Trakya Eğitim Dergisi
Cilt 9, Sayı 2
Mayıs 2019, 222-243

ISSN: 2630-6301

Trakya Journal of Education
Volume 9, Issue 2
May 2019, 222-243

Geliş Tarihi: 17.08.2018
Doi: 10.24315/tred.454360
Yayına Kabul Tarihi: 25.05.2019

Araştırma Makalesi

Investigation of Science Teachers' Technological Pedagogical Content Knowledge According to Activity Theory[1]

Fen Bilimleri Öğretmenlerinin Teknolojik Pedagojik Alan Bilgilerinin Etkinlik Kuramına Göre İncelenmesi

Tuna GENCOSMAN[2], Mustafa AYDOĞDU[3], Mustafa DOĞRU[4]

Öz: Bu araştırmanın temel amacı; Etkinlik Kuramı çerçevesinde devlet okullarında görev yapmakta olan fen bilimleri öğretmenlerinin sahip oldukları Teknolojik Pedagojik Alan Bilgilerini (TPAB)'nin içinde bulundukları bağlamla/ortamla ele alınarak, bireysel öğretim süreçlerinde ne ölçüde etkin olduğunu belirlemektir. Bu amaçla araştırmada, nitel araştırma desenlerinden durum çalışması kullanılmıştır. Çalışma, amaçlı örnekleme tekniği kullanılarak seçilen sekiz fen bilimleri öğretmeni ile yürütülmüştür. Veriler, araştırma problemleri dikkate alınarak gözlem, görüşme ve doküman incelemesi yöntemleri birlikte kullanılarak toplanmıştır. Elde edilen nitel verilerin analizi için sürekli karşılaştırmalı metot kullanılmıştır. Araştırmanın bulgularından elde edilen sonuçlara göre; öğretmenlerin, teknoloji ile öğretim uygulamalarını farklı konu alanlarına göre, farklı düzeylerde performans gösterdikleri tespit edilmiştir. Bununla birlikte öğretmenlerin, teknolojinin öğretim sürecinde kullanımının getirdiği katkılara bağlı olarak, öğretim uygulamalarını değiştirmek için gönüllü oldukları fakat bu süreçte bazı engellerle karşılaştıkları belirlenmiştir. Fen bilimleri öğretmenlerinin öğretim süreçleri ortamlarında, TPAB'ni kullanma düzeylerini etkileyen faktörlere ilişkin sonuçlar Etkinlik Sistemi'nin öğeleri ele alınarak ayrıntılı olarak sunulmuştur.

Anahtar sözcükler: *Teknolojinin eğitime entegrasyonu, fen öğretmenleri, teknolojik pedagojik alan bilgisi, etkinlik kuramı*

Abstract: The main aim of this research is to determine the efficiency of the Technological Pedagogical Content Knowledge (TPCK) of science teachers working in public schools. For this purpose case study which is one of the qualitative research patterns, was used. The study was conducted with eight science teachers who were selected from public schools by purposeful sampling method. For analyzing the qualitative data descriptive analysis and content analysis were used together with constant comparative method. According to the results obtained from research findings it was determined that teachers use technology and teaching applications during their individual teaching processes according to different subject fields, for different purposes and therefore demonstrate performance at various levels. The results related with factors effecting TPCK usages of science teachers in teaching process environments were presented in detail by handling elements of activity system created depending on activity theory.

Keywords: *Integration of technology in education, science teachers, technological pedagogical content knowledge, activity theory*

UZUN ÖZ

Giriş

Bilimsel ve teknolojik gelişmelerin temel dayanağı olduğu bilinen fen bilimleri alanında öğretmenlerden, öğrencileri bilim ve teknoloji okuryazarı bireyler olarak yetiştirmeleri beklenmektedir. Dolayısıyla fen bilimleri öğretmenlerinin sahip oldukları teknolojik bilgilerini, pedagojik ve alan bilgileri ile birleştirerek, sınıf içi uygulamalarda etkili ve verimli bir şekilde kullanmaları gerekmektedir (Niess, 2005; Mishra ve Koehler, 2006; Angeli ve Valanides, 2009). Öğretmenlerin sahip olması gereken bilgi türlerine teknolojik bilgi entegre edilerek, bu bilgi türü "Teknolojik Pedagojik Alan Bilgisi (TPAB)" olarak adlandırılmıştır (Koehler ve Mishra, 2005). Bu bağlamda fen eğitiminde teknoloji entegrasyonu, öğretim programının kazanımları doğrultusunda, öğrenci merkezli ve etkili bir şekilde kullanıldığı takdirde öğrencilerin konu içeriğini daha derinlemesine anlamalarını sağlamaktadır (McCrory, 2006).

---

[1] Bu makalenin yapılandırıldığı tez, Gazi Üniversitesi Eğitim Bilimleri Enstitüsü tarafından doktora tezi olarak onaylanmıştır.

[2] Dr., Özel Antalya Koleji, tunagencosman@gmail.com, *ORCID: 0000-0003-1556-301X*
[3] Prof. Dr., Gazi Üniversitesi, musayd@gazi.edu.tr, *ORCID: 0000-0003-1475-5925*
[4] Doç. Dr., Akdeniz Üniversitesi, mustafadogru@akdeniz.edu.tr, *ORCID: 0000-0003-0405-4789*

Teknolojinin öğrenme-öğretme sürecine entegrasyonu; öğretmenler, öğrenciler, okul yönetimi, eğitim programları ve okul kültürü gibi birçok dinamiği içinde barındıran karmaşık ve çok boyutlu bir süreç olduğundan, bu sürecin etkililiği açısından uygulamaların içinde bulunduğu sosyo-kültürel bağlamla birlikte ele alınmasının önemli olduğu dile getirilmektedir (Yamagata-Lynch, 2003). Bu noktada, öğretmenlik eğitiminin gerçekleştirildiği yapıda tüm unsurların dikkate alınarak yapılmasının daha uygun olacağını öngören "Etkinlik Kuramı" yaklaşımı alternatif bir model olarak önerilmektedir (Demiraslan ve Koçak-Usluel, 2006). Kuramın en önemli göstergesi; teknolojinin öğrenme ve öğretme sürecinde rol alan tüm bireyler ve özellikleri, rolleri, amaçları ile kullanılan araçların etkileşim içinde olması, dolayısıyla öğrenme ve öğretime olumlu bir şekilde yansımasıdır (Jonassen ve Murphy, 1999). Etkinlik kuramındaki temel vurgu ise; karmaşık bir etkinliğin gerçekleşmesindeki süreçte yer alan öğeler arasındaki etkileşimdir (Yamagata-Lynch, 2003). Etkinlik kuramındaki sistemin temel ögeleri; özne, nesne, araçlar, topluluk, kurallar, iş bölümü ve çıktılardan oluşmaktadır (Engeström, 2001). Bu noktada Etkinlik Kuramı çerçevesinde devlet okullarında görev yapmakta olan fen bilimleri öğretmenlerinin sahip oldukları TPAB'nin içinde bulundukları bağlam/ortamla ele alınarak, bireysel öğretim süreçlerinde ne ölçüde etkin olduğunu belirlemek, bu çalışmanın temel amacını oluşturmaktadır.

Yöntem

Çalışmada, nitel araştırma desenlerinden durum çalışması (örnek olay incelemesi) kullanılmıştır. Aynı zamanda, olasılık temelli olmayan amaçlı örnekleme tekniğinden yararlanılarak belirlenen ve uygulama sürecine katkı sağlamada gönüllü olan 8 fen bilimleri öğretmeni ile yürütülmüştür. Teknolojinin eğitime entegrasyonu bağlamında; fen bilimleri öğretmenlerinin bireysel öğretim süreçlerinde TPAB'ni kullanma düzeyleri, Canbazoğlu Bilici (2012) tarafından Magnusson vd. (1999) PAB modeline "teknoloji bilgisi" entegre edilerek oluşturulan bileşenler çerçevesinde, "TPAB Temelli Gözlem Formu" ile değerlendirilmiştir. Öğretmenlerinin sahip oldukları TPAB'nin içinde bulundukları sosyo-kültürel bağlamla ele alınarak, ne ölçüde etkin olduğunu belirlenmesi amacıyla yarı yapılandırılmış görüşmeler gerçekleştirilmiştir. Görüşme formunun geliştirilmesinde Etkinlik Kuramından yararlanılmış ve etkinlik sisteminin temel elemanlarından "Özne, Nesne, Araçlar, Kurallar, İş Bölümü, Çıktı", konu başlıkları olarak alınıp sorular bu başlıklar altında hazırlanmıştır. Aynı zamanda öğretmenler tarafından hazırlanan materyaller, gözlem formu ve görüşme kayıtları doküman olarak kullanılmıştır.

Araştırmada verilerin analizi için betimsel analiz ve içerik analizi yöntemi, sürekli karşılaştırmalı metot ile birlikte kullanılmıştır (Strauss ve Corbin, 1990). Öğretmenlerle yapılan görüşmeler, ders gözlem ve video kayıtları, ayrıca toplanan dokümanlara yönelik oluşturulan araştırma metinlerindeki hangi bilgilerin göz önünde bulundurulduğu araştırma sorularına dayandırılarak tespit edilmiştir. Buna göre, geçerli kodlar belirlenmiş ve kodlar arası ilişkileri ortaya koymada etkinlik sistemlerinin öğeleri (özne, temele alınmıştır. Her bir öğe altındaki kodlar ve bu kodlar arası ilişkilerin Etkinlik Kuramı bağlamında irdelenmesiyle temalar oluşturulmuştur.

Sonuç ve Tartışma

Araştırmanın bulgularından elde edilen sonuçlara göre, öğretmenlerin bireysel öğretim süreçlerinde, çoğunlukla derslerini bilimsel olguların öğrencilere aktarımı şeklinde işledikleri tespit edilmiştir. Ancak, TPAB'ın bu bileşenine ilişkin gösterdikleri performans düzeyleri, konu alanlarına göre farklılık göstermiştir. Öğretmenler genellikle işledikleri konunun öğretim programındaki kapsamı ve programdaki sarmal yapısını tamamen dikkate almalarına rağmen sınırlı sayıda materyal kullandıkları gözlenmiştir. Bunun yanı sıra, teknolojinin entegre edildiği öğretim programı ve materyal bilgilerinin, konu alanına göre değişkenlik gösterdiği tespit edilmiştir. Çoğunlukla öğrencilerin ön bilgileri, kavram yanılgıları ve öğrenmekte zorlanabilecekleri kavramlar tamamen dikkate alınmış, ancak öğrencilerin öğrenmekte zorlanabilecekleri kavramların üstesinden gelmek için sınırlı sayıda uygulama yapıldığı tespit edilmiştir. Genellikle konunun kapsamına tamamen uygun olarak öğrenci öğrenmesini kolaylaştıracak çoklu sunum veya etkinlikler kullanıldıkları tespit edilmiş ve bu durum konu alanlarına göre farklılık göstermemiştir. Öğretmenlerin ölçme ve değerlendirme tekniklerini kazanımlara uygun olarak kullanabilme ve öğrencilerin düşünme becerilerini ölçen sorular sorabilme bilgilerinin istenilen düzeyde olmadığı tespit edilmiştir. Konu alanına göre incelendiğinde ise; bu durumun değişkenlik gösterdiği görülmüştür. Bu çalışmada ayrıca teknolojinin eğitime entegrasyonu bağlamında; fen bilimleri öğretmenlerinin bireysel öğretim süreçlerinde, TPAB'ni kullanma düzeylerini etkileyen faktörlere ilişkin sonuçlar Etkinlik Sistemi'nin öğeleri ele alınarak ayrıntılı olarak sunulmuştur.

Genel olarak, teknolojinin eğitimde kullanımı ile ilgili düzenlemeler öğrenme, mesleki gelişim sağlama ve iletişim biçimini değiştirmektedir. Gerek teorik gerekse uygulama alanındaki çalışmalar, teknoloji entegrasyonunun hem öğretmen hem de sistemi yönetenler için oldukça zor bir iş olduğunu göstermektedir. Özellikle öğretmenlerin sınıf uygulamalarında teknolojinin kullanımı konusunda ve sınıf ortamının düzenlenmesi konusunda istekli görülseler de, teknolojinin eğitime entegrasyonu yavaş ve uğraştırıcı bir süreçtir. Bu alanda ortaya konulan teorik çalışmalar ve uygulama modelleri dikkate alınmalıdır. Bu sayede entegrasyon sürecinde insan kaynakları ve maddi kaynaklar uygun bir biçimde yürütülürse önemli yollar alınabilecektir.

INTRODUCTION

Today it is a requirement for people to follow up scientific and technological developments in their fields. One of the most important of these fields is education and training. This is due to the fact that information and communication technologies are a necessity in education and training, since it helps to create a quality educational approach.

International Society for Technology in Education (ISTE, 2008), is important for society as relating to the usage of technology in education, states that teachers should use their knowledge about the content, technology, education and training applications, in order to facilitate experiences that help the students to learn things permanently in face-to-face and virtual environments and for them to develop their creativity and innovative features. In this respect, technological knowledge is integrated into the knowledge which the teachers already have and the out coming knowledge is named "Technological Pedagogical Content Knowledge (TPCK)" (Koehler and Mishra, 2005).

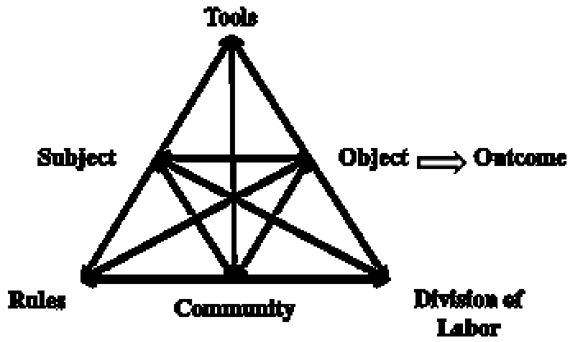
TPCK, is a teaching knowledge model developed by Mishra and Kohler (2006), which was derived by integrating technology into the Pedagogical Content Knowledge system developed by Shullman (1986,1987). In TPCK, the relationship and interactions between content knowledge, pedagogical knowledge, and technological knowledge are discussed as being three main concepts that are of equal importance which the teachers should have. According to this model, technology covers traditional tools (chalk, board, book, laboratory materials, teaching materials, models etc) and the advanced tools (internet, digital video, smart board, and software), Pedagogy covers education and training methods, strategies, and processes, while field covers the subject to be learned (Koehler and Mishra, 2005). Accordingly, TPCK defines in which area topics the technology should be used by teachers, which pedagogic techniques should be implemented to teach a subject, and how technology should be used to remove the obstacles as relating to the learning process of the students and to establish the prior knowledge that the students have (Mishra and Koehler, 2006).

In the field of sciences which is the beginning for all the scientific and technological developments, there is an expectation on teachers to raise students who are scientifically and technologically literate. In this regard, if technology integration in science education is used effectively as focusing on students in line with the gains from the education program, it can enable the students to understand the subject content in depth (McCrory, 2006).

Integrating technology into education and training process in return for the information provided is a complex and multi-dimensional process that has many dynamics such as teachers, students, school management, education programs, and school culture (Yamagata-Lynch, 2003). At this point, "Activity Theory" approach is the most appropriate in order for all particulars to be considered in the structure where teaching education is occurring (Engeström, 2001).

Basic emphasis of the Activity Theory is the interaction that occurs between the factors being part of the process that will help with the realization of a complex activity (Jonassen and Murphy, 1999; Yamagata-Lynch, 2003). The Basic elements of Activity Theory are subject, object, tools, rules, community, division of labor, and outcomes. In the system, "Subject" is the person or group, whose point of view is taken into consideration during the analysis of the activity. "Object", is the situation or problem area causing the subject to take part in the activity, as defining a requirement or an emotion and the reason for evoking the activity. "Tools", are concrete and abstract tools used in the the subject so as to obtain the results for the activity. "Rules", are formal and informal rules that control the actions and interactions of the activity. "Community", is the social group of which the subject is a member of, during the activity. "Division of Labor", defines how authority, statutes and work will be arranged among the members of community. "Outcomes", are the end products of the activity (Engeström, 2001). The structure of Activity System is shown in Figure 1 as schematically.

Figure 1. Structure of an activity system (Engeström, 1987)



At this point, it can be asserted that in regards to science teachers' using TPCK in the classroom, and being investigated in different processes and environments, therefore, Activity Theory can provide important opportunities for obtaining rich data sets. Therefore, teachers' making use of Activity Theory for investigating the current situation, specifying the conditions, defining the contradictions and creating solution proposals in order to examine TPCK multi-dimensionally, is an important concept for this study. Within the framework of Activity Theory, and examine the TPCK usage by science teachers working at the state schools in regards to the environment they are in, and finally defining the level of effectiveness of the individual learning processes is the main purpose of this study. For this purpose, questions for this research are below:

1. With respect to the integration of technology in education, what is the level of usage of Technological Pedagogical Content Knowledge by science teachers in the individual teaching processes?

2. With respect to the integration of technology in education, what are the factors that have an impact on level of usage of Technological Pedagogical Content Knowledge by science teachers within individual activity system (subject, object, tools, rules, division of labor, society, outcomes)?

METHOD

In this study, qualitative investigation was carried out for the purpose of evaluating the TPCK level of science teachers, with regards to the social-cultural respect within the framework of Activity Theory.

In defining the work group, use of purposeful sampling technique was used but not based on probabilities. Accordingly, a criterion for making choices was used to form the work group (Merriam, 2013). In regards to how the schools were chosen for the research, it was based on research that was carried out, firstly schools that have mass communication tools which can be used for educational purposes and can be placed next to books and white board, were considered. Science teachers in 15 schools being situated in city center were reached out to and as per Science Curriculum being revised in January, 2013, implementation of "Survey of Technological Pedagogical and Content Knowledge (TPACK)" (Şahin, 2011) was made for 30 science teachers who at that time were teaching 6^{th} grade students. The data obtained from the scale was ranked from the highest to the lowest and 10 science teachers who had the highest scores in regards to TPACK levels were determined to be the teacher that would be used in the research. The 10 science teachers that were chosen were than interviewed again and the research was carried out with 8 science teachers, who volunteered to be part of the working and implementation process.

2.1. Collection of Data

In the research, the process for collecting data was started in the second semester of the 2013-2014 school years. Interviews, observations, and collection of documents were planned out together with the researchers and the teachers in order not to disturb the everyday teaching process. Implementation process of the research is presented in Table 1.

Table 1. Implementation period of the research

Implementation	Measurement Tool
1. Structing of observations Living Things and Life (Systems in our body) 2. Realising the observations Substance and Change (Substance and Heat) 3. Realising the observations Physical events (Light and S ound) 4. Realising the observations Earth and Universe (What is the earth's crust composed of?)	TPAB Based Observation Form
Making the interviews	Interview Form

In the research, participant observation method was used (Böke, 2009), thus enabling the researcher to observe the subject being investigated directly. The direct observations were evaluated using the "TPCK Based Observation Form", created by Canbazoglu Bilici (2012) where validity and reliability studies were also conducted. The form was designed as a quartet performance level scoring key that used analytics and contained8 articles, TPCK components are;

1. Knowledge of science for the purpose of technology and education,
2. Knowledge of Science Curriculum and how technology is integrated,
3. Knowledge of using Technological Tools-Devices, enabling students to learn a specific science topic by understanding,
4. Knowledge of Education, Strategy, Methods and Technics supported by technology, to teach a specific science topic.
5. Knowledge of Measurement and Evaluation Technics that are supported by technology and are being used to assess understanding of a specific science topic by the students.

In this study, observation was made in the second semester of school's period, covering at least two lessons from each unit as relating to "Living Things and Life", "Matter and Change", "Physical Events", "Earth and Universe", and part of learning domain of science lesson of "knowledge" in 6th classroom. During the observation, in accordance with the criteria specified on the observation form, performance levels of teachers (PL) were ranked by the researcher. According to this, the highest score which a teacher can have as relating to the 8 articles is 32. During the observations methods such as observation form, video recordings, and note taking were used in unison.

By having the research consider the TPCK that each science teacher has, with respect to the social-cultural aspect and for defining the level of effectiveness, semi-structured interviews were also held. In order to develop the interview questionnaire Activity Theory was used and basic elements of activity system, namely "Subject, Object, Tools, Rules, Division of Labor, and Outcome" were used as subject titles and questions were created based around these titles. After the interview form consisting of 20 articles had been prepared, opinions of two lecturers who specialize in their own fields were taken and interviews were conducted with two science teachers who part of the research in order were not to make sure the questions were well devised. The interviews were recorded via audio tape and note taking.

2.2. Analysis of Data

In the research, descriptive and content analysis methods were used together with constant comparative method, for the analysis of data (Strauss and Corbin, 1990).

Observational data from the research was resolved by quantifying the qualitative data, in other words by transforming the data from written form into numbers and graph by applying specific processes to them (Yıldırım and Şimşek, 2005). Data obtained from observation form, were also used in establishing activity systems for each teacher.

Interviews held with the teachers, lesson observations, video recordings, and information in research texts that was to be considered in relation to the documents collected, were specified as being based on the research questions. Accordingly, valid codes were defined and particulars of the activity system were taken as basis for revealing relations between the codes. By examining codes under each element and the relations between these codes as regards to Activity Theory, themes were established. Afterwards steps were taken in the analysis of data collected throughout the case study, and are summarized below:

1. Specifying the valid codes by reading interview data many times,
2. Determining categories to cover more than one code,
3. Giving the final shape to the codes and categories,
4. Establishing the activity system
5. Defining the themes

While activity systems were being established, codes were defined, data analysis process was placed in activity units and they were supported with information obtained from different data sources. By revealing the contradictions between the particulars that were creating problems for the teacher and not allowing them to realize their classroom targets, different viewpoints could be provided as regards to the solutions that could be found by integrating technology into education process.

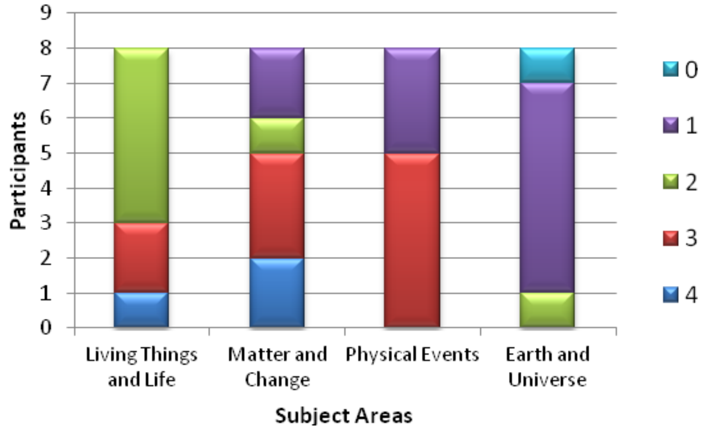
RESULTS

3.1 Findings and Interpretations as Relating with TPCK levels of Science Teachers within the Individual Education Process as Regards to the Integration of Technology into Education

Findings relating to this have been investigated separately and five components of TPCK were used. Furthermore, as per the nature of TPCK, performance levels (PL) of participants were analyzed in relation to the subject, and they were interpreted in line with their educational areas.

The findings obtained as relating to the performance levels of teachers "*Knowledge of Science relating with purpose and targets as regards to technology and education"* were investigated in line with subject areas and are summarized in Graphic 1.

Graphic 1. Examination of information of science for purpose and targets relating with technology and education that the teachers have as per subject areas

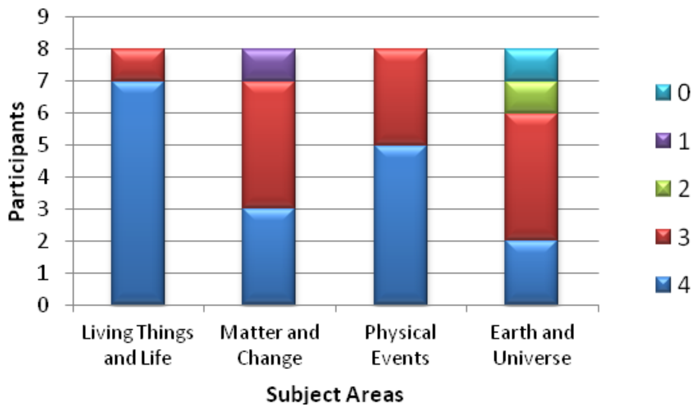


When Graphic 1 is analyzed, in relation to subject area of "Living Things and Life" it was observed that teachers mainly prefer to use activities designed to develop scientific processing skills of students (PL=2), in their individual educational period.

As relating to the subject areas "Matter and Change" and "Physical Events", teacher have mainly preferred to use activities designed for students to learn with simple tools (PL=3) within their educational process. Finally, in the subject area "Earth and Universe", it was observed that teachers mainly used their lessons to transfer scientific findings to the students (PL=1).

When it comes to the performance levels of teachers in relation with component of *"Knowledge on Science Educational Program to which Technology"* of TPCK are investigated as per subject areas, the findings obtained are summarized in Graphic 2 and Graphic 3.

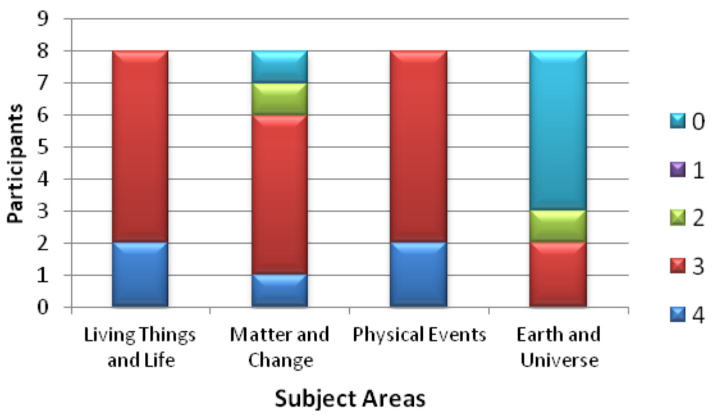
Graphic 2. Examination of educational program information of teachers as per subject areas



When Graphic 2 is analyzed, in relation to "Living Things and Life" and "Physical Events", it was observed that majority of teachers completely followed the curriculum of the program (PL=4). Accordingly, majority of teachers linked the lessons from 5th grade and expanded on those in the 6th grade lessons.

As for "Matter and Change" and "Earth and Universe", majority of students completely took into consideration only the content specified for the class where education is realized as regards to the lesson they were giving (PL=3) the students did not look to expand their knowledge outside the curriculum. Accordingly, teachers only focused on the making sure students knew and understood the content that is within the educational process.

Graphic 3. Examination of educational program materials of teachers as per subject areas

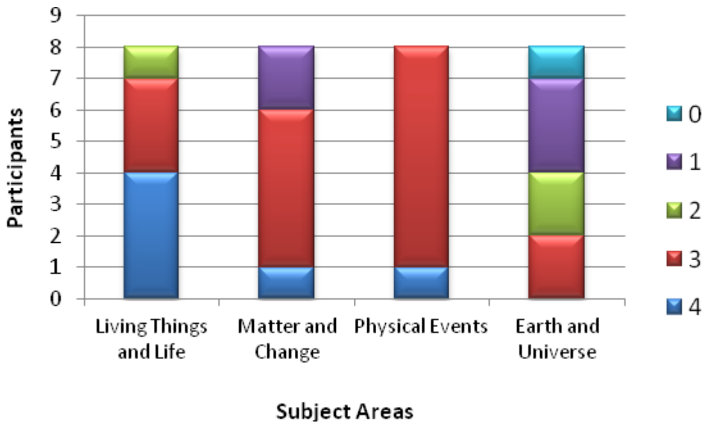


When Graphic 3 is examined, as relating with subject areas of "Living Creature sand Life", "Matter and Change", and "Physical Events", it was observed that majority of teachers used limited number of materials (PL=3), despite having wide variety of material to choose from.

A finally when it came to "Earth and Universe", it was observed that majority of teachers did not use any materials (PL=0).

Findings obtained in relation to the performance levels of teachers *"Knowledge of Using Technological Tools-Devices for the Students to understand and learn a Specific Science Topic"* as part of TPCK, and in the subject areas, are summarized in Graphic 4 and Graphic 5.

Graphic 4. Examination of information about the usage of technological tools-devices that the teachers have, as per subject areas

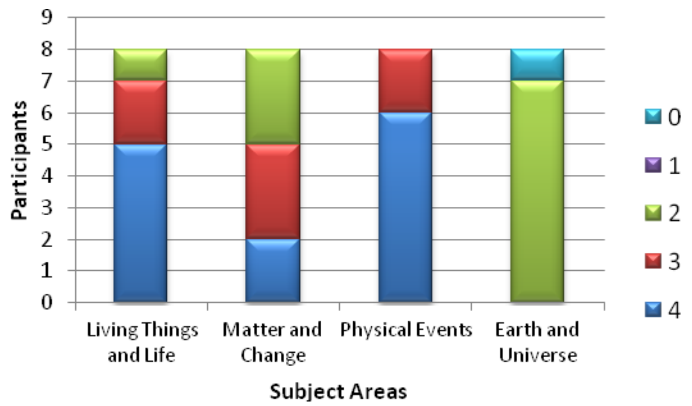


When Graphic 4 is examined, as relating with subject area of "Living Things and Life", it was observed that majority of teachers considered prior knowledge of students, conceptual mistakes, and the concepts where they can have difficulties during the lesson and had created many differentiations with their lessons in order to help students overcome any concepts they might be having difficulty with or the ones where they can have conceptual mistakes (PL=4).

Additionally, the subject areas of "Matter and Change" and "Physical Events" was where majority of teachers considered prior knowledge of students, conceptual mistakes and concepts where they can have difficulty in learning, during the lesson period but that they only had limited number of applications for the purpose of helping students to overcome any concepts where they may be having difficulty in or have conceptual mistakes in (PL=3).

Finally, as relating to the subject area of "Earth and Universe", majority of teachers do consider the conceptual mistakes and concepts where students have difficulty in learning but they haven't made any applications for them to overcome these (PL=1).

Graphic 5. Examination of information of teachers' considering learning styles of students as per subject areas

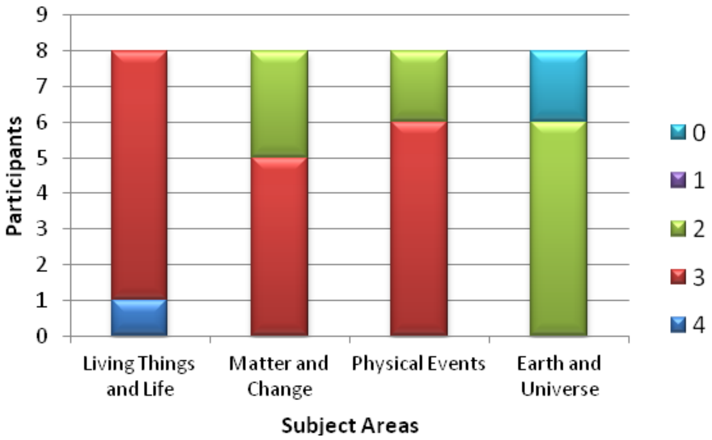


When Graphic 5 is examined, as relating with subject areas of “Living Things and Life” and “Physical Events” in a 6th grade classroom, it was observed that majority of teachers considered multi-learning platform that were being integrated (more than four), in order for students to comprehend science (PL=4). Accordingly, teachers have considered different learning types as physical, kinesthetic, social, verbal, aural, numeric, and visual.

As relating with subject areas of “Matter and Change” and “Earth and Universe”, it was seen that majority of teachers considered 2 or 3 learning styles during the lesson period (PL=2). Accordingly, teachers mainly focused on aural, visual and physical learning styles.

Performance levels of teachers as relating to *“Knowledge of Education, Strategy, Management, and Technics with technology support as being used in the training of a specific science topic”*, were examined as per subject areas and the findings are summarized in Graphic 6.

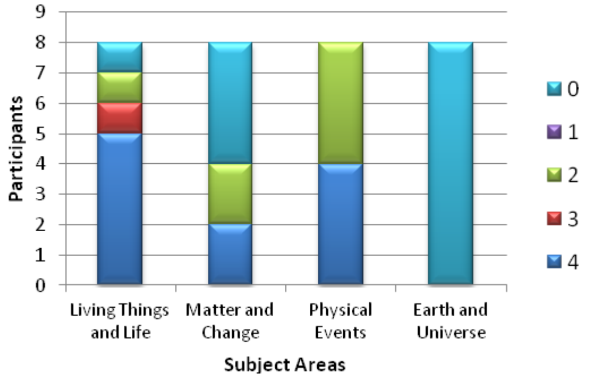
Graphic 6. Examination of information the teachers have as relating with education, strategy, method and technics with technology support, being used in the education of a specific science topic, as per subject areas



When Graphic 6 is examined, as relating to “Living Things and Life”, “Matter and Change” and “Physical Events”, it was seen that majority of teachers use multi-presentations and activities to facilitate children’s learning process and in line with the scope of subject (PL=3). For the subject area of “Earth and Universe”, teachers preferred to use presentations and activities to facilitate students’ learning process as they are in line with the subject’s scope and by using them in limited numbers (PL=2).

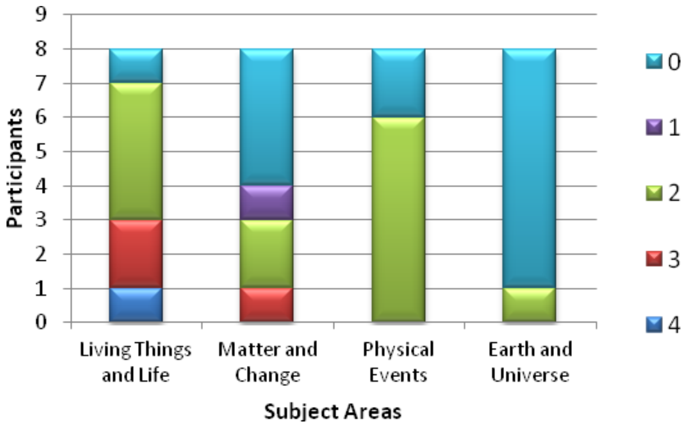
When performance levels of teachers are examined as relating to *“Measurement and Evaluation Technics with Technology Support used in the Assessment of understanding of students as regards to a specific science topic”* component of TPCK, the findings obtained are summarized in Graphic 7 and Graphic 8.

Graphic 7. Examination of information of teachers for using measurement and evaluation technics in accordance with the gains, as per subject areas



When Graphic 7 is examined, as relating to the subject area of "Living Things and Life", it was observed that majority of teachers have used all of the measurement and evaluation technics by first considering the gains (PL=4). For subject areas "Matter and Change" and "Earth and Universe", it was observed that majority of teachers considered the measurement and evaluation technics (PL=0). For subject area of "Physical Events", some of the teachers used measurement and evaluations technics in line with the gains (PL=4), while others randomly used some technics without considering the gains (PL=2).

Graphic 8. Examination of information that the teachers have as relating with their asking questions to measure thinking skills of the students, as per subject areas



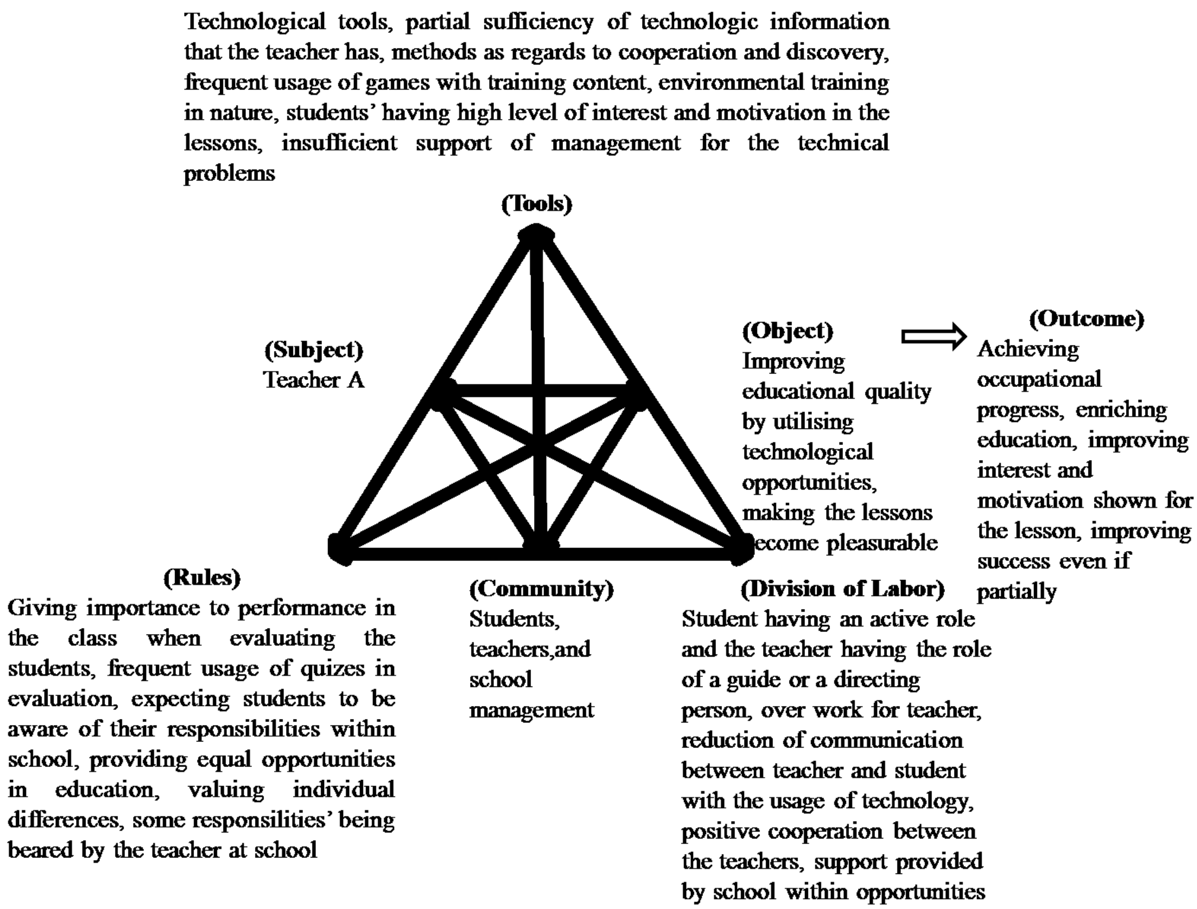
When Graphic 8 is analyzed, as relating to the subject areas "Living Things and Life" and "Physical Events", it was seen that majority of teachers had formed the measurement and evaluation questions and have quality measurements that examine the students thinking skills at one upper levels and at lower levels (PL=2). For subject areas "Matter and Change" and "Earth and Universe", it was observed that majority of teachers did not have questions that measured thinking skills of students during the educational process (PL=0). In this case, it can be stated that majority of teachers generally asked students' questions based on lower part of the thinking spectrum that includes information and conceptual thinking during the lesson. Plus, they used the evaluation questions from the study book, and this was the reason for the use of lower level thinking questions.

3.2 Findings and Interpretations as Regards to the Factors Influencing Level of Usage of Technological Pedagogic Content Knowledge by the Science Teachers as Part of the Individual Activity System and within the Scope of Integration of Technology to Education

By grouping different sources that were obtained according to their similarities and differences, findings for this part of the research question are explained within the framework of activities-based teaching. At the same time, contradictions within this system were also stated and examined separately for each teacher.

The activity system established for **Teacher A** within the frame of factors of Activity Hypothesis, are shown in Figure 2. Within this the contradictions within the system were also stated.

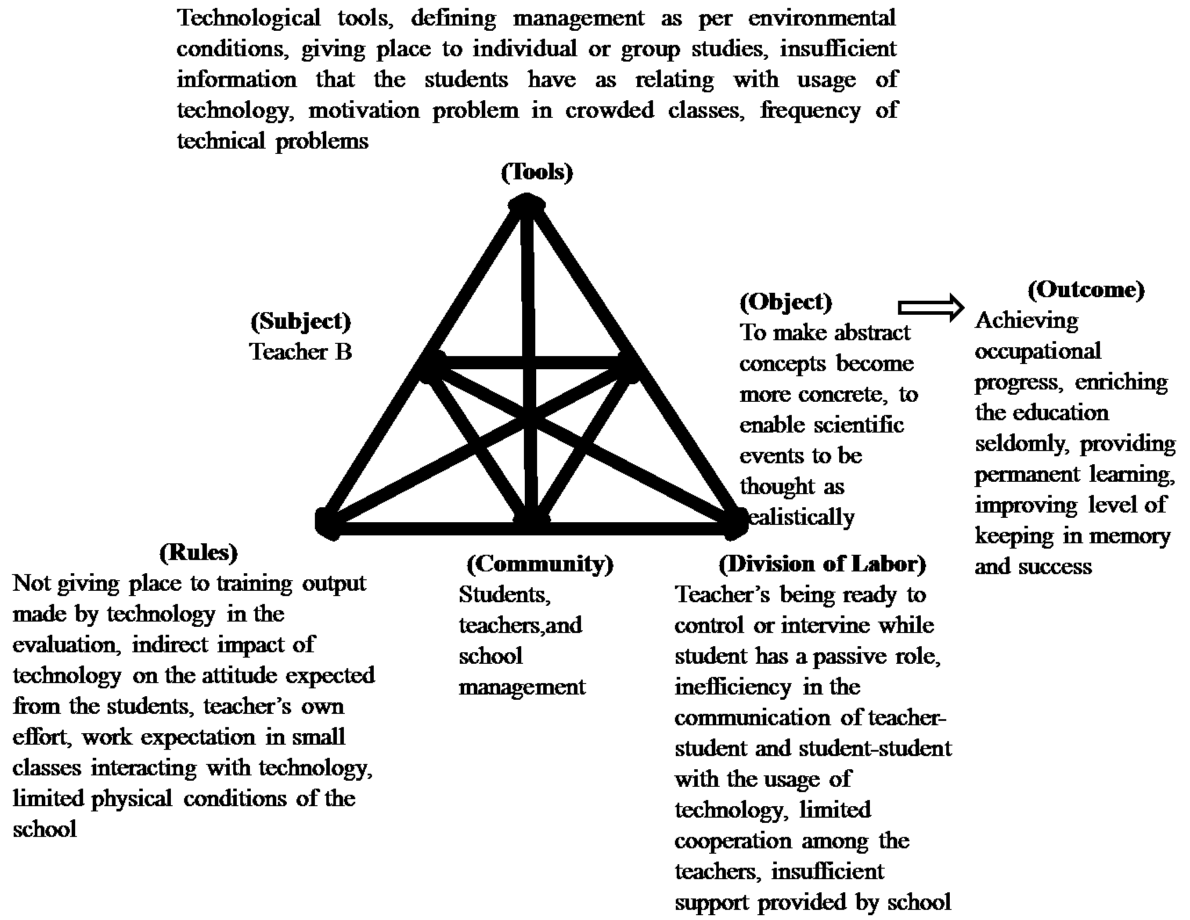
Figure 2. Activity system established for Teacher A



Most important factors effecting the mediation of teacher A for the realization of purpose within the activity system, are opportunities within school as regards to integration of technology in the education process, willingness of teacher, positive division of labor among teachers, and the interest shown by students to the lessons based around technology. As teacher A provides training to a village school, he makes use of environmental conditions in his lessons as well. Furthermore, since class attendance is low and there is only a total of three classes at a high school level, it was seen that the lesson load is not heavy. However, there was a difficulty in managing the classroom when it came to using technology and a teacher lost interaction between himself and the student once technology came into play there this can be seen as important sources of contradiction. At the same time, insufficient management of technical problems can also be shown as a contradiction.

Within the frame of factors of Activity Theory, the activity system established for **Teacher B** is shown in Figure 3. In that respect, problems faced by the teacher within the system are also stated.

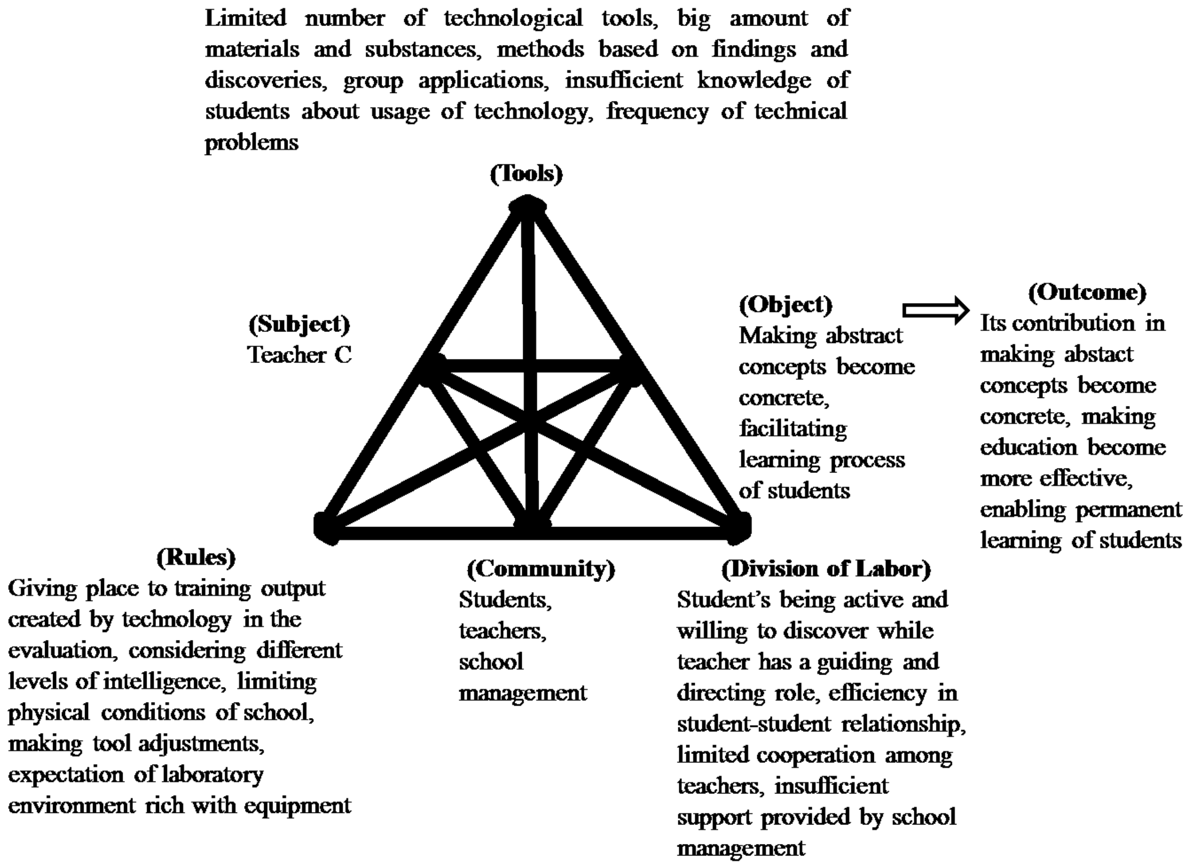
Figure 3. Activity system established for Teacher B



The most important factor in mediating the realization of purpose by teacher B in activity system is expectation of the training environments that have too much interaction in small classes regarding the integration of technology in education and his desire to improve himself in that respect. Insufficient resources provided by school management, crowded class attendances, students' not showing interest in technological tools or lessons, limited cooperation among teachers are the most striking sources of issues faced by the teacher.

Within the frame of factors of Activity Theory, activity system established for **Teacher C** is shown in Figure 4. The issues within the system are also stated.

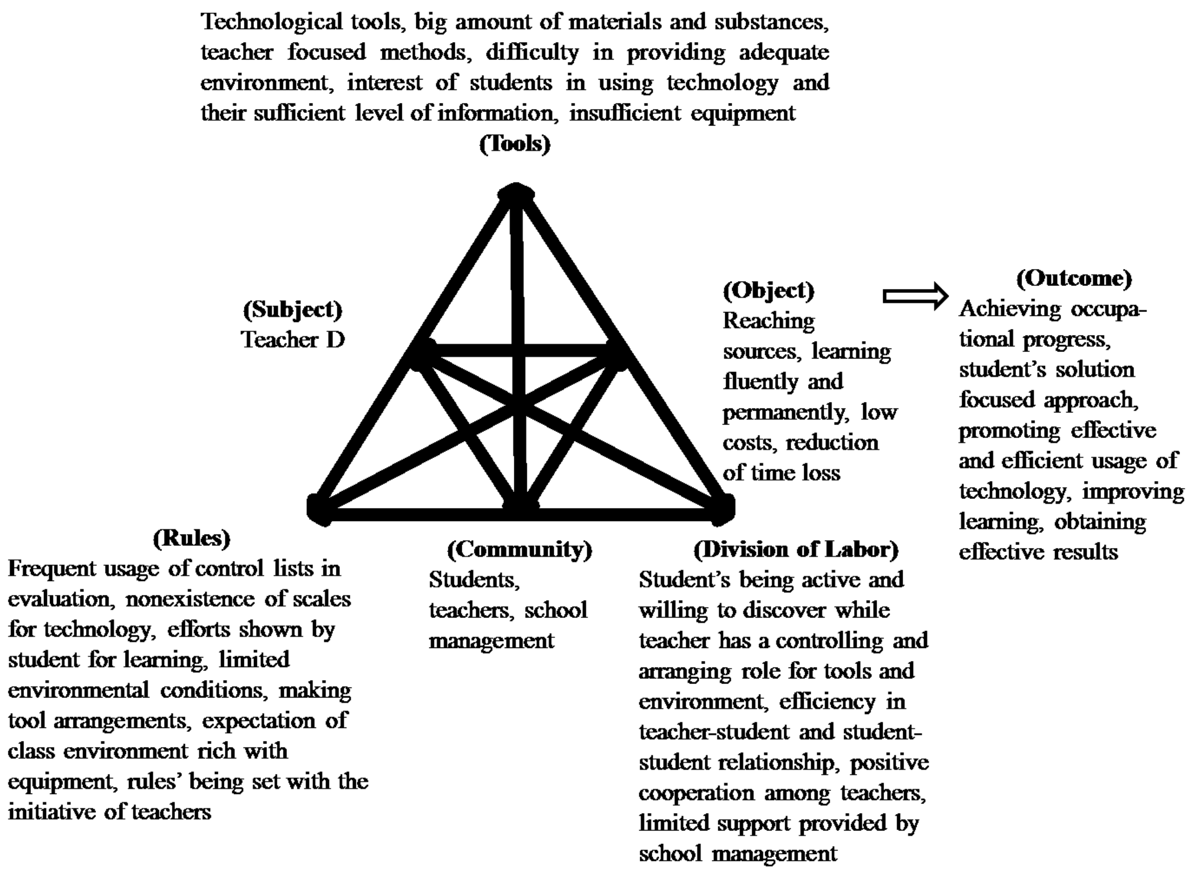
Figure 4. Activity system established for Teacher C



Most important factor having impact on mediation of teacher C in the realization of the purpose within activity system are him considering individual differences of students and different intelligence levels in regards to their learning process, him using technology as a tool in that respect, and having a high level of communication being realized among the students. Inadequate laboratory when it comes to the science lessons, limited role of class system in that respect, insufficient knowledge of students as regards to usage of technology, and lack of support by the school management are the most striking sources of issues.

Within the frame of factors of Activity Theory, the activity system established for **Teacher D** is shown in Figure 5. Problems face by the teacher within the system is also stated.

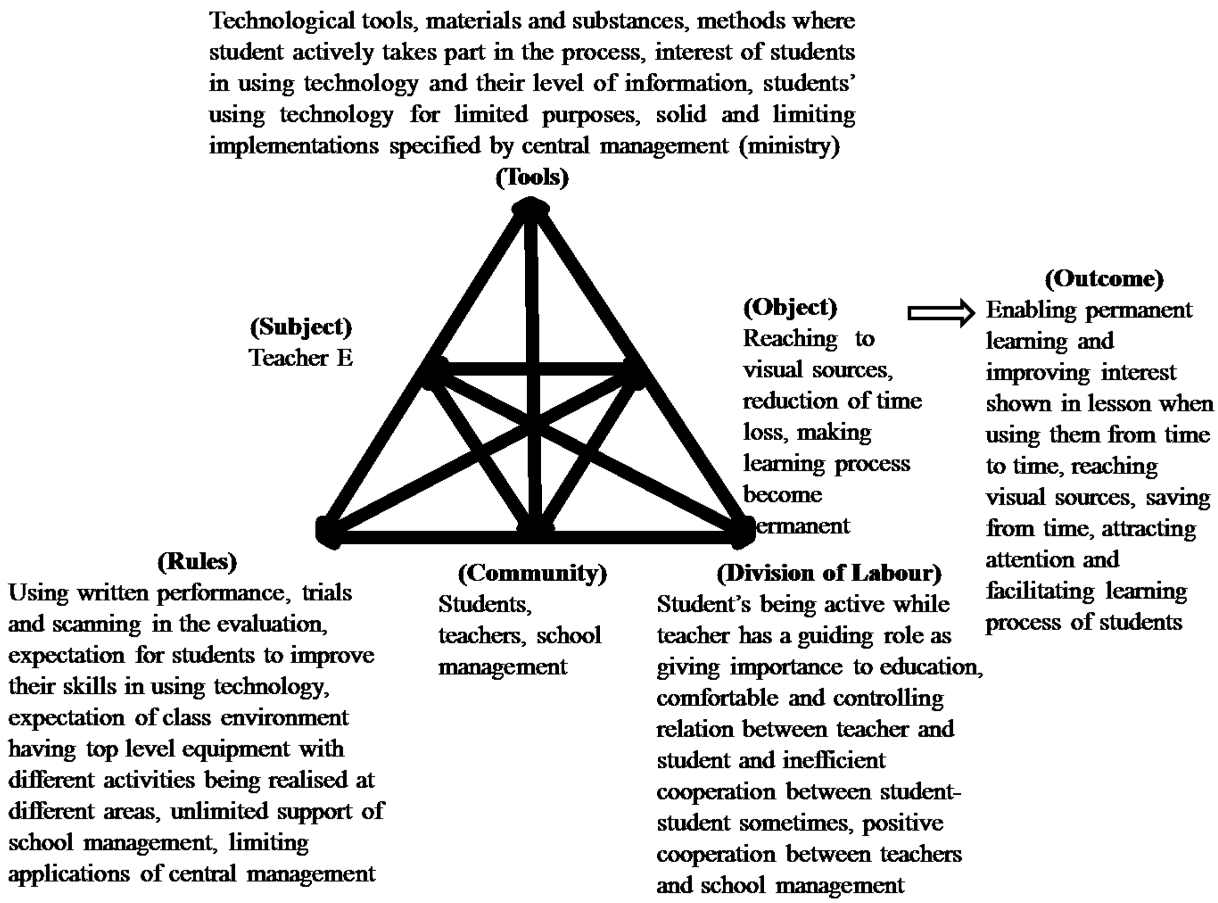
Figure 5. Activity system prepared for Teacher D



Biggest factors having impact on the mediation of teacher D in the realization of purpose within the activity system are sufficient level of knowledge that the teacher and students have as regards to the usage of technology, support of management as relating with usage of classrooms, rules' being arranged and implemented by the teachers, and efficiency of communication among teachers besides the efficient communication that exists between student-teacher and student-student. Teacher's consideration that the physical conditions and resources are insufficient, the opinion that students do not give enough effort when it comes to learning, not enough focus is given to technological implementations in the evaluation scales, and limited support by management are the most important sources of contradiction.

Within the frame of factors of Activity Theory, activity system established for **Teacher E** is shown in Figure 6. Problems face by the teacher within the system is also stated.

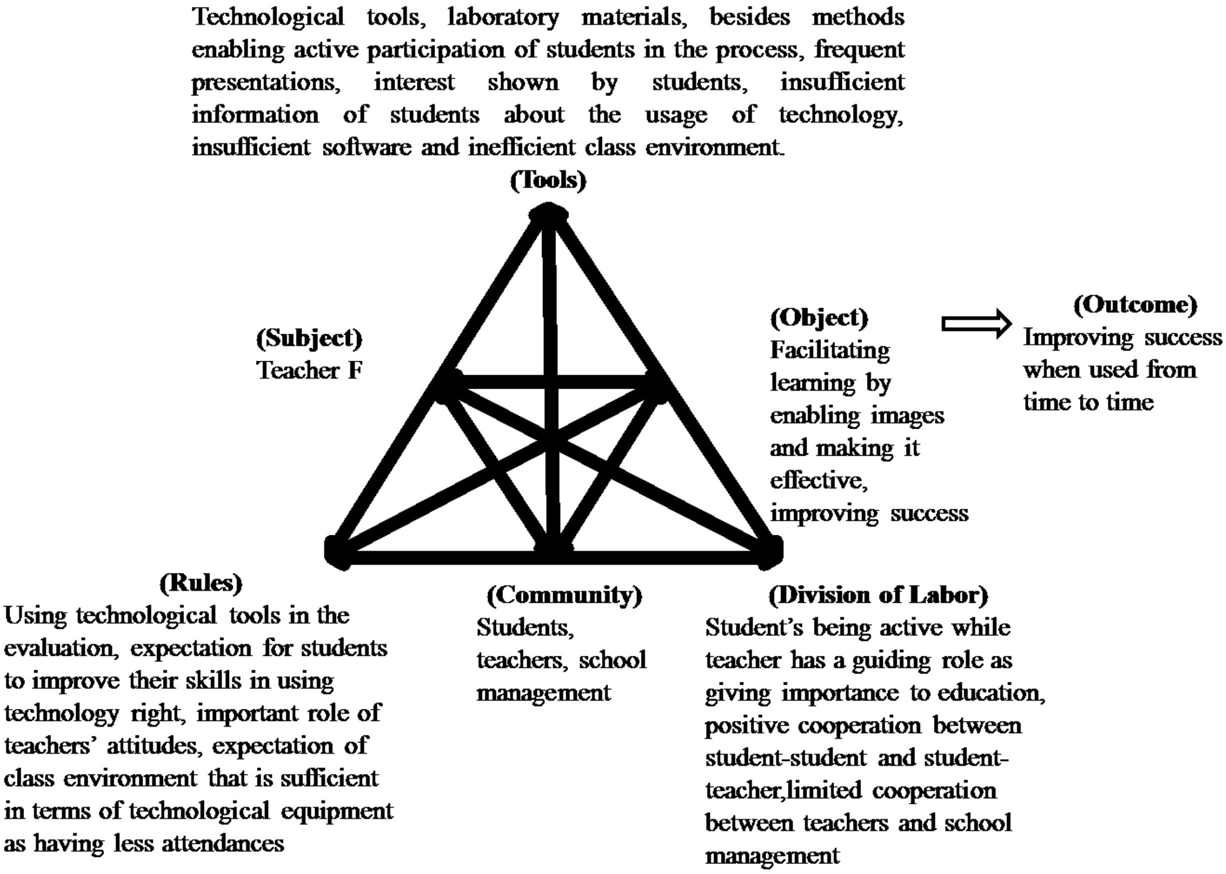
Figure 6. Activity system established for Teacher E



Most important factors having impact on the mediation of teacher E for the realization of purpose within activity system are knowledge and desire of the teacher and students to use technology, usage of different evaluation scales, positive and top-level cooperation among teachers and between teachers and students, and unlimited support provided by school management. Besides, students use technology for limited purposes, and it is not instructive, and there not being any adaption of it for a positive direction in their daily lives, weak communication among themselves, limiting and restrictive rules of central management are specified as the most important problem within the activity system.

Within the frame of factors of Activity Hypothesis, activity system established for **Teacher F** is shown in Figure 7. Problems face by the teacher within the system is also stated.

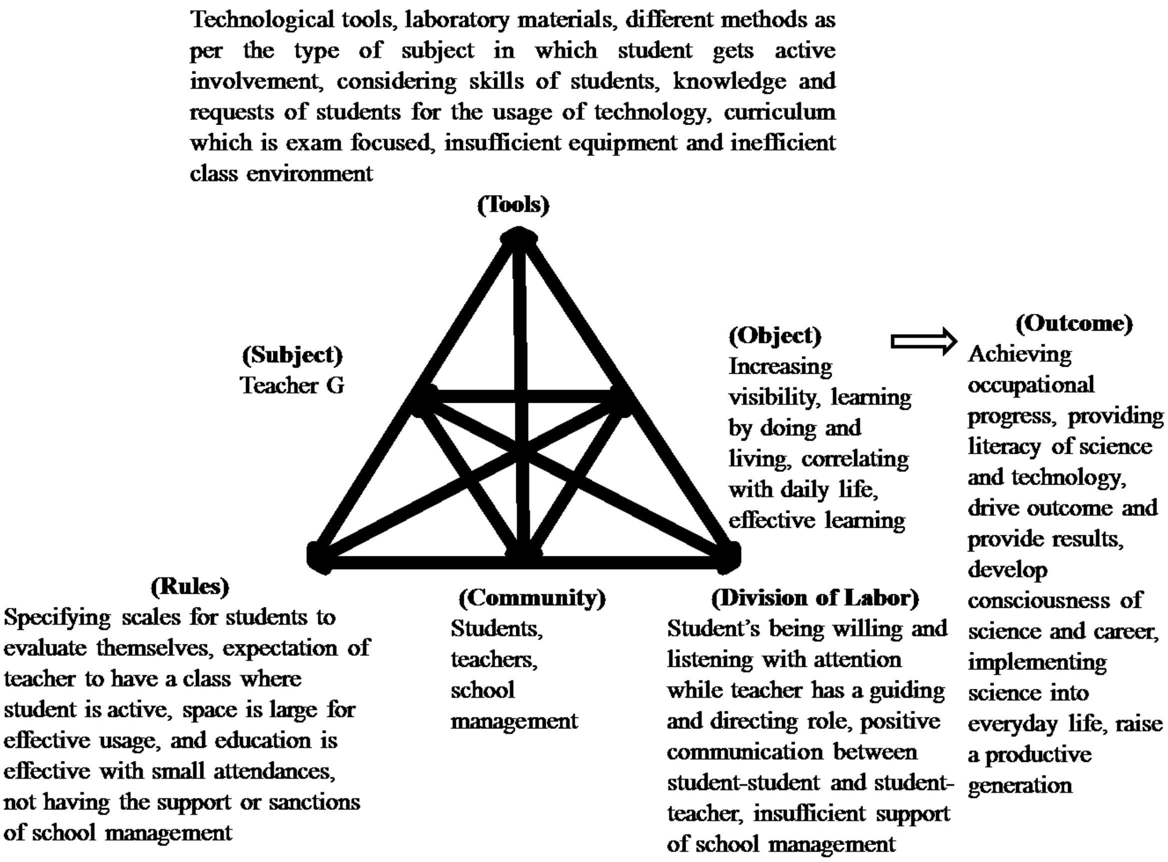
Figure 7. Activity system established for Teacher F



Most important factors having impact on the mediation of teacher F in the realization of purpose within the activity system are knowledge and desire of the teacher to use technology in his classroom, the attitude and the rules of teacher in the classroom, usage of technology in measurement and evaluation applications, positive level of communication between student-student and positive cooperation among teachers, and support of school management even if it is limited. Insufficient conditions in the classrooms, insufficient software, crowded classes, lack of knowledge that students have when it comes to using technology, problems faced when improving them, and lack of cooperation by the computer teacher who is not very supportive, are the most important factors that are not allowing for proper implementation of technology in the school.

Within the frame of factors of Activity Theory, activity system established for **Teacher G** is shown in Figure 8.

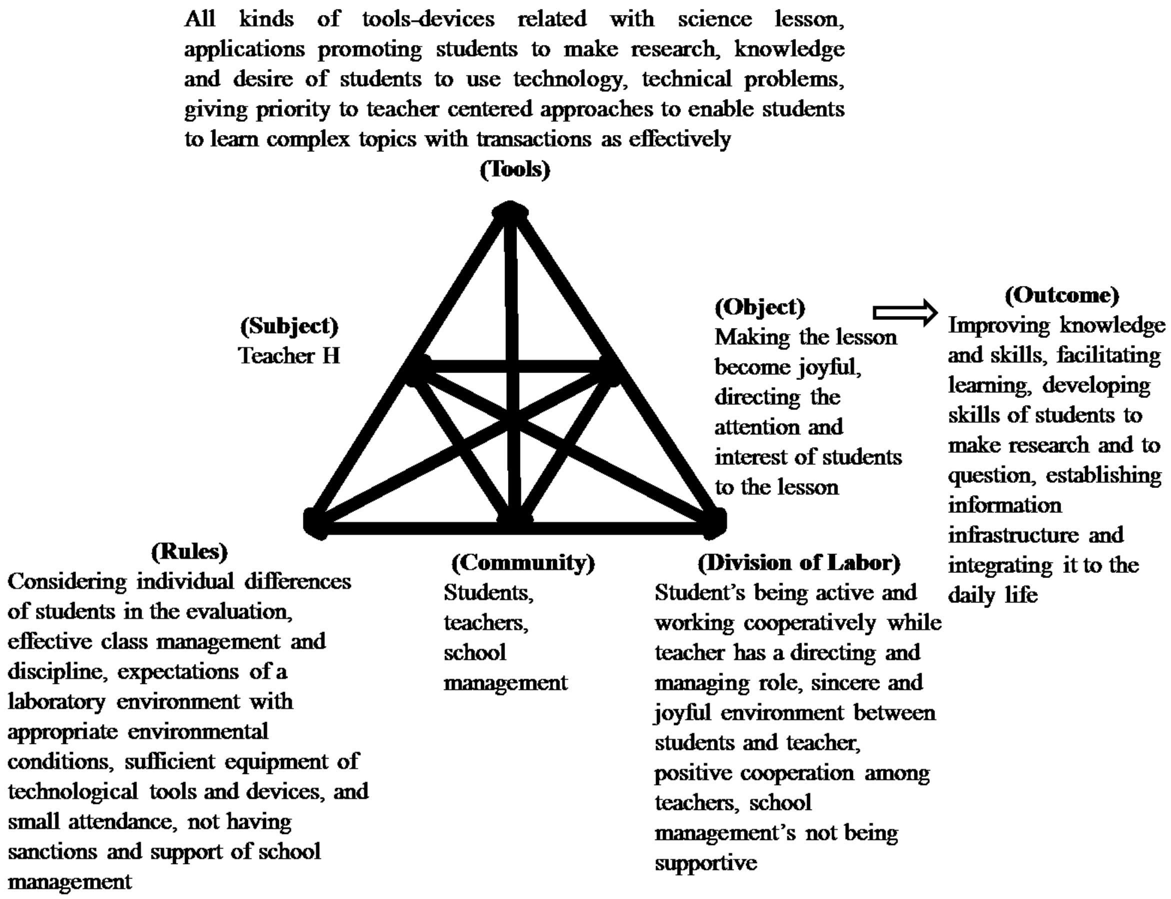
Figure 8. Activity system established for Teacher G



Most important factors having impact on the mediation of teacher G in the realization of purpose within the activity system are teacher's use of differentiation within the classroom depending on the type of subject, his focus on considering the skills and talent of student, students' showing interest in the lesson when technology is used, giving a place and time for students to evaluate themselves, interactive class environment, positive relationship between student-teacher and student-student, and cooperation among teachers.

Within the framework factors of Activity Theory, activity system established for **Teacher H** is shown in Figure 9. Problems face by the teacher within the system is also stated.

Figure 9. Activity system established for Teacher H



DISCUSSION

In this research, TPCK's of science teachers was evaluated as within the framework of components established by integrating "technology knowledge" by Canbazoğlu Bilici (2012) into PCK model of Magnusson, Krajcik and Borko (1999).

According to the results of the research, it was discovered that teachers gave their lessons mostly in the form of transferring scientific fact to the students within their own individual education process. But performance levels were different depending on the component of TPCK that was examined and the subject area that was looked at. Accordingly, it was seen that teachers preferred to use activities that are designed to develop students' scientific processing skills and to enable them to learn by using or learned through simple tools. Abell (2010) has stated that defining the component of knowledge and its purpose and that focus on science education in general view, instead of focusing on the subject, and working on thoughts regarding science education together with knowledge, belief, and values, has created limitations in science education. Similarly, the results obtained by Jang and Chen (2010) teachers taking part in the research stated that it was difficult to teach some scientific topics through traditional methods like direct instruction and they explained that some topics required the teacher to find relationship within daily life to those topics by using simulation technique or simple experimental setup while teaching these topics.

Although the teachers considered the coverage within the training program and the immersive structure of the program as relating to the topics they are teaching in their individual educational processes, they used limited number of materials. Furthermore, in educational program, where technology was integrated along with material knowledge of science teachers had a higher variation in subject area. It was emphasized that teaching experiences of the teachers provided contribution in the development of their program knowledge. It was seen that teachers who participated in elementary school classes regularly and gave lectures, were successful in regards to their program knowledge (Lankford, 2010). Another result obtained by Wakwinji (2011) in regards to improvement of program knowledge of teacher candidates increased as their educational experience increased. Therefore, it was an expected outcome that teachers should consider knowledge about the topic they are teaching, the coverage in educational program, and the immersive structure of program. However, according to the results obtained, teachers used limited number of materials as per their subject area during in their teaching. Especially in the final subject area of education period, it was observed that teachers did not demonstrate the same level of performance. In studies which investigated the conformity of science teachers within the program, it was seen that teachers had information about the program but that they either completely rejected the material for educational targets or that they adjusted them to their own teaching style (Mitchener and Anderson, 1989).

It was found that teachers completely took into consideration the prior knowledge of students, their conceptual mistakes and concepts which they may have difficulty in learning but they had made limited number of adjustments in regards to them. It was seen that teachers' knowledge of technological tools-devices needed so that students could understand and learn a specific science topic and that their level of consideration given to educational styles of students varied as per the subject area. These results are in conformity with those of Aydın and Boz (2012) as regards to teachers' not being aware of learning difficulties that students may face students or their conceptual mistakes and that teachers themselves could have conceptual mistakes. It was seen that teachers did not have the same level of knowledge when teaching concepts that are considered abstract, or in developing activities and presenting proposals (Niess, 2005).

It was discovered that teachers used multi-presentation or activities to facilitate learning process in students as were in conformity with the scope of subject most of the time. This situation shows variation in subject areas. While teachers had knowledge about education, strategy, method and theoretical techniques according to Canbazoğlu Bilici (2012), as a result of evaluation of lesson plans and lectures, it was found out that they had sufficient knowledge in education, strategy, methods and technics. Simmons et al. (1999) found out that even though new teachers supported student-centered education processes, they applied teacher-centered education processes within the class. Similarly, these findings were in line with the results obtained from educational processes applied by teachers in areas other than their specialization area (Hashweh, 1987; Sanders, Borko, Lockard; 1993).

It was seen that teachers' ability to use measurement s and evaluation technics in accordance with learning outcomes when it came to asking questions in order to measure thinking skills of students were not at the desired level. When analysis was made as per subject areas, it was seen that this situation showed variations. Staley (2004) has stated that teachers should use alternative evaluation methods like assessments that are based on performances, booklet entries, models, and portfolio in addition to traditional measurement and evaluation methods in science. In another research similar result were obtain as in this one, it was seen that by using the tests that were specified for the program or prepared by the teacher themselves, the assessments had conceptual understanding of students at all levels and subject areas (Yamagata-Lynch, 2003). The fact that teachers preferred to give a lecture instead of asking in depth questions to see whether students understood the lesson is consistent with the outcome of studies carried out by Terpstra (2010). But in the area of literature it has been frequently emphasized that point measurement and evaluations should be used in accordance with the purpose (Lankford, 2010).

In this study, with respect to integration of technology in education, results relating to factors that have an impact on usage of technological pedagogical content knowledge by the science teachers in educational processes are presented as articles by considering the particulars of an Activity System.

Accordingly, when integration of technology in education occurs, activity systems are established for teachers and are evaluated. Therefore, the main factors in mediation and in the realization of purpose were found and they were as follows;

- Willingness of the teacher to use educational applications that require the use of technology,
- Positive attitude and motivation of student in the relation to the lesson,
- A need for a teacher and students to have sufficient knowledge and skills when it comes using technological tools,
- The students' having a high level of interest in using educational applications that have been intergared via technology and in the materials prepared through technology,
- Make learning joyful and easy and thus enabling effective education,
- Sufficient opportunities in the school and complete set of tools and devices
- Having efficient cooperation from other teachers at the school and especially from the computer teachers
- Sufficient level of support needs to be provided by school management.

On the other hand, the strongest negatives that can prevent the teachers from properly integrate technology are:

- Teachers' not having sufficient resources or the management is not supportive enough,
- Problem relating to educational program not providing the gains on time in regards to the target and purposes of education program,
- Teachers' having difficult time dealing with classroom management where applications using the technology are made but not enough time is available.
- The thought that success will not be achieved if technology is heavily integrated in the classroom and that the interest of the students in the lessons would be reduced,
- Teachers' not using technology when it comes to measurement and evaluation technics and instead applying classic evaluation methods,
- Problems with implementation due to crowded classrooms,
- Teacher's being the authority in the educational applications that are being used.

In our time even though there is a desired to use technology in the educational process effectively, it is not easy to actually integrating to the education (Angeli and Valanides, 2005). Due to problems arising from educational system, teachers, and school environment, integration of technology into educational process becomes difficult. Furthermore, these obstacles also have an impact on TPCK development (Hew and Brush, 2007). Results similar to this research have been found and stated in other studies (Canbazoğlu Bilici, 2012; Demiraslan, 2005; Terpstra, 2010; Yamagata-Lynch, 2003). Canbazoğlu Bilici (2012) and Pirpiroğlu (2014) mentioned that due to lack of knowledge by the teachers and the problems originating from contextual factors, they had difficulty in integrating technology into educational process. Wakwinji (2011) emphasized that factors like physical conditions of the class, features of students, and internet access problem for some teachers influenced their TPCK performances.

As a conclusion, as technology constantly expands and grows studies in how to integrate it into education and to use it effectively will continue. The studies both theoretical and applicable demonstrate that technology integration is very difficult for teacher and system managers. Especially although teachers seem to be willing for usage of technology and regulation of class environment integration of technology to education is a slow and tiring process. It is recommended that potentials of technology in educations should be understood and that the obstacles should be avoided, by asking critical questions about this process and by making detailed analysis. In the process of integrating technology and using it effectively, all the richness and complexity of environment should be considered. Therefore, it is recommended for similar researches to be made not only in elementary schools but also at other educational levels and at institutions that have teachers.

REFERENCES

Abell, S. K. (1990). A case for the elementary science specialist. *School Science and Mathematics*, *90*(4), 291-301.

Angeli, C., & Valanides, N. (2005). Preservice elementary teachers as information and communication technology designers: An instructional systems design model based on an expanded view of pedagogical content knowledge. *Journal of Computer Assisted Learning, 21*(4), 293-302.

Aydın, S., & Boz, Y. (2012). Review of studies related to pedagogical content knowledge in the context of science teacher education: Turkish case. *Educational Sciences: Theory & Practice*, *12*(1), 479-505.

Böke, K. (2009). *Sosyal bilimlerde araştırma yöntemleri*. İstanbul: Alfa.

Canbazoğlu Bilici, S. (2012). *The pre-servıce scıence teachers' technologıcal pedagogıcal content knowledge and theır self-efficacy* (Unpublished doctoral dissertation). Gazi University, Ankara.

Demiraslan, Y. (2005). *Analyzing the integration of information and communication Technologies into teaching-learning process according to activity theory* (Unpublished master's thesis). Hacettepe Universtiy, Ankara.

Engeström, Y. (1987). *Learning by expanding: An activity-theoretical approach to developmental research.* Helsinki: Orienta-Konsultit.

Engeström, Y. (2001). Expansive learning at work: Toward an activity theoretical reconceptualization. *Journal of Education and Work, 14*(1), 133-156.

Hashweh, M. Z. (1987). Effects of subject-matter knowledge in the teaching of biology and physics. *Teaching and Teacher Education, 3*(2), 109-120.

Hew, K. F., & Brush, T. (2007). Integrating technology into K-12 teaching and learning: current knowledge gaps and recommendations for future research. *Educational Technology Research and Development, 55*(3), 223–252.

ISTE International Society for Tecnology in Education (2008). *Standarts for Teachers*. Retrieved from http://www.iste.org/docs/pdfs/20-14_ISTE_Standards-T_PDF.pdf

Jang, S. J., & Chen, K. C. (2010). From PCK to TPACK: Developing a transformative model for pre-service science teachers*. Journal of Science Education and Technology, 19*(6), 553–564.

Jonassen, D. H., & Murphy, L. R. (1999). Activity theory as a framework for designing constructivist learning environments. *Educational Technology Research and Development, 47*(1), 61-79.

Koehler, M. J., & Mishra, P. (2005). What happens when teachers design educational technology? The development of technological pedagogical content knowledge. *Journal of Educational Computing Research, 32*(2), 131–152.

Lankford, D. (2010). *Examınıng the pedagogical content knowledge and practice of experienced secondary biology teachers for teaching diffussion and osmosis* (Unpublished doctoral dissertation). University of Missouri, Missouri.

Terpstra, M. A. (2010). *Developing technological pedagogical content knowledge: preservice teachers' perceptions of how they learn to use educational technology in their teaching.* (Unpublished doctoral dissertation). Michigan State University, USA.

Wakwinji, J. (2011). *Exploring how a workshop approach helps mathematics teachers start to develop technological pedagogical content knowledge* (Unpublished master's thesis). Faculty of Science Universiteit van Amsterdam, The Netherlands.

Yamagata-Lynch, L. C. (2003). Using activity theory as an analytical lens for examining technology professional development in schools. *Mind, Culture, And Activity, 10*(2), 100–119.

Yıldırım, A., & Şimşek, H. (2005). *Sosyal bilimlerde nitel araştırma yöntemleri*. Ankara: Seçkin.

Magnusson, S., Krajcik, J., & Borko, H. (1999). Nature, sources and development of pedagogical content knowledge for science teaching. In. J. Gess-Newsome, & N. G. Lederman (Eds.), *Examining Pedagogical Content Knowledge* (pp. 95-132). Dordrecht, Netherlands: Kluwer Academic.

McCrory, R. (2006). Technology and science teaching: A new kind of knowledge. In E. A. Ashburn, & R. E. Floden (Eds.), *Meaningful learning using technology: What educators need to know and do* (pp. 141-160). New York: Teachers College.

Merriam, S. B. (2013). *Nitel araştırma: Desen ve uygulama için bir rehber* (S. Turan, Trans.). Ankara: Nobel.

Mishra, P., & Koehler, M. J. (2006). Technological pedagocical content knowledge: A framework for teacher knowledge. *Teacher College Record, 108*(6), 1017–1054.

Mitchener, C. A., & Anderson, C. W. (1989). Teachers' perspective: developing and implementing an STS curriculum. *Journal of Research in Science Teaching*, *26*(4), 351-369.

Niess, M. L. (2005). Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge. *Teaching and Teacher Education, 21*(5), 509 -523.

Pirpiroğlu, İ. (2014). *Investigation of pedagogical content knowledge of science and technology teachers, who have different occupational and contextual knowledge* (Unpublished master's thesis). Gazi Univesity, Ankara.

Sanders, L. R., Borko, H., & Lockard, J. D. (1993). Secondary science teachers' knowledge base when teaching science courses in and out of their area of certification. *Journal of Research in Science Teaching, 30*(7), 723-736.

Simmons, P. E., Emory, A., Carter, T., Coker, T., Finnegan, B., Crockett, D., et al. (1999). Beginning teachers: beliefs and classroom actions. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching, 36*(8), 930-954.

Staley, K. N. (2004) *Tracing the development of understanding rate of change: A case study of changes in a pre-service teacher's pedagogical content knowledge* (Unpublished doctoral dissertation). North Carolina State University, ABD.

Strauss, A., & Corbin, J. (1990). *Basics of qualitative research: Grounded theory procedures and techniques.* Newbury Park, CA: Sage.

Şahin, İ. (2011). Development of survey of technological pedagogical and content knowledge (TPACK). *Turkish Online Journal of Educational Technology, 10*(1), 97–105.