katılımcı öğretmenler zümre yapacaktır. Zümre faaliyetleri çerçevesinde öğretmenler sırasıyla birbirlerine 10. sınıf modern fizik ünitesinin konu ve kavramlarını anlatacaklardır. Öğretmenlerin gerekli yerlerde işbirliği ve tecrübe paylaşımı yapmaları beklenmektedir.

Öğretmenlerin (a) kursa karşı tutumu, (b) kursun faydası, (c) araştırmacının etkinliği ve (d) kursun öğretmen bilgilerine (Shulman, 1987) etkileri, <u>kursa katılan öğretmenler</u> tarafından, bu form doldurularak araştırılacaktır.

a. Kursa karşı tutum boyutunda, öğretmenlerin yapılan kurstan memnun olup olmadıkları, kursu sevip sevmedikleri araştırılmaktadır.
b. Kursun faydası boyutunda, öğretmenlerin kurstan yararlanıp yaralanmadıkları, paylaşım yapıp yapmadıkları ve özellikle kurstan sonra modern fizik ünitesini sınıflarında rahat anlatıp anlatmadıkları araştırılmaktadır.
c. Araştırmacı boyutunda, kursu düzenleyen ve yürüten araştırmacının kurs esnasındaki etkinliği ve güvenirliği araştırılmaktadır.
d. Yapılan kursun öğretmenlerin bilgilerine Shulman’ın (1987) etkileri üç alt boyutta araştırılmaktadır. Tablo 1’de kısaca açıklanan bu boyutlar pedagojik alan bilgisi, pedagojik bilgi ve konu alan bilgisi boyutlarını kapsamaktadır.

Tablo 1: Öğretmen bilgisi (Shulman,1987)

Öğretmen bilgisi boyutu	**Açıklama**
Konu alan bilgisi (subject matter knowledge-SMK)	Konu alan bilgisi, öğretmenin konuyu ne kadar bildiğini ve konunun öğretmende ne düzeyde organize olduğunu göstermektedir. Konu bilgisi, bir alandaki sadece kabul edilen doğruların öğrenciye aktarılması değildir. Öğretmenler, bir konunun neden gerekli olduğunu, neden öğrenmeye değer olduğunu ve konunun diğer konulara nasıl bağlı olduğunu teori ve

	pratik anlamda açıklayabilmeliler (Shulman, 1986). Konu alan bilgisi, herhangi bir konunun içeriğini açıklayabilmektir. Konuyu kavramları, şekilleri, grafikleri, formülleri, ilkeleri ve teorileri ile bilip açıklayabilmedir.
Pedagojik alan bilgisi (pedagogical content knowledge-PCK)	Alan bilgilerinin pedagojik kuramlar, teoriler ve prensipler ışığında yeniden organize edilerek öğrencilerin anlayabileceği formata dökülmesi sürecinde bir öğretmenin ihtiyaç duyacağı bütün bilgiler pedagojik alan bilgisi kapsamında değerlendirilebilir (Shulman, 1986). Pedagojik alan bilgisi, içerik ve pedagojinin birleşimi olan bilgidir. Bir konunun nasıl öğretileceğini, konunun bilinen/bilindik yönlerini bilmedir.
Pedagojik bilgi (pedagogical knowledge-PK)	Genel pedagojik bilgi; öğrenme kuramları ve genel öğretim ilkeler bilgisi, eğitimin çeşitli felsefelerini anlama, öğrenenler hakkında genel bilgi ve sınıf yönetimi ilke ve prensiplerini bilmeyi içerir (Grossman & Richert,1988). Pedagojik bilgi, konudan bağımsız, genel eğitim öğretim prensiplerini bilmedir.

B. Aşağıda verilen tabloları kurs değerlendirme formundaki maddelere göre doldurunuz

Tablo 2: Anlaşılmadığını düşündüğünüz maddeler varsa bunları numaralarını yazarak belirtiniz. Varsa nasıl daha anlaşılır hale getirilebilecekleri ile ilgili görüşlerinizi tabloya ekleyiniz.

Tablo 3: Çıkmasını önerdiğiniz maddeleri, numaralarını yazarak ve çıkartma sebebini belirterek tabloya ekleyiniz.

Tablo 4: Eklenmesini önerdiğiniz maddeleri, boyutunu da belirterek tabloya ekleyiniz.

Tablo 5: Boyutu uygun olmayan maddelerin, hangi boyutta olması gerektiğini tabloya ekleyiniz.

Tablo 2: Anlaşılmayan maddeler

Madde no	Önerileriniz

Tablo 3: Çıkması önerilen maddeler

Madde no	Sebep

Tablo 4: Eklenmesi önerilen maddeler

Boyut	Eklenecek madde

Tablo 5: Boyutu uygun olmayan maddeler

Madde	Gitmesi gereken boyut

C. Formun başlığı uygun mudur? ( ) Evet ( ) Hayır
D. Giriş açıklaması uygun ve yeterli midir? ( ) Evet ( ) Hayır
E. Puanlama uygun mudur? ( ) Evet ( ) Hayır
F. Sizce bu form, yapılan kursu değerlendirmek için yeterli midir?
( ) Evet ( ) Hayır

G. Varsa diğer öneri ve görüşlerinizi lütfen yazınız:

APPENDIX T

COURSE EVALUATION FORM-INITIAL VERSION

KURS DEĞERLENDİRME FORMU-İLK SÜRÜM

Sevgili Öğretmenim,

Bu sorular katıldığınız profesyonel gelişim kursunu sorgulamaktadır. İçtenlikle vereceğiniz cevaplar yapılan kursun etkinliğini belirlemede kullanılacak ve bundan sonra düzenlenecek kursların içeriğini belirlemede kullanılabilecektir.

Formu doldururken maddelerin 'Bu kurs' veya ' Kursta araştırmacı' gibi sözcüklerle başladığına dikkat ediniz.

#	A. Kursa karşı tutum	Kesinlikle Katılıyorum	Katılıyorum	Fark etmez	Katılmıyorum	Kesinlikle Katılmıyorum
	Bu kurs;					
1	…a katılmakla doğru bir karar verdim	1❑	2❑	3❑	4❑	5❑
2	…a katılmaya ihtiyacım vardı	1❑	2❑	3❑	4❑	5❑
3	…a keşke arkadaşım da katılsaydı	1❑	2❑	3❑	4❑	5❑
4	...u sevdim	1❑	2❑	3❑	4❑	5❑
5	…ile modern fizikünitesine ilgim arttı	1❑	2❑	3❑	4❑	5❑

6	…a benzer bir programa tekrar katılmak isterim	1❑	2❑	3❑	4❑	5❑
7	…a katılmaktan memnun oldum	1❑	2❑	3❑	4❑	5❑
8	…tan sonra okulumdaki öğretmenlerle benzer çalışmalar yapayı düşünebilirim	1❑	2❑	3❑	4❑	5❑
9	…ile modern fizikünitesini daha çok sevdim	1❑	2❑	3❑	4❑	5❑
	B. Kursun faydası					
	Bu kurs;					
10	…benim için faydalı oldu	1❑	2❑	3❑	4❑	5❑
11	…tan umduğumdan daha çok istifade ettim	1❑	2❑	3❑	4❑	5❑
12	…ta çok şey öğrendim	1❑	2❑	3❑	4❑	5❑
13	…ta güzel dostluklar kurdum	1❑	2❑	3❑	4❑	5❑
14	…ile birlikte modern fizikünitesini coşkulu bir şekilde anlattım	1❑	2❑	3❑	4❑	5❑
15	…ile birlikte modern fizikünitesini rahat tavırlar içinde anlattım	1❑	2❑	3❑	4❑	5❑
16	…ile modern fizik ünitesindeki birçok eksiğimi giderdim	1❑	2❑	3❑	4❑	5❑
17	…ta faydalı bilgi paylaşımın da bulundum	1❑	2❑	3❑	4❑	5❑
18	…ta diğer öğretmenlerden faydalı ders materyalleri aldım	1❑	2❑	3❑	4❑	5❑
19	…ile öğrencilerimle modern fiziķünitesinidaha rahat tartıştım	1❑	2❑	3❑	4❑	5❑
20	…a katılan arkadaşlar ile iletişimimi devam ettireceğim	1❑	2❑	3❑	4❑	5❑
21	…a katılan öğretmenlerle faydalı işbirliği yaptık	1❑	2❑	3❑	4❑	5❑
22	…a katılan öğretmenlerle faydalı iş bölümü yaptık	1❑	2❑	3❑	4❑	5❑
23	...a katılan öğretmenlerin ders anlatım tekniklerini beğendim	1❑	2❑	3❑	4❑	5❑
24	…ta iyi ders anlatan öğretmenler olduğunu gördüm	1❑	2❑	3❑	4❑	5❑
	C. **Kursta araştırmacı**					
	Araştırmacı;					
25	…kurs boyunca gayretli idi	1❑	2❑	3❑	4❑	5❑
26	…kursu güzel organize etmiş	1❑	2❑	3❑	4❑	5❑
27	…nın tecrübesinden yararlandım	1❑	2❑	3❑	4❑	5❑
28	…bana samimi davrandı	1❑	2❑	3❑	4❑	5❑
29	…hepimize samimi davrandı	1❑	2❑	3❑	4❑	5❑
30	…ya güvendim	1❑	2❑	3❑	4❑	5❑
31	…nın araştırma sonuçlarını bizimle paylaşacağına inanıyorum	1❑	2❑	3❑	4❑	5❑
32	…ile iletişimimi devam ettireceğim	1❑	2❑	3❑	4❑	5❑

	D. Kursun pedagojik alan bilgisine etkisi					
	Bu kurs ile birlikte modern fizik ünitesi;					
33	…nde bilinen kavram yanılgılarını açıklayabildim	1❑	2❑	3❑	4❑	5❑
34	…nde yeni materyaller (şekil, şema, grafik, formül vb.) kullanabildim	1❑	2❑	3❑	4❑	5❑
35	…nin diğer üniteler ile olan ilişkilerine değinebildim	1❑	2❑	3❑	4❑	5❑
36	…ndedaha önce yapmadığım tartışmalar yapabildim	1❑	2❑	3❑	4❑	5❑
37	…nde yeni animasyon/simülasyonlar kullanabildim	1❑	2❑	3❑	4❑	5❑
38	…nde yeni benzetmeler kullanabildim	1❑	2❑	3❑	4❑	5❑
39	…ndenyeni soru çeşitleri çözebildim	1❑	2❑	3❑	4❑	5❑
40	…nde yeni soru çözme teknikleri kullanabildim	1❑	2❑	3❑	4❑	5❑
41	…ndeki konu ve kavramları yeni bir sıraya göre işleyebildim	1❑	2❑	3❑	4❑	5❑
42	…nde anlaşılmayan konuları farklı yöntem (şekil-grafik-gösteri vb) ile anlatabildim	1❑	2❑	3❑	4❑	5❑
43	…ndedaha önce sormadığım soruları sorabildim	1❑	2❑	3❑	4❑	5❑
44	…ndekonuyu açıklayıcı örnekler verebildim	1❑	2❑	3❑	4❑	5❑
45	…ndeihtiyacı olan öğrenciye yardım etmek için ders işleme şeklimi değiştirebildim	1❑	2❑	3❑	4❑	5❑
46	…nde öğrencileri tartışmaya yönlendirici sorular sorabildim	1❑	2❑	3❑	4❑	5❑
47	…nde öğrencilerin dikkatini çekecek aktiviteler yapabildim	1❑	2❑	3❑	4❑	5❑
48	…ile öğrencilerin konuyu anlayıp anlamadıklarını anlayabildim	1❑	2❑	3❑	4❑	5❑
49	…ni anlayamayan öğrencilere faydalı geri dönüşüm yapabildim	1❑	2❑	3❑	4❑	5❑
50	…ndeöğrencilerin konuları kavramalarına yardımcı olabildim	1❑	2❑	3❑	4❑	5❑
51	…ile ilgili öğretim programı bilgim arttı	1❑	2❑	3❑	4❑	5❑
52	…ile ilgili öğretim programında eksiklerimin olduğunu anladım	1❑	2❑	3❑	4❑	5❑
53	…ile ilgili öğretim programını sevdim	1❑	2❑	3❑	4❑	5❑
54	…ile ilgili öğretim programının yapısını daha iyi anladım	1❑	2❑	3❑	4❑	5❑
55	…ninokutulmasının gerekli olduğunu anladım	1❑	2❑	3❑	4❑	5❑
	E. Kursun genel pedagojik bilgiye etkisi					
	Bu kurs ile modern fizik ünitesini anlatırken;					
56	…derse yeterli katılım sağlayabildim	1❑	2❑	3❑	4❑	5❑
57	…derste yapılacaklardan bahsedebildim	1❑	2❑	3❑	4❑	5❑
58	…demokratik bir sınıf ortamı sağlayabildim	1❑	2❑	3❑	4❑	5❑

59	…öğrenci motivasyonunu sağlayabildim	1❑	2❑	3❑	4❑	5❑
60	…zamanı verimli kullanabildim	1❑	2❑	3❑	4❑	5❑
61	…bireysel farklılıkları göz önüne alabildim	1❑	2❑	3❑	4❑	5❑
62	…disiplinsizliğe karşı uygun önlemler alabildim	1❑	2❑	3❑	4❑	5❑
63	…öğrencilerle etkili iletişim kurabildim	1❑	2❑	3❑	4❑	5❑
64	…sözel dilimi etkili biçimde kullanabildim	1❑	2❑	3❑	4❑	5❑
65	…beden dilimi etkili biçimde kullanabildim	1❑	2❑	3❑	4❑	5❑
66	…tahtayı düzenli kullanabildim	1❑	2❑	3❑	4❑	5❑
67	…öğrencilerle kişisel olarak ilgilenebildim	1❑	2❑	3❑	4❑	5❑
68	…gerekli yerlerde özetleme yapabildim	1❑	2❑	3❑	4❑	5❑
69	…konunun anlaşılıp anlaşılmadığı kontrol edebildim	1❑	2❑	3❑	4❑	5❑
70	…öğrencileri tartışmaların içine çekebildim	1❑	2❑	3❑	4❑	5❑
	F. Kursun konu alan bilgisine etkisi					
	Bu kurs ile modern fizik ünitesin deki/ i anlatırken;					
71	…öğrenci sorularına ikna edici cevaplar verebildim	1❑	2❑	3❑	4❑	5❑
72	…günlük hayat ile ilişkisini kurabildim	1❑	2❑	3❑	4❑	5❑
73	…kavramları birbiri ile ilişkilendirebildim	1❑	2❑	3❑	4❑	5❑
74	…bilgimin arttığını fark ettim	1❑	2❑	3❑	4❑	5❑
75	…soruları rahat çözdüm	1❑	2❑	3❑	4❑	5❑
76	…kavram yanılgılarını öğrendim	1❑	2❑	3❑	4❑	5❑
77	…kendi kavram yanılgılarımı giderdim	1❑	2❑	3❑	4❑	5❑
78	…konuları daha düzenli anlattım	1❑	2❑	3❑	4❑	5❑
79	…bilimsel hatalarımı düzeltim	1❑	2❑	3❑	4❑	5❑
80	…önemli yerleri vurgulayabildim	1❑	2❑	3❑	4❑	5❑

Katıldığınız bu program ile ilgili başka görüşleriniz varsa lütfen yazınız:

APPENDIX U

COURSE EVALUATION FORM-FINAL VERSION

KURS DEĞERLENDİRME FORMU-İLK SÜRÜM

Sevgili Öğretmenim,
Bu sorular katıldığınız profesyonel gelişim kursunun içeriğini ve olası etkilerini sorgulamaktadır. İçtenlikle vereceğiniz cevaplar yapılan kursun etkinliğini belirlemede kullanılacak ve bundan sonra düzenlenecek kursların içeriğini belirlemeye yardımcı olabilecektir.
Formu doldururken maddelerin 'Bu kurs' veya ' Kursta araştırmacı' gibi sözcüklerle başladığına dikkat ediniz.

		Kesinlikle Katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle Katılıyorum
#	**A.**					
	Bu kurs;					
1	…a katılmakla doğru bir karar verdim.	1❑	2❑	3❑	4❑	5❑
2	…a benzer bir programa tekrar katılmak isterim.	1❑	2❑	3❑	4❑	5❑
3	…a karşı olumlu hislerim oluştu.	1❑	2❑	3❑	4❑	5❑
4	…ta farklı öğretmenlerden ders dinlemek hoşuma gitti.	1❑	2❑	3❑	4❑	5❑
5	…ile modern fizik ünitesine ilgim daha fazla arttı.	1❑	2❑	3❑	4❑	5❑
6	…ile modern fizik ünitesini daha zevkli anlattım.	1❑	2❑	3❑	4❑	5❑

7	...u sevdim.	1❑	2❑	3❑	4❑	5❑
8	…ile modern fizik ünitesini daha çok sevdim.	1❑	2❑	3❑	4❑	5❑
9	…tan sonra okulumdaki öğretmenlerle benzer çalışmalar yapmayı düşünebilirim.	1❑	2❑	3❑	4❑	5❑
10	...a katılan öğretmenlerin ders anlatım tekniklerini beğendim.	1❑	2❑	3❑	4❑	5❑
	B.					
	Bu kurs;					
11	…benim için faydalı oldu.	1❑	2❑	3❑	4❑	5❑
12	…tan umduğumdan daha çok istifade ettim.	1❑	2❑	3❑	4❑	5❑
13	…a katılmaya ihtiyacım vardı.	1❑	2❑	3❑	4❑	5❑
14	…ta çok şey öğrendim.	1❑	2❑	3❑	4❑	5❑
15	…ta güzel dostluklar kurdum.	1❑	2❑	3❑	4❑	5❑
16	…a keşke arkadaşım da katılsaydı.	1❑	2❑	3❑	4❑	5❑
17	…ile birlikte modern fizik ünitesini coşkulu bir şekilde anlatabildim.	1❑	2❑	3❑	4❑	5❑
18	…ile birlikte modern fizik ünitesini daha rahat anlatabildim.	1❑	2❑	3❑	4❑	5❑
19	…ile modern fizik ünitesindeki birçok eksiğimi giderdim.	1❑	2❑	3❑	4❑	5❑
20	…ta faydalı bilgi paylaşımın da bulundum.	1❑	2❑	3❑	4❑	5❑
21	…ta diğer öğretmenlerden faydalı ders materyalleri aldım.	1❑	2❑	3❑	4❑	5❑
22	…ile öğrencilerimle modern fizik ünitesini daha rahat tartıştım.	1❑	2❑	3❑	4❑	5❑
23	…a katılan öğretmenler ile iletişimimi devam ettireceğim.	1❑	2❑	3❑	4❑	5❑
24	…a katılan öğretmenlerle işbirliği yaptık.	1❑	2❑	3❑	4❑	5❑
25	…a katılan öğretmenlerle iş bölümü yaptık.	1❑	2❑	3❑	4❑	5❑
26	…ile modern fizik ünitesinin okutulmasının gerekli olduğunu anladım.	1❑	2❑	3❑	4❑	5❑
	C.					
	Araştırmacı;					
27	…kurs boyunca gayretliydi.	1❑	2❑	3❑	4❑	5❑
28	…kursu güzel organize etmiş.	1❑	2❑	3❑	4❑	5❑
29	…nın tecrübesinden yararlandım.	1❑	2❑	3❑	4❑	5❑
30	…bana samimi davrandı.	1❑	2❑	3❑	4❑	5❑
31	…hepimize samimi davrandı.	1❑	2❑	3❑	4❑	5❑
32	…ya güvendim.	1❑	2❑	3❑	4❑	5❑
33	…nın araştırma sonuçlarını bizimle paylaşacağına inanıyorum.	1❑	2❑	3❑	4❑	5❑

34	…ile iletişimimi devam ettireceğim.	1❑	2❑	3❑	4❑	5❑
	D.					
	Bu kurs ile birlikte modern fizik ünitesi;					
35	…nde bilinen kavram yanılgılarını daha iyi açıklayabildim.	1❑	2❑	3❑	4❑	5❑
36	…nde yeni materyaller (şekil, şema, grafik, formül vb.) kullanabildim.	1❑	2❑	3❑	4❑	5❑
37	…nin diğer üniteler ile olan ilişkilerine daha fazla değinebildim.	1❑	2❑	3❑	4❑	5❑
38	…nde daha önce yapmadığım tartışmalar yapabildim.	1❑	2❑	3❑	4❑	5❑
39	…nde yeni animasyon/simülasyonlar kullanabildim.	1❑	2❑	3❑	4❑	5❑
40	…nde yeni benzetmeler kullanabildim.	1❑	2❑	3❑	4❑	5❑
41	…nden yeni soru çeşitleri çözebildim.	1❑	2❑	3❑	4❑	5❑
42	…nde yeni soru çözme teknikleri kullanabildim.	1❑	2❑	3❑	4❑	5❑
43	…ndeki kavramları yeni bir sıraya göre işleyebildim.	1❑	2❑	3❑	4❑	5❑
44	…nde anlaşılmayan konuları farklı teknik (şekil,-grafik,-gösteri vb) ile anlatabildim.	1❑	2❑	3❑	4❑	5❑
45	…nde daha önce sormadığım soruları sorabildim.	1❑	2❑	3❑	4❑	5❑
46	…nde konuyu açıklayıcı örnekler verebildim.	1❑	2❑	3❑	4❑	5❑
47	…nde ihtiyacı olan öğrenciye yardım etmek için ders işleme şeklimi değiştirebildim.	1❑	2❑	3❑	4❑	5❑
48	…nde öğrencileri tartışmaya yönlendirici sorular sorabildim.	1❑	2❑	3❑	4❑	5❑
49	…nde öğrencilerin dikkatini çekecek aktiviteler yapabildim.	1❑	2❑	3❑	4❑	5❑
50	…ile öğrencilerin konuyu anlayıp anlamadıklarını anlayabildim.	1❑	2❑	3❑	4❑	5❑
51	…ni anlayamayan öğrencilere faydalı geri dönüş yapabildim.	1❑	2❑	3❑	4❑	5❑
52	…nde öğrencilerin konuları kavramalarına yardımcı olabildim.	1❑	2❑	3❑	4❑	5❑
53	…de öğrencilerin kavram yanılgısına daha fazla sahip olduğunu öğrendim.	1❑	2❑	3❑	4❑	5❑
54	…ile ilgili öğretim programı bilgim arttı.	1❑	2❑	3❑	4❑	5❑
55	…ile ilgili öğretim programında eksiklerimin olduğunu anladım.	1❑	2❑	3❑	4❑	5❑
56	…ile ilgili öğretim programının yapısını daha iyi anladım.	1❑	2❑	3❑	4❑	5❑
	E.					
	Bu kurs ile modern fizik ünitesini anlatırken;					

57	…öğrencilerimin derse katılımını arttırabildim.	1❑	2❑	3❑	4❑	5❑
58	…derste yapılacaklardan daha çok bahsedebildim.	1❑	2❑	3❑	4❑	5❑
59	…daha demokratik bir sınıf ortamı sağlayabildim.	1❑	2❑	3❑	4❑	5❑
60	…öğrenci motivasyonunu daha fazla sağlayabildim.	1❑	2❑	3❑	4❑	5❑
61	…zamanı daha verimli kullanabildim.	1❑	2❑	3❑	4❑	5❑
62	…bireysel farklılıkları daha fazla göz önüne alabildim.	1❑	2❑	3❑	4❑	5❑
63	…disiplinsizliğe karşı daha fazla uygun önlemler alabildim.	1❑	2❑	3❑	4❑	5❑
64	…öğrencilerle daha fazla etkili iletişim kurabildim.	1❑	2❑	3❑	4❑	5❑
65	…sözel dilimi daha etkili biçimde kullanabildim.	1❑	2❑	3❑	4❑	5❑
66	…beden dilimi daha etkili biçimde kullanabildim.	1❑	2❑	3❑	4❑	5❑
67	…tahtayı daha düzenli kullanabildim.	1❑	2❑	3❑	4❑	5❑
68	…öğrencilerle kişisel olarak daha fazla ilgilenebildim.	1❑	2❑	3❑	4❑	5❑
69	…gerekli yerlerde daha fazla özetleme yapabildim.	1❑	2❑	3❑	4❑	5❑
70	…konunun anlaşılıp anlaşılmadığını daha fazla kontrol edebildim.	1❑	2❑	3❑	4❑	5❑
71	…öğrencileri tartışmaların içine daha fazla çekebildim.	1❑	2❑	3❑	4❑	5❑
	F.					
	Bu kurs ile modern fizik ünitesin deki;					
72	…konuları daha düzenli anlattım.	1❑	2❑	3❑	4❑	5❑
73	…bilimsel hatalarımı düzelttim.	1❑	2❑	3❑	4❑	5❑
74	…düşünce deneylerini daha iyi kavradım.	1❑	2❑	3❑	4❑	5❑
75	…kavramları daha derinlemesine öğrendim.	1❑	2❑	3❑	4❑	5❑
76	…bilgimin arttığını fark ettim.	1❑	2❑	3❑	4❑	5❑
77	…kendi kavram yanılgılarımı giderdim.	1❑	2❑	3❑	4❑	5❑
	Bu kurs ile modern fizik ünitesini anlatırken;					
78	…öğrenci sorularına daha ikna edici cevaplar verebildim.	1❑	2❑	3❑	4❑	5❑
79	…soruları daha rahat çözdüm.	1❑	2❑	3❑	4❑	5❑
80	…formülleri daha iyi yorumlayabildim.	1❑	2❑	3❑	4❑	5❑
81	…günlük hayat ile ilişkisini daha fazla kurabildim.	1❑	2❑	3❑	4❑	5❑

82	…kavramları birbiri ile daha fazla ilişkilendirebildim.	1❑	2❑	3❑	4❑	5❑
83	…görselleri daha iyi yorumlayabildim.	1❑	2❑	3❑	4❑	5❑
84	…önemli yerleri daha fazla vurgulayabildim.	1❑	2❑	3❑	4❑	5❑
85	...formüllerle kavramlar arasındaki ilişkiyi daha iyi açıklayabildim.	1❑	2❑	3❑	4❑	5❑

Katıldığınız bu program ile ilgili başka görüşleriniz varsa lütfen yazınız:

APPENDIX V

THE TTT PD COURSE SCHEDULE

TTT PD KURS ÇİZELGESİ

Sunucu	Kazanımlar	Zaman
Araştırmacı	• Eylemsizliği cismin durgun, sabit hızlı ve sabit ivmeli hareketi ile ilişkilendirerek açıklar. • Cismin eylemsizliğinin kütlesinin bir ölçüsü olduğunu örneklerle açıklar. • Etki ve tepki kuvvet çiftlerini örneklerle açıklar.	Ocak 1. Hafta
Araştırmacı	• Net kuvvet ile cismin ivmesi ve kütlesi arasındaki bağıntıyı kullanarak problemler çözer. • Tek boyutta sabit ivmeli hareketleri örneklerle açıklar.	Ocak 2. Hafta
Öğretmen -1	• Modern fiziğin doğuşuna katkıda bulunan gelişmeleri açıklar. • Işık hızının eylemsiz referans sisteminden bağımsız olduğunun ileri sürülmesine neden olan araştırmaları açıklar.	Nisan 2. Hafta
Öğretmen -2	• Özel görelilik kuramının temel kabullerini açıklar.	Nisan 3. Hafta
Öğretmen -3	• Işık hızına yakın hızlardaki hareketli için uzunluk değişimlerini yorumlar.	Nisan 4. Hafta
Öğretmen -4	• Işık hızına yakın hızlardaki hareketli için zaman değişimlerini yorumlar.	Mayıs 1. Hafta
Öğretmen -5	• *Işık hızına yakın hızlar için yeniden yorumlanması gereken bazı temel kavramları örnekler vererek açıklar.	Mayıs 2. Hafta

*Haftalık iki saat fizik dersi olan öğretmenler bu kazanımı sınıflarında anlatmadılar

APPENDIX W

KEY WORDS USED IN THE LITERATURE REVIEW

LİTERATÜR TARAMASINDA KULLANILAN ANAHTAR KELİMELER

Professional development, Professional development + teachers

Professional development + physics teachers

Professional development + science teachers

Professional development + mathematics teachers

Professional development +review

Professional development+ Meta analysis

Teacher collaboration, Teacher cooperation, Staff development

Teacher +in-service training

Professional development + student achievement

Effective professional development programs

Effective professional development design

Professional development programs in Turkey, Just –in time training

Just –in time training + Professional development

Just –in time teaching + physics, Just –in time teaching + science

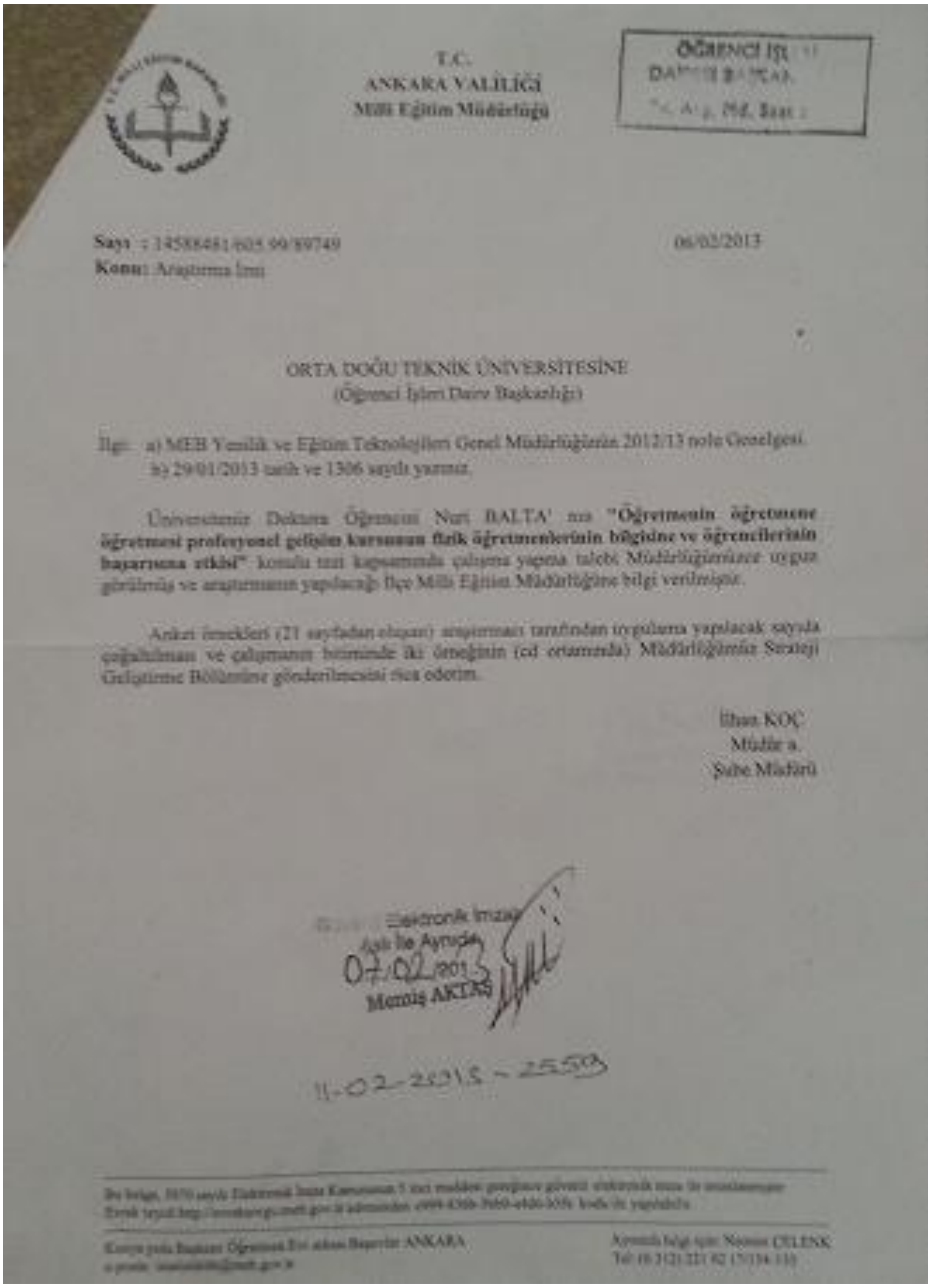
Learning community + teaching practice, Professional learning communities

Professional communities + student achievement

Teacher training + teacher quality + student achievement

APPENDIX X

PERMISSION LETTER



T.C.
ANKARA VALİLİĞİ
Milli Eğitim Müdürlüğü

Sayı : 14588481/605.99/89749 06/02/2013
Konu: Araştırma İzni

ORTA DOĞU TEKNİK ÜNİVERSİTESİNE
(Öğrenci İşleri Daire Başkanlığı)

İlgi: a) MEB Yenilik ve Eğitim Teknolojileri Genel Müdürlüğünün 2012/13 nolu Genelgesi.
b) 29/01/2013 tarih ve 1306 sayılı yazınız.

Üniversiteniz Doktora Öğrencisi Nuri BALTA'nın **"Öğretmenin öğretmene öğretmesi profesyonel gelişim kursunun fizik öğretmenlerinin bilgisine ve öğrencilerinin başarısına etkisi"** konulu tezi kapsamında çalışma yapma talebi Müdürlüğümüzce uygun görülmüş ve araştırmanın yapılacağı İlçe Milli Eğitim Müdürlüğüne bilgi verilmiştir.

Anket örnekleri (21 sayfadan oluşan) araştırmacı tarafından uygulama yapılacak sayıda çoğaltılması ve çalışmanın bitiminde iki örneğinin (cd ortamında) Müdürlüğümüz Strateji Geliştirme Bölümüne gönderilmesini rica ederim.

İlhan KOÇ
Müdür a.
Şube Müdürü

Elektronik İmzalı
Aslı İle Aynıdır
07/02/2013
Memiş AKTAŞ

11-02-2013 - 2559

APPENDIX Y

A SCENE FROM TTT PD COURSE

TTT PROFESYONEL GELİŞİM KURSUNDAN BİR SAHNE

Below is the document that includes some activities and discussions took place during the sixth TTT PD course:

Initially the researcher made and introduction, he stated the topic that will be held next week. Since it was going to be the last week of TTT PD, he stated the importance of the last week and he talked about surprize that was going to take place at the last week. Then, he started repeating the previous week's topic. Following is a part of the repetition of the last week's topic done by researcher.

Researcher: In the previous week we tried to explain two things: the basic postulates of the special relativity… The first, the laws of physics are the same in any inertial frame of reference, second, the speed of light in a vacuum is the same in any inertial frame of reference, regardless of the relative motion of the source and observer. In order to explain the first postulates we gave an example… What does 'the laws of physics are the same in any inertial frame of reference' mean? Why do we need these postulates? More, it is an essential postulate!… Just like the base of a building, the modern physics is built on these two postulates. In order to understand this, there are two observers; one in the car (he drew a car and the observers) and the other is outside the car. For the observer in the car, the ball (he drew a ball moving up and down) thrown up will straightly move up and down. According to the other observer, the ball will follow this path (he drew a parabolic path for the ball). Now there are two different motions. This one sees a different motion and this one sees a different motion. They measure both the speed that the objects hit the ground and the kinetic energy of the objects differently.

Not this experiment, let's do another experiment. A force F acts on an object in a moving car (he drew a car, an object and a force vector). While the car is moving a force is acting on it. While the car is moving both this and this observer make observations (he drew two observers outside and inside the car). These two observers are going to measure different final velocities of the object. But, what is the reason behind this difference. The reason of different results is because the physical laws are different in this and this reference frames (He drew the reference frames on the car and on the ground)?.... Physical laws are same in all inertial reference frames but the results can be different. The first postulate especially emphasise this. Do you have any questions? This is important because we have to repeat this to students. We have to reveal what this postulate says.

Teacher 12: I have a question. We had an example…. The one that explains the interpretation of a car moving with the speed of…(*The researcher interrupted).*

Researcher: I will explain it, it is about second postulate. But this is about the first postulate. The results may be different but the physical laws are same. In other words we don't use different law here and here.

Teacher 9: Do we need to say this: Galileo also said the same thing… Mechanic laws are same in all inertial reference frames. But when he came to optics, magnetism and electric, he encounter with nuisance. With special relativity it was understood that in all physics the physics laws are the same. Do we have to also teach this to students?

Researcher: We can teach this… Unlike Galileo, Einstein enlarges the condition and says that physics laws, including optics, magnetism and so on, are same in all inertial reference frames. What I am obsessed is why do we need this? What is the connection between this and special relativity? Why do we introduce this as a sine qua non for the postulate of special relativity? I understand like this: In a moment you are going to present it (pointing the teacher that going to teach that day). According to different observers or different inertial reference frames the time measurement wouldn't be different? Wouldn't the length measurement be different? What is the reason behind the differentness? Is it because that physics laws are particular? No… The physics laws are same… Because of the laws of the nature or because of the laws that God legislate, even though the physics laws are same, the results can be different. This is what I understand, are there any mistakes?

Now let's look at the second postulate. For second postulate, saying that 'the speed of light is same in all inertial reference frames' and then ending it is not correct. You have to state the postulate but it is not enough, we have to make its application. You can say: A car is moving toward that side (he drew car-K) with 0.5c, another car is moving in the opposite direction (he drew another car-L) with 0.6c. How much the observer in car K does measure the speed of light coming from car L?

Teacher 6: It measures 1.1c

Researcher: Students mostly will say 1.1c.

Teacher 9: They may say 0.1c also.

Researcher: Right, they can say 0.1c. But the answer is c. All right, what speed of light coming from K does L measure?

Teacher 9: He/she also will measure c.

Teacher 8: There is something like this… For instance there is a car moving with c away from earth. After a while one turns on a lamp. Will this light reach the car?

Researcher: Could you please repeat the question.

Teacher 8: A car is moving away from earth with speed of light, if we sent a light after the car will it reach the car?

Researcher: Good question. According to which observer?

Teacher 8: Now, if the light reaches, it means that the observer in the car will see it.

Teacher 3: Or the observer in the space car will see it in the rear-view mirror! (*Several teachers laughed*)

Researcher: Can the man in the car see the light sent from the earth? Yes, he can see.

Teacher 17 (a teacher participated most of the TTT PD, however she was not a school teacher): Don't they have a distance between them? Don't they move with constant speeds? How it will cover this distance?

Researcher: For example this one (K), how it will cover this distance? It will go this distance like this: When it is moves with speed of light the distance decreases to zero. The related formulas also give this result. When you go with speed of light there is no distance between objects.

Teacher 5: Then it will see the car at the edge of the earth.

Researcher: Yes it will see the car at the edge of the earth.

Teacher 5: But it is still moving

Researcher: Once this start motion it will see the distance as zero. It means it will reach the car. If you go with speed of light the time passed will be zero also, it will reach the car at the moment. But, this is the result according to the light itself. I want to say this: In how much time does the light of sun reach us? According to us it takes approximately eight minutes. But according to a photon leaving the sun, the time is zero. It comes spontaneously! Why? Because as you speed up, the distance becomes smaller, once you reach the speed of light the distance becomes zero.

Teacher 5: The car that moves with speed of light will see that it is not moving away from the earth. Because the distance is zero!

Teacher 8: Something like this happens: The light exists at both places at the same time. The students will think like this.

Researcher: It is perceived at both places at the same time. But according to the observer in the car, the light will reach to the observer in the car after $t=x/t$. According to the light that leaves the earth it will reach the car spontaneously.

Teacher 5: But the car is moving with speed of light and the distance (x) always increases. Thus, since the light that leaves the earth also moves with c the distance should remain constant.

Researcher: But the car will see the light coming toward him with speed of light. This is what the second postulates states. But you claim that since the car also moves with speed of light, the light from earth will never reach. Actually good interpretation! Will it not reach?

Teacher 8: The light from Sun comes to us in about eight minutes. If earth move with speed of light, will it again reach us?

Researcher: This is also a good question.

Teacher 8: Can we speak with cell phone or send SMS during moving with speed of light? It seems that it depends of the direction of motion.

Researcher: We can make this discussion but first, let's finish this discussion. First let's make the discussion; 'can we see us in the mirror while we are moving with speed of light'.

Teacher 4: The students can also ask this question: Which speed of car L is going to be measured by the observer in car K?

Researcher: Well, the curriculum does not include 'which speed of car L is going to be measured by the observer in car K'.

Teacher 4: Then, what we are going to say if such a question is asked?

Researcher: We are going to say that the speed of light cannot be exceeded. The measured speed will be smaller than c and we are not going to explain further.

Teacher 13: Well, we know that the maximum possible speed is the speed of light. Are there any particles that are moving faster than light?

Researcher: No, not sir.

Teacher 13: Well, let me think like that: We say that light travels from sun to earth in 8 minutes. But, when I imagine sun, I go there and 8 minutes does not pass. Thus, I am reaching the sun in less than one second. Does this mean that I am faster than speed of light?

Researcher: As an imagination you can go sun faster than light. You can say that imagination is faster than light. Not only Sun, even, you can imagine yourself in the centre of Milky Way. But, is it true to compare the imagination and the light? Isn't it just like mixing apples and the pears? We have to be careful, because one of them is imagination and the other one is light. Is it okay?

Teacher 13: Okey

Researcher: Let's return to 'what we are going to see in the mirror while we are moving with speed of light'. While the man is looking at the mirror, the mirror itself also is moving with speed of light (he drew a man holding a mirror). There is another version of this question: The mirror is stationary you are moving toward the mirror. Let's discuss it also. The first, you hold the mirror like this (he described it with his hands) and you are moving with speed of light. We have to discuss this with students, in terms of classical and modern physics. According to classical physics the answer is this and according to modern physics the answer is this. Now, if we think according to classical physics: A photon reflected from the face of the man will move toward the mirror with speed of light, but, since the mirror is also moving with speed of light the photon will not strike the mirror and according to classical physics the man will not see himself in the mirror. But, according to modern physics, whatever is the speed of the mirror the light will come closer to it with the speed c and the light will strike the mirror.

Teacher 8: By the way you are giving the answer of the aforementioned question. The same logic can be used for that question.

Researcher: Yes, it is the same logic. Let's think according to modern physics. The car (He drew the earth and a car moving away from earth) is moving with speed c and a light from earth follow it with speed c. Just like in the previous logic. Whatever is the speed of the car the light from the earth will come closer with speed c.

Teacher 6: Could you please make the interpretation in terms of modern physics ones more?

Researcher: According to classical physics there is no problem isn't it? According to modern physics the light strike to our face and reflects with speed c. Right? Even though the mirror is moving with speed of light, the light will move toward the mirror with c, it will move always with c, because the speed of light in a vacuum is the same in any inertial frame of reference. According to reference frame of the mirror, even though it is moving with speed c, isn't it an inertial frame of reference? The speed of light is the same in any inertial frame of reference, accordingly, according to mirror this light will move toward the mirror with speed c. It means that the light reflected from the face will reach to the mirror and it will produce an image.

…..

Similar discussion and teachings took place for about 21 more minutes. Once the researcher finished the repetition of the last week's topics, the presenter of the sixth week (Teacher 9) started teaching the fourth objective specified in the tenth grade curriculum. Actually he started to this objective the week before. That week's objective relatively took short time. That's why an introduction was made to the fourth objective.

Teacher 9: Last week we explained up to this point. Last week I tried to show you some animations, however, I couldn't. Let's look at these animations. We mentioned the Hafele-Keating experiment.

Researcher: Please let's don't make this discussion.

Teacher 9: No, no I will not start the discussion. Remember they put caesium atom clocks in jet planes and the clocks were moving with high speeds. They determined that the time for the clock in the plane was different from the time for clock on earth. There is a video about this experiment.

The video, summarizing the experiment, was about three minutes.

Researcher: It said that the time difference was about one in forty billions of a second isn't it? Moreover it said that the calculated time difference was compatible with theoretical calculations.

Teacher 9: With this experiment they have shown that the time dilation is real. This was a video from YouTube. I can give the link anybody who wants. You can start teaching time dilation in your class by introducing this experiment. It is better to first watch this experiment and then teach the topic.

Researcher: You can have the video or the link.

Teacher 9: Yes, we can give the link. Moreover, there are some other links related to time dilation, I will give all of them to you… Hafele-Keating then published a related article.

Is it better to first show the animation about time dilation or first introduce the topic?

Researcher: You know, but in my opinion let's first listen to the topic.

Teacher 9: In order to explain the time dilation mathematically, Einstein designed a taught experiment. There is an observer in a train moving with constant velocity and there is a stationary observer on the ground (he showed a picture in PPT). Since it is moving with constant velocity it is an inertial frame of reference. The reference frame of the train is x'- y', I drew it with red colour. On the other hand the reference frame of the stationary observer is x-y reference frame. One of these reference frames is moving with constant speed with respect to the other one. Now…The experiment done by the observer in the train: There is a light source on the base of the train, there is a mirror at the ceiling, a light pulse is sent from the light source, he measures the time that pass for the motion of the pulse between the source and the mirror. Let's say he measures this time as t_o. 't_o' is the time measured by the observer who is stationary with respect to the event. This is the time for the light to move up and down. The stationary observer on the ground also measures the up and down motion of the light pulse. He measures it as 't'. However, they realize that the time spans that they measure are different. What is this difference? In order to calculate it, let's construct this ABC triangle (He drew it both on the picture of the train and separately). Now, we defined the distance between the light source and the mirror as 'd'. By the way we have to take this also into consideration: Both observers see the speed of light same. This was because of the result of the second postulate. Light travels independently than the inertial reference frames. We can write $d=c.t_o/2$, t_o was the time of the up and down motion, $t_o/2$ is the time for only moving up. This is the height of the triangle. By the way, according to the observer on the ground while the light pulse moves up it also moves toward right together with the train. This blue path is the path of the light seen by the observer on the ground. Thus, for this side of the triangle we can write c.t/2. This observer sees that the light moves with speed c and the light reaches the mirror in t/2 time. We wrote this distance as c.t/2. Well, during this time what is the distance taken by the train? According to the observer on the ground the train has moved for a time span of t/2. Thus we wrote v.t/2 and from Pythagorean Theorem we can write this equation.

He then made some mathematical calculations and proved that $t = \frac{t_o}{1-\frac{v^2}{c^2}}$.

He afterwards defined γ *and stated that in some books it is defined as* $\overline{1-\frac{v^2}{c^2}}$ *and in some books it is defined as* $\frac{1}{1-\frac{v^2}{c^2}}$ *. He go further and recommended to use only one of them and recommend to use first one. He then simplified the equation and wrote both* $t = t_o\gamma$ *and* $t = \frac{t_o}{\gamma}$.

Researcher: I am sorry, but I have to interrupt. Showing γ as in the first case is completely wrong. γ has only one definition… Not several… γ is defined as $\frac{1}{1-\frac{v^2}{c^2}}$ and γ is always bigger than one. If you define it as in the first case γ will be smaller than one.

Teacher 9: When the books write the first definition for the γ, they express that γ is always smaller than one.

Researcher: Indeed! They use the first case and state that γ is smaller than one! By the way, γ has a graph.

Teacher 9: I will show it. But, I looked at Serway and it also uses this definition: $\frac{1}{1-\frac{v^2}{c^2}}$. However, when it describe the length contraction it uses the $\overline{1-\frac{v^2}{c^2}}$.

Researcher: It is impossible.

Teacher 9: Serway is here (he opened pdf form of Serway and tried to find the aforementioned part, but he couldn't). Let me look at it after a while.

Researcher: Okey, while we discuss you can look at it.

Teacher 9: But, I prepared the presentation according to this representation of γ.

Researcher: No, not. Teachers will confuse, we cannot use this definition of γ. So, it is not important, let's change all γ instantaneously.

Teacher 9: Okey, I will change instantaneously. As a result $\gamma = \frac{1}{1-\frac{v^2}{c^2}}$ and thereby we are going to write $t = \gamma t_o$. γ is always bigger than one. Let's solve a problem.

Astronauts are taught to be paid in proportion to the time they spend in space. An astronaut moves to space with a speed of 0.8c and returns back. Will he/she want to be paid according to the clock on earth or the clock in the spaceship? It is a simple question, what is your opinion?

Researcher: It is not so simple where did you get this question?

Teacher 9: It should be in Serway.

Teacher 8: Good question. He/she will want to be paid according to the clock on earth, because much time passes there

Teacher 11: Yes, you are right.

Teacher 9: We can find the answer by looking at γ. The time that the moving observer measures (t_o) will be smaller than the time (t) that the stationary observer on the ground measures. Thus, astronauts will not want to be paid according to their own clocks. Since the time measured by the stationary clock will be more, the astronauts will want to be paid according to this clock. This was a question to clarify the $t = \gamma t_o$.

Again let's do a simple question. How much does an astronaut moving with a speed of 0.6c ages while a man on earth ages 15 years?

Teacher 8: In my opinion, we have to teach this question. Aging related to time is controversial. Remember the twin paradox. The moving or the stationary twins, there is no answer of the question 'which one ages more?'

Teacher 9: We are going to explain it soon.

Teacher 8: Here, 15 years passed for the observer on earth… perhaps 12 or 10 years passed. Thus, both may have aged equally.

Teacher 9: No.

Teacher 8: You cannot say that aging is biological.

Teacher 9: According to the stationary observer the biological activities also slows down. In other words, the stationary observer measures the heartbeats of the moving one as slowed down. But, according to astronaut his heartbeats are running normally. But, when the stationary attempts to measure the astronaut's heartbeats, he sees it as slowed down.

Researcher: Well, what is the question? 'how much does the astronauts age' according to whom?

Teacher 9: According to himself.

Researcher: According to himself or according to the stationary observer?

Teacher 12: According the stationary observer?

Researcher: According to the stationary? Namely, according to whom?

Teacher 9: When the astronaut goes and returns back to earth the result is same for both.

Teacher 8: Actually the question should be like this: How much time pass according to the astronaut when 15 years pass on earth?

Teacher 6: It should be according to the stationary observer.

Teacher 13: It should be according to the stationary observer, because, it is the astronaut who goes and returns back, he cannot feel the result.

Teacher 6: Yes you are right.

Teacher 9: Let me explain like this: If I recall correctly the result should be 12 years. He feels that he is 12 years aged, according to his own clock. He came to the earth; the man on the earth has aged 15 years, but he is 12 years old! The result is same for both. If he has aged 12 years it means that he has aged 12 years.

Teacher 13: But physically we see that he has aged.

Researcher: Let's think like this: There is a clock of the astronaut. He went and came back with o.6c. Now, he went and came back, does this clock will show that 15 years passed?

Teacher 3: No, it will show fewer.

Researcher: Well, they are going to put the clocks side by side and the astronaut will see that his clock is back! But during the journey the astronaut is not aware that his clock is lagging back, isn't it. Is he aware during the journey that his time is slowing down?

Teacher 9: No during the journey he cannot notice it.

Teacher 5: Because his sensation also slows down.

Teacher 4: The question is deficient, it should state according to whom…

Teacher 3: Yes you are right.

Teacher 9: Let me solve this question as I understood. Remember our formula was $t=t_o\gamma= \frac{t_o}{1-\frac{v^2}{c^2}}$. What is 't' and what is 't_o' these are the questions that students mostly confuse. In the equation, they can write them instead of each other and can find different and wrong results. That's why we have to define them clearly. t_o is the time measured in the reference frame in which the event takes place. What is the event? It is the motion of the spaceship. The observer in that reference frame is the astronaut. The time that he is going to measure is t_o. The time that the astronaut measures… An observer on earth, a stationary observer measures 15 years. Then let me write the formula. Since we don't know how much time is being measured by the astronaut, we can write $15 = \frac{t_o}{1-\frac{(0.6c)^2}{c^2}}$.

Researcher: Let's explain to students like this: Does the time of the one that goes to space and comes to back will be less? Yes. Namely, we are going to measure the time of astronaut isn't it? Therefore, if you confuse the 't' and 't_o', try both in the formula, the one which calculated fewer is the 't_o'. In other words, in any case they have to measure the time of the astronaut fewer. Isn't it true?

Teacher 9: The moving clock runs slower.

Teacher 17: Last week you stated that these are not reversible. I mean…

Teacher 9: I will narrate it also…. While I teach the twin paradox I will mention it.

Teacher 8: No, here we have to discuss. Now, according to the man moving with this speed the man on earth will also recede with 0.6c.

Teacher 9: This is the paradox anyway. We are going to recite it.

Teacher 8: But in this question when it asks 'how much does the astronaut age' it should specify the reference.

Teacher 9: At this stage, what we have to do is to induce the students that according to the clock on earth the moving clock runs slower. The moving clock will run slower and will measure less time. First, we have to inculcate this to students mind by interpreting the formula. Then we have to teach, what is 't'? What is 't_o'? The observers in different reference systems measure which one? How to use the formula? At this stage this is enough. Now, from the formula t_o=12 year. In other words, the time the astronaut measure is 12 years. Is it correct? Now, since in the frame of reference of the astronaut 12 years pass, he will age 12 year when he return to earth. Now, what is the meaning of the question ‘does according to astronaut or according to the man on earth 12 years pass’ I didn’t understand. If we interpret differently, if we ask according to another one, what will be the result?

Researcher: What do you mean? Do you mean; the astronaut went and returned back, he put his clock next to the clock that was on earth, his clock will show that 12 years and the other clock will show that 15 years has passed? Do you mean that both are going to say that the astronaut has aged 12?

Teacher 9: Yes

Researcher: In this sense it is true. We are going to discuss further but first let’s give a break.

Several teachers wanted to continue and finis the discussion.

Teacher 10: May I ask a question?

Researcher: In order not to conduct these complex calculations, it is better to introduce a simple way to make these calculations.

Teacher 9: Actually it is not to complex. All is to calculate the $\sqrt{1-\frac{v^2}{c^2}}$ isn’t it?

Researcher: Yes, I mean that

Teacher 9: After several questions I will come to this point.

Researcher: Okey, teacher 10 was going to ask a question.

Teacher 10: I want to ask a similar question. It is in the book. There is a lamp in the room. There is an observer in the room. There is another observer out of the room moving in a space ship. Time span of the lamp giving light is 100 seconds. The observer in the room sees 100 seconds. In these cases what will be seen by the observer in the spaceship?

Teacher 4: You mean does he/she see the more or see the less.

Teacher 9: He will measure a less time, accordingly he will measure a time span less than 100 seconds. In other words the stationary observer will measure 100 second isn’t it? The clock of the one who is moving will run slower, accordingly will calculate a time span less than 100 seconds.

Teacher 7: There is one more point. We cannot detect which is mobile

Teacher 8: Right. Already we cannot determine which one is mobile.

Teacher 9: Now, there are two objects apart, two objects in space, if there are noting around we cannot detect which one is mobile. But now, not only earth there are also, sun, moon and other planets… but one of them is moving… discussion which one is mobile is meaningless, because, when you look at all objects in the space that one is moving. The earth is stationary, moon, sun and all other things in space are stationary but the object is moving. This is related to the explanation that we are going to make after the twin paradox. In other words, it is not possible to determine which object is mobile.

Researcher: Let's give the answer of the question of our friend and have a break. Could you repeat the question please?

Teacher 10: A lamp is shining in the room. The time span of the lamp shining is 100 seconds. An outside observer in the spaceship measures this time. How many second does he/she measure? Let's he/she is moving with 0.6c.

Teacher 9: The time measured by the observer in the stationary frame of reference is 100 seconds.

Researcher: Let's define it as 't_o'.

Teacher 9: This is the time measured by the observer who is stationary with respect to the event. This event is not a turn on and turns off a lamp. The event here is the time measurement of the moving observer.

Teacher 10: Now, do you mean that the stationary observer measure 100 seconds?

Teacher 9: The stationary observer measures 100 seconds. How much does the moving observer measure if his speed is 0.6c?

Teacher 10: But, when you started the topic you defined the 't_o' as the time measured in the reference frame where the event occur.

Teacher 9: The event here is the duration that the astronaut or the moving observer measure.

Researcher: The event is measured by the astronaut; the astronaut assumes himself as stationary and sees that the earth is moving backward.

Teacher 9: Namely this is the t_o

Researcher: Because, the one that measures the event assumes himself stationary, he/she assumes as if he/she is on earth. He/she sees that lamp as if it is receding. Although yet it recede from earth, according to him at the same time the earth recede. Thus, according to astronaut he is stationary and the earth moves back. Solving this question accompanied with the following question will be better. There is a person on earth and he/she has a pendulum, there is one also in the spaceship moving with 0.6c. Let's say they are spring-mass systems because pendulums may work differently in different places. Now, there are two identical spring-mass systems here and there. How do they measure each other's periods? If such a question is asked… or how much will they measure the period? Both will measure the period as same. Because both will see the spring-mass systems near themselves. Correct? But will they measure each other's period the more or the less?

Teacher 8: They will measure 'more'.

Teacher 6: Well then, don't we say that the time passes slower in the systems moving with speed of light? Why the spring-mass systems oscillate same in both cases?

Researcher: According to whom?

Teacher 6: The question is not according to whom… If I am moving with speed of light and if the entire things move slower or everything functions slower (all chemical or physical events), why then the spring-mass systems oscillate with same periods?

Teacher 9: Physics laws are same in all inertial reference systems. The period of spring-mas system is calculated with this formula: $T = 2\pi\sqrt{\frac{m}{k}}$. If it moves with speed of light or with a speed close to the speed of light, he/she will measure the period of the spring-mass system, in his/her reference system, like this. But since it measures the time differently, he/she will see the other one differently.

Then a ten minute break took place. During the break the lecturer of the week looked at the Turkish version of the Serway for the definition of γ. It was seen that γ was defined as $\sqrt{1-\frac{v^2}{c^2}}$*! Then when it was compared with the original Serway it was understood that there was a translational error! After the break, discussions took place on the following question:*

Teacher 9: Here we have two spaceships. In each there are photons. The photons are moving up and down. One of the spaceships is going to move with a high speed. We are going to look at the motion of the photons in spaceships. We are going to arrange the speed of the above one to 0.4c.

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CURRICULUM VITAE

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EDUCATION

Degree	**Institution**	**Year of Graduation**
Ph.D.	METU, Physics Education	2014
MS	GAZİ University, Physics Education	2009
BS	Boğaziçi University, Physics Education	1994
High School	Anatolia Navigational Vocational School, İstanbul	1989
Middle	Arpaçay Regional Boarding School, Kars, & Cumhuriyet Middle School, Erzincan	1985
Elementary School	Arpaçay Regional Boarding School, Kars	1982

WORK EXPERIENCE

Year	**Place**	**Enrollment**
1994-2001	Kazak Turkish Schools, Jhezkazgan & Almaty, Kazakhstan	Physics Teacher
2001-2006	Yelkenoğlu Collage, Kayseri	Physics Teacher
2006-2008	Samanyolu Collage, Ankara	Physics Teacher
2007-2009	Ulugbek International School, Tashkent, Uzbekistan	Physics Teacher
2009-2012	Samanyolu Cemal Şaşmaz School, Ankara	Physics Teacher
2012-2013	Ahmet Ulusay School, Ankara	Physics Teacher
2013-Present	Canik Başarı University, Samsun	Project Office Coordinator

FOREIGN LANGUAGES

English, Kazakh, Russian

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HOBBIES

Football, basketball, table tennis, travelling, gardening