HIGH AND MIDDLE SCHOOL SCIENCE, MATHEMATICS AND COMPUTER SCIENCE TEACHERS' PERCEPTIONS AND ATTITUDES ABOUT TEACHER COLLABORATION

by

Utku Öztekin

B.S, M.S Secondary School Science And Mathematics Education, Boğaziçi University, 2013

Submitted to the Institute for Graduate Studies in
Science and Engineering in partial fulfillment of
the requirements for the degree of
Master of Science

Graduate Program in Secondary School Science and Mathematics Education
Boğaziçi University

2019

HIGH AND MIDDLE SCHOOL SCIENCE, MATHEMATICS AND COMPUTER SCIENCE TEACHERS' PERCEPTIONS AND ATTITUDES ABOUT TEACHER COLLABORATION

APPROVED BY:

Assoc. Prof. Serkan Özel (Thesis Supervisor) .....

Assoc. Prof. Fatma Aslan Tutak .....

Prof. Mehmet Tekerek .....

DATE OF APPROVAL: 29.08.2019

ACKNOWLEDGEMENTS

First, I would like to thank my wife Ela for her endless support starting from my undergraduate years. She is the source of my continuous interest and patience for this challenging path.

Secondly, I would like to thank my thesis supervisor, Assoc. Prof Serkan Özel, for his guidance and patience to encourage my inquiry on my research field.

I, also would like to thank my thesis committee members Prof. Mehmet Tekerek and Assoc. Prof. Fatma Aslan-Tutak for their valuable comments and feedbacks. With their valuable feedbacks I could improve my thesis.

Finally, I would like to thank my friends and colleagues, especially to Nil Arabacı, Ezgi Senger and Ekin Mahmuzlu for all their patience to answer my questions. And special thanks to Bogazici University, all staff and members to make me feel at home since 2006.

ABSTRACT

HIGH AND MIDDLE SCHOOL SCIENCE, MATHEMATICS AND COMPUTER SCIENCE TEACHERS' PERCEPTIONS AND ATTITUDES ABOUT TEACHER COLLABORATION

Collaborative working skills is one of the most important dimensions for improving instructional quality through STEM and 21st century skills. Based on an action research guided by explanatory sequential mixed-method design, this research sought to investigate teachers' perceptions and attitudes for teacher collaboration in Professional Learning Com- munity (PLC) framework. The study focusses on descriptive questions with contextual and procedural structures. Data collection is made through online documents for preliminary investigation for research site; Demographic Analysis Teacher Questionnaire (DATQ) to gather information about teachers' characteristics and attitudes in the school setting, School Professional Staff as Learning Community Questionnaire (SPSLCQ) for contextual analysis and Teacher Collaboration Assessment Rubric(TCAR) for conceptual analysis; and semi-structured interview for an in-depth understanding of effective collaboration. 33 teachers attended quantitative and 6 teachers attended qualitative part of the research. The first major finding is the difference between the mean scores for frequencies of using fundamental collaboration skills (74.50%) and effective collaboration skills (35.12%). Differences between the contextual and conceptual collaboration scores of high school and middle school teachers are investigated through interviews. Results show that interdisciplinary collaboration oriented planning of middle school administration enhances teacher's effective collaboration attitude. When the procedural focus of the collaboration is considered, evaluation comes up as the part that is needed to focus on. A collaborative process is finalized with the end of the action part.

ÖZET

ORTAOKUL VE LİSE MATEMATİK, FEN BİLİMLERİ VE BİLİŞİM TEKNOLOJİLERİ ÖĞRETMENLERİNİN ÖĞRETMEN ARASI İŞBİRLİĞİ ÜZERİNE GÖRÜŞ VE TUTUMLARI

İşbirlikli çalışma becerileri, öğrenim kalitesini STEM ve 21. yüzyıl beceriler aracılığıyla arttırmanın en önemli boyutlarından biridir. Bu araştırma, karma desenlerden sıralı açıklayıcı tasarımın rehberliğinde bir eylem araştırmasına dayanarak, öğretmenlerin Professional Learning Community (PLC) çerçevesinde öğretmen işbirliğine yönelik algı ve tutumlarını incelemeyi hedeflemektedir. Çalışma, bağlamsal ve prosedürel yapıları olan tanımlayıcı sorulara odaklanmaktadır. Veriler çevrimiçi dökümanlar, Demographic Analysis Teacher Questionnaire (DATQ), School Professional Staff as Learning Community Questionnaire (SPSLCQ), Teacher Collaboration Assessment Rubric (TCAR) ve son olarak etkili işbirliğinin detaylı anlaşılması için yarı yapılandırmış mülakatlar aracılığıyla toplanmıştır. Araştırmanın nicel kısmına 33 öğretmen, nitel kısmına ise 6 öğretmen katılmıştır. İlk önemli bulgu, temel işbirliği becerilerinin (74.50%) ve etkili işbirliği becerilerinin (35.12%) kullanım sıklığı arasındaki fark olarak ortaya çıkmıştır. Ortaokul ve lise öğretmenlerinin bağlamsal ve kavramsal işbirliği puanları arasındaki fark mülakatlar aracılığıyla incelenmiştir. Ortaokul yönetim planlamasının disiplinlerarası işbirliğine yönelik oluşunun öğretmenin etkili işbirliği tutumunu arttırdığını göstermektedir. İşbirliğinin prosedürel kısmı göz önüne bulundurulduğunda ise değerlendirme işbirliği için ağırlık verilmesi gereken bir aşama olarak ortaya çıkmıştır. İşbirliğini engelleyeci faktörleri ortadan kaldırmak için ihtiyaç duyulan en önemli etmenin zaman planlaması ve yapılandırılması olduğu gözlendi.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

Improving instructional quality is a worldwide trending topic for educational reform studies (Woodland *et al.*, 2013). Even it is a multi-dimensional case, for the improving instructional quality, implementation of STEM and 21st-century skills turns to a key factor. (OECD, 2012). When all together are defined as a 21st-century school, reform in teacher attitudes and teaching trends is inevitable. For the 21st century and even before, teacher collaboration has accounted as a significant factor that affects student achievement. (Farmer, *et al.*, 2015; Goddard, *et al.*, 2007). Even this positive impact is rationally apparent, not having a clear definition even for term "collaboration" makes it hard to set the limits and assess the rate of collaboration. Teacher col- laboration, Professional Learning Communities (PLC), Community of Practice (CoP), teacher teams, teacher learning groups, collaborative practice networks are the most common terms that imply collaboration. (Vangrieken, *et al.*, 2015). Even they have the same idea in its core, they all have differences to discuss in order to achieve a clear definition of collaboration.

Although teacher autonomy creates a boundary over the restructuring of education (Zito, 2011, changing characteristics of education (OECD, 2012) necessitates a change in teachers' practice. Even the collaboration beyond the solo teachers shows its impact in many areas in schools, if the case is STEM teaching and learning, the importance of partnerships both "outside the school walls" and "inside the school walls" in all manners becomes more apparent (Metz, 2009). Lortie (1975) discuss the problem of teacher isolation for the first time as a need for professional interaction among teachers, which is discussed as collaboration today. So many researches have made on this problem, but a unique structure and all-in-one framework is not configured because of its variable-dependent nature (Shakenova, 2017).

For the subject school, an Innovation Center is planned for encouraging and helping the development of multidisciplinary and interdisciplinary activities within the framework of STEAM. For a successful implementation process, STEM education

directs the teacher to work together on correlated subjects while taking individual characteristics, rigor and depth of the main discipline in mind (National Research Council, 2011). By using this idea, the Innovation Center takes on a consolidative responsibility. In this study, the researcher will take a closer look at STEM Field (Science, Math, and Computer Science) teachers' collaborative attitudes and skills and their attitudes on professional learning communities.

1.1. Theoretical Framework

Collaborative work among teacher groups appears in many different forms. Need for a framework becomes important since any group work may be defined as collaboration. Professional Learning Communities (Hord, 1986) is used to provide a basis for teacher collaboration for this study. Social learning and cognitive apprenticeship are the first to discuss the idea of learning with the help of interaction with practitioner communities (Vygotsky, 1987). Using the community as a resource for learning than defined as Community of Practice (Lave and Wenger, 1991). Hord's PLC has its roots from Community of Practice but has its own structure (Hord, 1986), so social learning and cognitive apprenticeship theory and Community of Practice framework will not be discussed in detail.

An analysis of terminology used for collaboration shows that terminology used are various (Vangrieken, Dochy, Raes, and Kyndt, 2015). When the existing research has been considered, the most typical terms that are used are: teacher teams, teacher collaboration, professional learning communities (PLC), and community of practice (CoP), (Vangrieken *et al.*, 2015). Also, terms like group work, teamwork, collaborative work, group practice are used to define collaborative groups with different views and perspectives (Ferguson, 2006). Definition of collaboration is made previously by New England Program In Teacher Education (1973) as development of the model of joint planning, joint implementation, and joint evaluation between individuals or organizations (Durham, 1973). Hoyt (1978) on the other hand, defined collaboration as a term that implies the parties involved shared responsibility and authority for basic policy and decision making (Hoyt, 1978). Kelchtermans (2006) defined collaboration

as teachers' cooperation aimed at achieving the school objectives. according to Kruse (1999) collaboration is defined as shared values, decision making about teaching practice and interaction between teachers, which promotes students' performance and the professional development of staff.

Hord (1986) combined these definitions and started the baby steps of PLC with the purpose of reaching a separation between collaboration and cooperation (Hord, 1986). It is claimed that cooperation is considered as an action where two or more teachers consent to improve their individual practice through working together. While collaboration means sharing obligations and involving teachers in decision making about shared teaching practice. Thus, collaboration means shared values through teachers' learning which influences teaching practice and students' achievements. Moreover, shared decision making about common goals and practice plays a pivotal role in school improvement, and is based on cooperation between teachers and collegial relationships

1.1.1. Choosing the Framework

This research study has its origin as collaboration, but introductory reading reveals the lack of consensus on literature, even though collaboration and cooperation are terms that is discussed in many studies. Hord (1986) had finalized this argument with his study that differentiates cooperation and collaboration with two different model. While the cooperation is an autonomous process which two or more parties agree to work together, main differentiation between collaboration and cooperation is stated for shared responsibility and authority for the organizational process (Hord, 1986). As the founding theory of professional learning community, organizational collaboration has its updated impact on PLC.

There is not an accepted universal definition for PLCs. There are different descriptions which try to explain meaning of PLC (e.g., Darling-Hammond, 1996; Hord, 1997; Senge 1990; Stoll, Bolam *et al.*, 2003). When the existing definitions (eg., Bolam *et al.*, 2005; Toole and Louis 2002) are combined, PLC is realized with a group of people

working together and the practice is critically investigated in a continuous, reflective, collaborative, with a focus on learning and growth of the process of learning. Aim of all actions is to increase the effectiveness as professionals for the students' learning. PLC also is termed as communities of continuous inquiry and improvement. With respect to the school's vision, mission and goals, PLC are integrated and function in the school's framework. On an inquiry-based and students' outcomes related framework professional learning communities have a broad possibility of professional development for teachers. (Boyle *et al.*, 2004; Corcoran 1995; Desimone 2011; Garet *et al.*, 2001; Villegas-Reimers 2003). There are updates as shown above; however, definition of the PLC is standardized for this study with respect to its frontier's definition. Hord (1997) defined PLC as a professional community of learners' with a detailed classification of the learner which the teachers in a school and their administrators continuously seek and share learning.

PLC can be handled both as a way of structuring an intervention for organizational reform process and analyzing the current structure of the community with respect to standards defined according to the theory of professional learning communities. In this study, the researcher analyzed the most common alternatives namely, group work, teamwork, collaborative work, group practice, CoP, and decided to use PLC to analyze the current status of organizational collaboration in the subject school. Even the above terms are mostly used interchangeably need for a framework and need of clear definitions appear for the analyses of the variables. PLC is not an accreditation system that a school can be labeled. However, with the data provided by subject

There are 5 major dimensions that enlighten the contextual structure of PLC. They are shared and supportive leadership; shared beliefs, values and vision; collective learning and its application; shared practice and supportive conditions (Hord, 1996). With a more detailed interpretation commitment to continuous improvement; results orientation is also discussed in the literature.

1.1.1.1. Evidence 1. The subject school which will be investigated for this research study declares its mission statement as "Discovering and developing our true potential through critical thinking, effective collaboration and meaningful contributions as world citizens".

As the researcher of this study, also a teacher in this school, has the observation that school has actions which are planned in harmony with the school mission statement. For this evidence, shared beliefs, values and vision can easily be observed. All teachers of the subject school share the idea of letting students find themselves and learn through their own curiosity. Commitment to continuous improvement as one another aspect that can be observed. Teachers in the school materialize the mission statement as assessing students' performances individually. In other words, teachers focus on progress of students.

1.1.1.2. Evidence 2. When the philosophy of education statement of the subject school is investigated it is explained that:

(i) We believe learning through understanding holds a natural place in our daily lives.
(ii) We are committed to continuous improvement in learning.
(iii) We offer rich educational, co-curricular and extracurricular opportunities for our students in facilities which reflect versatile learning environments.
(iv) We provide a high-quality inclusive environment created by the mutual respect and interactions characterized by trust among students, as well as between students and teachers.
(v) We believe in a strong work ethic and that this work ethic can lead us to high-quality performance.
(vi) We promote full collaboration with all our partners in a democratic and transparent atmosphere, one in which each party is autonomous yet in coordination and cooperation. with all others.

With respect to these statements in which the teachers in a school and its administrators continuously seek and share learning and then act on what they learn. The goal of their actions is to enhance their effectiveness as professionals so that students benefit. This arrangement has also been termed communities of continuous inquiry and improvement. Within these definitions, the subject school's statements and actions correspond to the PLC as a collaborative workplace.

To start with the second statement, the relation is not only an interpretation but also a direct link with the PLC and subject school. When the third and fourth items are considered focus of the leadership is supporting student progress which shared and supportive leadership has the same focus. Last but not least, sixth item shows the collaborative nature of the school. This collaborative expression is a typical example of a group of PLC which covers almost all dimensions.

1.1.1.3. Evidence 3: Commity Based Decision Making Mechanism. For the subject school, even though like many schools there is a classical structure in the school management general manager, school principals, vice principals and department headsthere is a new attempt to create subject specific committees. Details of the committees are discussed in the research site section of the thesis. However, the committees provide a strong proof for the professional learning community framework. Executive Committee, first of all, directs the decision-making mechanism from domination of a single to a group discussion. Other committees that operates under Executive Committee are Advisory Committee on Education Policy, Advisory Committee on Technology/Innovation Policy, Committee for Arts, Culture, Sports Events, Committee for Admissions Evaluation, Committee for General Data Protection. These committees have members both in and out of school. External members of the committees are university members and pioneers in specific fields like educational technology, law, innovation in education, and so on. These committees meet regularly with respect to their agenda and process their own decision making, application and evaluation mechanisms. As a result of their yearly effort, committees report their progress to Executive Committee.

When, all the aspects of committee system are considered; focus of the shared and supportive leadership, collective learning, supportive conditions and results orientation are targeted with the purpose of this structure. With this administrative framework, a professional learning community is realized with almost all dimensions.

1.1.2. Collaboration with Professional Learning Communities

In the book, Peter Senge (The Fifth Discipline, 1990), which instructors are motivated with the utilization of collaboration inside learning communities, collaborative learning organizations are described with details. Also, Hord used the book of Astuto and his colleagues, Challenges to Dominant Assumptions Controlling Educational Reform (1993) as a primary source for her definition of a professional community of learners. The book focuses on teachers' and supervisors' effort on continuous seeking and sharing learning in order to increase the effectiveness of education and students' benefits from school and school time (Hord, 1997). With this book, also the connection between the collaboration among teachers and its impact on students are discussed with details at a professional community of learners.

When the five aspects of PLC is considered which shared and supportive leadership; shared beliefs, values and vision; collective learning and its application; shared practice and supportive conditions; PLC appears as a structured framework for teacher collaboration (Bolam *et al.*, 2005). Collaborative culture in a PLC encourages teachers and curriculum studies. Collaboration, in this case, becomes more and more important in a PLC and makes it popular within educators as working collaboratively equates with PLCs (Hargreaves, Dawe, 1990; Hord, 2008).

Even the collaboration is a broad term which all kinds of interactions among teachers are sometimes assumed as collaboration, DuFour (2011) stressed that collaborative teaching must move beyond what is expected to teach and how the teacher will know when each student has learned. In that case, the purpose of the collaboration is not just doing things together but improving professional practice and achievement of students (DuFour, 2011). The discussion of isolation is not just an idea which is

discussed for the opposite of collaborative working. For the study of interrelationships, isolation of individuals who must be in relationship with other individuals and groups is the main problem to focus on (Hord, 1986).

Even the impact and benefits of effective collaboration on teaching is proved to be useful, it faces with the most apparent problem of schools isolation (DuFour, 2011). In the contemporary world, collaborative working is not a choice but a must. Assuming the collaboration is not choice but a must considered as a solution for the isolation (DuFour, 2014). Even the collaboration in a PLC may be set with regular meetings, it may not be enough unless collaboration is turned to a collaborative culture which spontaneous, voluntary, need and development-oriented over time (Datnow, 2011).

Developing a technique or model to build up collaboration is considered important and necessary to enhance professional development and to support a PLC in schools (Sigur-ardottir, 2006). In that manner, the concept that collaboration is labeled is needed to clarify.

1.1.3. Collaboration among STEM Disciplines Teachers

Collaboration is the term mostly discussed for all school structure instead of subjects or disciplines since it is mostly described as a culture but not a thing on a list to do for successful schools. Even the collaboration is needed for overall the school, STEM Education or STEM fields education (separately taught) as discussed below is a trending topic (Capraro and Han, 2014). In this case, teacher collaboration becomes not an advantage, but a must for a learning process, which students learn with respect to needs of 21st century and STEM Education (Corlu *et al.*, 2014). For this reason, teachers from STEM disciplines (Science, Mathematics and Computer Science, Engineering) are suggested as participants.

1.1.4. Stem

The acronym "STEM" stands for science, technology, engineering, and mathematics. It is first started to use in undergraduate courses then it is transferred to K-12 education. It has its roots as the combination of the four disciplines for the undergraduate courses but when it is transferred to K-12 education, the meaning is expended and it is turned to comprehensive and interdisciplinary teaching and learning approach especially for four disciplines (Capraro *et al.*, 2013; Gonzalez and Kuenzi, 2012).

According to the report Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Future (National Academies 2006), the United States accused for losing its competitive position in innovation and technology. With the advantage of dealing with a future problem, stakeholders of the USA came together to find a solution to this problem in education policy. For America's future scientist, engineers, technologists, a reform movement has started (Wang, *et al.*, 2011).

The term STEM appeared at the National Science Foundation's work. Reports from the 1980's stated a need for better math and science education (Breiner, Sheats Harkness, Johnson, Koehler, 2012). The early acronym was "SMET". There was belief that this term was not professional; therefore, the acronym was changed to STEM (Sanders, 2009). A movement for a change in policy and in school curriculum within the fields of science, technology, engineering and mathematics has begun with STEM.

The term "STEM" does not have an exact definition that was left open for interpretation (Ayres, 2016). There are different views, approaches, and assumptions for countries, districts, schools and also for teachers. Variables like difference between inter and multidisciplinary teaching and learning, meaning of learning, integration of STEM are needed to be discussed for the STEM education (Wang, *et al.*, 2011). Being open for interpretation turns to an advantage for many countries. The USA based system has different manipulations which all focus on develop in technology and innovation (MNE, 2016). China has updated its curriculum for 10th to 12th grades ad STEM subjects have been integrated into teacher training programs, Russia focus its

orientation to improving mathematics education, enhancing the quality of engineering programs, Norway has adopted "STEM of course" plan to improve STEM learning and teaching skills, France, Malta, England, Switzerland and so many countries are making interpretations of STEM with respect to their national needs (MNE, 2016).

STEM Education based its roots in two perspectives. First, STEM education directs the teacher to work together on correlated subjects while taking individual characteristics, rigor and depth of the main discipline in mind (NRC, 2011). A transformation, in this model, is needed from departmentalized model to an integrated model. Also, there is a need for teachers who are not only professional in the subject area but also in another STEM field like both in science and mathematics or mathematics and technology (Sanders, 2009). The second perspective for STEM education provides freedom to the teachers with the purpose of increase in effectiveness. Freedom in this manner is described as the application of a flexible curriculum which lets teachers to teach STEM subjects in their natural context (Jardine, 2006). STEM education demands teachers to advance in making natural and active exchanges of knowledge and skills among STEM disciplines (Capraro *et al.*, 2014).

Most of the science teachers may claim that they are teaching with respect to STEM principles, while they use math skills in science class (Roth, 1993; Roth and Bowen, 1994) However, if the mathematics used in science is mathematically rigorous, it may provide an understanding of STEM education which is not an independent meta discipline while preserving the subject-specific knowledge, skills, and attitudes (Capraro *et al.*, 2014). So, understanding about STEM and the fundamental requirements are important for teachers. That's why using math, for example, in physics class is not enough for STEM education. Support of math teachers for with a purpose of bringing his/her own objectives in learning process is required to tell about STEM education.

1.1.5. STEM and PLC

From the first definition of STEM to last, it is so clear that teachers need to work in groups to design and implement STEM strategy. National Science Foundation

reported that STEM teaching appears to be more effective and students' achievement is higher when teachers work in strong professional learning communities (Stoll, Bolam, *et al.*, 2006). With the evidence of teamed up teachers' ability to create a culture of success in schools, these teachers lead the improvements in education and student learning.

Performance assessment systems that focus on teacher efforts for building collaborative professional capacity could damage the preparation of today's students for 21st-century undergraduate education and for the rest of their lives. A teacher's excessive personal effort may be harmful for students when there is a need for joint power instead of a standalone teacher. Need for teachers with high potential for teaching is obvious. Nevertheless, teachers -under a shared and powerful leadershipworking in a group may unite with high proficiency while same goals are hard to achieve by a standalone teacher (Fulton, Doerr, and Britton, 2011). With the changing nature of teaching, learning is no longer the preparation for the job but the job itself. In other words, in future, if the students will reinvent their jobs in teams, they need schools which are learning organization that they will work in the rest of their lives (Fulton *et al.*, 2011).

With respect to research result of The National Commission on Teaching and America's Future (NCTAF) (Fulton *et al.*, 2011) teacher who collaborate in learning teams can successfully engage STEM discussions about STEM disciplines that they teach, also understand the mathematics and science better and feel more prepared to teach mathematics and science. The teachers who attended the PLC settings are considered as better candidates for STEM education. A PLC group is not only a discussion about content knowledge but also a pedagogical and techno pedagogical knowledge. Teacher who attends STEM PLC groups improved their practice by more research-based methods for teaching mathematics, science, technology and engineering. They started to pay more attention on reasoning and understanding and finally they used a wide variety of modes of reaching students' interests in problem-solving skills (Fulton *et al.*, 2011).

With respect to review (Fulton *et al.*, 2011) made over 74 examples of published expert advice, First, PLC's have a positive impact on teacher practice, school climate, teachers' perceptions of self-efficacy, and student achievement wherein schools which PLC based teacher education is confirmed. Second, the advantage of PLC is simply discovered as a reflection on practice, focus on content knowledge and improved pedagogy are stated at most studies. Third, Case studies about PLCs focus on PLC's increasing impact on teacher practice, school climate, perceptions of self-efficacy and student achievement. Forth, Principles of effective PLCs and discussion about team structure which will function with high efficiency are the gathered information mostly from How to PLC guides. Fifth, PLC's may function as discussion teams that focus on instructional material and how to implement them. In that case, PLCs be used as the best support mechanism for course preparation. (Fulton *et al.*, 2011)Advantages of PLC and needs of STEM education are shows a mutual affinity. STEM teaching needs a collaborative teaching. When the fundamentals of PLC and above outcomes are considered, it provides the framework for teachers who work together for STEM education.

STEM education requires a collaborative workplace for course planning, implementation, assessment and evidence gathering for learning. For this research, teachers' skills and proficiencies are not tested but the focus is the collaborative attitude and perceptions of teachers. However, requires teachers with a collaborative culture. The Ministry of National Education in Turkey also is working on a long-term reform process within Vision 2023 program in which science and mathematics education has a common understanding in teaching with purpose of increasing future capacity of science and technology-based innovation overall country. When the details of the program are considered, discussed teaching skills are in harmony with STEM education. That's why, in addition to high and middle school principles, science department, mathematics department and computer science department teachers are titled as STEM teachers and will be invited to study as participants.

2. REVIEW OF LITERATURE

Professionalization of teaching and teacher development of teachers have been the main focus in school reform procedures since 1983. (Lieberman, 1995). This focus is based on developmental issues like national licensing, fair and equitable pay, rigorous standards for entry into the teaching profession and sustainable professional development. (Louis, *et al.*, 1996). For collegial support, systems require additional strategies (Lieberman, 1990; Little and McLaughlin, 1993). Although professional teacher networks serve as important systems of collegial support, professional community offers the more inclusive support of a whole school (Louis *et al.*, 1996), promoting collaboration among staff members, breaking down barriers that isolate teachers in their work, and supporting improved professional practices (Scribner, *et al.*, 1999).

2.1. Professional Learning Community (PLC)

Even the terminological framework discusses different terms that are used interchangeably collaboration, in this study, collaboration is discussed as not just working together but any kind of communication in a collaborative environment. So, professional learning communities have a broader definition than collaboration. A differentiation between collaboration and PLC is made by DuFour. DuFour defined PLC as "an ongoing process in which educators work collaboratively in recurring cycles of collective inquiry and action research to achieve better results for the students they serve" (DuFour, DuFour, Eaker, andMany, 2010, p 111). Similarly, Achinstein defined the PLC as "a group of people across a school who are engaged in common work; share to a certain degree a set of values, norms, and orientations towards teaching, students, and schooling; and operate collaboratively with structures that foster interdependence" (Achinstein, 2002, p. 422).

In the beginning of 1960's, Professional learning community (PLC) first emerged as an alternative to the isolation problem to the teaching profession in the United States. Since the beginning of PLC, teacher collaboration is linked to student achievement-

oriented goals to improve teacher learning, higher levels of teacher engagement, confidence about effective teaching and learning. In the subsequent work, DuFour and Eaker describe the members of a school that operates as a professional learning community:

- Collectively pursue a shared mission, vision, values, and goals.
- Work interdependently in collaborative teams focused on learning.
- Engage in ongoing collective inquiry into best practice and the "current reality" of student achievement and the prevailing practices of the school.
- Demonstrate an action orientation and experimentation.
- Participate in systematic processes to promote continuous improvement.
- Maintain an unrelenting focus on results (DuFour and Eaker, 1998).

With DuFour and Eaker's above description, a PLC is summarized on three big ideas: ensuring that students learn, a culture of collaboration, and focus on results (Dufour, 2004). Since the learning process shows its results on student achievement; student's learning and the result of this learning process requires so much attention. However, in this research, the culture of collaboration is the main focus with all details. Even the collaborative culture is the main focus, the reason for collaboration in a professional learning community is originated from the idea that teachers need to work together to achieve their schoolwide purposes (Hord, 2004). Therefore, teachers create structures and networks to work together. An easily founded network may focus on different facets of the school's operation, such as discipline, technology, and social climate. However, a powerful collaborative network characterizes professional learning communities is a systematic process in which teachers work together to analyze and improve their classroom practice (Dufour, 2004).

2.1.1. Advantages to Consider on PLC

With respect to a three-year study of Southwest Educational Development Laboratory (SEDL) in Texas, the reform process is taken into examination for the assessment of the efforts. After the first year, SEDL researcher identified five core issues that affecting schools' efforts as the improvement of organizational structures, focus on

improvement work, personal and social dynamics, contextual influences and leadership (Morrissey, 2000). These five issues are identified later for the characteristics of the low performing schools with barriers to the improvement process where 5 attributes of PLC (Hord, 1997) were believed to be able to support improvement process (Morrissey, 2000).

Even the research on literature for the PLC mostly based on interventions made with supervision of professionals, there is a clear evidence that PLC's reduced teacher isolation, increased commitment to the school's mission and goals, a feeling of shared responsibility for the holistic development of students, an ethos of the powerful learning that defines good teaching and classroom practice and an enhanced understanding of course content and teacher roles (Hord, 1997).

As repeated, it is mostly used in literature, the impact of any intervention is measured with respect to student achievement (Hord, 1997). In addition to student achievement increase in professional learning activities are also an indicator of effective PLC (Bolam *et al.*,2005). Another indicator of a successful PLC is identified with respect to four key processes which are the optimization of resources and structures, promotion of individual and collective learning, the explicit promotion and support of an effective PLC, and the effective delivery of leadership and management. (Bolam *et al.*, 2005). With the increase in the extent that schools have strong professional communities, there is an increase in the extent of student learning (Bolam *et al.*, 2005).

On a review made for the impact of PLC, ten empirical study are investigated. Vescio and colleagues reported that PLCs have a positive impact on both teachers and students (Vescio *et al.*,2008). With respect to their review, PLC increase collaboration, encourage a focus on student learning, improve teacher authority or empowerment, and promote continuous learning. As the most important outcome, researchers stated that teachers in PLC have a positive impact on students' achievement scores over time, with respect to non-PLC attending teachers' students' scores (Vescio *et al.*, 2008).

2.2. Major Themes in PLC as A Collaborative Workplace

2.2.1. Shared Beliefs, Values and Goals

A compelling PLC holds fast to a vision of student learning, a vision that goes about as a reliably verbalized and referenced guidepost in settling on choices about teaching and learning (Hord, 1997). The mission or motivation behind a PLC group is to guarantee that all students learn through the collaborative, interdependent practice of educators.

DuFour and Eaker (1998) named this component as cooperative energy of endeavors in which staff members are focused on standards each has faith in and progresses in the direction of executing. Based on a review of the curriculum, important learning outcomes are decided for all students, assuring the teaching of the curriculum in a way that is workable and well-planned (Langston, 2006). And all in all, staff members have a shared mission, vision, values and goals which focuses on a transparency exists concerning what students must know and be able to do (DuFour, *et al.*, 2006).

When this idea is considered, a PLC based school environment provides an environment for teachers who work together with a detailed set of communication on planning, coursing and evaluating which may be defined as collaboration.

2.2.2. Commitment to Continuous Improvement

As a natural process teams are in a sustainable cycle of ongoing improvement (DuFour, 2004). These teams in a PLC aim to reach and sustain the organization's ideal mission and vision. Such a commitment is inside a setting in which the aggregate cooperative energy, creative ability, spirit, motivation, and persistent learning of educators lean toward enhancing teaching aptitudes (Huffman *et al.*, 2001). With the enhanced aptitudes teachers regularly expand their desired outcomes to challenge themselves and to increase student learning rate (Bierema, 1999).

2.2.3. Collective Inquiry

Reflective dialogue and collective inquiry are found to be an important theme for a strong PLC. Team members have a discussion and focus on curriculum formative assessments, instruction, and expected job-embedded professional development activities for effective instructional strategies (Langston, 2006). As an example of this case teachers challenges themselves and their groups practice in spirited but optimistic ways (Sparks, 2005). They also considered students' needs, applying new ideas (Hord, 1997) and analyze existing applications with student outcomes and analyze the relationship between practice and the effects of practice (Huffman *et al.*, 2001). All in all, in a manner of collective inquiry, teachers spend their time to question, search, analyze, develop, test and evaluate skills, strategies, awareness, attitudes and beliefs that promote student learning (DuFour and Eaker, 1998).

2.2.4. Supportive and Shared Leadership

For a strong PLC there is a need for a leader who is not the manage people but encourages all teachers and members of PLC for development (Bierema, 1999). Leadership turns to an important theme since it has different aspects. The school leader is likewise a student going to proficient staff improvement and is amicable and facilitative in sharing administration, power, and expert through giving staff decision making input (Hord, 1997). In a team leadership is shared among formal and informal leaders (Phillips, 2003). For a leadership with positive impact on teams or overall PLC, respect, trust and openness to improvement is a key factor (Kruse *et al.*, 1994).

2.2.5. Supportive Conditions

With respect to literature, circumstances and environment of the school is a must to take into consideration (Phillips, 2003). For a PLC, the need for a school-wide plan with a chance to provide time and support for increasing the student achievement and planning time for teachers requires structural and cultural arrangements (Langston, 2006). For a working and effective PLC, time and physical conditions for

teams to meet and talk, also communication structures are necessary (Roberts and Pruitt, 2003). In addition to these needs to maintain supportive conditions, reduced isolation, increased number of staff, providing a productive and proactive environment and improved quality of programs is are also needed to advance in the quality of PLC's (Hord, 1997).

2.2.6. Results Orientation

In a PLC assessment is important for an effective learning, teaching and working environment which all are resulted in same place (DuFour and Eaker, 1998). Since the school community is focused on students, assessment of the student learning is tool for the assess the success of PLC attempts (DuFour *et al.*, 2006). When the impact of formative assessment is considered as a discussion of assessment reveal areas for intervention and enrichment activities and areas to improve instructional practices.

2.2.7. Collaborative Culture

When structure of a PLC is considered, collaboration among contributors of PLC becomes important, especially for educators. (Shellard, 2002). A systematic learning process in which teachers work together with respect to grade level, vertical, special topic or subject matter teams to impact professional practice to improve personal and teams results for students. With the help of collaborative work, responsibility for the students' learning is shared through team meetings for learning, implementation and assessment. When teachers work together for a common purpose, it provides a chance to teachers to learn from their experiences which provides a continuous improvement (DuFour and Eaker, 1998).

Researchers added three characteristics for PLCs that emerged from a combination of the workshop conferences, case studies, and the survey (Bolam *et al.*, 2005). Openness, networks and partnerships outside of the school. Inclusive membership by including other professionals who closely work with students, like learning support assistants. Mutual trust, respect, and support. With the addition of these updates we

have a chance to understand the PLC and also the characteristics provide a method for organizing the different areas that involve or can affect collaboration with a PLC.

2.3. Collaboration

Even the terminology for the field is not clear and precise, collaboration in its own history eventually defined by Louis and Kruse within five characteristics of successful teacher communities: shared values, deprivatization of practice, reflective dialogue, focus on student learning, and collaboration (Kruse, *et al.*, 1995). The framework created by Kruse and Louis is grounded on both organizational learning theory and professional community theory (Scribner *et al.*, 1999). With respect to this domain collaboration is defined as the use of others' expertise within professional communities. Content of collaboration is suggested to focus on

- the on-going study of teaching and learning;
- examination of existing beliefs and distribution of new knowledge
- providing support in case of implementing new or challenging methodologies

Within this framework collaborative work is declared to increase teachers' sense of affiliation with each other and support and responsibility for the effectiveness of instruction (Louis, 1992).

With respect to foundational findings of professional communities Louis and Smith stated the importance of emergent professional communities with the increase in the amount and quality of feedback mechanisms which increases classroom practice and the development of supportive relationships among staff (Louis and Smith, 1992).

When the study of Louis and Kruis that is made to develop a framework for school-based professional communities (Kruse and Louis, 1995) components of a community is characterized by shared values, reflective dialogue, de-privatization of practice, focus on student learning and collaboration. Even the collaboration is already discussed in here, a better understanding is possible with clarification with other char-

acteristics. First, reflective dialogue provides a system that teachers share the roles. This system comes with a deeper understanding of the product and process within teaching and learning procedures. Reflective dialogue in a collaborative group needs to be academic, socially efficient, developmentalist and social constructivist oriented. Second, de-privatization of practice focuses on working in public. Peer coaching relationships has seen as a method to improve classroom practice and collegial relationships. Collective focus on student learning, third, describes all the efforts like plans, discussions and acts which are realized on students learning process. As expected, the main focus is always student learning. Forth, shared norms and values is an important factor for sustainability. Individuals common beliefs about human activity, relationships, organization's role in society and its relationship with the environment are needed to affirm. In school environment, shared value base assumed to be supportive of student learning (Kruse and Louis, 1995).

All these four components and collaboration as a fifth one added to each other, the structure represents a framework to create, facilitate and analyze a communication system for teachers. However, Scribner and his colleagues offered shared leadership and mutual independence as an addition to list made by Louis and Kruse (Scribner *et al.*, 1999).

When the purpose of the school and needs of the 21st century is taken into account, teachers have the biggest influence on student learning. Teachers' effectiveness improves student learning when teachers reflect on their instruction. Increasing the effectiveness which develops over personal limits requires a system which guides teachers to bring different abilities together. Professional Learning Communities (PLCs) are one of the powerful tools for schools and so teachers. Collaboration is one of the most important benefit of PLCs. However, from the definition of PLC and collaboration to their applications there is not a consensus. Details for the possibilities of PLC and collaboration are discussed in the Theoretical Framework part. However, current studies which investigates the relation between, PLC, collaboration and STEM field teachers will be discussed in this chapter.

STEM, on the other hand, is a broad topic which is very popular and so still open for discussion. Regardless of the philosophy and implementation, STEM requires teachers from different disciplines to work together, which requires collaboration. Since the participants of this study is chosen from science, technology, mathematics and computer science teachers from middle school and high school departments, STEM is chosen as a concept to be taken into account. With respect to statement given above, introductory and descriptive literature is discussed in theoretical framework but not in literature review.

2.4. Benefits of Teacher Collaboration

2.4.1. Student Oriented Benefits

At the time teachers collaborate even with the simplest form of collaborationteachers share their experiences and information. When the organizational theory is considered, collaboration is a form of lateral coordination that is a factor to improve performance by advancing "creativity and integration around specific problems' (Bolman and Deal, 2003 as cited in Goddard, Goddard and Tschannen-Moran, 2007). Goddard, Goddard and Tschannen-Moran (2007) conducted their research on a large urban district located in midwestern United States, with teachers and students from elementary schools. With respect to study, there is a statistically significant positive relation between teacher collaboration and students' mathematics and reading achievement (Goddard and Tschannen-Moran, 2007).

Egodawatte and colleagues (2011) stated that there is a statistically significant relation between teachers' teamwork and student success. With the project, they let an increase in meeting of collaborative group which consists of teachers, support staff and administrators that mostly works on Individualized Education Plan (IEP). There is an apparent increase in student achievement in the provincial assessment test, Ontario's Education Quality and Accountability Office (EQAO) (Egodawatte, *et al.*, 2011).

Main and Bryer (2005) have conducted a long-term research which teams (collaborative groups) have been observed during 3 years. Local middle schools are observed on ongoing experiences. These observations have occurred in the course of teaching middle school classes as a participant-observer, conducting a single case study of a state P-12 school that established a middle school program. With respect to data gathered in the research Main and Bryer observed an increase in student learning with respect to many variables.

2.4.1.1. Organization Oriented Benefits. Gable and Manning (1997) discussed the impact of collaboration in school reform. With respect to research data, collaboration supports an environment which seeks for new aspects, opportunities and attitudes (Gable and Manning, 1997).

Slavit and his colleagues discusses six teacher groups' time spent working with data and time devoted to particular kinds of inquiry activities by teachers. Research group make use of a framework useful for collaboration. Collaboration provides a cultural shift to more equity for school society, school-wide attention for the mathematical needs of all students and flattened power structure (Slavit *et al.*, 2011).

Westmeister (2008), in his book chapter, states as an addition to benefits of teacher collaboration to students and teachers, he stated as the benefit of collaboration as making ideas matter and realising a culture of intellectual enquiry: fostering of a professional culture of intellectual enquiry in the workplace and pursuing democracy and a communal way of life (Westmeister, 2008).

2.4.2. Teacher Oriented Benefits

Lyailya Shakenova (2017) conducted a research to examine the literature on collaboration with a deep analyses of collaborative culture. In her study, she analysed 334 articles and 52 books. With respect to her analyses; Hargreaves (1994) stated the positive impact of collaboration on teacher efficacy, professional development and learning

opportunities, responsibility for work, reflection on instructional practice and reducing work overload. (Shakenova, 2017). Johnson (2003) states that collaboration creates opportunity to learn from each other for teachers. Also, collaboration is described to be effective for teachers to make networks which can help them to share their reflective experience, evaluate beliefs on teaching and learning and also knowledge construction in a group (Achinstein, 2002; Chan and Pang, 2006; Clement and Vandenberghe, 2000).

In their study, Collaborative Teacher Inquiry Project, researchers had looked for the impact of project not only on students but also on teachers. The data gathered from different schools which joins the project, shows the qualitative evidence, that an improvement in goal achievement, increased capacity to initiate and improve professional development, decreased workload with co-planning, co-teaching possibilities, increase in efficiency, communication and technological skills (Egodawatte, *et al.*, 2011).

Main and Bryer (2005) at the end of their long-term research, have resulted that teacher in middle schools have improved teacher motivation, teacher collegiality, reduced personal isolation, increased sense of work related enjoyment in a manner of socialisation and raise in professional dialogue, sharing ideas and resources (Main and Bryer, 2005). Where Johnson (2003), in the same direction with Main and Bryer stated the increase in teacher morale, moral support, increased opportunities to learn from each other (Johnson,2003).

Westmeister (2008) in his book chapter at Handbook of research on teacher education (Cochran-Smith, S. Feiman-Nemser, and J. McIntyre, pp. 756-782, 2008) stated improving teacher practice, chance to work as leaders of the school site, increased probability for learning from novice teachers and reduced alienation (Westmeister, 2008) for the collaboration among teacher in PLC settings.

On the report published by Bill and Melinda Gates foundation, benefits of collaboration at professional learning communities are listed as Overall satisfaction with day-to-day "workflow" with 47%, perceived effectiveness with 59%, aid to differentiate with 50% (Bill and Melinda Gates foundation, 2015).

Reeves and his colleagues conducted a quantitative study that examines impacts of collaboration with respect to type and frequency of collaborative activity. Collaborative activities are discussing how to teach a topic with other teachers, collaborating in planning and preparing instructional materials, sharing teaching experiences, visiting other classrooms to learn about teaching, and working with other teachers to try out new ideas. With broad data provided by TIMSS research group had compared teachers and students in Japan and the USA. Even there is not statistically significant relation for the Japanese teachers(N=181), for the USA based participants(N=559), collaboration during planning (p=0.02), working collaboratively on new ideas(p=0.05) and sharing teacher experiences (p=0.08) are found to be significant predictors for job satisfaction (Reeves *et al.*, 2017).

2.4.3. Structure and Purpose of Collaboration

Because of the unclear and not unified boundary of collaboration (Kruse, and Louis, 1995), there are numerous studies in a descriptive manner which is needed to be discussed in a manner of the theoretical framework. Moreover, the literature contains more empirical and/or descriptive studies that enlighten the focus and depth of the collaborative work.

For a deeper understanding about the collaborative attitude of teachers, gaining insight view for the focus of teacher collaboration and the level of depth is important (Vangrieken, *et al.*, 2015). Because there is not a consensus about the definition of collaboration; different assumptions, types, procedures which means different frameworks appears on the literature.

To start with Little (1990) there are four different steps explained which range from independence to interdependence. They are storytelling and scanning for ideas, aid and assistance, sharing and finally joint work. For the independence steps of the collaboration Little stated storytelling and scanning for ideas and also for the interdependence steps of collaboration aid and assistance and sharing takes place. When the terms are considered, it is clear that scope of the collaboration increases from soft

interaction to mutual increase in planning, acting and assessment which brings more conflict. As a final step which is considered as the highest level of interdependence, joint work becomes the advanced level of collaboration. For the process of joint work, it is the process which the shared responsibility for the work of teaching (Little, 1990).

When there is a need to define a purpose for Collaboration, first classification can be made within grade and cross-grade level collaboration (Supovitz, 2002). In addition to grade level, in the literature there are studies which may classified with respect to disciplinary and interdisciplinary property of the studies. For the disciplinary collaboration, it is meant to be collaboration of teachers who are teaching same subjects and interdisciplinary collaboration it is meant to be collaboration of teachers from different subject areas (Vangrieken, *et al.*, 2015).

With respect to detailed review of Vangrieken, it is stated that teachers tend to collaborate with colleagues from same grade level. Also, interdisciplinary collaboration is higher than disciplinary collaboration in current literature (Vangrieken, 2015).

In their research, Gajda and Koliba have stated the purpose of collaboration with respect their framework development study as setting goals for instruction, public sharing of practices, observation and examination of collaborative behavior, feedback on team performance, accountability and responsibility to others (Gajda and Koliba, 2008).

Havnes (2009) classified teacher collaboration with respect to interaction processes of teachers which are preserving individualism, coordination, and cooperation sharing. (Havnes, 2009).

These four class have a hierarchical order which simply covers focusing on individual teacher responsibility and autonomy, without a discussion about the content of teaching coordination of responsibilities and staff to do, by focusing on the content and process of classroom activity organization of a common understanding for a joint enterprise and finally sharing and clarification of pedagogical motives (Havnes, 2009;

Vangrieken, *et al.*, 2017).

The researchers from different cultures Paine and Ma (1993), from the USA and China wrote their field observation and professional experiences in China. In this study, collaboration is categorized with respect to four different types with the names informal, invisible, distanced and jiaoyanzu (Paine andMa, 1993). In a school setting, there are teachers with different experiences in different professions at different ages. So, the collaboration encouraged by these different status among teachers is called informal collaboration which appears with respect to social norms. School is a living mechanism and it cannot be simplified to a place where just teachers and students come together. So invisible collaboration is defined as the interaction between staff members and school setting. Even physical distance is important for sharing, teachers are reading journals and stories in books which affects their plans, assessments and teaching skills. When a teacher or teachers benefit from such a source the process called as distanced collaboration.

Last type of the collaboration, given in japanese as jiaoyanzu, is the type of collaboration which appears as the most obvious way to work together among Japanese teachers overall the country throughout the elementary and secondary school. Elementary teachers in Japan, are organized by jiaoyanzu groups. For the group they have a leader which knows as the best. The leader is also the one who the principal of the organisation prefers to work with instead of individual teachers. Within a jiaoyanzu group teachers have a common place instead of personal space. Teachers, for example, do not have their personal desks in classrooms but they have a teacher (jiaoyanzu) room. There are weekly group meetings and frequent group activities to improve educational practice. In these meetings, teachers discuss the national teaching strategy, design lesson plans, organize student meetings for feedback, organize peer observation and inservice teacher evaluation meetings, support pre-service teachers and facilitating the induction of new teachers (Paine andMa, 1993).

Hargreaves (1994) describes collaboration as a culture and so it needs to be unpredictable, spontaneous, voluntary, development oriented, incisive over time and

space.

Also, collaboration needs to evolve from teachers not by administrators, but they may support this collaborative culture. With respect to research data, Hargraves state that collaborating teachers need to believe working together is productive, enjoyable and valuable (Hargreaves, 1994). With respect to results of the study, scheduled meetings are important and needed but it is not the main way in which teachers work together. In that manner, Hargreaves describes a collaborative group which the result of collaboration does not need to be predicted.

DuFour (2004), as the leading researcher working the PLC framework, stated three big idea mentioned before. When second idea is considered, it gives a clear direction about a culture of collaboration. Collaboration in DuFour's description involves a process to analyze classroom practice and improve it in order to increase the number of students who are not left behind. For such a learning environment, teachers work together in all manners. However, DuFour (2004) detailed collaboration with five important elements. First of all, all teachers belong to a team and show active participation within this team. Secondly, teams meet regularly in workday throughout the year. Third, teams work on answers to the question which are crucial and related to learning. These questions may be about learning outcomes, assessment, individual or overall student progress, lessons and strategies related with lessons. Forth, teams generate statements which are norms and agreements. With these agreements, all the participants of a team expectations, roles, responsibilities and relationships become clear. Finally, teams have a lens which is in harmony with the school, district or country-based goals (DuFour, 2004).

Collaboration in another study, is defined as teachers' cooperative actions like doing things together (Kelchtermans,2006). Kelchtermans stated a difference between collegiality and collaboration. That is, collegiality refers to the quality of the relationships, while the collaboration is actual actions (Kelchtermans, 2006).

Lavie (2006) discussed five property of collaboration. These are, namely, cultural, effectiveness, school-as-community, restructuring and critical discourses. Cultural discourse on teacher collaboration provides a view about beliefs and values in collaborative groups. The effectiveness, secondly, focus on leadership skills like shared vision, consensus in practices and increased expectations. When the school is considered as a community, there are things to consider like caring, acceptance of others, inclusivity in the school community. With the restructuring, Lavie considered the teachers' role outside the of the classroom. On critical dimension, collaboration is described as a collective and participative practice with shared reflection.

The UK has analyzed 18 primary school in Wales (James, Dunning, Connolly, and Elliott, 2007). Researchers defined collaboration as joint working. It is concluded that, everyone in the team has equal rights and their contributions is equally valued even their professions are different. In the study, a collaborative practice model is proposed with three linked foundational elements; collaboration, reflective practice and focus on the primary mission which is increasing the benefit of all students from learning process (James *et al.*, 2007).

On a nationwide study made in Sweden and Greece, 1160 teachers attended to study in order to highlight teacher collaboration. With respect to results of the study collaboration is defined with respect to categories: formal cooperation, deprivatized practices and personalized interaction. Scheduled meetings are considered with formal cooperation, deprivatized practices are considered as lesson planning, sharing lessons or working on common projects as a group. Personalized interaction on the other hand, is stated as professional closeness which sharing and working together are kept private (Kougioumtzis and Patriksson, 2009).

In another study, made in Beijing, China 210 teacher from secondary and high schools are surveyed for the collaborative practice (Tang Keow Ngang, 2012). Ngang, guided the study with six teacher collaboration dimensions: creating energy, building capacity, securing environment, extending the vision, meeting and minimizing crisis and seeking and charting improvement. To start with creating energy, this dimension refers

to the teachers work and learn together to teach. . Building capacity is described when teachers provide higher achieving students to lead a process or make extracurricular activities. Securing environment as the third dimension, is about keeping learning environment safe and set for learning. With the extending vision dimension, it is expected from teachers to spend time to realize the mission and vision of the institute, and also expand them. In crisis management dimension, teacher, student, parent triangle is set to manage student behavior and progress. At the final step, for seeking and charting improvement, teachers share idea and techniques or attend workshops for professional development and so for institutional development (Tang Keow Ngang, 2012).

Just like in this research, need for a clear definition of collaboration exists in also literature. Honingh and Hooge (2014) have conducted a research 614 primary and secondary school teachers to state the extent that teachers collaborate and to identify the impacts related with teacher collaboration. In this research, collaboration is described as intellectual interaction between teachers about curriculum and instruction. In the analysis of research data, working together in an intellectual way is accepted as the first step for deprivatization of teaching practice (Honingh and Hooge, 2014).

In addition to the clarification on theoretical framework, Wiggins and Damore (2006) have worked on a framework to assess effective collaboration. A collaborative group has defined with the elements, positive attitude, benefits, team proces, resources, leadership and professional development. Within these elements levels of collaboration is classified as initial level, emerging level and effective level with respect to structure of collaboration (Wiggins and Damore, 2006).

Teacher collaboration is a popular issue for researchers. Terminological, conceptual and contextual variety hinders a consensus for a common framework. The purpose of literature review chapter for this research is bringing existing theories into the open. However, in order to provide a clear understanding for the collaboration, literature is filtered with respect to theoretical framework of the study. So, PLC related studies have more detailed investigation among other theories. The purpose of in-depth de-

scription of PLC is to provide a complete understanding. PLC is used as a framework for the rest of the study to represent collaboration. Existing structures of the collaboration is also discussed with purposes and benefits in order to get evidence for the need of teacher collaboration for STEM teaching and learning implementation process. Also, even the variables used in this study is discussed with details major themes are mentioned with the interpretations of different researchers and research teams.

3. SIGNIFICANCE OF THE STUDY

As discussed earlier, STEM teaching especially in an integrative manner requires partnership both inside and outside the school walls. This partnership needs to be strong especially "inside the school walls' (Metz, 2009; Merill *et al.*, 2012). Even though there is a broad field to study in STEM education, most of these studies are based on multidisciplinary STEM activities while implementation has studied less in the literature (Brown, 2012). With respect to Brown's systematic review of the literature, 50 of 61 studies are assigned as Integrative STEM Studies while only one is labelled as Implementation study (Brown, 2012).

A successful STEM Implementation, on the other hand, has its most important barriers as lack of preparation for the implementation, lack of pd and lack of effective collaboration inside and outside the school (Eijwale, 2013). In this case, collaboration among STEM teachers appears as an important topic to be studied.

The collaboration among teachers is studied under many different terminologies like team, group, Community of Practice, Professional Learning Community, etc. Literature on collaboration mostly focuses on the effects of teacher collaboration, why teachers should collaborate and what is needed to collaborate but not focused on clear and empirical insight into characteristics of teacher teams (Vangrieken *et al.*, 2015).

With this study, having an insight for teacher collaboration, specifically STEM teachers, is aimed. Even the results are limited with the cultural theme of the research site, collaborative perception, attitude and needs for effective collaboration are investigated deeply in this study. The study is limited with 33 teachers from science, math and computer science departments. But, a detailed observation and description of the research site and demographic properties of the participants (via two different quantitative instrument and semi-structured interviews) are gained an insight for the case studied in this research which is teacher collaboration in STEM fields.

In addition to the importance of the study for the literature, the subject school has the potential to use the findings of this study as a field report in order to understand their needs for a successful STEM implementation process, in case of effective collaboration. Also, the subject school has an important position to lead the innovation for Turkey. So the actions that is possible to be taken by school administration with respect to results of this study, will provide a consolidation for other schools that have similar vision for education.

4. STATEMENT OF THE PROBLEM

The researcher of this study is also a teacher of the subject school. As a continuous follower of STEM applications and research, the researcher has an active role in the development of policies related to STEM education and innovation in education. For the educational year 2019 2020, the Executive Committee of the subject school has approved the establishment of an Innovation Center to encourage and help the development of multidisciplinary and interdisciplinary activities within the framework of STEAM (Science, Technology, Engineering, Arts, and Mathematics). Details of the Innovation Center will be discussed in Methodology part.

Beside his personal interest as a member of the organization committee of Innovation Center, the researcher has a role in the implementation of STEAM education. Even the implementation of STEAM education differs from country to country, school to school, literature shows that there is a clear and positive impact on students' achievement in many aspects (Capraro and Han, 2014). In addition to these differences, common ground in all successful implementation examples is that teacher work together on correlated subjects during all aspects of teaching and learning process (National Research Council, 2011).

4.1. Rationale of the Study

When the purpose of the Innovation center is considered, prerequisites of STEM Implementation process becomes an important variable for a student-oriented implementation process. That is, fixed systems in education are said to be safe since its non-risk-taking nature. However, the reform process has always its costs and benefits together. Educational reform process includes students who are affected by every small change in educational practice, but costs are not easy to undertake like any other fields. That's why, preparation for a reform process needs to be assessed carefully to decrease the cost of change.

STEM education with an integrated framework (Sanders, 2009) requires a change in current shape of departmentalization in school setting. With such change, an important dimension, collaborative working skills, becomes more and more important for comprehensive and interdisciplinary teaching and learning approach especially for the teachers in the field of STEM (Capraro *et al.*, 2013; Gonzalez and Kuenzi, 2012).

Even the subject school, as will be discussed in methodology, has high participation on existing STEM activities, a shift in teaching and learning is possible with actions to be taken by Innovation Center. In such an emerging environment, there is an obvious need for an analysis of current attitude and variables affecting the reform process. For a successful mechanism, one of the most important prerequisites is collaboration among teachers. (Corlu, *et al.*, 2014). Definition and scope of collaborative work is not clear in the literature. It is observed that, this not because of the limitations of the theoretical foundations, but because of the difference at the perceptions of teachers, researchers, principals and other stakeholders in education. During the preparation period of this study, the researcher has an exact result of informal observation (made with colleagues) that shows each teacher has a different conception for collaboration and its dimensions. This variety requires a clarification and analysis to provide an institutional collaborative environment for a successful STEM education. That's why researcher of this study has decided to conduct a research on STEM Fields Teachers' collaborative attitudes and for the variables affecting the collaboration with respect to current literature. Also, by using the Hord's Professional Learning Community Framework, the researcher tries to provide a basis for assessing personal and institutional performance in a manner of collaborative work.

4.2. Research Questions

(i) What are middle and high school science, mathematics and computer science teachers' contextual perceptions (shared and supportive leadership; shared beliefs values and vision; collective learning; shared practice; supportive conditions) about teacher collaboration in a private foundational school?

(ii) What are middle and high school science, mathematics and computer science teachers' procedural perceptions (dialogue, decision making, action, evaluation) about teacher collaboration in a private foundational school?

(iii) What are the science, mathematics and computer science teachers' current attitudes for teacher collaboration in a private foundational school?

(iv) What is the reciprocal effect of school characteristics and actions on the variation of teachers' perceptions and attitudes about teacher collaboration?

5. METHODOLOGY

5.1. Research Design

5.1.1. Introduction

This research study used explanatory sequential mixed method design (Creswell, 2012) which quantitative data collected and analyzed first, then the qualitative data is collected. Quantitative data is collected through Descriptive Analysis Teacher Questionnaire, School Professional Staff as Learning Community Questionnaire and Teacher Collaboration Assessment Rubric. With respect to analysis of quantitative data, a study group is formed to conduct semi-structured interviews that provide extensive data to understand the needs of effective collaboration in depth. Online documents are used to explore the research site.

Since the study is planned for the needs of the subject school, the results derived from the study is specific the subject school. So, the teacher collaboration for the subject school appears as a specific case in this study. When the focus group of the study is considered it has the characteristics of ethnographic case study. In addition to ethnographic property, there is a reform process in the field of school management and decision-making mechanism. One example of these mechanisms is Advisory Committee on Technology/ Innovation Policy and Innovation Center structure. Since one of the focus of this committee is STEM teaching and learning an action research focuses on STEM related teachers that reveals the attitude and needs of collaboration is seen necessary. So, this study is designed as a descriptive case study in which explanatory sequential mixed method design is used for data collection and analysis.

Even the qualitative and quantitative part seems convergent, quantitative part of the study focus on the definition of the current status and qualitative part focuses on in depth understanding for successful STEM implementation by focusing on collaborative needs. The quantitative data provides a wide variety of information about

collaboration, for the qualitative part of the study increasing the collaborative working habits for the integrated teaching both disciplinary, interdisciplinary manner is chosen for the main focus for a successful STEM implementation process.

Variety in the definition of collaboration, shows its impact on teachers' perceptions. Different skills and attitudes are considered as collaboration for teachers. For this study collaborative skills in a school setting are defined as observing other teachers in class, teaching jointly, engaging interdisciplinary and transdisciplinary activities, exchanging teaching materials, engaging about the learning development of specific students, working with others to ensure common standards for assessing progress, team conferences, and taking part in collaborative professional learning. Frequencies of the collaborative skills which teachers use are measured. When teachers' contextual and conceptual perceptions are measured with the collaborative skills, a descriptive definition for collaboration is derived for the subject school.

When the qualitative part of the study is considered, it is aimed to elaborate teacher collaboration for the subject school. With respect to analysis of quantitative data, respondents are chosen for semi-structured interview to explore the highlights for the good collaboration. An action plan is derived for the subject school to improve collaborative practice for the STEM implementation process.

5.2. Research Site

In Turkey, there are 3 different types of school with respect to proprietary characteristics: public schools, private schools, and foundation schools. All these three types of schools are registered and accredited by the Ministry of National Education (MNE). Public schools are the ones that are administered and funded by the Ministry of Education and are totally free. Private schools are the private enterprise of the owner. Even for private schools, school manager principal, is appointed by MNE which looks for legal qualifications. Foundational Schools are the ones which are non-profit organizations and managed by a board where school principle operates dependent to them. When these types are considered, it is easy to see that three different school culture

comes with these structures.

In general, a study which focuses on one of these three types of schools won't be cumulative for all. However, these three cultures vary with respect to so many variables and so it is almost impossible to drive a cumulative result unless a nationwide study is made. For this study population is selected through purposeful sampling for the following reasons.

Since the education is an ever-growing process, being up to date is hard for most communities. For the subject school, there are 220 teachers according to 2018 -2019 data. For this group of teachers, seven different professional development opportunity is provided. They are SUNY Master's Program, Bogazici University Mini Master's Program, In-house Ed-Tech Trainings, Principals Training Center (PTC) Programs, Harvard Graduate School "Leading Learning" Certificate Program, Language Training Program and Understanding by Design (UbD) Training and Mentoring. Teachers that appear in national and international seminar and conference programs have a positive impact on following the trends in education.

Even the K-12 education is a continuous process in a manner of curriculum implementation, connection between middle school to high school and connection between the undergraduate education are made through high stakes exams. However, the subject school provides all four levels: pre-school, elementary school, middle school and high school. It means a student who is registered for pre-kindergarten level has a chance to complete high-school education if the requirements are met. It is important for two reasons; first continuity of students through the levels puts vertical alignment on agenda for school success. Secondly, most middle school students, willing to continue to high school for the same school. The ratio of students that are registered to high school from middle school is 95% with respect to 2017-2018 data. This creates and opportunity to stay away from to stress that is caused by the fear of success at high stakes exams. These exams are based on multiple choice questions which an exam preparation period is required. Narrowing curriculum with the exam related topics and drill-like teaching to the test, would undermine the country's ability to produce critical

thinkers and innovators that is the most common problem of these exam preparation period. That's why both teachers and students have a chance to focus on learning by taking school's mission and vision into account.

University entrance exams are also another problem that challenges the quality of education. That is, most schools targets university entrance exams as an indicator of success. When the focus turns to exam success rather than learning, both students and teachers have their focus on exam related objectives. In this case, paid attention to contextual or conceptual learning is shifted to discipline-based content knowledge with the exam focus. On a research made on students who are registered to university exam training centers, only 0.7% states that they use the center to support school while 98.0% states that the course is the place they prepare for exam since teachers in school are not dealing with exam preparation. For the same research 49.7% of students says there are less chapters covered in the center however, 85.4% thinks that they will get a better score in the exam thanks to the training center (Yesilyurt, 2008). When these results are interpreted, if a school turns to exam preparation center students will have the same benefit from school but the point of the school is shifted from education to exam preparation. However, with respect to 2018-2019 data 85% of 12th grade students have acceptance from overseas universities mostly from the USA, Canada and the EU. This fact creates an alternative for educational approaches since extra curricular studies, project work, interdisciplinary skills and attitudes are important aspects for acceptance especially for the USA and Canada. For the overseas applications, students take SAT and/or AP Exams that multiple choice and free response or essay questions are asked together. In addition to exam scores, students extra-curricular activities are as important as exam scores for their application and approval process. While the expectations are based on student experience, a collaborative environment for teachers is required for providing appropriate environment for students.

Even the STEM education is relatively new in Turkey, the subject school has a background in student centered projects and a special interest in STEM related disciplines. Students work on project based on practical applications like hackathons, robotics or engineering competitions; or theoretical and experimental science projects

and olympiads organized by The Scientific and Technological Research Council of Turkey (Tu¨rkiye Bilimsel ve Teknolojik Ara¸stırma Kurumu [TUBITAK]) or other national and international organizations. Many students present their research projects in seminar programs. The subject school has wide opportunity for scientific research and engineering projects. There are physics, chemistry, biology, engineering and computer science labs that are full of materials for research and student projects.

Subject school with the 2018 2019 education year goes into a strong change with a new assignment of the headmaster. Even the subject school has its own characteristics, last changes also creates the rationale of this research. The first change after the headmaster's inauguration is the formation of the Executive Committee (EC). After the formation, the EC is positioned as the decision-making authority that provides the shared responsibility and school wide control. Submissions to school principals are evaluated in weekly meetings and act is taken with respect to school mission and vision. The EC consists of school principals, director of finance and administrative affairs and human resources head. Taking decision making mechanism from the responsibility of one person to a group of people increased rate of developmental acts that are discussed as follows.

Shifting from board oriented management to management by multiple committees under the control of board has changed the decision-making process in school. As the first act of EC, Advisory Committee on Education Policy is established. Committee consists of two university members and all principal and vice principals from preschool, kindergarten, primary, middle and high school. The Advisory Committee for Education Policy serves at the pleasure of the Founder's Representative and the Executive Committee. It is the role and the sole prerogative of the Executive Committee to enact education policy. The Advisory Committee is expected to offer recommendations for instructional programs and to provide information relevant about the teaching and learning to the general manager and the executive committee.

The Committee is created to carry out work in collaboration with all relevant parties and shall limit its activities to advising on matters that directly concerns the

educational system. The specific objectives of the Committee include evaluating subject school's current academic performance and to research for greater academic quality at the subject school; reviewing the current teaching and learning in a holistic way, overseeing the ongoing and, when necessary, establishing new critical academic indicators periodically and communicating the end result to all related parties; proposing methods that will help capture the perceptions of institutional fit, climate or students' goal achievement through multiple programs of study and redefining excellence so as to guide towards a clear designation for a challenging but at the same time joyful learning process for school students.

In addition to Advisory Committee on Education Policy, Committee for Arts, Culture and Sports Events, Committee for Admissions Evaluation, Committee for General Data Protection and Advisory Committee on Technology/ Innovation Policy is also established. Teachers, vice principals and professionals that work on related fields are members of these committees.

Advisory Committee on Technology/ Innovation Policy has an emphasis for this research study. Committee has 10 members: one of the subject school's board members is the high school vice principal, one of the member is representative of the board and other eight members are out-of-school participants in positions like CEO, CTO of Turkey of well known, national and international tech-based companies. With respect to data provided, committee presents its objectives as to review the current teaching and learning practice at subject school in terms of its attainment of learning objectives; to well-prepare students for the future of technology and for the knowledge society; to evaluate school's current technology and innovation performance; to help modernize, integrate and support STE(A)M curricula, recognizing the increased importance of interdisciplinary, multidisciplinary and transdisciplinary approaches embedded in the K-12 structure and designing experiential opportunities to promote creativity across all disciplines; to recommend innovative technology where applicable throughout the school; to recommend methods that will increase the awareness of the students about the impact of technology on societal norms and public policy and to help incorporate the principles of social innovation into coursework; to teach students the essentials of

entrepreneurship and intellectual property rights and to carry out mentoring in the art of pitching and the process of designing.

As the last but not least, the most important detail that leads this study is School Innovation Center. Representors from science, math and computer science department come together with the purpose of encouraging and helping the development of multi-disciplinary and interdisciplinary activities at subject school, within the framework of STEAM. Even the Innovation Center has a broad field to work on it. The purpose of the center is declared -with the focal of STEAM education in harmony with subject school's mission and visionto promote STEAM learning activities with an experiential education that excites, engages, and enriches through a hands-on, learn-by-doing approach for subject school's students including creativity and critical thinking skills; to maintain PreK-12 horizontal and vertical alignment and provide a cumulative base for horizontal alignment; to promote opportunities for authentic learning between students and professionals in STEAM fields; to increase educational, physical and logistical opportunities for teachers to increase the quality of STEAM based applications; to develop sustainability projects with environmental citizenship focus for grades PreK-12.

When all these changes, especially the ones in the field of STEM education are considered, an action research focuses on STEM related teachers that reveals the attitude and needs of collaboration is seen necessary. That's why teachers from Science, Mathematics and Computer Science departments of middle and high school are chosen to be participants for this study.

5.2.1. Participants

In the school setting Science department is divided in two as the high school division and middle-elementary school division. There are 11 teachers (4 physics, 3 biology, 3 chemistry, 1 department head). For the middle school division, there are 5 teachers. For the mathematics departments there are two groups like the science department for the high school group there are 8 teachers and there are 8 teachers for the middle school department. Computer science department is working as a K-12

level. There are 5 teachers working in this department for middle school and high school classes. Since the CS department has its own schedule for k-12 integration, vertical alignment meetings are not presented for this department. In total there are 37 teachers are expected to participate in this study.

5.2.1.1. Quantitative Data Collection Participants. For the quantitative part of the study, data is collected through online and paper-based forms. Descriptive Analysis Teacher Questionnaire (DATQ) and School Professional Staff as Learning Community Questionnaire (SPSLCQ) is transferred to online platform and divided in 3 parts. With respect to pilot study conducted on two actual participants time needed to complete the online part is measured as 25 30 minutes. In order to let participants to complete the survey in their free time, the survey divided in 3 parts which takes 810 minutes to complete each part. TCAR is presented as hardcopy since the structure of the rubric is not suitable with any form of item types on Google Forms.

Online part of the study is presented to all 37 participants. Two of the participants refused to join the study and one of the participants has completed the online part except the TCAR rubric. Also one participant has submitted first and third section of the online part but not submitted the second, so the data is taken out.

Table 5.1. Department vs level crosstabulation.

		Level				
		Middle School	High School	Both, generally High School	Both, Generally Middle School	Total
Department	Science	5*	10*	0	0	15
	Mathematics	6**	7**	1	1	15
	Computer Science	0	2	0	1	3
Total		11	19	1	2	33
Note. *One of the teachers is the department head.						
**One of the teacher is department head and one of the teacher is vice-principal.						

A total number of 33 participants have responded to study. Teachers level and departmental variance are given in Table 3.2. Three of the participants are also de-

partment heads who also have classes but less than (10 to 12 hours) other teachers. Two of the participants are vice principals who have a small four to six hours of classes but mostly administrative work.

Table 5.2. Highest level of education and Level based department crosstabulation.

	Highest Level of Education				Total
	a.	b.	c.	d.	
High School Science	0	3	6	1	10
High School Mathematics	4	3	1	0	8
High School Computer Science	1	1	0	0	2
Middle School Science	3	0	2	0	5
Middle School Mathematics	3	2	2	0	7
Middle School Computer Science	0	0	1	0	1
	11	9	12	1	33
Note. a. undergraduate, b. master with thesis, c. master without thesis, Ph.D.					

5.2.1.2. Qualitative Data Collection Participants. For the qualitative part of the study seven teacher including the researcher of this studyare selected with respect to their departments and their levels. Two of the teachers are selected from middle school science department that shows attitude of high collaboration with respect to TCAR results and collaborative skills responses in DATQ. And two of the teachers are selected from high school science department since one of the teachers is the researcher of this study another teacher is invited to study group to limit impact of researcher as a participant. Other teachers are selected from high school mathematics department, middle school mathematics department, computer science department. While the representation of departments is the main prerequisite for the selection of each participants, teachers with high collaborative attitude, teachers who wants to collaborate more are chosen with respect to analysis of the quantitative data.

5.3. Instruments

To provide an in-depth understanding for teacher collaboration, four different instruments are used in this study. For the quantitative part of the study, Descrip-

tive Analysis Teacher Questionnaire (DATQ), School Professional Staff as Learning Community Questionnaire (SPSLCQ) and Teacher Collaboration Assessment Rubric (TCAR) are used. For the qualitative part of the study, semi-structured interview is made with participants.

5.3.1. Descriptive Analysis Teacher Questionnaire

Descriptive Analysis Teacher Questionnaire (DATQ) is adapted from Teaching and Learning International Survey (TALIS) in order to gather essential information from the participants. This instrument is planned as a demographic form by the researcher of this study. The OECD's Teaching and Learning International Survey (TALIS) has been developed as the project of the OECD Indicators of Education Systems (INES) project (OECD, 2009). TALIS is the first international survey that reveals the learning environment and teachers' working conditions (OECD, 2009). Since the purpose of DATQ is to collect information, TALIS questions are analyzed with respect to need of this study and eliminations are made. With the TALIS intention is to draw a picture of the different educational practices that is not all the sections of TALIS are represented in this study. For the DATQ, five parts are formed in harmony with the TALIS. They are, Background and Qualification, Current Work, Professional Development, Teaching in General, School Climate and Job Satisfaction (See Appendix E).

Background and qualification part of the DATQ consists of profession based demographic questions like work experience, level that teacher works, highest level of education completed before. For the current work part of the DATQ, a teacher's weekly schedule is considered. In other words, time a teacher uses for preparation, covering lesson, assessment and other work-related stuff is investigated. Teacher professional development is an important part of DATQ. Even most of the questions focus on last 12 months, there are comprehensive questions that investigate also the content of PD activities for the long term. Feedback part of DATQ helps the researcher to understand school setting and communication between hierarchical settings. Further information like categories of feedback, rate of feedback, source of feedback and outcome of feed-

back is questioned in this part. For the part of "teaching in general" questions are asked about personal beliefs on teaching and learning. Different teaching and learning strategies and frequency of using these strategies are asked for this part. For the last part of the DATQ, teachers' beliefs about school and their satisfaction for their job in general, and their job satisfaction with respect to school-based variables are asked. Questionnaire is prepared to present for online submission and the printed copy is also available. In total, there are 34 main questions to be answered.

For the category "Background Information" there are 11 main questions. Five of these questions are categorical demographic questions like level of education and gender. Four of these questions are numeric questions like work experience and age. Two of the questions are presented as multiple choices grid which have numeric and rating scale answers. Categorical answer in the question varies from "not at all" to "very well" which are coded 0 to 3, since not at all represents the absence of the variable.

For the category "Teacher Professional Development" there are 12 questions. Seven of the questions are Y/N questions which will be coded as 1 and 0. All these questions have sub-domains that details the question. Four of the questions are presented as multiple choices grid which have categorical answers. Categorical answers will be coded from 0 to 3 since the lowest level in answer includes absence of the variable. One of the question will have a numeric answer which is related with the number of PD activities.

For the category "Feedback" there are four main questions that are presented in multiple choice grid. Rows describes different variables like origin, method and source of the feedback. First question has categorical answers while the other answers have strength from zero to three.

For the category "Teaching in General" teaching habits are investigated under 3 main questions which are presented as multiple choices grid. For each question, rows represent different variables important on teaching while columns are adjusted to

strength of the related row. Numerical values for the columns will be coded from zero for “not at all” or “strongly disagree” to 3 for “a lot” or “strongly agree”.

For the last category “School Climate and Job Satisfaction” there are four main questions which is presented in multiple choice grid. For each question, there are numerous rows for different facts and columns are prepared for the first 3 questions from strongly disagree (0) to strongly agree (3) and for the last question from strongly disagree (0) to strongly agree (4).

5.3.1.1. Validity and Reliability. For the first part of the data collection process, Descriptive Analysis Teacher Questionnaire (DATQ) consists of questions that reveals demographic information about teachers’ background, qualification and current work, professional development, teaching in general, school climate and job satisfaction. All questions are prepared using Teaching and Learning International Survey (TALIS 2013). Since the purpose of the DATQ is to collect information to reveal demographic and descriptive statistics two different reliability analysis was carried out. For the first one, all 141 items are are tested. Cronbach’s alpha showed the questionnaire to reach acceptable reliability, $\alpha = 0.72$. Most items appeared to be worthy of retention, resulting in a decrease in the alpha if deleted. However 11 of the items like gender, department, age, primary duty are removed and Cronbach’s alpha would increase to $\alpha = 0.85$ with the analysis of 130 items. Detailed investigation of reliability scores is listed in Table 5.3.

Table 5.3. DATQ reliability score in details.

	Cronbach’s Alpha	Cronbach’s Alpha Based on Standardized Items	N of Items
Background & Qualification	0.622	0.492	10
Current Work	0.636	0.714	16
Professional Development	0.913	0.920	63
Teaching In General	0.814	0.818	24
School Climate and Job Satisfaction	0.725	0.804	28

5.3.2. School Professional Staff as Learning Community Questionnaire

School Professional Staff as Learning Community Questionnaire (SPSLCQ) measures the progress of a school and maturity level as PLC setting. There are five attributes focused on this instrument which are not empirical: shared and supportive leadership; shared beliefs, values, and vision; collective learning and its application; shared personal practice; and supportive conditions. Seventeen items, with five-point rating scale (1=low, 5=high), measures these five attributes (See Appendix E). For each item, three anchor statement that is equivalent to one, three and five points, are given to guide respondents. In total, there are 17 points minimum and 85 points maximum can be scored. Assessment of the instrument shows an overall construct for a total scale score that implies the degree to which teachers view their school as a positive learning community. Five attributes are also analyzed separately to gather more detailed information for contextual structure of collaboration.

5.3.2.1. Validity and Reliability. For the pilot test of the instrument made by Hord and colleagues (1999), 28 participants attended to study (Hord *et al.* 1999), and concurrently was assessed using the School Climate Questionnaire (SCQ). The correlation of the total scores of the SPSLCQ with the SCQ was 0.82. For the same test, Cronbach's alpha for the 17 items was 0.92 which indicates an appropriate instrument internal consistency. For the test-retest procedure, Cronbach alpha of the study is measured as 0.94.

For the current study Cronbach's alpha for the 17 items is calculated as 0.90. When the Cronbach's alphas for each dimension are calculated, it is 0.81 shared and supportive leadership; shared beliefs, values and vision has 0.682; collective learning and its application has .893; shared and personal practice has 0.818 and supportive conditions has 0.773 Cronbach's Alpha scores which all but shared beliefs, values and vision are acceptable.

A field test was conducted by Hord and colleagues with 690 teachers in 21 schools throughout Kentucky, Tennessee, Virginia, and West Virginia. Concurrent validity was assessed by administering a school climate instrument to a subsample (n = 114). The correlation between the SPSLCQ and the climate instrument was 0.7489 (p ¡ 0.001). Construct validity was assessed using the known-group methodology and factor analysis (Hord *et al.*, 1999). For the internal consistency of the study, Cronbach's alpha was measured as 0.94. Also, alpha reliabilities are calculated for the 21 schools who participate in the field test. The range of the reliability scores is between 0.62 to 0.95 with most scores are between 0.80s and 0.90s.

Content validity was assessed by Hord (1997) at three steps: development process, pre-review, and final reformatting of the instrument. For the development process, Hord established the content of the five attributes from her review of the literature (Hord, 1997), as well as through her field research with southwest U.S. schools that functioned as PLCs. For the pre-review part of the content validity assessment was conducted by three Regional Educational Laboratory Appalachia staff members, who independently reviewed the five dimensions and 17 descriptors. The instrument is slightly modified after the review to gain additional clarity and consistency. The content validity assessment was completed in the third stage after the Hord agreed with the proposed changes. In addition, the test-retest reliability coefficient was computed with a subgroup of four high schools. The calculated value for the total instrument was 0.6147, which was decided to be marginally satisfactory, with the potential to increase or decrease with changes in sample size (Blitz, Schulman, 2016).

5.3.3. Teacher Collaboration Assessment Rubric

Teacher Collaboration Assessment Rubric (TCAR) consists of 26 set of items grouped as 2, 1 and 0 points in 4 sub-categories: Dialogue, Decision Making, Action and Evaluation (See Appendix D). The four categories represent structural components of a cycle of team inquiry. The intent of the instrument is to analyze the behavioral, observable, and measurable attributes of rigorous preK-12 PLC's. Developmental, formative and outcome evaluation of collaborative groups can be empirically examined

with this instrument. (Woodland, H, 2016) Evaluators have used the TCAR in order to examine developmental and formative quality of PLC initiatives on instructional quality, student learning and other essential organizational outcomes (Woodland, H,2016).

5.3.4. Validity and Reliability

The TCAR has not been validated. However, an updated version of TCAR, namely teacher collaboration assessment survey is empirically validated (Blitz, Schulman, 2016). The TCAS was determined to be valid based on response processes (Woodland, Lee, and Randall, 2013). Preand post-survey administration interviews with school leaders and teachers and focus group interviews are used to generate evidence. Evidence in this scale measured the extent to which participants viewed and understood the TCAS items and instructions in the way instrument was intended. Construct validity is measured as adequate with respect to Rasch Analysis (Woodland, Lee, Randall, 2013). The convergent and divergent validity of the TCAS was measured by examining the relationship between the four components which reveals all the variables had positive relationships with another that demonstrates both convergent and divergent validity. For the overall outfit mean square of the instrument was 1.07, that suggests items in the scale work well together as the reliability of the instrument.

In this study reliability statistics is calculated through Cronbach's Alpha, which is measured as .947 for 26 items. Cronbach alpha measurements of the five attributes of SPSLCQ is listed in Table 7.4.

Table 5.4. Reliability measurements for five attributes of SPSLCQ.

	Cronbach's Alpha and Cronbach's Alpha	Based on Standardized Items	N of Items
Dialogue	0.743	0.759	7
Decision Making	0.834	0.831	7
Action	0.855	0.854	6
Evaluation	0.830	0.827	6

5.3.5. Semi Structured Interview Form

Semi structured interview is designed both to provide in depth understanding for the variables discussed in TCAR and SPSLCQ, and to discuss the result of the quantitative data to enlighten teacher needs for effective collaboration at the subject school. There are 13 main questions with various sub-questions to extend and deepen the conversation if needed. First 5 questions are prepared for the dimensions of SPSLCQ and next three questions are prepared for TCAR. Finally, the last 5 questions are prepared to discuss the quantitative result and teachers' needs for effective collaboration (See Appendix G).

Semi-structured Interview is made with 5 teachers. Two of the teachers are from middle school science department, one of the teachers is from middle school math department, one of the teachers is high school science department, one of the teachers is from high school math department and finally one of the teachers is from computer science department. Two teachers are selected from middle school science department since this department has relatively high scores for almost all categories than other departments.

5.4. Data Collection Methods

For the first part of the study DATQ and SPSLCQ instruments will be applied to the teacher participants. An online form is presented. The online form consists of 3 parts. For the final part of the quantitative part of the TCAR is presented as hardcopy with the instructions.

For the semi-structured interview data is collected via phone interview. Due to the the time limitation and summer break, face-to-face interview became impossible, so phone interview is preferred. Each interview takes 50 to 60 minutes and each participant completed interview in one session. Using headphones are suggested and time setting is made with respect to needs of the participants. Even guiding questions are used to drive the conversation, researcher of this study has let transition between

questions and themes. Main reason for this issue is to provide in depth understanding and reveal the facts that can not be enlightened via surveys and questionnaire.

6. ANALYSIS

For this study, both qualitative and quantitative data is collected. Quantitative data is collected through survey and questionnaire and qualitative data is collected through semi-structured phone interviews.

6.1. Analysis of Quantitative Data

All the quantitative data collected and coded through SPSS ver 0.24. 189 variables are created for the analysis of DATQ, SPSCLQ and TCAR. In addition to raw data, three variables are inverted since the items have negative implication which maximum point refers to minimum for analysis. They are "I regret that decided to being a teacher", "I would like to change to another school", "I wonder whether It would have been better to choose another profession". For the SPSLCQ questions one and two are combined for the variable, shared and supportive leadership score. Question three, four and five are combined to get shared beliefs, values and vision score. Question six, seven, eight, nine and ten are combined to calculate collective learning and its application score. Questions 11 and 12 are combined to get shared supportive conditions and finally questions 13,14,15,16 and 17 are combined calculate supportive conditions. These five new variables are also combined to get total score for SPSLCQ. For the dimensions of TCAR. Average scores are calculated: for dialogue score with items from one to seven; for decision making with items eight to 14; for action with items 15 to 21; for evaluation with items 22 to 27. TCAR overall score is calculated by combination of items one to 27. In total 220 variables are analyzed.

6.2. Analysis of Qualitative Data

For the analysis of qualitative data the technique, rapid identification of themes from audio recordings (RITA) (Neal, *et al.* 2015) is used as rapid evaluation and assessment methods (REAM; McNall, Foster-Fishman, 2007). With this method transcription is not made.

Before going into details of analysis data RITA is a relatively new method with respect to more traditional method. Therefore, advantages and disadvantages are needed be discussed with a convenience filter for this study.

Advantages specific to RITA will be discussed, for the general framework, REAM has the focus of time constraint which traditional methods are not possible to use. With RITA, also, expeditious identification of themes in qualitative data is maximized (Neal, *et al.*, 2015). However, theme identification techniques like RITA are reliable as coding from transcripts in traditional methods. (Gravois et al, 1992) This approach has the time and economic advantages associated with analysis of field notes, but like analysis of verbatim transcription maintains the benefit of identifying themes with a moderate level of detail based on all of the verbal information in the interview (Neal, *et al.*, 2015). Another advantage of RITA is the ability to capture nuance and using this nuance as an opportunity to capture the valance of particular themes (Neal, *et al.*, 2015). For the current study, if the position of the researcher is considered as a threat, the most important evidence appears for interviewing. Since the researcher and respondents are working in the same school, a social connection in addition to researcher-participant relation may be observed in sessions. Using this impact as an advantage is possible with RITA, by analyzing recordings in a context. Whether themes are mentioned in a positive, negative, or neutral context is important for this study, since the purpose is providing in-depth understanding. Disposition of the respondent is lost in transcripts or may cause misinterpretation analyzing via transcripts (Tessier, 2012). However, since the previously mentioned relation of the researcher with the participants will provide a background, disposition of the participants will be held in control for the analysis of qualitative data. RITA, is useful for identifying themes within a short time without loss of quality. However, this technique is should not be viewed as a standalone analysis technique. When the nature of this study is considered purpose of the qualitative part is to provide in depth understanding, create a position for emerging themes and to discuss quantitative analysis results. All in all, qualitative part of this study is designed with an assistive purpose which does not exceeds the RITA.

For the analysis of qualitative data, a codebook is created (See Appendix H). For the existing themes TCAR and SPSLCQ variables are used but an overview is made for confounding variables. First interviews are skimmed to find the needs to refine codebook. After the codebook is created a coding form is also made with positive contribution, negative contribution, neutral contribution, yes and no signs. When the purpose of the interview and structure of interview questions are considered, keyword-based coding system is not used. However, thematical coding is made with detailed sub categories.

Time length for period is divided for 5 minutes which roughly represents the time that participants mostly use to answer a question. Refining the coding form is made during analysis. First of all, there is a need for adding comments during analysis for making interpretation easier. In order to make an useful commenting system extra codes for commenting is created. Each time section is labeled with letters and each category detail is labeled with a number. So, the researcher used this system to make comment during analysis (See Appendix I). Since the number of participants for the qualitative data is not high, such a review is easier and inclusive. To make analysis easier, the coding form is printed in A3 size to fit all variables in a page. When the coding has completed, analysis for frequencies of negative, positive and neutral indicators has made.

7. RESULTS

Online part of the study is presented to all 37 participants. Two of the participants refused to join the study and one of the participants has completed the online part but did not submit the TCAR rubric. Also one participant has submitted the first and third section of the online part but not submitted the second section, so the data is taken out. So, the quantitative part of the research is finalized with 33 participants. During the analysis, descriptives are used to reveal mean, sum and standard deviation of variables. Also, cross tabulations are used to understand the characteristics of different groups as mentioned in the discussion part. For the qualitative part six interviews are made with teachers (See Appendix G). Analysis of the qualitative.

7.1. Cultural Structure

Since the educational research is strongly bounded with the participants of the study, a generalization will not possible. However, a detailed understanding of the culture is important to describe the case.

7.1.1. Demographic Characteristics

Eleven of the respondents are middle school teacher while 19 of them are high school teachers. Three of the teachers have classes both in high school and middle school. Teachers level and departmental variance are given in Table 3.1. Three of the participants are also department heads who also have classes but less than (10 to 12 hours) other teachers. Two of the participants are vice principals who have a small four to six hours of classes but mostly administrative work (see Table 7.1).

Table 7.1. Primary job and level-based department crosstabulation.

		Level Based Department						Total
		High School Science	High School Math.	High School Computer Science	Middle School Science	Middle School Math.	Middle School Computer Science	
Primary Job	Teacher	10	6	2	4	5	1	28
	Head of Department	0	1	0	1	1	0	3
	Vice Principal	0	1	0	0	1	0	2
Total		10	8	2	5	7	1	33

Even the undergraduate education for teaching is enough to work as a teacher, most of the teachers continue their education for various reasons. Just like professional development activities graduate level and studies are seen as a significant indicator for teaching ability (Forte, and Flores, 2014). Even the data is limited with the number of respondents, number of teachers with master and above is relatively high from teachers with undergraduate education (See Table 7.2).

Table 7.2. Highest level of education with respect to departments and levels.

		Highest Level of Education				
		Undergraduate	Master with Thesis	Master without Thesis	Doctorate	Total
Level Based Department	High School Science	0	3	6	1	10
	High School Mathematics	4	3	1	0	8
	High School Computer Science	1	1	0	0	2
	Middle School Science	3	0	2	0	5
	Middle School Mathematics	3	2	2	0	7
	Middle School Computer Science	0	0	1	0	1
Total		11	9	12	1	33

The subject school was founded more than 20 years ago as a primary school and gradually middle school and high school were established. Mean value of the respondents' experience at the subject school is relatively high when it is compared to mean value of the respondents' total experience (See Table 7.3). About 47% of respondents' teaching life is passed on the subject school which is an important sign for job satisfaction and school's opportunities with respect to other schools (Pelgrim, *et al.*, 2012).

Table 7.3. Experience at the school and in total.

	N	Min	Max	Mean	Std. Deviation
Experience at the Subject School	33	1	18	7.8485	4.38122
Experience in Total	33	3	30	16.6364	9.24263

7.1.2. Working Hours

For the subject school, a regular workday starts at 07:30 am and classes start at 08:10 am. Each weekday lunch break lasts 40 minutes and there are 9 periods of class on each day except friday. On Fridays, students have 8 periods of class. In total 44 class periods with a time length of 40 minutes covered in the subject school which makes 29.3 60-minutes hours. However, teachers leave the school at 16:30 on Monday, Tuesday and Thursday, at 17:00 on Wednesday and at 15:30 on Friday. All in all, teachers have 41work hours with the exception of lunch breaks. However, it is observed that most teachers use lunch breaks for extra studies with students.

Teachers working time is divided in groups as teaching, planning and lesson preparation, teamwork and dialogue and marking and corrections, counseling, participation in school management, administrative work, communication and cooperation with parents and extracurricular activities. Teaching in this questionnaire both regular classes and after school studies where the average is 16.8 60 minutes hours. Since the parent-teacher meetings are scheduled by the school administration, each teacher has a 40 minutes session which is divided for 4 parents. However, weekly reports, mailing is also added for this category (See Table 7.4).

When the time spend on teamwork and dialogue is taken into account mean value is calculated as 4.48 60 minutes hours. However, High School Computer Science department and Middle School Science department has an average significantly above the mean value (See Table 7.4).

Table 7.4. Time spend by teachers with respect to departments.

Level Based Department		Time Spend on Students Counseling	Time Spend on Participation In School Management	Time Spend on Administrati Work	Time Spend on Communication and Co-operation With Parents	Time Spend on Extracurricular Activities
	High School	Mean	16.6	6.6	2.5	4.1
	Science	Std. Dev.	4.14193	1.7127	1.2693	1.44914
	Department	N	10	10	10	10
	High School	Mean	14.625	6.375	4.75	2.25
	Mathematics	Std. Dev.	4.59619	5.31675	6.29626	0.70711
	Department	N	8	8	8	8
	High School Computer	Mean	19.5	9.5	7	7
	Science	Std. Dev.	7.77817	7.77817	4.24264	4.24264
	Department	N	2	2	2	2
	Middle School	Mean	21.4	7.4	6.2	4.8
	Science	Std. Dev.	4.03733	4.50555	2.38747	1.09545
	Department	N	5	5	5	5
	Middle School	Mean	13.5714	7.1429	4	3.4286
	Mathematics	Std. Dev.	5.34968	4.14039	2.64575	2.43975
	Department	N	7	7	7	7
	Middle School	Mean	30	10	12	10
	Computer Science	Std. Dev.	.	.	.	.
	Department	N	1	1	1	1
		Mean	16.7879	7.0606	4.4848	3.9697
	Total	Std. Dev.	5.60556	3.93652	3.95381	2.27053
		N	33	33	33	33
High School Science Department						
	Mean	1.8	1.3	3	1.5	1.9
	Std. Dev.	0.78881	0.48305	1.88562	0.52705	1.1005
	N	10	10	10	10	10
High School Mathematics Department	Mean	1.75	6.25	2.25	1.5	1.375
	Std. Dev.	1.38873	13.67741	1.58114	1.41421	0.74402
	N	8	8	8	8	8
High School Computer Science Department						
	Mean	3.5	3.5	7	2	2
	Std. Dev.	3.53553	0.70711	4.24264	1.41421	1.41421
	N	2	2	2	2	2
Middle School Science Department						
	Mean	1.8	1.2	3.2	1	2.4
	Std. Dev.	0.83666	0.44721	2.04939	0	2.19089
	N	5	5	5	5	5
Middle School Mathematics Department						
	Mean	6.2857	7.2857	3	4.4286	2.2857
	Std. Dev.	10.54695	14.46506	3.16228	6.94879	1.49603
	N	7	7	7	7	7
Middle School Computer Science Department						
	Mean	5	4	4	4	5
	Std. Dev.	.	.	.	.	.
	N	1	1	1	1	1
Total	Mean	2.9394	3.9697	3.1212	2.1515	2.0303
	Std. Dev.	5.04938	9.34908	2.38167	3.36453	1.40278
	N	33	33	33	33	33

7.1.3. Professional Development

Keeping up with the trends in education, being open for development are important aspects when teachers are in a reform process. Professional Development activities are one of the most important key for thinking about teacher's own teaching and working habits (Killion, 2015). For the subject school, 12.1% of teachers are not attended throughout the year while 24.2% attended only one PD activities. Also 63.6% of the respondents attended more than one PD activities (See Table 7.5).

Table 7.5. Participation to PD Activities.

	Frequency	Percent	Valid Percent	Cumulative Percent
Not Attended Any PD Activities	4	12.1	12.1	12.1
Attended One PD Activities	8	24.2	24.2	36.4
Attended More Than One Activities	21	63.6	63.6	100
Total	33	100	100	

Even PD activities shows their impact on educational life of teachers, 36.5% of respondents stated their activity as a network of teachers which provides a suitable background for teacher collaboration. In other words, openness for communication is implicitly provided with respect to the choice of teachers (See Table 7.6). Even most of the impacts of PD discussed in this study have close amount of weight, Cross-Curricular Skills and two important aspects appear as relatively high and low with respect to other impacts. Even the shared responsability for a collaborative workplace is one of the five key components of effective collaboration, respondents have a lack of enough PD activities and so low impact for school management and administration. Impact on cross-curricular skills on the other hand, has a strong impact than all others which is an important variable for STEM Implementation in a school setting (See Table 7.7).

Table 7.6. Type of pd activities.

		Responses		Percent of Cases
		N	Percent	
Type of	Qualification Program	8	15.40%	29.60%
Professional	Participation in a Network of Teachers	19	36.50%	70.40%
Development	Individual or Collaborative Research	14	26.90%	51.90%
Activities	Mentoring and/or Peer Observation by School	11	21.20%	40.70%
Total		52	100.00%	192.60%

Table 7.7. Impact of PD activities.

		Responses		Percent of Cases
		N	Percent	
Impact of PD Activities	Knowledge and Understanding of The Curriculum	4	5.80%	19.00%
	Pedagogical Competencies in Teaching Subject Field	7	10.10%	33.30%
	Knowledge of the Curriculum	6	8.70%	28.60%
	Student Evaluation and Assessment	5	7.20%	23.80%
	ICT Skills	6	8.70%	28.60%
	Behaviour and Classroom Management	8	11.60%	38.10%
	School Management and Administration	2	2.90%	9.50%
	Individualised Learning	7	10.10%	33.30%
	Multicultural and Multilingual Learning	3	4.30%	14.30%
	Students with Special Needs	5	7.20%	23.80%
	Cross-curricular Skills	10	14.50%	47.60%
	New Technologies	5	7.20%	23.80%
	Student career Guidance and Counselling	1	1.40%	4.80%
Total		69	100.00%	328.60%

For the subject school teachers' willingness for professional development activities are seen as an important strength of the school. Even the school provides PD alternatives like masters program and others, necessary adjustments are not made with respect to analysis of data. That is, 54.5% of the respondents stated that the time for PD activities are not scheduled for teachers. Also, salary supplement and non-monetary support is neglected by the school administration (See Table 7.8). When barrier for PD are asked to respondents as a separate questions feedback of the respondents are reliable with the schools' support. Pre-requisites, family responsibilities, lack of PD offerings, lack of incentives, budget, lack of support, conflict with work schedule are listed as the reasons for the barriers on PD. Mean value over 3 is assigned 1.6970 and 1.4242 for lack of support and conflict with work schedule respectively. For the

interpretation of data 3 represent strongly agree while 0 represent strongly disagree.

Table 7.8. School's support for pd activities.

			Participation to PD Activities			Total
			Not Attended Any PD Activities	Attended One PD Activities	Attended More Than One Activities	
Scheduled Time for Workinghours	No	Count	2a	4a	12a	18
		% within	50.00%	50.00%	57.10%	54.50%
		% of Total	6.10%	12.10%	36.40%	54.50%
	Yes	Count	2a	4a	9a	15
		% within	50.00%	50.00%	42.90%	45.50%
		% of Total	6.10%	12.10%	27.30%	45.50%
Salary Supplement	No	Count	2a	7a	16a	25
		% within	50.00%	87.50%	76.20%	75.80%
		% of Total	6.10%	21.20%	48.50%	75.80%
	Yes	Count	2a	1a	5a	8
		% within	50.00%	12.50%	23.80%	24.20%
		% of Total	6.10%	3.00%	15.20%	24.20%
Non-monetary Support For Activities	No	Count	3a	7a	16a	26
		% within	75.00%	87.50%	76.20%	78.80%
		% of Total	9.10%	21.20%	48.50%	78.80%
	Yes	Count	1a	1a	5a	7
		% within	25.00%	12.50%	23.80%	21.20%
		% of Total	3.00%	3.00%	15.20%	21.20%

Even there is a lack of institutional support for facilitating PD for the respondents, there is a lack of interest on PD in case of respondents too (See Table 7.9). That is, when the PD needs of the teachers is asked, high level of need is rarely seen with 6.5% ratio while no need has 25.6% and low level of need is chosen 39.6% for the listed categories of PD stated in Table 7.10.

Table 7.9. Teachers PD Needs in General.

		Responses		Percent of Cases
		N	Percent	
Need for PD Activitiesa	No need at present	110	25.60%	333.30%
	Low level of need	170	39.60%	515.20%
	Moderate level of need	121	28.20%	366.70%
	High level of need	28	6.50%	84.80%
a Activities are listed in Table 7.10.				

Table 7.10. Teacher's expectations about PD.

		Frequency	Percent	Valid Percent	Cumulative Percent
Knowledge and Understanding of Subject Fıeld	No need	11	33.3	33.3	33.3
	Low	17	51.5	51.5	84.8
	Moderate	5	15.2	15.2	100
Pedagogical Competencies in Teaching Subject Field	No need	11	33.3	33.3	33.3
	Low	14	42.4	42.4	75.8
Knowledge of the Curriculum	No need	19	57.6	57.6	57.6
	Low	8	24.2	24.2	81.8
	Moderate	6	18.2	18.2	100
Student Evaluation and Assessment	No need	11	33.3	33.3	33.3
	Low	13	39.4	39.4	72.7
	Moderate	8	24.2	24.2	97
	High	1	3	3	100
ICT Skills	No need	3	9.1	9.1	9.1
	Low	18	54.5	54.5	63.6
	Moderate	8	24.2	24.2	87.9
	High	4	12.1	12.1	100
Behavior and Classroom Management	No need	12	36.4	36.4	36.4
	Low	10	30.3	30.3	66.7
	Moderate	10	30.3	30.3	97
	High	1	3	3	100
School Management and Administration	No need	16	48.5	48.5	48.5
	Low	9	27.3	27.3	75.8
	Moderate	7	21.2	21.2	97
	High	1	3	3	100
Individualised Learning	No need	3	9.1	9.1	9.1
	Low	13	39.4	39.4	48.5
	Moderate	12	36.4	36.4	84.8
	High	5	15.2	15.2	100
Multicultural and Multilingual Learning	No need	8	24.2	24.2	24.2
	Low	15	45.5	45.5	69.7
	Moderate	9	27.3	27.3	97
	High	1	3	3	100
Students with Special Needs	No need	3	9.1	9.1	9.1
	Low	13	39.4	39.4	48.5
	Moderate	9	27.3	27.3	75.8
	High	8	24.2	24.2	100
Cross-curricular Skills	No need	3	9.1	9.1	9.1
	Low	15	45.5	45.5	54.5
	Moderate	11	33.3	33.3	87.9
	High	4	12.1	12.1	100
New Technologies	No need	3	9.1	9.1	9.1
	Low	10	30.3	30.3	39.4
	Moderate	17	51.5	51.5	90.9
	High	3	9.1	9.1	100
Student Career Guidance and Counselling	No need	7	21.2	21.2	21.2
	Low	15	45.5	45.5	66.7
	Moderate	11	33.3	33.3	100

7.1.4. Teaching Culture

For a successful STEM teaching and learning implementation process impact of collaboration is one of the most important variables (Brown, *et al.*, 2011). However,

for any process related with education, teacher quality appears as the most important variable for the success of an educational system (Hattie and Timperley, 2007). Measuring teaching quality or effective teaching strategies are challenging via self-reports, level agreement or in-class observation (Little *et al.*, 2009). Additional data that correlates students' achievement like PISA is needed for an effective strategy (Le Donne, Fraser and Bousquet, 2016). For this study teaching culture is analyzed with respect to groups effective teaching strategies, teacher-student interaction (clarity of instruction), classroom management while the teacher collaboration is held separately. Even self-reports are still used for this study relation between teachers' effective collaboration score, TCAR Score and SPSLCQ score provide an understanding for the quality of teachers' self-assessment.

For the effective teaching strategies four questions are asked to 33 respondents. Even the school mission and vision statement and data gathered for the projects completed by students give an information about teachers' views about effective teaching, data is in harmony with the researcher observation in the field. 97% of the teachers believes power of inquiry-based education while 93% also thinks that student-centered problem-solving strategies.%100 of teachers responded cognitive activation is the most important focus on educational process (See Figure 7.1).

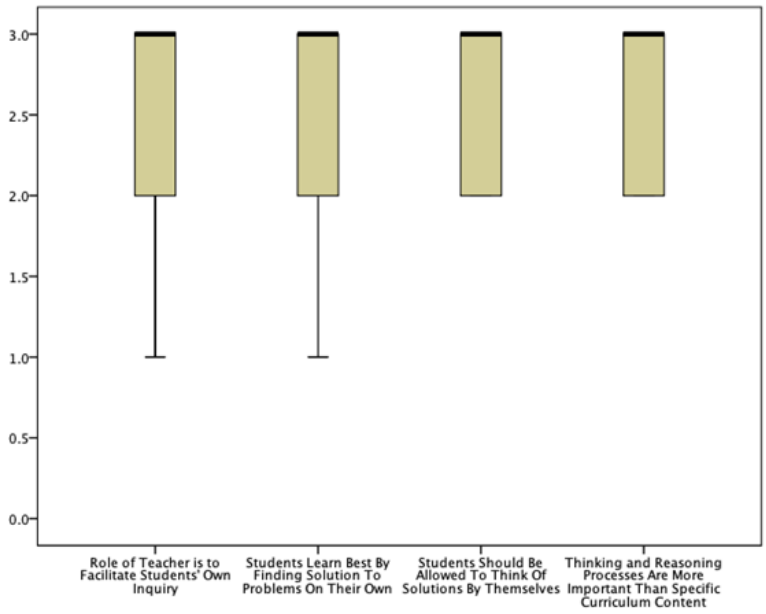


Figure 7.1. Teachers beliefs about effective teaching strategies.

As discussed earlier, measuring quality is a general problem in educational studies. Even the teaching strategies claimed by respondents are very close to today's needs, for more clarity respondents in and out of class interactions are questioned as a manner of teacher-student relationships and classroom management.

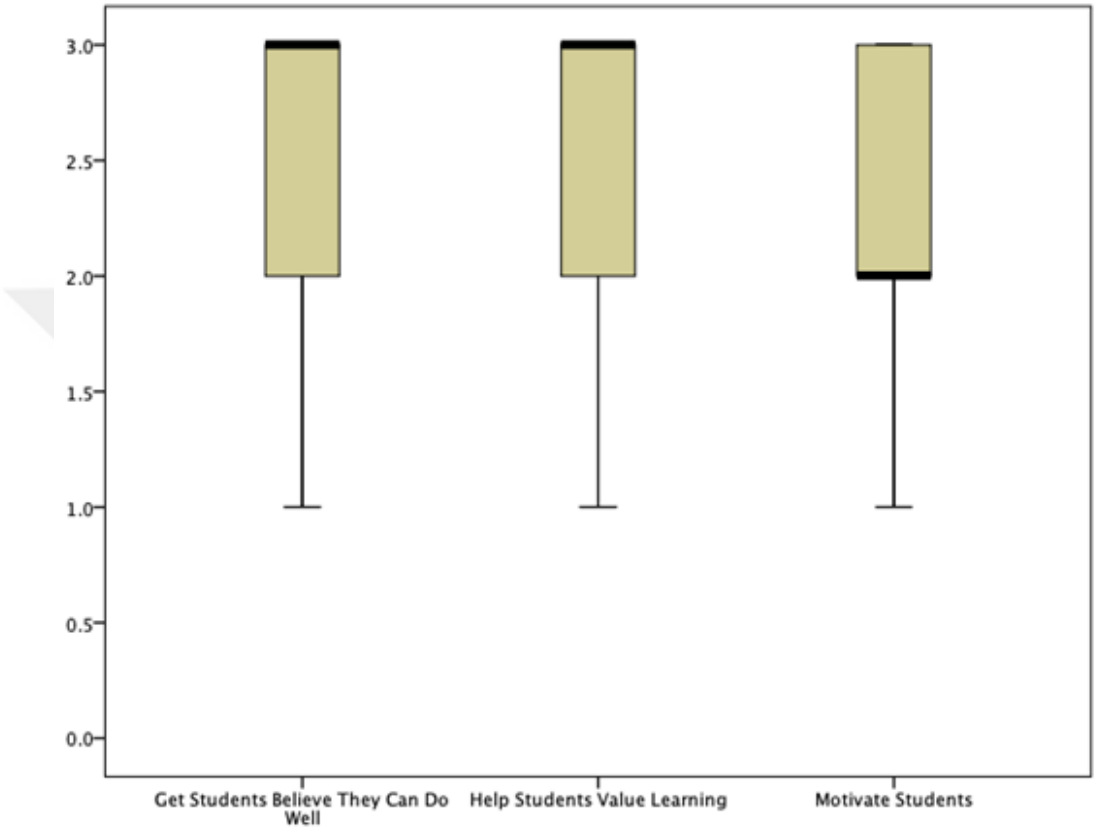


Figure 7.2. Teacher student relationship-interactions.

It is clear that teacher student relationship has an important aspect on students' attitude towards education. In this manner, teacher-student relationship is seen as an important aspect for a healthy school culture. Most of the participants shows extra attention to students' well-being (See Figure 7.2). While 97% of teachers get students believe they can do well, 80% of teachers motivate students for the lessons. Valuing the learning, on the other hand, has a 97% agreement by the respondents.

In addition to teachers' positive educational attitude towards students, ensuring the quality of instruction with respect to the needs of the students is also important. Even in depth research is needed to understand current status, with respect to feedback

collected from respondents, teachers plan their lesson and assessment plans with respect to needs of the students (See Figure 7.3). That is, using alternative instructional strategies, assessment methods and creating a student-oriented learning environment is quite popular among teachers.

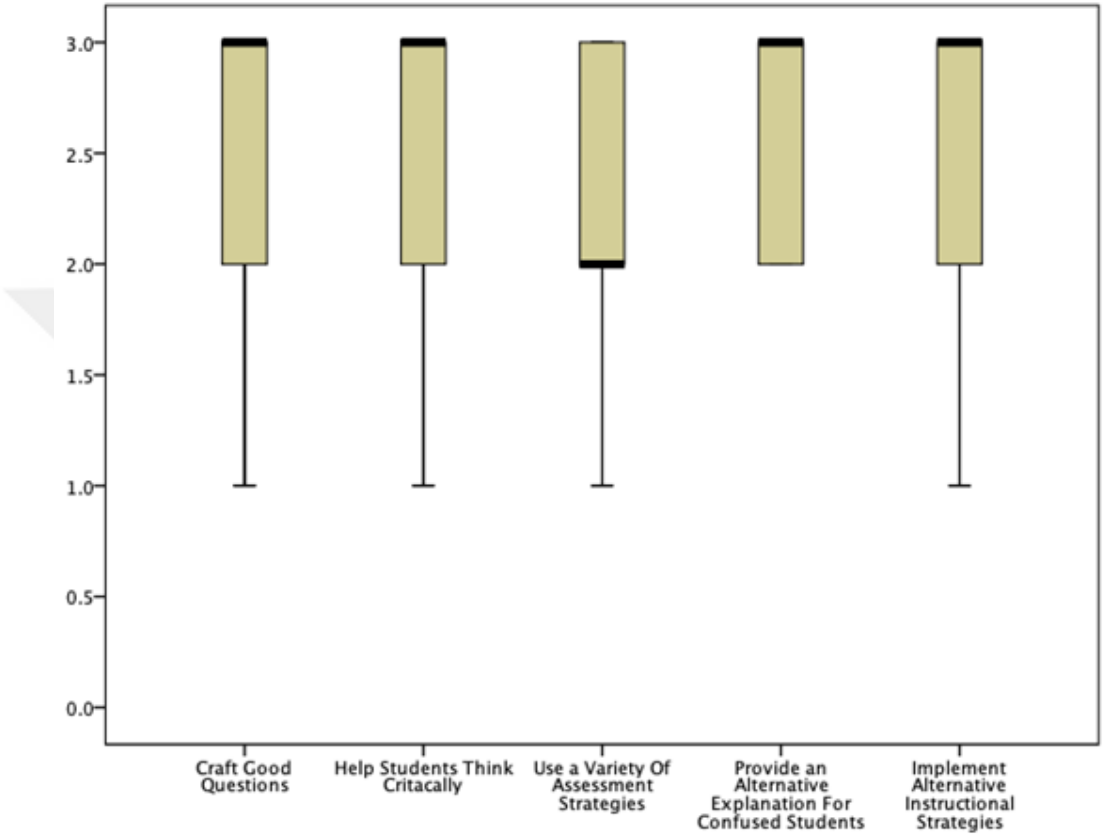


Figure 7.3. Teachers' Student Needs Oriented Strategies.

A pleasant learning environment is the need of both students and teachers. To be sure that an orderly environment and effective use of time during class time, teachers take actions as a manner of classroom management (Van Tartwijk and Hammerness, 2011). Even controlling the current status is an aspect of classroom management, being clear about expectations is also another important aspect for not to solve problems but prevent the appearance of the problem (Van Tartwijk and Hammerness, 2011). 94% of the teachers think that they let students to understand about their expectations clearly (See Figure 7.4). Most of the teachers (%94) participated in this study expect students to follow classroom rules, while 84% of teachers acts mostly to control disruptive behavior. However, teachers are quite keen to calm disruptive or noisy students

during class-time.

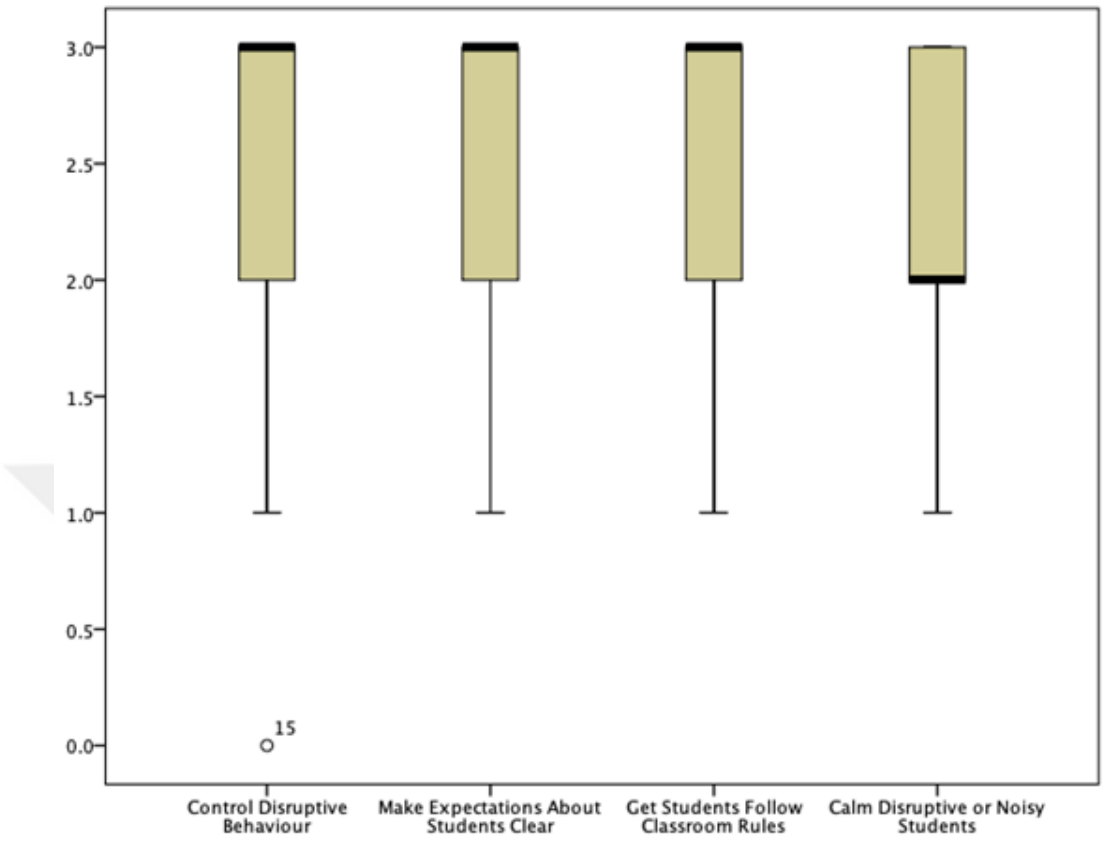


Figure 7.4. Classroom Management.

7.1.5. School Climate and Job Satisfaction

Being a volunteer for a change is a problem that literature also focuses on (Tschannen-Moran, Hoy, and Hoy, (1998). Commitment to workplace and being happy with the current status of the job are important aspects of changing a community for a better workplace. STEM implementation procedure requires a change of teachers' way of education, assessment and working habits. In that case, school climate and job satisfaction turn to an important aspect as a variable for a more collaborative workplace for STEM education.

The participants already responded with their own attitudes, a school wide assessment is needed to understand the collaborative culture. Even the participants' assessment for themselves contains the challenge of assessing themselves, the school-

wide assessment shows a similar result too. Feedback from the respondents shows that teachers in the subject school have their primary focus on students (See Figure 7.5).

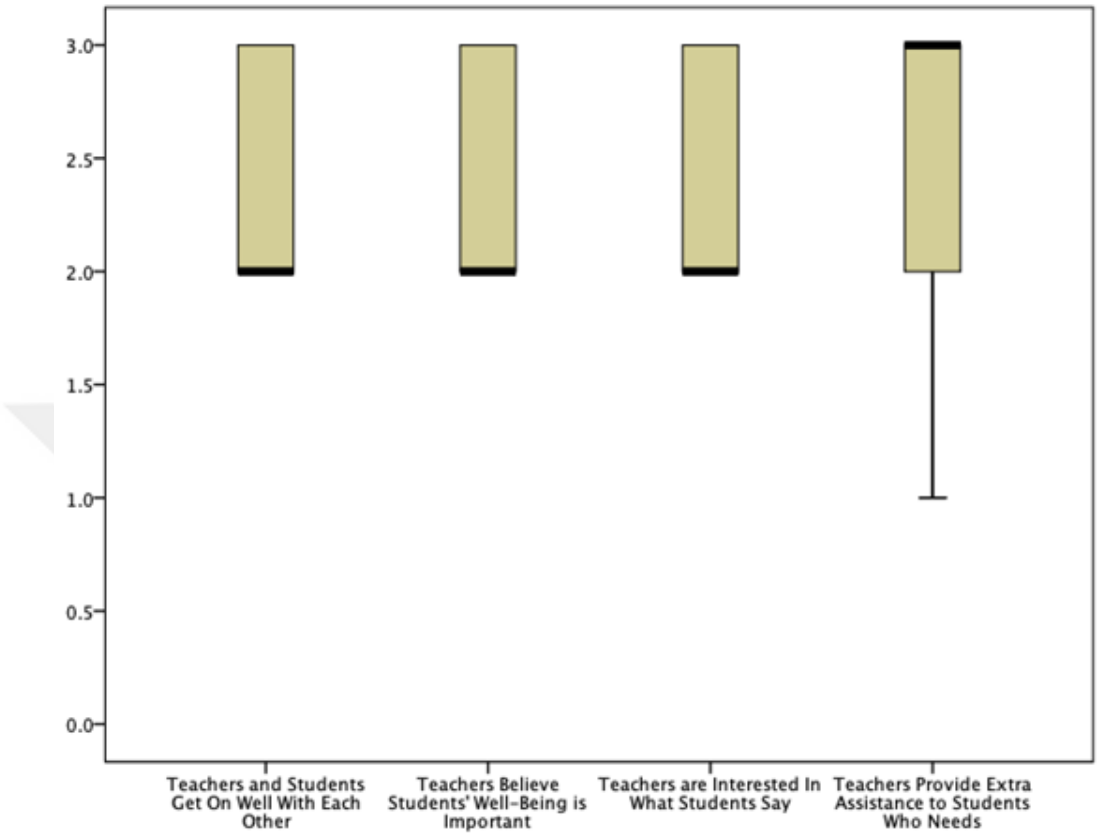


Figure 7.5. Teachers' view for the school.

Social status of teaching as a profession changes from society to society (OECD, 2019). With respect to feedback collected from participants 54.6% of teachers believe that teaching is valued in society while, 45.4% of the teachers are opposed to this idea (See Figure 7.5). However, for the subject school all of the respondents (40% Agree, 60% Strongly Agree) recommend the subject school as a good place to work while 94% of the teachers enjoy working at this school (See Figure 7.6). All in all, most of the participants (78.8%) are happy to be a teacher which brings 87.9% overall job satisfaction.

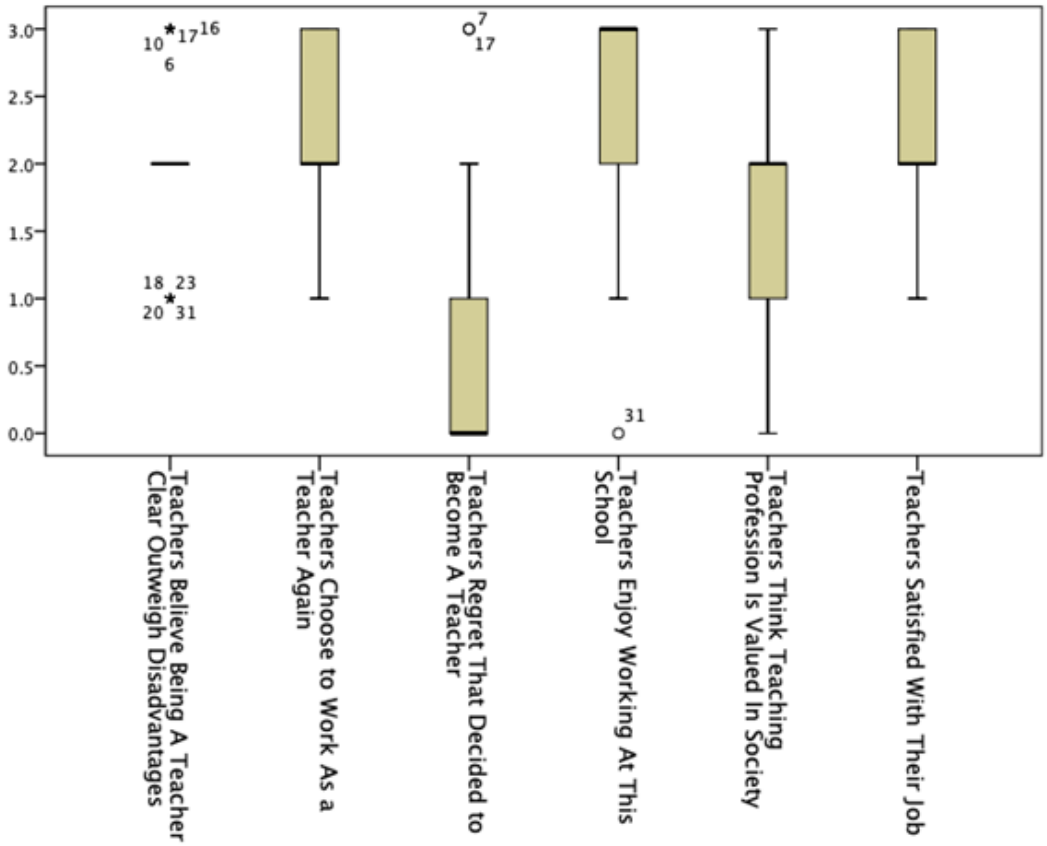


Figure 7.6. Job satisfaction.

7.1.6. Collaborative Culture

Even the collaboration among teachers will be investigated deeply, collaborative culture is an important aspect to understand the culture of the subject school. When teachers are asked to assess active participation of staff, parents and students most of the answers lay between agree and disagree. 73% of the respondents stated that the staff actively participates in school decisions with 22 agree and two strongly agree over 33 respondents. Parents participation, on the other hand, is calculated as 85% with 24 agree and four strongly agree. Students as the main focus of the school have 69% participation rate with 20 agree and 3 strongly agree (See Figure 7.7). Even these results are promising for a collaborative culture, for the sake of shared responsibilities aspect of collaborative work an extra effort is needed to work on it (Hord, 2009).

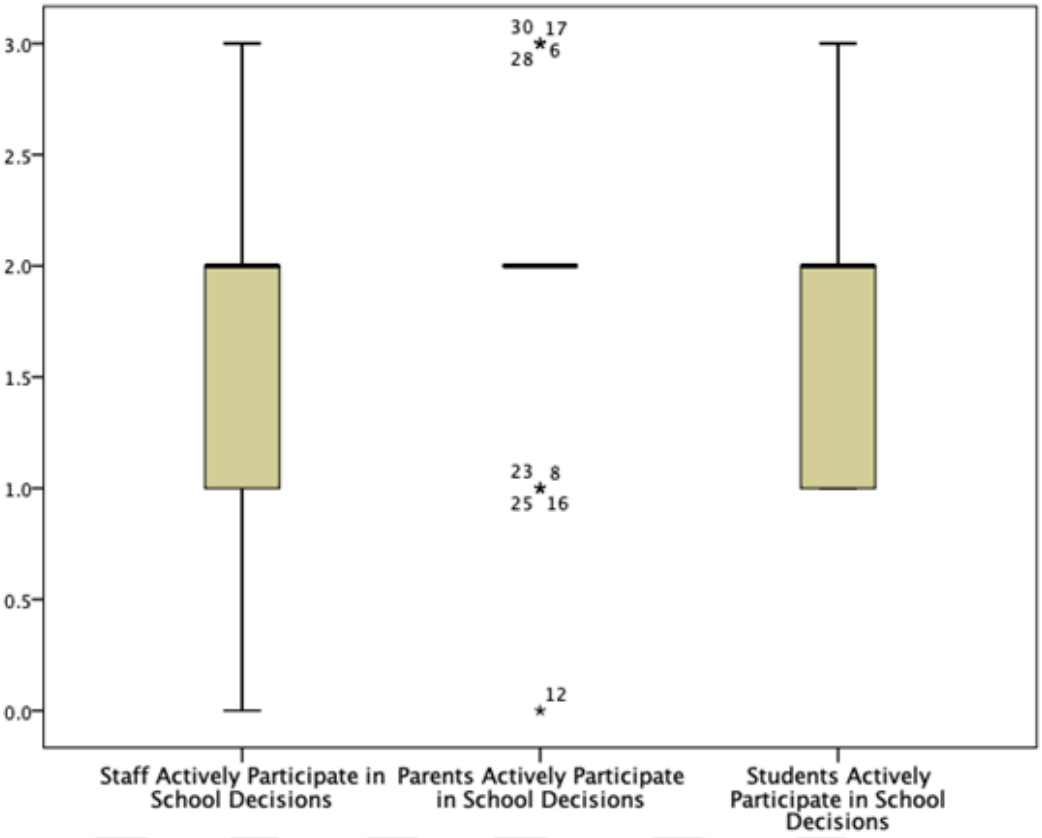


Figure 7.7. Participation in school decisions.

In addition to collaborative culture in decision making process, teachers' collaborative habits are also asked. For a proper implementation process, collaborative work is accepted as one of the most important components for this study. Collaborative work in this study is investigated as observing other teachers' classes and providing feedback, teaching together in the same class, engaging joint activities across different classes and age groups, exchanging teaching materials and discussing about students with special needs, working together to ensure common standards for assessing students' progress, attending team conferences, taking part in collaborative professional learning. The data is collected through 5-point likert scale which ranges from never to once a week or more.

First of all, the exchange of teaching materials among teachers is not a choice but a tradition in school setting, for the purpose of providing same material to the students. In other words, if at least two teachers have the same grade level in a course, they need

to use almost the same materials. Even the expectation is providing structured set of materials, as seen, 60.6% percent of the teachers share their materials once a week or more during a school year (See Table 7.11). Sharing the material is one of the most fundamental collaborative skill. However, 18.2% of teachers stated that they exchange their materials 2-4 times a year at most where 9.1% of teachers are almost never exchange materials.

Table 7.11. Teachers' rate of exchange teaching materials.

	Frequency	Percent
Never	1	3
Once a year or less	2	6.1
2-4 times a year	3	9.1
5-10 times a year	7	21.2
Once a week or more	20	60.6
Total	33	100

Just like changing materials, as a manner of team conferences is assumed as a regular event in the school setting. Departmental meetings are held at least twice a year and General assembly is held in the beginning and at the end of the year. Departments are free to hold these meetings more as much as they want to do. However, team conference is not a term that is limited with department meetings, but it may cover some PD activities too. Also, some participants ignored departmental meetings to count as attending team conferences (See Table 7.12).

Table 7.12. Frequency of Attending Team Conferences.

		Attend Team Conferences					Total
		Never	Once a year or less	2-4 times a year	5-10 times a year	Once a week or more	
Level Based Department	High School Science Department	3	4	2	1	0	10
	High School Math. Department	1	1	1	4	1	8
	High School Computer Science Department	0	0	0	1	1	2
	Middle School Science Department	0	1	2	1	1	5
	Middle School Math. Department	0	3	1	1	2	7
	Middle School Computer Science Department	0	0	1	0	0	1
Total		4	9	7	8	5	33
% within Attend Team Conferences		12.10%	27.30%	21.20%	24.20%	15.20%	100.00%

Education as a continuous process requires both formative and summative assessment as a part of learning cycle. The subject school uses two different online system for assessment. First system is a yearly planning system which is not directly focuses on assessment but yearly planning, material sharing, interdisciplinary planning, assessment, etc. However, the second system is founded on intranet for the overall grading and evaluation system. It is expected that teachers submit their objectives for each question on each exam and make grading on this system. As a result of this system, reports generated by the system automatically is shared with teacher and school administrators. With respect to observation of the researcher, this system is not used effectively. Even the online system can take place of face to face meetings, efficiency of the produced data needed to be measured for the subject school. When the online system is not efficient, need for face-to-face meetings is apparent within discipline and interdisciplinary manner. With respect to response of participants meeting for assessment strategies are not controlled by school but teachers themselves. Even the highest percentage is 33.3% for 2-4 times a year, 5-10 times a year and once a week or more have close frequencies respectively 24.2% and 27.3% (See Table 7.13). It is important to notice that all teachers who participate this study, meet with colleagues at least once a year for their assessment strategies.

Table 7.13. Teachers working with other teachers to ensure common standards for assessing students' progress.

	Frequency	Percent	Valid Percent	Cumulative Percent
Once a year or less	5	15.2	15.2	15.2
2-4 times a year	11	33.3	33.3	48.5
5-10 times a year	8	24.2	24.2	72.7
Once a week or more	9	27.3	27.3	100
Total	33	100	100	

Individualized Education Plan (IEP) is realized as a manner of inclusion in education. Applications and rules of this program is set by the Ministry of Education

and so the schools have to follow directions. For the subject school there is a special department that works with psychological counselling office for students with special needs. These students have differentiated education and assessment plans with respect to their needs. In this manner, teachers work with IEP counselor with respect to number of IEP students and their specific needs. Also, in the school setting there are some students which are not in IEP program but have different needs which longs through the year or for a time. In that case, teachers mostly work with counselors and/or related vice principal. Again, these meetings are not school-wide but needs oriented.

Table 7.14. Frequency of discussions about the learning development of specific students.

	Frequency	Percent	Valid Percent	Cumulative Percent
2-4 times a year	8	24.2	24.2	24.2
5-10 times a year	17	51.5	51.5	75.8
Once a week or more	8	24.2	24.2	100
Total	33	100	100	

In this manner, when the frequency of teachers meeting for students with specific needs is taken into account, 51.5% of teachers held these meetings 5-10 times a year for the recent year. Since these meetings are need-oriented, it is hard to discuss about the fairness of the number of these meetings. However, each teacher attended these meetings at least 2-4 year which represents all teachers are open for spending their time for student development when it is needed (See Table 7.15).

Even the fundamental needs of collaboration turn to standards for the 21st century, interdisciplinary and transdisciplinary aspects are still seen as extra projects that is dependent on teachers' choices. In this manner observing other teachers' classes and providing feedback, teaching jointly in the same class, engaging joint activities across different classes and age groups and taking part in collaborative professional learning groups are analyzed separately than other collaborative skills to outline possible actions

to take place in the school setting.

Needs of the students and therefore teaching is changed with the changing world. Professional development activities are one of the most important aspect for teachers to come together for both networking and learning from each other.

Table 7.15. Take part in collaborative professional learning.

	Frequency	Percent	Valid Percent	Cumulative Percent
Never	4	12.1	12.1	12.1
Once a year or less	6	18.2	18.2	30.3
2-4 times a year	9	27.3	27.3	57.6
5-10 times a year	9	27.3	27.3	84.8
Once a week or more	5	15.2	15.2	100
Total	33	100	100	

12.1% of the respondents have never attended collaborative professional learning groups while 15.2% stated that they have attended once a week or more. Collaborative Professional Learning activities have some examples that is organized in the school setting. Weekly ICT meetings, UbD sessions are some example of these studies. In this manner 5-10 times a year and more is the expected answer with respect to observation of the researcher of this study. However, 57.6% of the respondents take part in these learning groups 4 times in a year and less which reveals and open field to understand the reason (See Table 7.16).

Another important aspect for STEM education is the process that is presented via interdisciplinary and transdisciplinary projects. Even solo teachers may develop such projects with their own inquiry, in a school setting it requires teachers from different disciplines to work together. Unfortunately 42.4% of teachers have never attended to joint activities through the year. All in all, 93.9% teachers attended at most 4 projects in a year which may be increased for more effective teaching with a better collaborative

attitude See (Table 7.17).

Table 7.16. Engaging joint activities across different classes and age groups.

	Frequency	Percent	Valid Percent	Cumulative Percent
Never	14	42.4	42.4	42.4
Once a year or less	9	27.3	27.3	69.7
2-4 times a year	8	24.2	24.2	93.9
5-10 times a year	2	6.1	6.1	100
Total	33	100	100	

Table 7.17. Teaching jointly as a team in the same class.

	Frequency	Percent	Valid Percent	Cumulative Percent
Never	15	45.4	45.5	45.5
Once a year or less	13	39.4	39.4	84.8
2-4 times a year	3	9.1	9.1	93.9
5-10 times a year	1	3	3	97
Once a week or more	1	3	3	100
Total	33	100	100	

STEM Education shows its biggest impact on interdisciplinary and transdisciplinary projects since students focus on real problems in a wider scope. However, such projects require extra work especially in planning part. Another possible solution for effective STEM education is contextual education with the jointly teaching. Even such an application requires an interdisciplinary curriculum which does not exist in Turkey, teachers may sometimes plan their lesson when different disciplines come together in a topic. Teachers from same disciplines on the other hand, may come together for lessons which focusses on alternative teaching strategies. Even such applications have positive impact on student learning and their attitude towards Science, Mathematics and Engineering which is one of the main purpose of STEM education it is clear that evidence

for the subject school is not satisfactory in this manner (Wang *et al.*, 2011). When the feedback from respondents are considered 45.4% of teachers have never organize a joint lesson while 39.4% have organized once at most. So, 84.8% of teachers are not experienced about joint classes which is in fact an important aspect of collaboration and so STEM education (See Table 7.18).

Although joint classes are hard to organize when most of the teachers spend their half of their work time in class, following up colleagues' classes to observe and give feedback is more possible. For the subject school even the rate of peer observation is higher than the joint classes 39.4% of the teachers observed other teachers once at most (See Table 7.21). Also, since there is not a system formed to give feedback by teachers to teachers, purpose and mechanism of this feedback process also needed to be analyzed separately for efficiency. It is needed to be noticed that, there are 5 participants in this study who have administrative duties like department head and vice principal. Teacher observation and feedback is a specifically a defined duty for these teachers. When all comes together, frequency of teacher-teacher observation gets low. In this case, it becomes an important aspect to discuss about if an action plan will be made to increase collaboration among teachers.

Table 7.18. Teachers who observe other teachers' classes and provide feedback.

	Frequency	Percent	Valid Percent	Cumulative Percent
Never	4	12.1	12.1	12.1
Once a year or less	9	27.3	27.3	39.4
2-4 times a year	12	36.4	36.4	75.8
5-10 times a year	7	21.2	21.2	97
Once a week or more	1	3	3	100
Total	33	100	100	

For the collaborative culture impact of duties in school are investigated for an in-depth understanding (See Table 7.19). Teacher with extra duties like department

head or vice principle has the responsibility operate feedback mechanism in school. However, for the effective collaboration in school feedback mechanism is offered for not only managers but also for all teachers. For observing other teachers' classes and providing feedback has an overall mean 1.75 while only teachers have mean 1.2. Teaching jointly as a team in class is one another important aspect which shows a small increase. However, when teaching hours of teachers with extra duties are considered this difference may be acceptable. For other collaborative skills even all scores shows a decrease with respect to others, this difference is reasonable when the supportive duties of head of departments and vice principal's considered.

Table 7.19. Collaborative skills with respect to duties.

Primary Job In School Setting		a	b	—c—	d	e	f	g	h
Teacher	Mean	1.20	2.10	0.82	0.92	3.25	2.92	2.60	1.89
	N	28	28	28	28	28	28	28	28
Head of Department	Mean	3.00	2.66	1.00	1.33	3.33	3.33	2.66	2.33
	N	3	3	3	3	3	3	3	3
Vice Principal	Mean	3.50	2.00	0.00	0.50	4.00	3.50	3.00	3.50
	N	2	2	2	2	2	2	2	2
Total	Mean	1.75	2.15	0.78	0.93	3.30	3.00	2.63	2.03
	N	33	33	33	33	33	33	33	33
Note. a. Observe Other Teachers' Classes and Provide Feedback,									
b. Take Part In Collaborative Professional Learning									
c. Teach Jointly As A Team In Same Class,									
d. Engage Joint Activities Across Different Classes,									
e. Exchange Teaching Materials,									
f. Engage In Discussions About The Learning Development Of Specific Students,									
g. Work With Other Teachers To Ensure Common Standards For Assessing Students' Progress,									
h. Attend Team Conferences									

When the collaborative skills are compared with respect to level of education, results are surprising. Especially for the effective collaboration skills (See Table 5.20 column a, b, c, d) teachers frequency to apply these skills decreases with the increasing level of education. For the fundamental collaborative skills (See Table 7.20 column e, f, g, h) on the other hand, have similar result which reveals random differences.

Table 7.20. Collaborative skills with respect to level of education.

Highest Level of Education		a	b	c	d	e	f	g	h
Undergraduate	Mean	2.63	2.09	1.09	1.00	3.27	3.09	2.72	2.81
	N	11	11	11	11	11	11	11	11
Master Without Thesis	Mean	1.83	1.50	0.58	0.91	3.41	2.83	2.50	1.08
	N	12	12	12	12	12	12	12	12
Master With Thesis	Mean	2.11	1.66	0.77	1.00	3.11	3.00	2.77	2.33
	N	9	9	9	9	9	9	9	9
Doctorate	Mean	1.00	2.00	0.00	0.00	4.00	4.00	2.00	2.00
	N	1	1	1	1	1	1	1	1
Total	Mean	2.1515	1.7576	0.7879	0.9394	3.303	3.00	2.6364	2.0303
	N	33	33	33	33	33	33	33	33
Note. a. Observe Other Teachers' Classes and Provide Feedback,									
b. Take Part In Collaborative Professional Learning									
c. Teach Jointly As A Team In Same Class,									
d. Engage Joint Activities Across Different Classes,									
e. Exchange Teaching Materials,									
f. Engage In Discussions About The Learning Development Of Specific Students,									
g. Work With Other Teachers To Ensure Common Standards For Assessing Students' Progress,									
h. Attend Team Conferences									

7.2. Contextual Theme (Analysis of School Professional Staff as Learning Community Questionnaire)

Perceptions of participants of this study reveal their thoughts about the school as a professional learning community through School Professional Staff as Learning Community Questionnaire (SPSLCQ). Questionnaire assesses teachers' perceptions about five dimensions of collaboration that is discussed earlier, through 17-item rating scale. These dimensions are shared and supportive leadership; shared beliefs, values and vision; collective learning and application; shard personal practice; and supportive conditions. Analysis of the results reveal the respondents' perceptions about school's level of maturity as a professional learning community, which is held as the framework of collaboration for this study.

Responses are collected with grading ranging through 5 which means highest to 1 which means lowest degree.

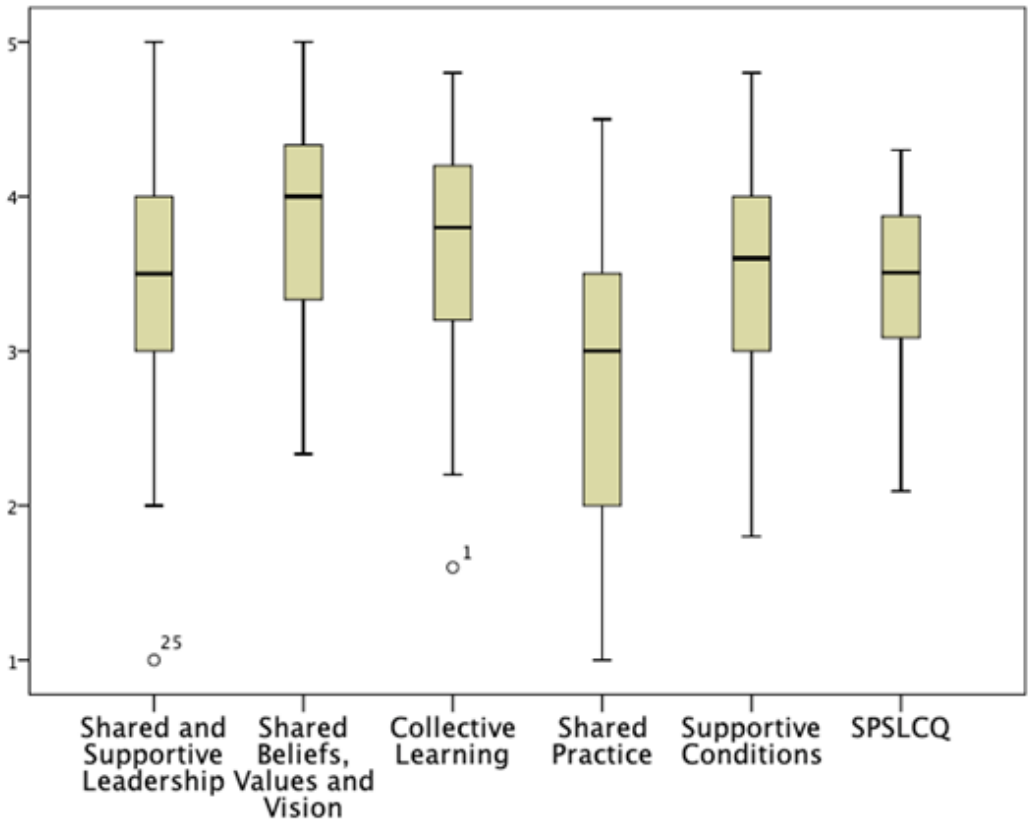


Figure 7.8. SPSLCQ and subcategories.

As seen in Figure 7.8, 5 categories of SPSCLQ have varying results. Even overall mean and all sub-categories except shared practice have median between 3 and 4, shared practice shows a relatively low score with respect to other categories.

For the total score of SPSLCQ, is tested for Pearson correlation with the variables, collaborative skills, job satisfaction and teachers' overall PD score. While job satisfaction and teachers' overall PD score does not have a significant correlation, collaborative skills score has a significant correlation ($p < 0.05$) with the SPSLCQ score (See Table 7.21).

Table 7.21. Pearson correlation for SPSLCQ, collaborative Skills, PD score and job satisfaction.

		SPSLCQ	Collaborative Skills	PD Score	Job Satisfaction
SPSLCQ	Pearson Correlation	1	0.370*	0.287	0.181
	Sig. (2-tailed)		0.034	0.106	0.313
	N	33	33	33	33
Collaborative Skills	Pearson Correlation	0.370*	1	0.166	0.096
	Sig. (2-tailed)	0.034		0.355	0.597
	N	33	33	33	33
PD Score	Pearson Correlation	0.287	0.166	1	0.117
	Sig. (2-tailed)	0.106	0.355		0.517
	N	33	33	33	33
Job Satisfaction	Pearson Correlation	0.181	0.096	0.117	1
	Sig. (2-tailed)	0.313	0.597	0.517	
	N	33	33	33	33
*. Correlation is significant at the 0.05 level (2-tailed).					

Departments and grade levels are also tested for significance. While the scores are significantly difference with respect to grade levels ($p < .05$); departments are not a variable for the SPSLCQ scores (p=.054) (See Table 7.22 and Table 7.23) In order to understand the relation between sub-categories of SPSLCQ and grade levels, each category is investigated separately.

Table 7.22. ANOVA Test for Departments and SPSLCQ Score.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	902.442	5	180.488	2.512	0.054
Within Groups	1939.8	27	71.844		
Total	2842.24	32			

Table 7.23. Independent sample t-test for grade level and SPSLCQ score.

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
SPSLCQ Score	Equal variances assumed	3.748	0.062	3.503	31	0.001	10.1154	2.88726	4.22677	16.004
	Equal variances not assumed			3.951	30.243	0	10.1154	2.56051	4.88788	15.34289

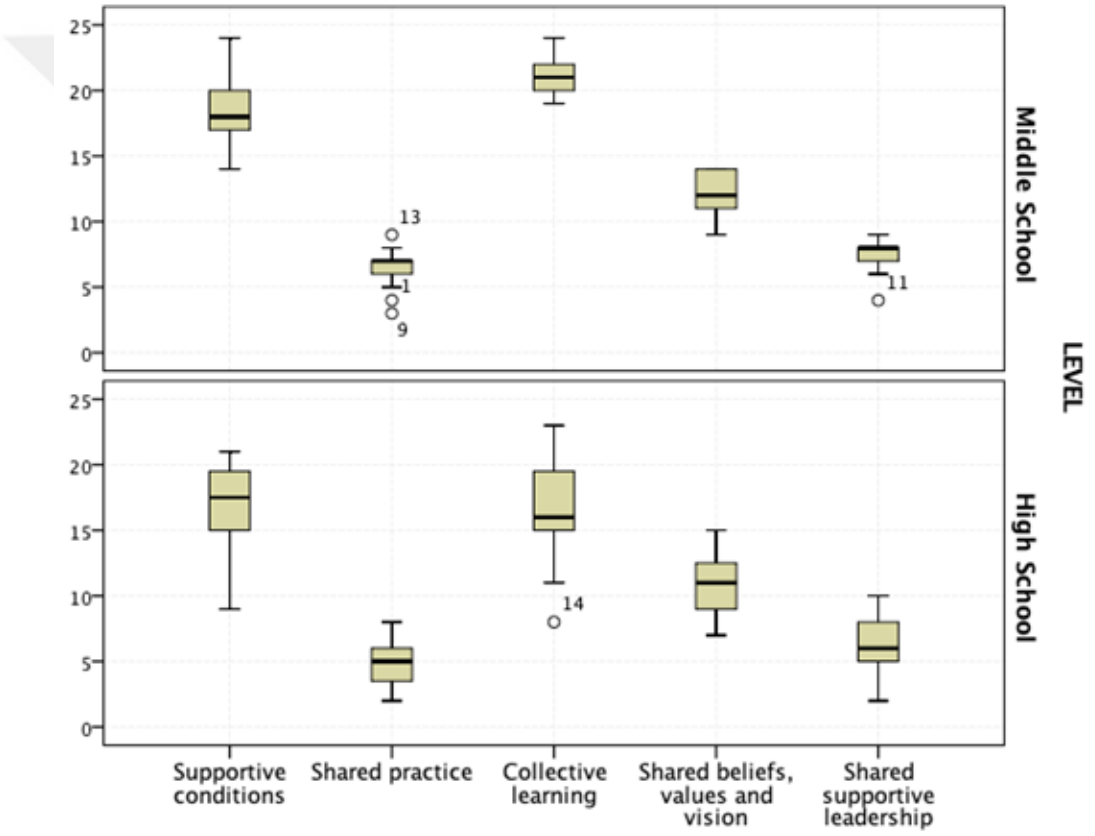


Figure 7.9. SPSLCQ sub-categories with respect to grade level.

Table 7.24. SPSLCQ sub-categories average scores compared with respect to grade level.

	High School			Middle School		
	Mean	Std. Deviation	Median	Mean	Std. Deviation	Median
Shared and supportive leadership	3.2	0.93752	3	3.7308	0.72501	4
Shared beliefs, values and vision	3.6833	0.72123	3.6667	4.0769	0.51197	4.0667
Collective Learning	3.3	0.72402	3.2	4.2154	0.33128	4.2
Shared Practice	2.425	0.94972	2.5	3.2308	0.83205	3.3571
Supportive Conditions	3.34	0.63941	3.5	3.6769	0.51341	3.6667

7.2.1. Shared and Supportive Leadership

SPSCLQ Questionnaire is analyzed under the five dimensions. For the shared and supportive leadership mean is measured 3.41 over 5 points (See Table 7.21). Teachers participation for the decision-making mechanism is questioned for the first part. With respect to mean value, administrators invite advice and counselling from staff and then make decisions themselves mostly. In addition to decisions made by administrators, a small committee, council, or team of staff is involved in administration system. All in all, shared and supportive leadership is needed to be focused on for an action plan but not with highest priority.

For the shared and supportive leadership, high school and middle school differs from each other with an apparent median. Teachers from middle school feel their participation for the final decision while teachers from high school express their participation independent from the final decision. With respect to data gathered from participants high school teachers have less right for final decisions. (See Table 7.24)

7.2.2. Shared Beliefs, Values and Vision

For the shared beliefs, values and vision, an overall mean is calculated 3.66 over three questions. Analysis revealed that visions for improvement are not mutual decisions that are obtained directly by all teachers. However, there is a strong agreement on these visions for improvement that are mostly focused on teaching, and learning. Finally, when the goal of visions is asked, quality of learning experiences for all is the primary focus but students' individual abilities are also effective. Even extra planning may be done on values and vision for effective collaboration, a quick action is not required for the short term.

Table 7.25. Descriptives of SPSLCQ with respect to five dimensions.

	N	Max	Mean	%	Std. Deviation	Variance	Skewness		Kurtosis	
							Statistics	Std. Error	Statistics	Std. Error
Shared and Supportive Leadership	33	5	3.41	68	0.888	0.788	-0.563	0.409	0.204	0.798
Shared Beliefs, Values and Vision	33	5	3.84	76	0.667	0.445	-0.322	0.409	-0.555	0.798
Collective Learning	33	5	3,66	73	0.747	0.559	-0.758	0.409	0.372	0.798
Shared Practice	33	5	2.74	54	0.977	0.955	-0.256	0.409	-0.897	0.798
Supportive Conditions	33	5	2.47	49	0.608	0.37	-0.647	0.409	0.993	0.798

7.2.3. Collective Learning and Its Application

Staff's collective learning and application of these learnings are questioned in the third part with five questions. An overall 3.66 mean is calculated over 5 points. When the size and schedule of the collective learning process is questioned, it reveals that the school focuses on subgroups (90%, N 33) while only one participant declared that the entire staff come together to discuss issues and learn from each other. Even this idea is plausible with subject oriented approach, when the idea is effective collaboration for STEM Education, an interdisciplinary grouping is needed (Merrill and Daugherty, 2010). For the substantive student-centered issues respondents stated that meetings are set occasionally (79.2%, N 33) which is an expected result since it is hard to find a regular time for all teachers. One of the most important aspect that is needed for effective collaboration, is the discussion for the quality of teaching and students'

learning. Unfortunately, the results show that teachers do not often discuss their instructional practices and its influence on students learning (72.7% N 33). Another important aspect of effective collaboration is the reflection of PD learnings through the school. With respect to the result of the study, the staff occasionally act on their learning and make and implement plans to improve teaching and learning (63.7%, N33). Finally, the question is asked for the feedback mechanism. Even the results based on application are high, the staff infrequently assess their actions and seldom make revisions based on the results (69.4%).

Collective learning is another important aspect that differs between middle school and high school teachers (See Table 7.29). As mentioned in Discussion part, attempts for effective collaboration create important difference especially for the collective learning part which implies teachers' skills to work and learn together.

7.2.4. Shared Practice

For the shared practice part of the SPSLCQ, mean score is calculated 2.74 which is relatively low with respect to other dimensions. Shared practice is questioned with two questions. For the first question frequency of the class visits are asked to the teachers. Without making a distinction between administrator or teacher, the question is asked as they are staff members. According to the data, the staff members rarely visit and observe one another's teaching (81.8%, N 33). For the second question, feedback mechanism among staff member is questioned. The result is interesting because response rate for each item are so close to each other. While 18.2% of teachers think that staff members do not interact after classroom observations, 21.2% states the interaction is very low or off-topic. While 27.3% of teachers responded that feedback is not teaching related, only 6.1% states that staff members provide feedback to one another about teaching and learning based on their classroom observations.

7.2.5. Supportive Conditions

Final dimension of the SPSLCQ is about supportive conditions. For effective collaboration, school-wide precautions are needed to let teachers manage their work schedule. In that manner, supportive conditions are measured within 5 questions. For the time management of meetings, participation of all staff members are considered by the school administration (72.8%, N33). Even the school has appropriate physical structure for meeting, 57.6% of participants stated that considering the size, structure, and arrangements of the school, the staff are working to maximize interaction. With the digitalized world, way of communication is increased with Internet. Even there are alternatives for communication, school focuses on a single method, but this is not used frequently (84.8%, N33). Trust and openness are seen as important factors for effective collaboration (Hord, 2009). For the subject school, not all but most of the staff members are seen trusting and open (81.8%, N33). Last aspect of supportive conditions is an overview of overall collaboration. According to respondents, caring and collaboration are inconsistently demonstrated among the staff members (87.9).

Table 7.26. Highest Level of Education PLC Dimensions Crosstabulation.

Highest Level of Education		Shared and Supportive Leadership	Shared Beliefs, Values and Vision	Collective Learning	Shared Practice	Supportive Conditions	SPSLCQ
Undergraduate	Mean	3.54	3.96	3.78	3.00	3.67	3.59
	N	11	11	11	11	11	11
Master Without Thesis	Mean	3.37	3.97	3.60	2.62	3.45	3.40
	N	12	12	12	12	12	12
Master With Thesis	Mean	3.33	3.59	3.53	2.44	3.31	3.24
	N	9	9	9	9	9	9
PhD	Mean	3.00	3.00	3.80	3.00	3.00	3.44
	N	1	1	1	1	1	1
Total	Mean	3.40	3.83	3.66	2.74	3.47	3.42
	N	33	33	33	33	33	33

When all aspects of PLC are considered with respect to SPSLCQ results are promising not close to maximum value. In order to understand the needs of a better PLC setting, highest level of education, extra duties in the school and job satisfaction scores are compared with respect to dimensions of PLC and SPSLCQ mean score (See Table 5.24, Table 5.25 and Table 5.26). When the PLC dimensions and SPSLCQ results are compared with respect to level of education, teachers with undergraduate

degree has highest score in general and for each dimension (See Table 5.24). Even the number of participants for each sub-group is not enough for generalization, level of education shows a decrease with the increasing PLC capabilities. Teachers additional responsibilities like department management is also investigated for their impact on PLC and SPSLCQ scores. Head of departments as the mechanism between the school management and teachers have the highest scores among others (See Table 5.25). When teachers job satisfaction is calculated for a mean score, none of teachers have a score (.00 to .99) that represent strongly disagree. However, number of teacher for the low job satisfaction (N=1) is not enough for interpretation. When the scores are compared for each dimension and SPSLCQ score, teachers have a professional attitude with respect to their responsibilities. In other words, teachers with different job satisfaction have similar scores with respect to five dimensions of PLC and overall SPSLCQ score (See Table 7.28).

Table 7.27. Extra Duties In School PLC Dimensions Crosstabulation.

Primary Job In School Setting		Shared and Supportive Leadership	Shared Beliefs, Values and Vision	Collective Learning	Shared Practice	Supportive Conditions	SPSLCQ
Teacher	Mean	3.25	3.75	3.57	2.67	3.40	3.33
	N	28	28	28	28	28	28
Head of Department	Mean	4.00	4.44	4.20	3.50	3.80	3.98
	N	3	3	3	3	3	3
Vice Principal	Mean	4.75	4.16	4.00	2.50	4.00	3.88
	N	2	2	2	2	2	2
Total	Mean	3.40	3.83	3.66	2.74	3.47	3.42
	N	33	33	33	33	33	33

Table 7.28. Job Satisfaction PLC Dimensions Crosstabulation.

Job Satisfaction		Shared and Supportive Leadership	Shared Beliefs, Values and Vision	Collective Learning	Shared Practice	Supportive Conditions	SPSLCQ
Disagree	Mean	3.00	4.00	4.40	2.50	3.60	3.50
	N	1	1	1	1	1	1
Agree	Mean	3.34	3.76	3.36	2.34	3.21	3.20
	N	13	13	13	13	13	13
Strongly Agree	Mean	3.47	3.87	3.82	3.02	3.64	3.56
	N	19	19	19	19	19	19
Total	Mean	3.40	3.83	3.66	2.74	3.47	3.42
	N	33	33	33	33	33	33

7.3. Procedural Theme (Analysis of TCAR)

School leaders are trying techniques in order to assess the quality of teacher collaboration through team agendas, collecting minutes, and observing teacher teams in actions (Pappano, 2007). Even these methods have the possibility to give an idea, an enhanced analysis through an assessment rubric has the potential to provide a deeper understanding (Gajda and Koliba, 2008). Teacher Collaboration Assessment Rubric provide a deeper understanding with respect to four dimensions namely dialogue, decision making, action and finally evaluation. There are 26 items with textual responses that corresponds to zero, one and two points. Textual response in this rubric means that, there are three expression for each items where two points represents the most positive response and zero point represents least positive response.

Table 7.29. Summary of TCAR for four sub-categories.

	N	Maximum	Mean	Percentage	Std. Deviation	Skewness		Kurtosis	
						Statistics	Std. Error	Statistics	Std. Error
Dialogue	33	14	10.75	10.75	2.39	0.129	0.409	1.338	0.798
Decision making	33	14	10.66	10.66	2.56	0.017	0.409	1.538	0.798
Action	33	12	8.72	8.72	2.64	0.266	0.409	1.125	0.798
Evaluation	33	12	7.96	7.96	2.72	0.352	0.409	1.055	0.798

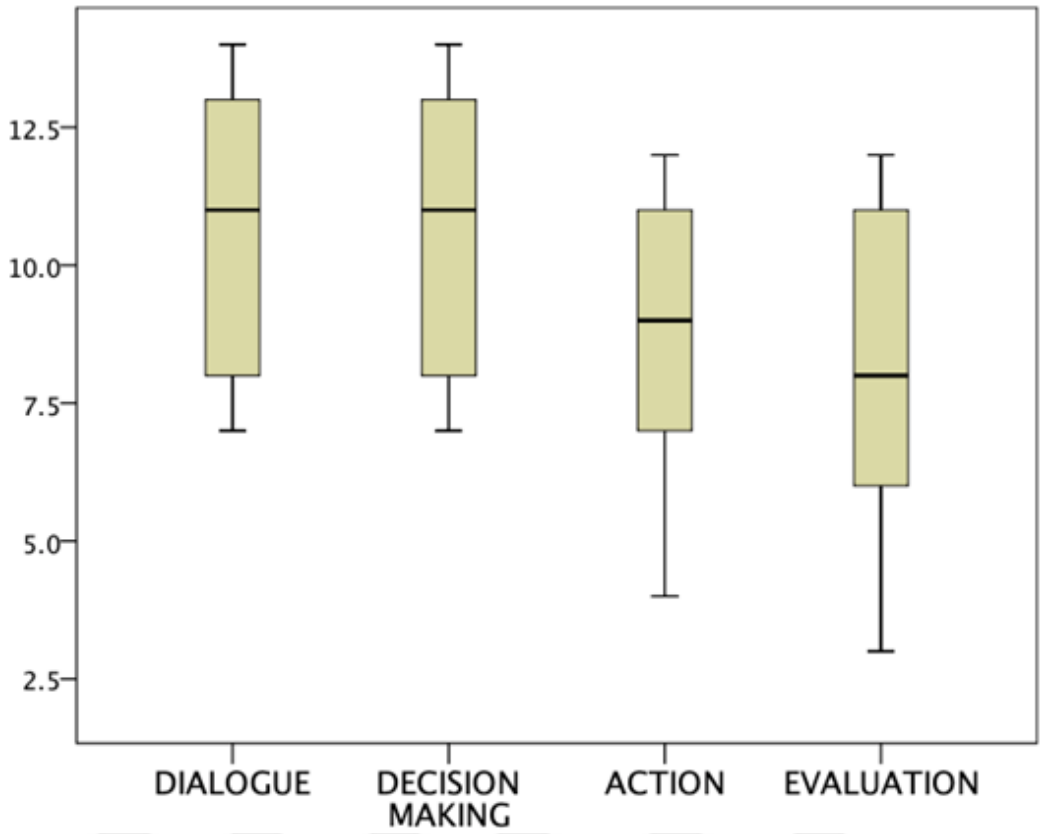


Figure 7.10. TCAR sub-categories.

When the sub-categories are considered, two different group can easily be detected. Dialogue and Decision-making categories appear with medians between 10.0 and 12.5; and action and evaluation appear with medians between 7.5 and 10.0. The reason for this difference is not because of the low scores but because of the difference between the number of questions for sub-categories. Dialogue and Decision-making parts have seven questions while Action and Evaluation parts have six questions. This difference leads to maximum 14 points for the first group and 12 points for the second group. Even each sub-category has its own characteristics, evaluation has a wider distribution and relatively low median than all categories.

Just like the SPSLCQ score, there is an apparent difference between middle and high school teachers' responses ($p < .001$). Not only for overall TCAR score, but also for all four categories there is a significant difference between middle school and high school teachers where middle school teachers responded high scores and a narrower

distribution (See Figure 7.11).

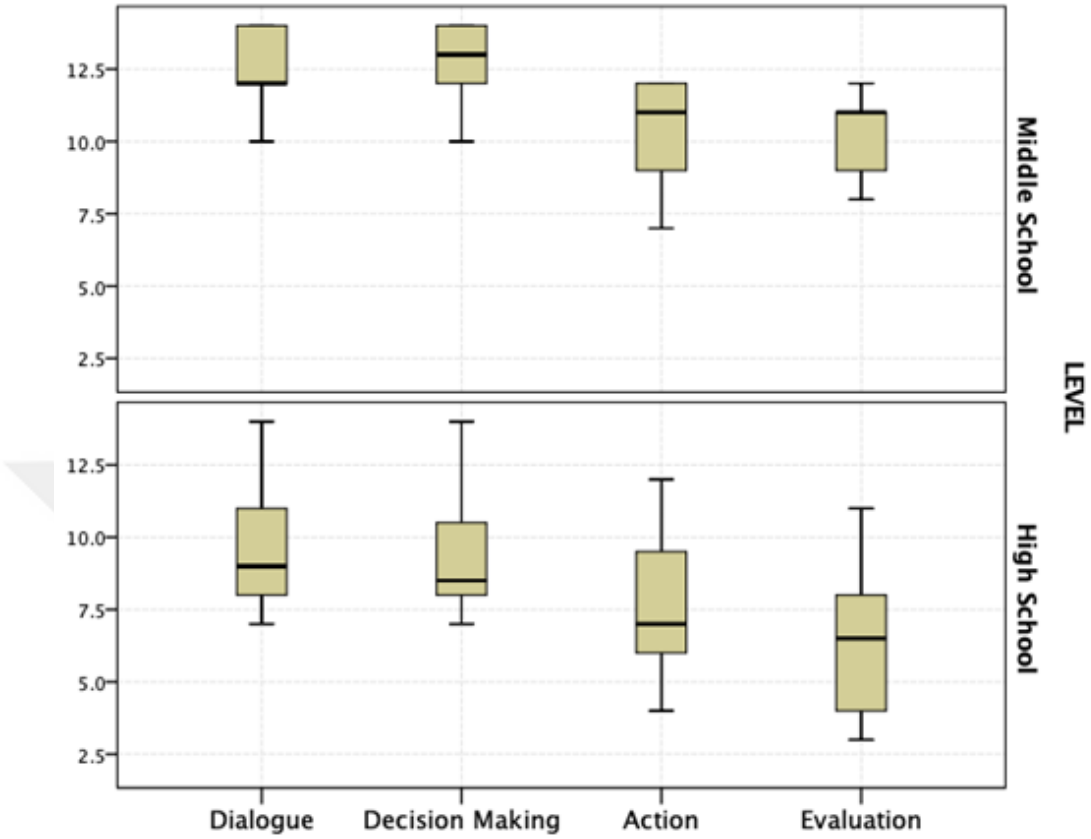


Figure 7.11. TCAR sub-categories compared with respect to level.

The difference between levels are more apparent than SPSLCQ score. For dialogue part middle school teachers have a median 12.00 while high school teachers have 9.00. Even the decision-making mechanism must be same for all school, the difference is 13.00 for middle school and 8.50 for high school. Although interview results give an idea about the action part, the gap between median scores are wider than other two categories. For the action category middle school teachers have 11.00 while high school teachers have 7, and for the evaluation part middle school teachers have 11.00 while high school teacher have 6.50.

7.3.1. Dialogue

For the first part of TCAR, dialogue explores the level of engagement of interpersonal communication about leadership and improvement of teaching practice through

effective dialogue. When all responses are considered, 10.76 average score is calculated over 14 points which represents 76.85% grade for the dialogue is gathered.

As seen in Figure 7.12, all seven items lay between 1 and 2 points. However, items 1, 2, 4, 5 and 6 have their median as 2 which is the maximum score that can be gathered.

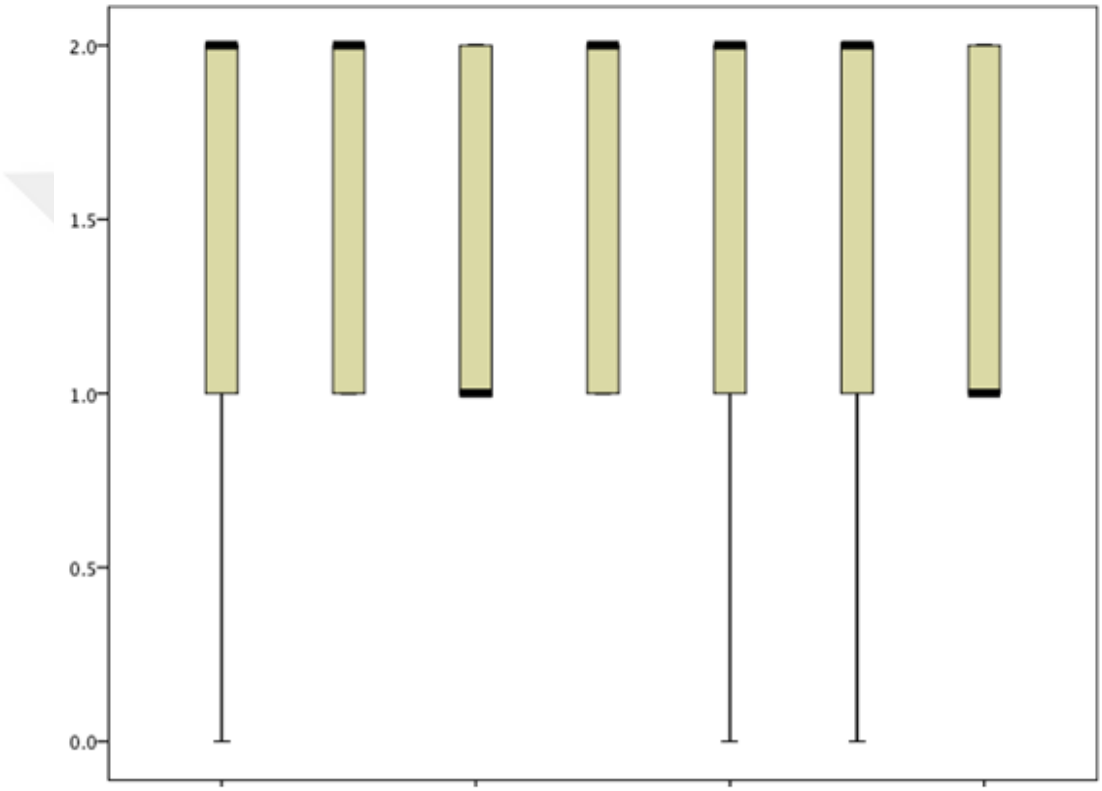


Figure 7.12. TCAR sub-category dialogue related questions.

7.3.2. Decision Making

For the decision-making part, effectiveness or/and value of teams' practices are questioned. With respect to analysis of the collected data, 10.67 average score is calculated over 14 points which represents 76.21% grade for the decision making.

Just like dialogue section decision-making part have also relatively high scores. Items 3, 5, 6 and 7 have their median as 2.0 that are in harmony with dialogue part of

the TCAR (See Figure 7.13).

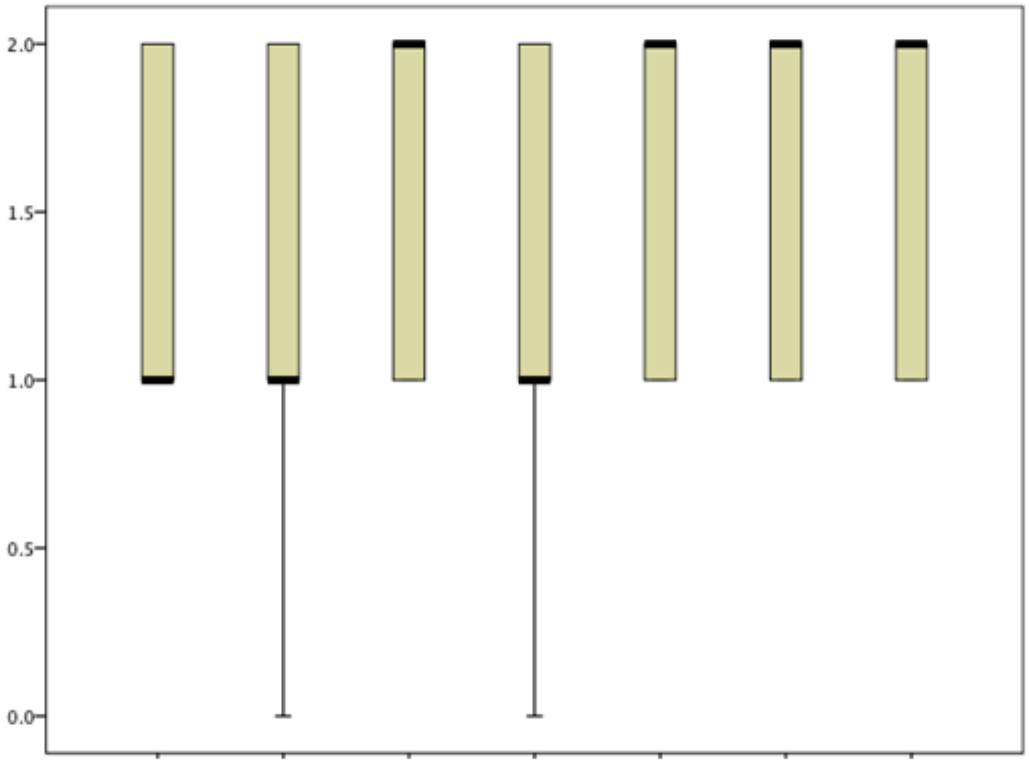


Figure 7.13. TCAR sub-category decision-making related questions.

7.3.3. Action

For the action part, making decisions in practice is questioned. Conformity between actions and decisions that are made are investigated. 8.73 points means score over 12 is calculated which is 72.75% mean grade for action part. It shows a relatively low result that needs an extra investigation for the study.

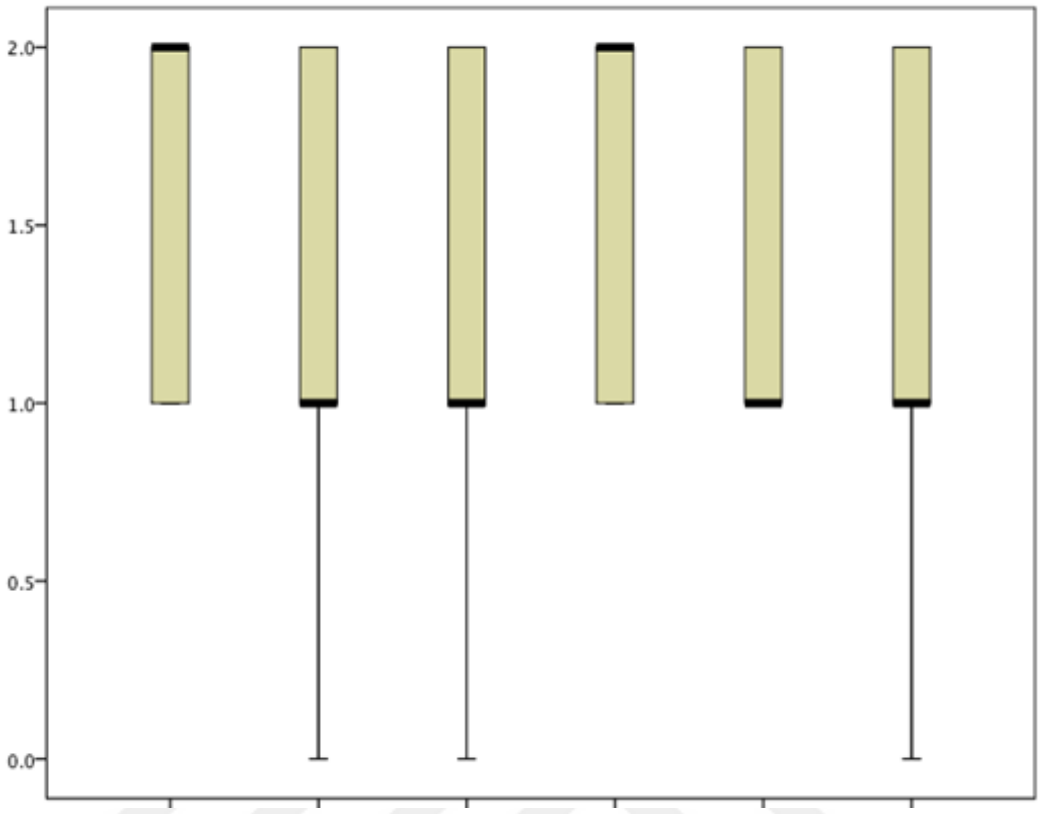


Figure 7.14. TCAR sub-category action related questions.

7.3.4. Evaluation

For the evaluation part, team's engagement in the evaluation of their practices by taking systematic collection and examination of performance data is considered. 7.97 mean score is calculated over 12 points. 66.41% grade is calculated for the evaluation score which is the lowest score among the four dimensions.

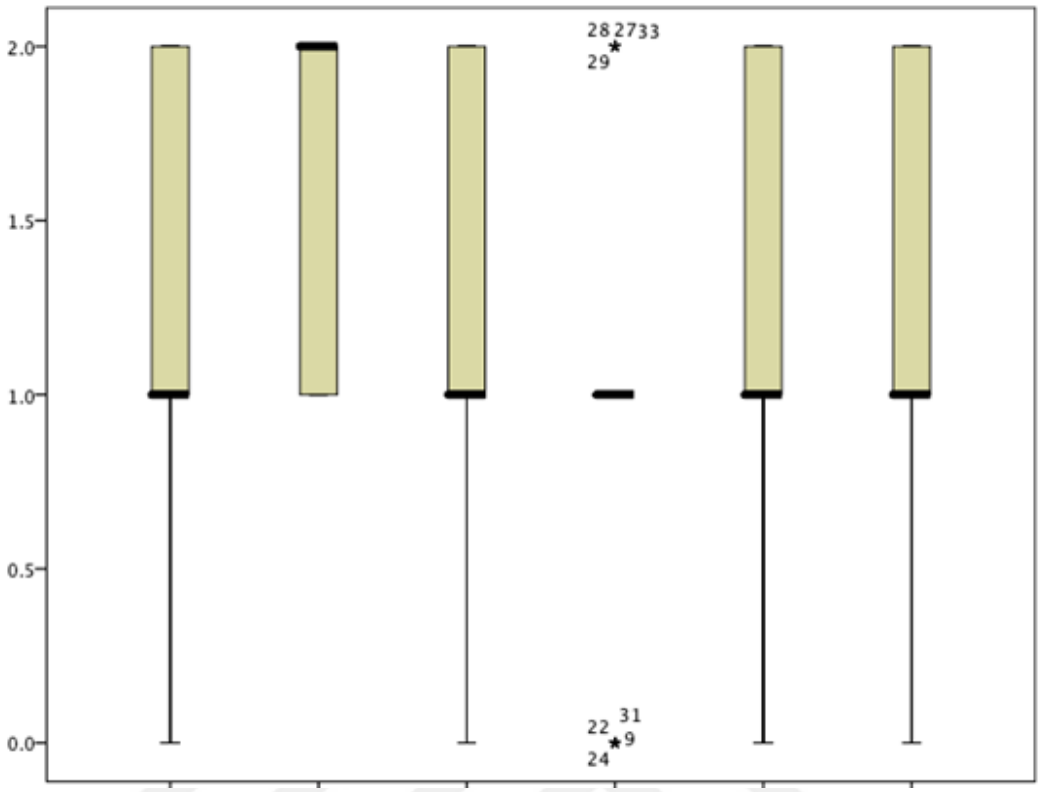


Figure 7.15. TCAR sub-category evaluation related questions.

Table 7.30. Extra Duties in School - TCAR Dimensions Crosstabulation.

Primary Job in School Setting		Dialogue	Decision-making	Action	Evaluation	Overall
Teacher	Mean	10.57	10.46	8.42	7.67	37.14
	N	28	28	28	28	28
Head of Department	Mean	11.66	11.33	10.00	10.00	43.00
	N	3	3	3	3	3
Vice Principal	Mean	12.00	12.50	11.00	9.00	44.50
	N	2	2	2	2	2
Total	Mean	10.75	10.66	8.72	7.96	38.12
	N	33	33	33	33	33

Table 7.31. Highest Level of Education PLC Dimensions Crosstabulation.

Highest Level of Education		Dialogue	Decision-making	Action	Evaluation	Overall
Undergraduate	Mean	11.09	11.18	9.27	9.09	40.63
	N	11	11	11	11	11
Master Without Thesis	Mean	10.41	10.58	8.08	7.41	36.50
	N	12	12	12	12	12
Master With Thesis	Mean	10.77	10.22	9.22	7.77	38.00
	N	9	9	9	9	9
Doctorate	Mean	11.00	10.00	6.00	4.00	31.00
	N	1	1	1	1	1
Total	Mean	10.75	10.66	8.72	7.96	38.12
	N	33	33	33	33	33

Table 7.32. Job Satisfaction - TCAR Dimensions Crosstabulation.

Job Satisfaction Mean Score		Dialogue	Decision-making	Action	Evaluation	Overall
Disagree	Mean	12.00	12.00	7.00	8.00	39.00
	N	1	1	1	1	1
Agree	Mean	10.38	10.15	7.76	7.07	35.38
	N	13	13	13	13	13
Strongly Agree	Mean	10.94	10.94	9.47	8.57	39.94
	N	19	19	19	19	19
Total	Mean	10.75	10.66	8.72	7.9697	38.12
	N	33	33	33	33	33

Just like SPSLCQ , dimensions of TCAR is also analyzed with respect to teachers' extra duties in school setting, highest level of education and job satisfaction (See Table 5.28, Table 5.29, Table 5.30) When teachers focus in school setting is considered teachers' assessment for their collaboration increased proportionally with the increasing responsibility in management (Table 5.28). Even increasing managerial responsibility has an impact on TCAR scores, level of education does not have an apparent relation with teachers assessment of collaboration (Table 5.29). Just like PLCs, teachers' job satisfaction does not have a clear relation with job satisfaction (Table 5.30). Even this

result seems surprising, it is also an important indicator for professionalism. Teachers with different job satisfaction have almost same scores for their collaborative assessment.

7.4. Qualitative Results

Interview is planned for two purposes. First, to elaborate the results discussed for SPSLCQ and TCAR. Second, providing in-depth understanding for quantitative data results. To make it easy to read, results are shared within titles contextual and procedural, and specific results.

7.4.1. Contextual and Procedural Results

For the first part of the interview, school wide collaboration is discussed mostly. Both for high school and middle school respondents started their conversation about decision making mechanism. For both levels, there is a consensus for teachers' participation for the decision-making process that is valued by school administration. However, not all decisions are made by the participation of teachers. As a result, teachers' participation is valued when they are invited. For setting an agenda of decisions to be made, an important differentiation is observed among the responses of teachers and department heads. In other words, teachers are expected to be join in decision-making system. But, decision for the issues to be discussed is a problem mentioned during the interview. While teachers think that their proposal is opened for discussion if only managers agree that the issue is important; department head's claim that agenda is organized with respect to suggestion of teachers. In total, it is hard to talk about constitution of majority for the decisions. There are examples when teachers focus on a solution but leaders finalized the process with their own solution, while there are other examples which final decision is left to teachers' choices.

The school's mission and vision are the second issue discussed during interview. For the origin of the mission and vision statements participants first focus on their time of experience in the subject school. However, two of the respondents of the interview

are working in the school for longer than 10 years, even they claimed that they are not a part of the discussion for mission and vision creation process. Even all teachers claimed that the vision and mission of the school is stated by a higher authority, they all find these statements appropriate for the school and for themselves. All teachers are able point out mission statement with their own words which shows they all have the common understanding of mission and vision. The idea for the realization of the mission and vision statements is left to the teachers which respondents, especially department heads, stated that finding a meaning for mission and vision is left to the teachers' actions.

For the collective learning process, it is expected teachers to define the work groups that they have. Both for the middle school and high school, first choice of teachers is their departments. After some elaboration, level-based study groups are also mentioned. School-wide groups are not mentioned. When the reason is asked, teachers responded in a way that the size of the group is too big and way of coming together and meeting process includes being a guest instead of being a part of it. Level-based study groups are deepened to learn more about interdisciplinary dimension of collaboration. However, purpose of these meetings are stated as to follow-up each class, student progress and student behaviors. These meetings are held by school administration and guidance and counselling office. For the interdisciplinary manner, high school teachers does not have any expression for teaming up; however, middle school teachers stated that these interdisciplinary projects are a result of informal meetings. These are called as "tea-talks, smoking room projects' and so on. Middle school teachers are also stated a specific meeting for interdisciplinary projects which all middle school teachers come together to plan. This plan is detailed through the end of interview for specific results. For the meetings that focus on student learning, instruction, content and educational purposes only example is departmental meetings. For the middle school science and mathematics departments, there are weekly meetings that all teacher come together. There are also level meetings which only teacher who have same level come together. These meetings are made weekly and if the more is needed, scheduling is made by the participation of teachers. For the high school science department, department meetings are said to be rare and organized with respect to direction of department head. For

the high school mathematics department, general meetings are infrequent but teachers from same level come together for their weekly plan once a week or more.

For the shared personal practice middle school and high school shows different characteristics. For the middle school, in both departments course materials are prepared as a product of whole group. A teacher is responsible from a specific task like preparing sixth grade second chapter booklet. But all teachers from sixth grade working on this booklet and all department reviews the booklet for feedback. Teachers from middle school science department use the advantage of having different professionality's like physics, chemistry and biology. That is a science teacher who has degree in physics is working on a biology dependent chapter for seventh grade, the teacher who has a degree on biology contributes to this chapter even s/he does not have any seventh grade for the relevant year. On middle school mathematics department, even the assigned teachers are pay most of their time on a specific task, all teachers review and feedback on the product. For the high school mathematics course, revision is not made frequently since teachers have departmentalization. In other words, 9th grade, 10th grade, regular mathematics, AP mathematics teachers are set in fixed positions for years. So department-wide collaboration is not needed but teachers from the same level come together. For the high school science department, teachers grouped as physics, chemistry and biology, so there is not enough information for generalization with respect to interview data.

One of the most important difference is in feedback system for the school. Both for high school and middle school there is feedback system which is configured based on supervision. In other words, department heads, school principals or vice principles have class visits for observation. For the high school, teachers claim that this system is not operating for various reasons. First reason is stated as the system is not configured for teacher effectiveness and instructional quality. Second reason, there is not an observation protocol. Third, scheduling is not set, observer may come to class any time. For this reason, by the way, respondents have the drawback for misunderstanding that if they know they are being observed, they will do an extra study to show observer. However, two of the teachers stated that teaching in class is not a set of

static behaviors. They may use direct instruction or may use completely inquiry based strategies with respect to their needs. So they have the problem for "labeling" as a traditional teacher since they are solving a problem on the board at that time. To clarify the visit process one of the participants stated that "Any day, any time of the class school principle may enter the classroom. Having them in class is not a problem. But they don't know about content, they don't know about current status of the class, they don't know what we did five minutes ago or what we are going to do five minutes later. So this is not an observation, and I personally can not take a feedback serious as a result of such observation. As I said, this is not an observation. But this is literally a visit, so if it is a visit, misafir umduğunu değil bulduğunu yer (A Turkish idiom that tells guest can not have choice to eat what they want but they eat what is offered)". Even the response of the participant is so specific statement are almost similar for the high school. In addition to school principal's observation, department heads are expected to observe class in a more structured way. However, common voice for this observation activity is focus on a frequency "maybe once a year or less". For the high school teacher to teacher observation and feedback system is not present and almost all teachers stated that "I may accept teachers in my class sometime, but there are a lot of teachers who misunderstood if I request them to be a guest in their class". Only one teacher express that s/he may go any class since his/her intention is not the criticize.

For the middle school, teachers did not give any information about the previous years, but they all focused on a relatively new plan. In the beginning of the recent year an extra classroom visit protocol is designed by middle school administration. With respect to this protocol it is expected from teachers to make four pre-planned classroom visits. This system is not mandatory but highly suggested by middle school administration. Two of these visits are suggested to be departmental and two of them are interdisciplinary. Even only one teacher of the participants stated to complete all four visits, others also stated that it s a really good act for peer to peer observations. An online form is created for this system. Scheduling and feedback mechanism work on this system. Not criticizing the observed teacher but trying to learn from each other is said to be suggested so many times. One of the teachers tells his/her visit to history class and express his/her feelings as "nourishing" since the content is far away from

his/her discipline and teacher's method is so different. Also observing students in a different environment created a different perspective with respect to comments of this teacher. Supportive conditions are also a part of the interview. Even structural needs are also discussed during interview, almost all teachers have their focus on managerial support. While talking about collaboration, it is observed that teachers have their focus on departmental collaboration. For the departmental collaboration, natural setting in the school let teachers act as they want. But an important output is about assessment of teacher's work. A consensus is observed that school's acts put the course hour as the primary responsibility. One of the example responses from a teacher is "this school has a great position in Turkey. However, there are so many teachers in this school who think that covering the class is enough. It is not true; I'm not educated for teaching in this way. But when the school does not pay attention to extra works that teachers do or does not pay attention to teacher who do nothing but just going to class with aged materials, I feel like I'm doing all these preparation for nothing". Mostly high school but in general all teachers stated the need for an adjustment in responsibilities. In total, teachers wanted to have designated times for department meetings for each department that people must work for planning and other stuff.

Interdisciplinary collaboration on the other hand, appears as a more important aspect that managerial support is needed. Since teachers stated most of the fundamental collaborative aspects as their duty, works are managed by themselves mostly for their departments but for interdisciplinary collaboration teachers need guidance and assistance. Teachers especially from middle school, mention about the impact of the management-based projects and two of the teachers stated that if they had a place and time to meet for teachers, number of collaborative activities are increased a lot. On the other hand, management of interdisciplinary collaboration is seemed as a problem by high school teachers. One of the responses is "We need to work together, but we don't have to. If, for example, we don't organize any interdisciplinary project, no one will ask why we are that much isolated. However, if time for weekly meetings with other departments are added to our schedule, we will need to plan and act together". As seen, teachers are volunteer to work together but they want to be seen by the management. Also, for both middle school and high school teachers stated a need for a

place to work together.

For the procedural part, teachers daily routines, mechanisms for dialogue, decision making, action-taking and evaluation are focused. To start with the internal structure of dialogue, structure of departmental and interdisciplinary meetings are asked. Even meeting if needed is a general phenomenon, weekly meetings are said to be important especially for middle school teachers. For the interdisciplinary meetings, pre-planned meetings are mostly focus on the demand of counselling office. That is, students with special needs, behavior assessment, end-of-term evaluation and management-based issues (e.g., making next year's class lists) are the focus of these meetings. When the interdisciplinary projects are discussed, these meetings are evaluated as mostly random, spontaneous. Even all teachers prefer face-to-face chats, teachers claim that most of the conversation is maintained through e-mail. When more discussion is made for this issue, "having an appropriate time for more than two teachers is so close to impossible" is a summarizing comment for all discussions. Even there are not enough evidence to say topic of interdisciplinary dialogues are student learning, teachers think that each decision made in a school setting is related with student learning. However, when student oriented objectives of a meeting like sharing different teaching strategies, coming up with an idea for alternative assessment method is remembered; they express that the focus, in that case, is not student learning. The last thing that is discussed for the dialogue of teachers is the time management of the process. As discussed, for smaller groups teachers adjust their schedule and come together only in their free time. For bigger groups an online invitation is sent to teachers but all teachers argued that the appropriateness of the meeting time for the participant that is individual plans are not considered for this planning. However, two department heads stated that the meetings are set online since teachers' daily schedule is in this system and they find the most appropriate time for meeting by running a feature on this system. In such a case, if a teacher has a work to do which is not assigned in his/her schedule, teacher - manager conversation is said to be enough to find a solution.

Departmental characteristics have an important impact on decision making mechanisms. It is hard to drive a result from the responses but for each department, consen-

sus is the expected, but majority is acceptable. Department head's individual decisions for the department is not observed frequently but one of the department heads specifically stated that "It is not possible to be planned and act democratically all the time. Spontaneous problems need quick actions. I can neve say I am the decision maker but just like teachers in class, we sometimes make decision without asking the department. However, when I make a decision for the department by myself I always filter this process by thinking each participant of my group and their possible responses". Even conflicts and conflict resolution is an important aspects for the groupwork, a special need for conflict resolution is not observed. Teachers share the common sense for their focus. That is, since their decisions are based on "making the best for students" conflicts can be chosen without any help with more discussion.

Evaluation is one of the most important issue discussed in this part, since the quantitative scores are relatively low with respect to other dimensions. Just like the need for a system that manages teachers schedule for effective collaboration, evaluation is a need for teacher stated by them to work more collaboratively. Both for middle school and high school, teachers claim that a procedural framework that manage and assess teachers' performances is not apparent. However, department heads at this point discuss about Marzano forms which is a framework to assess and give feedback for teacher performance. When teachers' and department heads' responses are compared it can be said that this system does not have an impact on teachers, so they even don't remember. However, most of the teachers expressed their interest in assessment. Teacher expect observation and feedback for their own professional development. Also one of the teachers stated that, "having such a system will show who is really working and who is just acting" which implies an anger for the lack of fair assessment.

Both in the middle school and high school teachers have a consensus for weakness in the evaluation part. In other words, planning and acting for a project operates well, but for the assessment part there is a need for development. Since almost all the projects are student oriented, teachers and managers have their focus on students' learning. So final part of the project is assumed as the students' assessment and evaluation part. After the evaluation is completed for students, evaluation of the project

is not done most of the time. So, efficiency measurements mostly done personally and not officially. When the reason for this problem is discussed with elaboration, two result appears as most common result. First, the curriculum is not flexible, and teachers have to keep up with curriculum planning. Projects for alternative assessment and especially interdisciplinary projects are said to be time consuming when the time designated for these objectives and time needed for the projects are compared. So, teachers feel themselves in hurry especially for the last part of the project. Second, since these projects are extra work, and teachers come together voluntarily such an evaluation is not requested by any managerial position. Even this idea is more common for high school participants, middle school teachers are not far away from this result.

7.4.2. Specific Results

In this section questions are asked separately with respect to analysis of quantitative data. As the firs question, the difference between the SPSLCQ and TCAR scores for the middle and high school is asked. For the middle school teachers direct their attention to curriculum mostly. Computer science course curriculum is open for any project. Also, science and math curriculum have many interdisciplinary connections that creates space for teachers to work together. Also, especially for science course, interdisciplinary project with computer science and mathematics and also with other departments is required to complete some course objectives. When the same question is asked for the high school teachers, two of the teachers complaining about the lack of time for such a collaboration and one of the teachers stated that content specific courses limit teachers more than other courses. This teacher has classes both in high school and middle school and up to this teacher, teaching specific courses like AP Physics or Geometry cause a narrow perspective in applications, since most of the course objectives are so detailed and content specific. The most interesting result for this question is not about the difference but teachers in high school started their answers by saying "I'don't know what is going on in middle school exactly' and teachers from middle school say the same thing "I'don't know what is going on in high school exactly". This answer is important because collaboration for middle school mustn't be limited with the school level.

Even teachers have already told about their classroom observation protocol another important detail that cause this difference is appeared with the next question. In the beginning of the semester, all teachers are invited to seminar room for an interdisciplinary projects workshop. Object is meeting is stated clearly to the teachers. Teachers from different departments share their curriculum and objectives. They also shared possible areas for interdisciplinary projects. Sharing and planning is made during the day. At the end of the day teachers leave the meetings with so different project ideas. After the meeting management of the process is left to teachers and teachers claimed that most of these projects come true throughout the year.

When the high school and middle school is compared by the teacher who has classes in both levels, middle school management's attempt to remove the departmental borders and bring departments closer show its results as difference between middle and high school. When this specific teacher's or other teachers' comments are collected about the difference, middle school's attempt is interpreted as essential. High school management, on the other hand, is not accused but more active participation of the management to the collaborative process is seemed necessary.

Even the above act of the middle school has the potential to increase effective collaboration, one of the most important need claimed for effective collaboration is stated as the evaluation of collaborative work. Teachers who focus on the interdisciplinary project workshop state that if this workshop is repeated at the end of the year with a review and evaluation of results meeting the project may double its potential for the next year. Need for evaluation is not a need for middle school teachers but as discussed previously high school teachers also state the need for evaluation.

Fundamental collaborative skills are more frequent than effective collaborative skills with respect to quantitative data. Also, teachers' examples are asked for collaboration and almost all the answers are based on fundamental collaborative skills. When effective collaborative skills are asked to the teachers hindering factors are not easy to conclude. For the school culture there is not an obstacle to be more collaborative. However, there is also not a facilitator process. Teacher from the high school stated

that they are not used to have another professional in class; however, there is not any reason to get used to it. For the middle school, observation protocol seems like changed this idea. Teachers from middle school state that "when there is a direction for classroom observation for example, I feel free to visit a teacher's class without feeling strange". Managerial support is in this point appeared as a need for all teachers.

Even lack of time is a frequent reason for teachers' distance to effective collaboration, teachers for the subject school stated that lack of time is always a problem. One of the high school teacher claim that "I have 21 hours class a week and I don't have time, I had once 26 hours class a week and I didn't have time, if I have 15 hours I'm sure I won't have time". This statement provides a good summary for the response of other teachers. Both department heads and teacher have the same idea that time can be adjusted if the need for the new idea is clear for all. While time is considered like this, when teachers compare their departmental collaboration with the interdisciplinary collaboration, the first reason is directly related with time: "I started to day in department room, then I go to class, come back to the room and go to class again. In such a case, only teachers that I meet are my friends from my department and teachers that I run into on corridor". When their previous response is asked to teachers, they stated to importance of scheduling. "When you have no class, you spend your time with course preparation or do your paperwork. But if I have a specific time for meeting. It will be my focus for this hour and be there for the meeting". Is an important response for the need for official scheduling that also prevents excuse for lack of time.

Another important aspect that is needed to be considered is a place for teamwork. Reason for high percentage of departmental and fundamental collaboration instead of effective and interdisciplinary collaboration is mostly seen as the physical structure of the school. That is teachers have their seats in their department rooms. So, in their free time they see their colleagues more frequently than teachers from other disciplines. Coming together with a teacher from another room requires an arrangement which is not easy and also a teacher's response express also other teachers feeling about this arrangement process: "Knocking a door and saying", "Hi" I come to work with you' is a little bit foolish. Transforming department rooms into a general staff room is

asked to respondents. All teachers object to this idea since working in such a crowded room is considered as impossible. However, all the teachers agree that a place for the teachers work, plan and act together would increase the potential for interdisciplinary collaboration and “it would be more motivating than teapot or smoking-room chats”.

8. DISCUSSION

When the current literature is considered, studies which try to enlighten teachers' current attitude are rare. Even the suggestion for the further research directs studies to clear and empirical insight into characteristics of teacher teams (Vangrieken, *et al.*, 2015). It is hard to provide an understanding without a clear definition of collaboration. When the interview data is compared with the SPSLCQ and TCAR, there are some important results that are needed to be discussed for teachers understanding about collaboration. During the study, definition of collaboration is not asked directly but implications are collected at different stages.

8.1. Professional Learning Community Perspective as a STEM Community

Because of the complex nature of learning process teacher competencies are insufficient to explain student achievement in general. (Eijwale, 2013) However, studies have shown that poor preparation and shortage in supply of qualified STEM teachers is one of the most important barrier for STEM integration (Eijwale, 2013). When Eijwale's (2013) interpretation is followed the list goes with "Lack of investment in teachers professional development" and "poor preparation and inspiration of students". When these three barriers are considered, an effective preparation period becomes more important fore STEM implementation process.

While STEM education referred to each of the individual disciplines within their own context, integration of four disciplines creates a more meaningful learning experience for students (Sanders, 2009).While curriculum and content is another aspect of integration process, this study focus on teacher collaboration. Just like Eijwale(2013), Ayres (2016) reviewed the fundamental need for a successful curriculum, a deep shift in teacher thinking within a collaborative partnership. Such a partnership sort individual teachers' problem out by creating space for teachers for their self-efficacy, lack of confidence etc. (Ayres, 2016).

While the need for collaboration is that much clear, Professional Learning Community framework has chosen to investigate the structure of collaboration in subject school.

Dimensions of a PLC: Shared and supportive leadership; shared beliefs values and vision; collective learning; shared practice; supportive conditions will be discussed as the pre-requisites of teacher collaboration for STEM integration. Scores for each dimension is measured for the study and analyzed with the help of interviews. Demographic properties and school characteristics are distinctive to compare results. But it is important to see both national and international position of the school for each dimension. When the studies are compared three studies come forward to show a picture of professional learning communities with its five dimensions. The first study is from Turkey which 490 participants responded to SPSLCQ for PLC (Bellibas *et al.*, 2016). In their study researchers investigate Turkish schools' capacity for supporting professional learning communities and to examine factors that account for variation in the current level of development. Other two studies provide international examples for the PLC. Cassity (2012) worked with 59 teachers from Alabama to examine relationships among perceptions of professional learning communities, school academic optimism, and student achievement in middle and high schools. As a final study, Yarbrough (2010) examined the perceptions of administrators and teachers in the state of Georgia with 78 participants who surveyed using SPSLCQ to determine perceptions about the effectiveness of their PLC.

Table 8.1. PLC dimensions compared to literature.

Mean Score	N	Shared Leadership	Shared Vision	Collective Learning	Shared Practice	Supportive Conditions
Current Study	33	3.40	3.84	3.66	2.74	3.42
Bellibas, *et al.*, 2016	490	2.81	2.74	2.67	2.7	2.58
Cassity, 2012	59	3.60	3.95	3.83	2.84	3.61
Yarbrough, 2010	78	4.15	4.24	4.13	4.04	4.24

For the shared leadership even the subject school has higher score(3.40) than Turkey's average (2.81), the score is lower than the scores gathered in both Alabama

and Georgia. However, for the study in Turkey and the current study participants does not have any treatment for PLC, while Cassity and Yarbrough worked with previously existing PLC schools. So even Yarbrough's (2010) result is still high, results gathered in Cassity's(2012) study reveals a potential for the subject school when there is no treatment for this study.

Shared vision is one of the most important aspect for not only PLC but also STEM Integration. That is, teachers will collaborate to reach their maximum performance. Each individual use his/her strength as a contribution. In this position sharing a common vision and mission is important to increase the potential of the group. Within this context, subject school has a differentiating quality for the shared values and vision in Turkey (See Table 6.1.). However, there is a need for development to compete in the international league.

Just like shared vision, collective learning is an important aspect for effective collaboration in STEM teaching. Collective learning refers to PLC's ability to work together collectively to come up with solution to numerous instructional problems. With increasing quality in collective learning PLC's will show its impact on STEM education. So, when the scores are compared, subject school is visibly higher than the Turkey's average but significantly lower than the other two studies (See Table 6.1). Increasing the focus on collective learning with PD activities, has an positive impact on shared vision and shared practice (Olivier et al,2003)

Shared personal practice is a case that is needed work on it with respect to Table 6.1. When the other four aspects are compared with Bellibas's (2016) results, there is a difference in scores ranging from 0.6 to 1.1. However, shared personal practice is almost equal to Turkey's average (See Table 6.1). For a school in Turkey, being close to average is not a problem; however, the issue discussed in here is the change in trends. The graph in Figure 6.1. is drawn to investigate change in trends of the studies. The data for current study and Belibas (2016) are compared to discuss subject school's trend with respect to Turkey's average. For the first three dimension, current study is above the average. However, the change observed for shared practice is significant.

For the overall quality of PLC for the subject school, extra attention is needed to be paid for shared practice. An average between 3.5 and 4 will keep the trend in line.

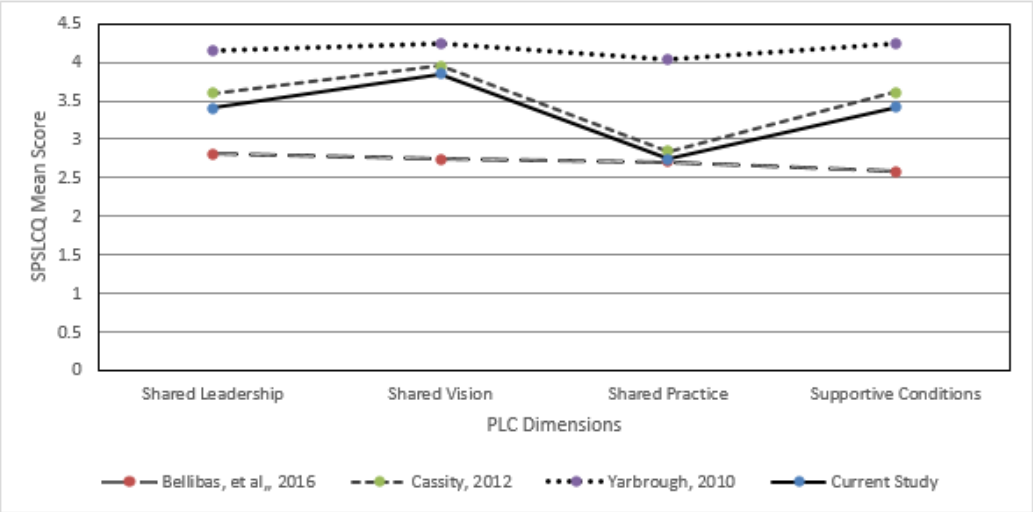


Figure 8.1. PLC dimensions compared to literature.

For the last dimension of the PLC, supportive conditions are discussed. Supportive conditions are grouped in two as relationships and structure (Belliebas, *et al.*, 2016). Breaking down the isolation and providing respect-based relationships among the participants of PLC is the part of relationship based supportive conditions. Promoting a culture of professional dialog among teachers and engaging teachers in a rewarding professional conversation is the structure based supportive condition of PLC. Just like first three components subject school has a high score than Turkey's average but lower than international studies.

When the all aspects are considered together, possibility of development is open for discussion. Even the hypothetical purpose is to reach 5.0 mean for all aspects, focusing on weaknesses is also an important act to provide a continuous cycle for PLC. For a continuous quality of PLC, shared practice is needed to be elaborated. However, the difference between the scores gathered for Turkey's average and are encouraging to focus on collaboration for a successful STEM implementation.

8.2. Collaborative Skills

During the study, collaborative work is limited with the observing other teachers in class, teaching jointly, engaging interdisciplinary and transdisciplinary activities, exchanging teaching materials, engaging about the learning development of specific students, working with others to ensure common standards for assessing progress, team conferences, and taking part in collaborative professional learning. When the items for collaboration are investigated, exchanging teaching materials (Mean, 82,5%), engaging about the learning development of specific students (Mean, 75%) and working with other teachers to ensure common standards for assessing students' needs (Mean, 66%) are considered as departmental duty. When the position of the school and common standards for education in high-level private schools are considered these items are seen as regular work for teachers. The score calculated over 75% varies from "5-10 times a year" to "once a week or more". So, all levels and departments have their base for collaboration.

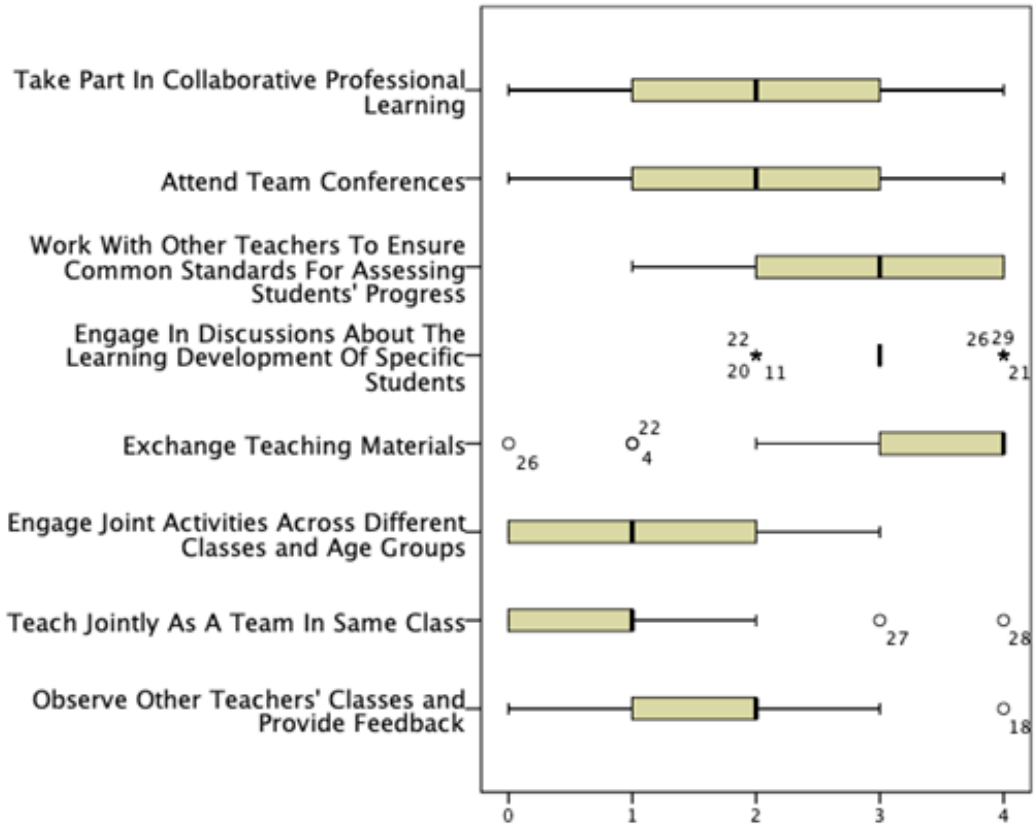


Figure 8.2. Collaborative skills.

However if the other items are grouped as an effective collaboration such as teaching jointly (Mean 20%), observing other teachers in class (Mean 44%), engaging joint activities (Mean 23,5%), taking part in collaborative professional learning (Mean 53%), reveals a decrease in the overall collaboration.

In Figure 8.2, 0 represents never, 1 is once a year or less, 2 is 2-4 times a year, 3 is 5-10 times a year and finally 4 represents once a week or more. As also discussed above, items like exchanging teaching materials or working with other teachers have higher median like 3 and 4; however, items like teaching jointly, engaging joint activities have relatively low scores.

In order to clarify respondents' understanding about collaboration, TCAR and SPSLCQ scores are compared with collaborative activities. As seen Table 6.1. Even the mean for TCAR and SPSLCQ are above 70%, teachers' collaborative activities are around 45%. For the first row, 45% represents the frequency of collaborative activities which varies between "once a year or less" and "2-4 times a year". It is important to notice that items listed as effective collaboration has relatively low frequency (35%). TCAR analyzes the procedural structure of collaboration, while SPSLCQ analyzes contextual structure.

Table 8.2. Collaboration scores compared.

	N	Maximum	Mean	Std. Deviation	%
Collaborative Skills Avg Total	33	32	14.8485	4.899	46,37%
TCAR Score	33	52	38.12	9.63	73,30%
SPSLCQ Score	33	85	59.48	9.424	70,00%

When these results are considered, it is possible to say that teachers for the subject school have mostly structured collaborative attitude which is also contextually satisfactory, but the frequency of the collaborative work and the quality in case of effective collaboration is relatively rare.

8.3. Hindering Factors for Effective Collaboration

The difference between the results of TCAR, SPSLCQ and Collaborative skills is investigated in interview. The literature lists the hindering factors in four main categories: personal characteristics, group characteristics, organizational characteristics and structural characteristics (Vangrieken *et al.*, 2015). For the subject school, interview results reveal common factors that prevents effective collaboration.

When the interview results and teachers' collaborative activities for effective collaboration are analyzed, increasing the collaboration for interdisciplinary purposes is needed. While, in most departments, teachers have weekly, or less frequently structured meetings, the interdisciplinary meet ups are significantly rare. When the purpose of these meetings is discussed during the interviews, they are mostly course content-oriented. So, the reason for the high scores of departmental collaborative activities might be these meetings. When the lack of interdisciplinary collaboration is discussed, there are various reasons and needs that are listed.

For the personal characteristics, even there are some other individual responses, lack of knowledge of team processes (Main, 2007) appears as the most common criteria. This fact appears as "we don't have a procedure to work together", "the school wants different departments to work together but there is not a goal or clear expectation". As a result, teachers are working together for their disciplinary purposes and also, they want to do so for interdisciplinary collaboration. However, they need professional development activities before they start working together.

Another important aspect appears as structural characteristics. Teachers are clear about "lack of time" (Rone, 2009) even though this is not an excuse, they need scheduling made by the school management. For the subject school, also for all schools teachers' workload is calculated with respect to their course hours. A teacher's first responsibility is covering the class hour. Paperwork, communication with parents and other responsibilities are assumed as secondary work. However, effective collaboration skills like interdisciplinary activities, joint classes, course visits, etc. are not discussed

as a responsibility. In this case, when teachers need to make a decision among their responsibilities that are required, that are better to do and their comfort zone (Rone, 2009), they stick on their primary and secondary responsibilities. That's why the facts that are still important but not compulsory have to wait for their free-time and interviewees have common need for the management of time for themselves. "We need to work together, but we don't have to. If, for example, we don't organize any interdisciplinary project, no one will ask why we are that much isolated. However, if time for weekly meetings with other departments are added to our schedule, we will need to plan and act together". This is one of the responses for a teacher's need to work more collaborative. Another impact of scheduling done by school management is the sense of equality (Westmeister, 2008). Teachers have a feeling that effective collaboration is not a must but an important aspect of being a good teacher. However, in the school setting, interview result shows that teacher's one of the most important comparison criteria is working with similar workload. Even some teachers have the feeling "being better for yourself", they still express that this process is not managed by school administration which means "our extra effort is worthless since there is not an evaluation criterion for this process".

The last most common hindering factor for effective collaboration is again structural. For the subject school, teachers are working in department rooms. For the middle school, science department is at the first floor and math department is at the second floor. For the high school, science department is at the basement, math department is at the fourth floor and computer science department is at the first floor. When the difference between disciplinary and interdisciplinary collaboration is investigated during the interview, physical distance (Smetser, 2007) is seen as one of the reasons for the disconnection between disciplinary and interdisciplinary collaboration which is an effective collaboration. Respondents of the interview declare their daily routine as "living in the classroom and department room". When the other hindering factors -discussed above- are considered, responses like "knocking a door and saying "hi! I come to work with you" is a little bit foolish". It is declared that working at different rooms create a boundary between different disciplines. Respondents declare that most of their meetings as "by coincidence on the same floor" or "in front of teapot" or "in

the smoking room". During the interview, decision of the teachers for a staff room or department room is asked that is in fact the solution of isolation problem. Almost all the teachers stated that "a room for all teachers sounds good for the solution of the problem but it is impossible to work in a room with 200 teachers". As a result, a more creative environment is needed for teachers, but a general staff room is not seen as a more productive environment when all dimensions are considered.

As stated before, the subject school shows the characteristics of a good Professional Learning Community where collaboration is highly active. However, when the collaboration is considered for STEM implementation process, there is a need to discuss the content of collaboration. In other words, interdisciplinary or transdisciplinary interactions are needed (MNE, 2016).

8.4. Difference between Middle School and High School

After the needs of the teachers for more effective collaboration and reasons for rare interdisciplinary collaboration are discussed, an important difference needed to be clarified. When the TCAR and SPSLCQ results are analyzed with respect to grade levels (middle school and high school) middle school has relatively high scores in all aspects than the high school teachers (see Figure 8.3, Figure 8.4 and Figure 8.5).

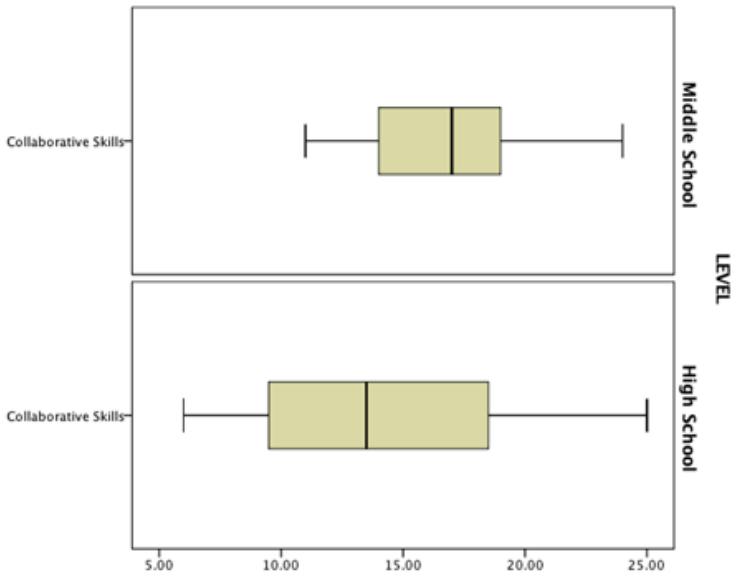


Figure 8.3. Collaborative skills compared with respect to grade level.

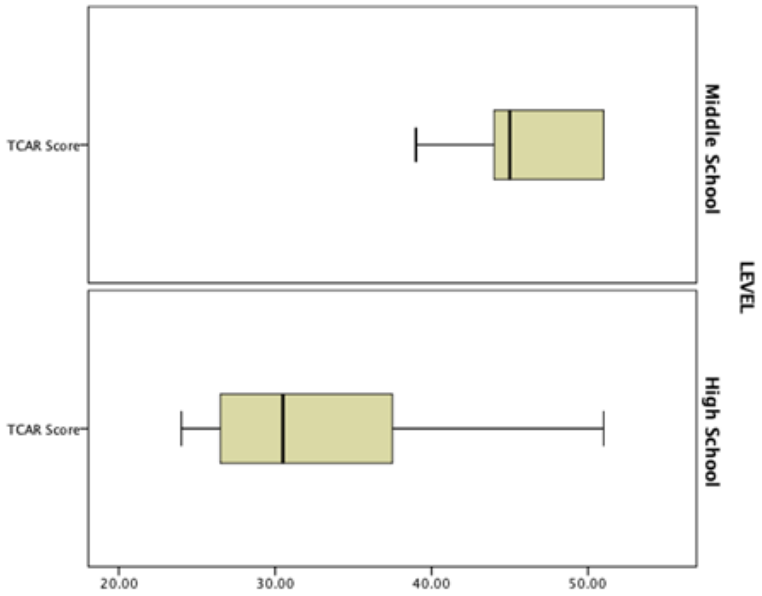


Figure 8.4. TCAR score compared with respect to grade level.

When the Figure 8.3 is considered, the horizontal axis represents the frequency of the skills: observing other teachers' classes and providing feedback, teaching together in the same class, engaging joint activities across different classes and age groups, exchanging teaching materials and discussing about students with special needs, working together to ensure common standards for assessing students' progress, attending team conferences, taking part in collaborative professional learning. "0" represents "never" and "25" represents "once a week or more". Even distribution is normal for both group, range is apparently narrow for middle school, which shows a consensus for their individual responses.

Difference between the two group is more apparent for TCAR scores. A total of 52 points is possible for 26 items. When the Figure 8.4 is considered, middle school teachers have a median 45, while high school teachers have 30. Even high school teachers have scores close to 50 which impacts the distribution,t first quartile is grouped around 33 while middle school teachers are grouped around 46.

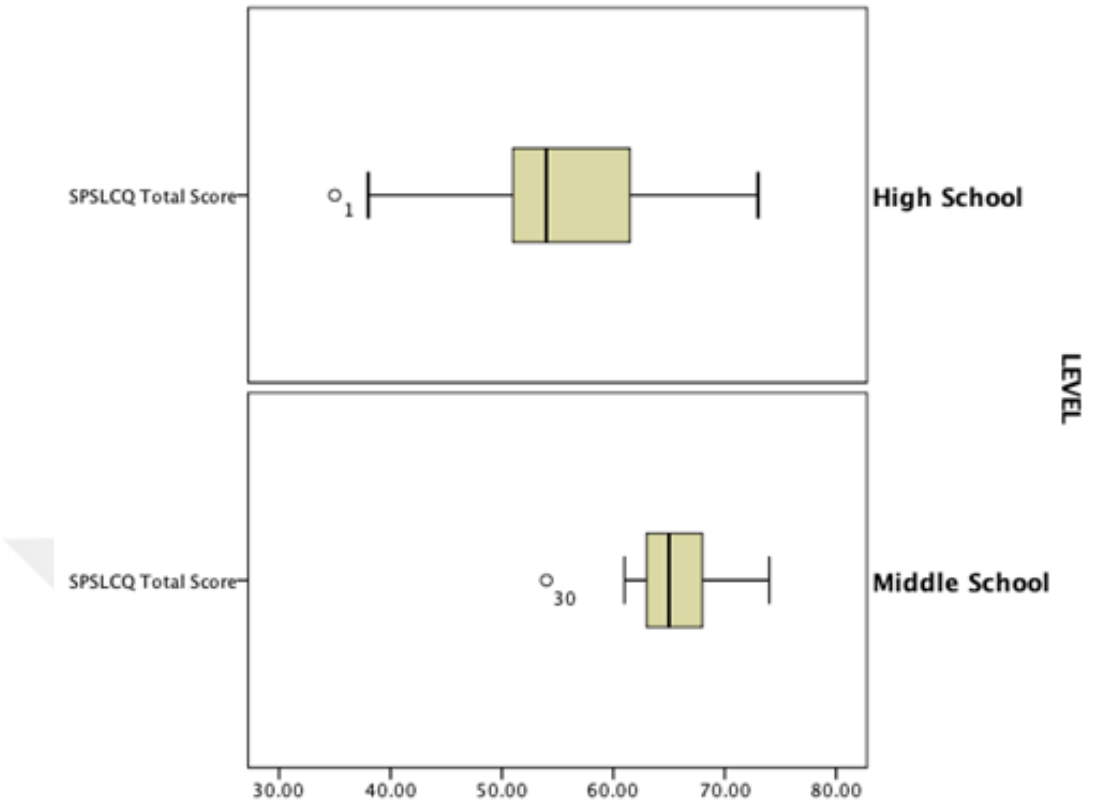


Figure 8.5. SPSLCQ score compared with respect to grade level.

Just like TCAR and collaborative skills scores, SPSLCQ score vary significantly between middle school and high school teachers. SPSCLQ has 17 items where there are possible 85 points maximum and 17 points minimum. Middle school teachers have a median 65 and high school teachers have 54. Just like TCAR, SPSLCQ has same distribution characteristics. Distribution is narrower for both first and second quartiles for the middle school teachers.

Even TCAR and SPSLCQ are used to reveal the characteristics of the collaboration in subject school, the difference between the middle school and high school requires a more detailed research. Within the framework of this research, semi-structured interviews are used to understand and analyze this difference. Although interview results reveal appropriate explanation for the difference, a specific research that focus on this difference has the potential to analyze more variables especially in the administrative base.

During the interview this difference between high school and middle school is investigated both directly and indirectly. First the result of the TCAR and SPSLCQ is shared with both middle school and high school teachers. With this question, one important fact appears as a side fact that teachers express their unawareness for the other school. For example, when this difference is asked to a middle school teacher, s/he starts his answer, "I don't know exactly what is going on in the high school". This case is same for all participants of interview, regardless of the level they work. So, both middle school and high school teachers do not aware of the other part of the school.

When the difference is asked directly, the answers are similar in groups. Most teachers, especially the ones that work in middle school, direct their attention to a curriculum. Middle school science and math curriculum is said to be more general than the high school. As a result, especially science teachers have the chance to manage interdisciplinary collaborative projects with STEM orientation. High school teachers also have a similar result. Focusing on the content area like physics or more specifically AP Physics Electricity and Magnetism, or Geometry obstruct looking in an interdisciplinary manner. High school teachers express that focusing on sub-disciplines creates different priorities for the course objectives.

Aforementioned, difference between middle school and high school is investigated both directly and indirectly. For the indirect investigation of the difference, current applications and routines are asked to the teachers. For the high school, teachers do not show any implication of effective collaboration as an attitude or a process that is managed by school administration. The only idea that is expressed by teachers is vertical alignment meetings. Not only high school but also middle school teachers from science and math departments express these meetings as a well-meant but vain process since the objects and purpose of these meetings are not clear and the procedure for the meetings were not set before the meetings.

For the middle school teachers, answer for their collaborative routines and significant applications that they did in last 12 months has richer content. Two applications

specific to middle school create a basis for a proper explanation for the difference.

In the beginning of the last year, all teachers from all departments are invited to a meeting room for a group activity. Intention of this activity is to make teachers aware about other teachers' course objectives, plans, etc. First, teachers share their course objectives and possible ideas for interdisciplinary projects. After initial sharing time, teachers from different departments discuss about alternative strategies. Horizontal alignment strategies and possibilities are discussed and so many interdisciplinary activities are decided to be organized. After this meeting, a report is prepared for the calendar year to remember the decisions made for each course. During the semester leading teachers (mostly the teachers who has most objectives for the activities) organize the procedure for the projects and most of the project are applied. This meeting created an environment for group projects, but the rest of the project is not controlled by the leaders of the meeting. Teachers' projects are not noted at the end of the meeting and assessment of the impact of project, the evaluation part, is left to teacher's choice. Even respondents of the interview state that such a follow up procedure may maximize the efficiency of the activity, it is obvious that such a triggering event created a difference for the middle school.

For the effective collaboration, one of the items that discussed is classroom visits and feedback mechanism. As mentioned in "Research Site" part, this feedback mechanism is a naïve approach thatt lacks sophistication and continuity. Moreover, feedback mechanism is operated by department heads and vice principals. Such a procedure decreases the advantage of peer-to-peer conversation but increase the feeling of criticism. However, another project is in practice at the beginning of the semester. For this time, the tradition is changed in the middle school and teachers have started to visit teachers. Middle school administration did not pin down these visits but clearly stated as highly suggested. With respect to this project, each teacher will visit four teachers on condition that two of them are from own profession and two of them are interdisciplinary. Object of these visits is not criticizing but observing for personal interest. An online observation form is created for teachers in order to take notes for the different techniques that teachers use. When a science teacher visits history

teacher, observes story telling activities, that gives an idea to teach about verbal topics in physics. Also, with respect to feedback from the participants of interview, science and mathematics teachers' collaboration apparently increased after they notice they can do so many things in common. Just like other projects, these projects has the need for follow up. In other words, this project is started in the beginning of the semester, however, respondents express that there is a need for evaluation for the impact and results of this feedback system. Nevertheless, most teachers from middle school have faith for the development of this project for the following years. The idea is that "It's a starting point for a meaningful feedback system. Even there are missing points, these points are not visible before acting. I believe next year feedback is collected for this new feedback mechanism and we will have a more effective period". It appears with different expressions but common feeling.

9. CONCLUSION

During a long-range change in the characteristics of education, STEAM education is one of the final reforms in education. STEAM teaching and learning require partnerships (Metz, 2009) that needs interdisciplinary work between teachers. Formation of a committee for Innovation Center for the subject school, shifted the focus on STEAM teaching learning. While a reform process in the STEAM teaching and learning is the future for the Innovation Center, fundamental needs are discussed to provide a foundation for an effective implementation process. For this implementation process, collaborative working skills and its efficiency become more and more important for the teachers in the field of STEAM (Capraro *et al.*, 2013; Gonzalez and Kuenzi, 2012). Lack of preparation, lack of PD and lack of effective collaboration are considered as the most important barriers for a successful STEAM implementation process (Eijwale, 2013).

The collaboration among teachers is studied under many different terminologies like team, group, community of practice, professional learning community, etc. Even there are different terms are used for the meaning of collaboration, there is a need for clear and empirical insight into characteristics of teacher teams (Vangrieken *et al.*, 2015). For this study, current position of the subject school and need that appears in the literature is considered.

This study is designed to provide an in-depth understanding for the contextual and procedural structure of the collaboration. In order to understand the structure of teacher collaboration, Hord's professional learning community framework is chosen for the theoretical framework. PLC is defined as a group of people working together and the practice is critically investigated in a continuous, reflective, collaborative, with a focus on learning and growth of the process of learning (Bolam *et al.*, 2005; Toole and Louis 2002).

In order to provide in-depth understanding 33 teachers are investigated. These 33 teachers are sampled from Science, Math and Computer Science departments from both middle school and high school. For the subject school middle school and high school sections are managed by different principals while they all operate under the control of the same executive committee. Even the self-management creates freedom for each section, K-12 integration connects middle and high school structures.

The collaboration is investigated in contextual and procedural manner. For the contextual manner, School Professional Staff as Learning Community Questionnaire (SPSLCQ) is used to provide an understanding for teachers' attitudes for five contextual variables: Shared and supportive leadership; Shared beliefs, values and vision; Collective learning and its application; Shared practice; Supportive conditions. For the procedural manner of collaboration, Teacher Collaboration Assessment Rubric (TCAR) is used. Procedural content of collaboration is investigated under four variables: Dialogue, Decision Making, Action and Evaluation.

The scores gathered from SPSLCQ and TCAR are promising but open for development. In contextual theme, shared and supportive leadership has 68%, shared beliefs, values and vision has 73%, collective learning and its application has 73%, shared practice has 54%, Supportive conditions has 79%. For procedural theme, dialogue has 77%, decision making has 76%, action has 73%, evaluation has 66%. Percentage scores given for variables demonstrate that the school has promising potential for the effective collaboration while all variables are needed to work on it. However, shared and supportive leadership for the contextual theme and evaluation for the procedural theme requires more emphasis than other variables.

In order to provide in-depth understanding for collaboration, demographics and characteristics of teachers who collaborate is also important. To provide detailed information Demographic Analysis Teacher Questionnaire (DATQ) is used. DATQ is adapted from Teaching and Learning International Survey (TALIS). Even TALIS has measurements in various categories, researcher of this study adopted this questionnaire in five sections. DATQ consists of Background and Qualification, Current Work,

Professional Development, Teaching in General, School Climate and Job Satisfaction.

As a result of DATQ, collaborative skills are decided to be grouped in two different parts. Collaborative skills are listed as observing other teachers in class, teaching jointly, engaging interdisciplinary and transdisciplinary activities, exchanging teaching materials, engaging about the learning development of specific students, working with others to ensure common standards for assessing progress, attending team conferences, taking part in collaborative professional learning. Four of the above skills are labeled as effective collaboration: teaching jointly, observing other teachers in class, engaging joint activities, taking part in collaborative professional learning. When the effective collaboration skills are considered separately, mean score 1.40 is calculated over 4 points. For the interpretation of the mean score 0 means "Never", 1.00 is "Once a year or less" and 2.00 means "2-4 times a year", 3.00 means "5-10 times a year" where 4 points means "Once a week or more". When the rest of the other skills are grouped as "fundamental collaborative skills" mean score is 2.80 which is more promising than "effective collaboration skills. As a result, to increase the quality of collaboration for STEM implementation process, focusing on effective collaboration skills has an important priority.

After the analysis of quantitative data, it is possible to see the strength and weakness of the components of collaboration for the subject school. Moreover, the results have significant difference with respect to different groupings like level, departments, collaborative culture, etc. To discuss and explain these differences, a more detailed investigation is required. In order to do so, a semi-structured interview has made with six teachers. These teachers are chosen from the respondents of the quantitative measurements. Two of the teachers are from middle school science department, one of them is from middle school math department, one of them is from high school science department, one of them is from high school math department and one of them is from computer science department. The purpose of this sampling is to provide appropriate representation of the number of teachers in each department and level rationally.

Quantitative analysis of data both TCAR and SPSLCQ scores are statistically significantly different (p ¡ 0.05, N 33) for the middle school and high school. Qualitative analysis of interviews revealed that actions taken by middle school administration increases teachers' collaborative performance. In other words, classroom observation plan and kick-off meeting for the interdisciplinary project at the beginning of the semester appears as the main difference in application between middle school and high school. As a result, middle school administration come up with clear expectation with a defined focus for both cases, teachers structured the process and application is put into practice. In order to increase effective collaboration, approach of the middle school may be used also in high school for further projects.

9.1. Implications for an Action Plan for Effective Collaboration

For a successful STEAM teaching and learning implementation process following actions are needed to take for increasing the effective collaboration. Since the exact need for STEAM education is interdisciplinary approach, interdisciplinary collaborative work is the focus for these suggestions.

First, job description of teaching needs a modification. Disciplinary and interdisciplinary collaboration is an expectation for the subject school. However, the understanding about collaboration appears as an extra-work that teachers make voluntarily. Adding the collaboration to teachers' daily schedule will show the need of collaboration clearly. As a result, effective collaboration skills like interdisciplinary activities, joint classes, course visits, etc. are needed to be discussed like other primary responsibilities.

- Second, teachers needed to learn how to work together as a collaborative group. Professional development for effective collaboration skills is needed. There are two needs listed in this part. Teachers need training for the context of collaboration skills. That is, there is a need for skills development for the actions that can be done as effective collaboration. On the other hand, a framework for effective collaboration and its process is needed. Even the subject school shows almost all outcomes of a professional learning community, there is not a framework to

follow. So, test scores for SPSLCQ and TCAR have the potential to increase with the processing an appropriate framework.

- Third, teachers need a place to work together. For the subject school, there are department rooms for teachers. Most teachers are not willing to have a common teachers' room instead of department rooms, because they think trying to work with more than hundred people may be disturbing. However, need for a place to come together with other teachers is mentioned so many times.
- Fourth, administrative support and guidance is needed to be increased. In other words, school administration needs to be active for starting and creating the procedure for collaboration. First three suggestions are derived from interview results. However, impact of administrative support and guidance shows its importance for the comparison of middle school and high school. Actions started by middle school administration reflect positively on TCAR and SPSLCQ scores of middle school teachers. That's why, to name administration as a participant and a stakeholder for collaborative work, will increase the impact of effective collaboration.
- Fifth, group leaders need to put emphasis on wrapping up and reporting. For a school year the most important variable to follow up is the curriculum. In other words, time management throughout the year is needed to be adjusted with respect to yearly plan. For most of the collaborative projects, application and evaluation for the students' products are the final step. However, assessment of the quality of the project and process of teacher collaboration is as important as the assessment and evaluation of student work. Unfortunately, limited time for keeping up the curriculum and other responsibilities, assessment of the teacher group and process is mostly neglected. However, teachers who have higher scores for effective collaboration expect to be assessed as a participant of a group, for their individual performance and for the quality of the outcome. In this case, assessment comprehends a feedback mechanism that is not designed to grade teachers but shows needs of the collaborative groups to work on it.

9.2. Implications for Further Research

Collaboration and STEAM teaching and learning are two popular and common issue discussed in the literature. For this study, the purpose is to provide an in depth understanding for the collaborative work of STEAM field teachers. Collaborative work is listed as observing other teachers in class, teaching jointly, engaging interdisciplinary and transdisciplinary activities, exchanging teaching materials, engaging about the learning development of specific students, working with others to ensure common standards for assessing progress, attending team conferences, taking part in collaborative professional learning. When all eight type of activity is considered, respondents of this study provide feedback with respect to their both disciplinary and interdisciplinary collaboration. Such response provides detailed information to understand the collaboration mechanism. However, there is need of investigation for another study which directly focusses on interdisciplinary collaboration mechanisms.

For this descriptive educational research, the purpose is understanding the collaborative structure and finding out the needs for effective collaboration. When the participant-dependent nature of the research is considered the results are specific to subject school. So, generalization of the results is not possible. However, DATQ results are used to provide a detailed description of the research site and characteristics of participants. With more research that investigates the research site in addition to research variables, generalization is possible for further research. So, the replication of this study for different schools, may provide a more general thesis statement for effective collaboration. This research is designed to shed light on the current collaborative working status of the subject school. However, with the PLC framework, a treatment may be planned to see the change in effective collaborative skills by comparing pre-test and post-test scores of TCAR and SPSLCQ instruments.

REFERENCES

Achinstein, B., "Conflict Amid Community: The Micro politics of Teacher Collaboration", *Teachers College Record*, Vol. 104, pp. 421-455, 2002.

Ayres D.C., a *Collaborative İntegrated Stem Teaching': Examination of a Science and Math Teacher Collaboration on an İntegrated Stem Unit*, M.S. Thesis, Purdue University, 2016.

Bierema L.L., "Invited Reaction: Setting the Stage for Further Study of Developmental Relationships", *Human Resource Development Quarterly*, 1999.

Bill and Melinda Gates Foundation, *Teachers Know Best: Teachers' Views On Professional Development*, Seattle, WA: Author, 2015.

Bolam R., A. McMahon, L. Stoll, S. Thomas and M. Wallace, "Creating and Sustaining Effective Professional Learning Communities", *Department for Education and Skills*, 2005.

Boyle B., D. While and T. Boyle, "A Longitudinal Study of Teacher Change: What Makes Professional Development Effective", *The Curriculum Journal*, Vol. 15, No. 1, pp. 45-68, 2004.

Breiner J.M., S. Sheats Harkness, C.C. Johnson and C.M. Koehler, "What is STEM" A Discussion About Conceptions of STEM in Education and Partnerships", *School of Science and Mathematics*, Vol. 112, No. 1, pp. 3-11, 2012.

Brouwer P., *Collaboration in Teams*, Ph.D., University of Utrecht, Netherland, 2011.

Brown J., R. Brown, C. Merill, "Science and Technology Educators' Enacted Curriculum:Areas of Possible Collaboration for an Integrative STEM Approach in Public Schools", *Technology and Engineering Teacher*, Vol. 71, No. 4, pp. 30-34, 2012.

Capraro R., M. Capraro, J.R. Morgan, *STEM Project-Based Learning: an Integrated Science, Technology, Engineering, and Mathematics (STEM) Approach*, Sense, Rotterdam, The Netherlands, 2013.

Capraro R., S. Han, "STEM The Education Frontier to Meet 21st Century Challenges", *Middle Grades Research Journal*, Vol. 9, No. 3, 2014.

Cassity, A., *Relationships Among Perceptions Of Professional Learning Communities, School Academic Optimism and Student Achievement In Alabama Middle and High Schools*, A Dissertation In The Graduate School of The University of Alabama Tuscaloosa, Alabama 2012.

Chan, C.K., and Pang, M.F., "Teacher Collaboration in Learning Communities", *Teaching Education*, Vol. 17, No. 1, pp.1-5, 2006.

Clement, M. and Vandenberghe, R., "Teachers Professional Development: A Solitary or Collegial (Ad) Venture", *Teaching and Teacher Education*, Vol. 16, No. 1, pp. 81-101, 2000.

Cohen, S.G. and Bailey, D.E., "What Makes Teams Work: Group Effectiveness Research from the Shop Floor to the Executive Suite", *Journal of Management*, 23, 239-290, 1997.

Corcoran T.B., "Helping Teachers Teach Well: Transforming Professional Development", *Consortium for Policy Research in Education*, 1995.

Corlu M.S., M.M. Capraro, R.M. Capraro and M.M. Capraro, "Introducing STEM Education : Implications for Educating Our Teachers For the Age of Innovation FeTeMM Eğitimi ve Alan Öğretmeni Eğitimine Yansımaları", *Eğitim ve Bilim*, Vol. 39, No. 171, pp. 74-85, 2014.

Darling-Hammond L., "The Right to Learn and the Advancement of Teaching: Research, Policy, and Practice for Democratic Education", *Educational Researcher*,

Vol. 25, No. 6, pp. 5-17, 2000.

Datnow A., "Collaboration and Contrived Collegiality: Revisiting Hargreaves in the Age of Accountability", *Journal of Educational Change*, Vol. 12, pp. 147-158, 2011.

Desimone L.M., "A Primer on Effective Professional Development", *Kappan*, Vol. 92, No. 6, pp. 68-71, 2011.

DuFour R. and R. Eaker, "Professional Learning Communities at Work: Best Practices for Enhancing Student Achievement", *National Educational Service*, Bloomington, IN, 1998.

Dufour R., "What is Professional Learning Community", *Educational Leadership*, May , pp. 6-11, 2004.

DuFour R., "Harnessing the Power of PLCS", *Educational Leadership*, Vol. 71, No. 8, pp. 30-35, 2014.

DuFour R., R. DuFour, R. Eaker, T. Many, "Learning by Doing: a Handbook for Professional Learning Communities at Work - a Practical Guide for PLC Teams and Leadership", *Solution Tree Press*, Bloomington, IN, 2010.

Dufour R., "Work together: But only if you want to", *Phi Delta Kappan*, Vol. 92, No. 5, pp. 57- 61, 2011.

Eijwale J.A., "Barriers to Successful Implementation of STEM Education", *Journal of Education and Learning*, Vol. 7, No. 2, pp. 63-74, 2013.

Ferguson D., "Working Together : Groupwork, Teamwork, and Collaborative Work Among Teachers", *National Institute for Urban School Improvement*, 2006.

Ferguson D., "Working Together : Groupwork , Teamwork , and Collaborative Work Among Teachers", *Great Urban Schools: Learning Together Builds Strong Com-*

munities, National Institute for Urban School Improvement, 2006.

Forte A.M. and M.A. Flores, "Teacher Collaboration and Professional Development in the Workplace: a Study of Portuguese Teachers", *European Journal of Teacher Education*, Vol. 37, No. 1, pp. 91-105, 2014.

Fulton K., H. Doerr and T. Britton, "STEM Teachers in Professional Learning Communities: from Good Teachers to Great Teaching", *Program Manager*, June, pp. 1-71, 2011.

Gable R.A. and M.L. Manning, "The Role of Collaboration in School Reform", *Childhood Education*, pp. 219-223, 1997.

Gajda R. and C.J. Koliba, "Evaluating and Improving the Quality of Teacher Collaboration: A Field-Tested Framework for Secondary School Leaders", *NASSP Bulletin*, Vol. 92, No. 2, pp. 133-153, 2008.

Garet M.S., A.C. Porter, L. Desimone, B.F. Birman and S.Y. Kwang, "What Makes Professional Development Effective" Results from a National Sample of Teacher", *American Educational Research Journal*, Vol. 38, No. 4, pp. 915-945, 2001

Goddard Y.L., D. Roger, M. Tschannen-Moran, "A Theoretical and Empirical Investigation of Teacher Collaboration for School Improvement and Student Achievement in Public Elementary Schools", *Teachers College Record*, Vol. 109, No. 4, pp. 877-896, 2007.

Gonzalez H.B., J.J. Kuenzi, "Science, Technology, Engineering and Mathematics (STEM) Education: a Primer", *Congressional Research Service*, Library of Congress, 2012.

Gravois, T., Rosenfield, S., and Greenberg, B., "Establishing Reliability for Coding Implementation Concerns of School-Based Teams from Audiotapes", *Evaluation Review*, Vol. 16, pp. 562-569, 1992.

Hargreaves, A., *Changing Teachers*, Changing Times: Teachers' Work and Culture in

the Postmodern Age, London: Cassell, 1994.

Hargreaves A., R. Dawe, "Paths of Professional Development: Contrived Collegiality, Collaborative Culture, and the Case of Peer Coaching", *Teaching and Teacher Education*, Vol. 6, No. 3, pp. 227-241, 1990.

Hattie, J., and Timperley, H., "The Power of Feedback", *Review of Educational Research*, Vol. 77, No. 1, pp. 81-112, 2007.

Havnes, A., "Talk Planning and Decision-Making in Interdisciplinary Teacher Teams: A Case Study", *Teachers and Teaching: Theory and Practice*, Vol. 15, pp. 155-176, 2009.

Honingh, M., and Hooge, E., "The Effect of School-Leader Support And Participation in Decision Making on Teacher Collaboration In Dutch Primary and Secondary Schools", *Educational Management Administration and Leadership*, Vol. 42, No. 1, pp. 75-98, 2014.

Hord S.M., "Evolution of the Professional Learning Community: Revolutionary Concept is Based on Intentional Collegial Learning", *Journal of Staff Development*, Vol. 29, No. 3, pp. 10-13, 2008.

Hord S., "A Synthesis of Research on Organizational Collaboration", *Educational Leadership*, Vol. 43, No. 5, pp. 22-26, 1986.

Hord S., "Professional Learning Communities: What Are They and Why Are They Important", *Schoology Exchange*, Vol. 6, No. 1, 1997.

Hord, S.M., *Professional Learning Communities: An Overview*, Leading Together: Changing Schools Through Professional Learning Communities, New York, NY: Teacher's College Press, pp. 5-14, 2004.

Huffman J.B., K.A. Hipp, A.M. Pankake, G. Moller, "Professional Learning Communities: Leadership, Purposeful Decision Making, and Job-Embedded Staff Devel-

opment", *Journal of School Leadership*, 2001.

Jame C.R., G. Dunning, M. Connolly and T. Elliott, "Collaborative Practice: a Model of Successful Working in Schools", *Journal of Educational Administration*, Vol. 45, pp. 541-555, 2007.

Jan van T. and K. Hammerness, "The Neglected Role of Classroom Management in Teacher Education", *Teaching Education*, Vol. 22, No. 2, pp. 109-112, 2011.

Jardine D.W., "On The Integrity of Things: Reflections on the Integrated Curriculum", *Curriculum in Abundance*, pp. 171-179, Mahwah, New Jersey, 2006.

Johnson B., "Teacher Collaboration: Good for Some, Not so Good for Others", *Educational Studies*, Vol. 29, No. 4, pp. 337-350, 2003.

Kelchtermans G., "Teacher Collaboration and Collegiality as Workplace Conditions", *Zeitschrift Für Padagogik*, Vol. 52, No. 2, pp. 220-237, 2006.

Killion J., "High-Quality Collaboration Benefits Teachers and Students", *Journal of Staff Development*, Vol. 36, No. 5, pp. 62-64, 2015.

Kougioumtzis, K., and G. Patriksson, "School-Based Teacher Collaboration in Sweden and Greece: Formal Cooperation", Deprivatized Practices and Personalized Interaction in Primary and Lower Secondary Schools, *Teachers And Teaching: Theory and Practice*, Vol. 15, pp. 131-154, 2009.

Kruse S.D. and K.S. Louis, "An Emerging Framework for Analyzing School-Based Professional Community", *Professionalism and Community: Perspectives on Reforming Urban Schools*, pp. 23-44. , 1995.

Kruse S., K.S. Louis, A. Bryk, "Building Professional Community in Schools", *Issues in Restructuring Schools*, Vol. 6, pp. 3-6, 1994.

Lave J., E. Wenger, "Situated learning: Legitimate peripheral participation", *Univer-*

sity of Cambridge Press, Cambridge, 1991.

Le Donné, N., P. Fraser and G. Bousquet, *Teaching Strategies for Instructional Quality: Insights from the TALIS-PISA Link Data*, OECD Education Working Papers, No. 148, OECD Publishing, Paris, 2016.

Leonard, L., and P. Leonard, *The continuing problem with collaboration: Teachers talk*, Current Issues in Education, 2003.

Lieberman A., "Schools as Collaborative Cultures: Creating the Future Now", *Falmer*, New York,1990.

Lieberman A., "Restructuring Schools: The Dynamics of Changing Practice, Structure", *The Work of Restructuring Schools: Building from the Ground Up*, pp. 1-17, 1995.

Lima J.A., "Forgetting About Friendship: Using Conflict in Teacher Communities As a Catalyst for School Change", *Journal of Educational Change*, Vol. 2, pp. 97-122, 2001.

Little J.W., "The persistence of privacy: Autonomy and initiative in teacher's professional relations", *Teachers College Record*, Vol. 91, pp. 509-536. , 1990.

Louis K.S., H.M. Marks and S. Kruse, "Teachers' Professional Community in Restructuring Schools", *American Educational Research Journal*, Vol. 33, No. 4, pp. 757-798, 1996.

Main, K., *A Year Long Study Of The Formation And Development of Middle School Teaching Teams*, Ph.D. Thesis, Middle School Team, 2007.

McNall, M.A., and P.G. Foster-Fishman, "Methods of Rapid Evaluation, Assessment, and Appraisal", *American Journal of Evaluation*, Vol. 28, pp. 151-168, 2007.

Mehmet S.B., O. Bulut and S. Gedik, "Investigating Professional Learning Communi-

ties in Turkish Schools: The Effects of Contextual Factors", *Professional Development In Education*, Vol. 43, No. 3, pp. 353-374, 2017.

Merrill C. and J. Daugherty, "STEM Education and Leadership: A Mathematics and Science Partnership Approach", *Journal of Technology Education*, Vol. 21, No. 2, pp. 21-34, 2010.

Metz S., "Outside the School Walls", *The Science Teacher*, Vol. 76, No. 4, pp. 8, 2009.

Metz S., "Science and Technology Educators' Enacted Curriculum: Areas of Possible Collaboration for an Integrative Stem Approach in Public Schools", *Technology and Engineering Teacher*, 2011.

Morrissey, M.S., *Professional Learning Communities: An Ongoing Exploration*, Murata, 2000.

Morrissey M.S., "Professional Learning Communities: an Ongoing Exploration", *Southwest Educational Developmental Laboratory*, Austin, TX. , 2000.

National Academies, "Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future", *National Academies Press*, Washington, DC, 2006.

National Research Council, "Successful K-12 STEM Education: Identifying Effective Approaches in Science", Technology, Engineering, and Mathematics, *National Academy Press*, Washington, DC, 2011.

Neal, J. W., Z.P. Neal, E. VanDyke and M. Kornbluh, "Expediting the Analysis of Qualitative Data in Evaluation: A Procedure for the Rapid Identification of Themes From Audio Recordings (RITA)", *American Journal of Evaluation*, Vol. 36, No. 1, pp. 118-132, 2015.

Ng, T., A *Teachers' Guide*, Talis, 2013.

Ngang, T. K., "Teacher Collaboration in Fengtai District, Beijing of China", *International Journal of Learning*, Vol. 18, No. 6, 2012.

OECD, Schleicher A., "Background Report for the International Summit on the Teaching Profession", *Oecd Ilibrary*, 2012.

Olivier, D.F., K.K Hipp, and J.B. Huffman, *Assessing schools as PLCS, Reculturing schools as professional learning communities*, Lanham, MD: Scarecrow Press, pp. 67-74, 2003.

Paine, L.W., and L. Ma, "Teachers Working Together: A Dialogue on Organizational and Cultural Perspectives of Chinese Teachers", *International Journal of Educational Research*, Vol. 19, No. 8, pp. 675-697, 1993.

Pappano, L., "More Than Making Nice: Getting Teachers To (Truly) Collaborate", *Harvard Education Letter*, Vol. 23, No. 2, pp. 1-3, 2007.

Pelgrim, E.A.M., A.W.M. Kramer, H.G.A. Mokkink and C.P.M. van der Vleuten, "The Process of Feedback in Workplace-Based Assessment: Organisation", *Delivery Continuity Medical Education*, Vol. 46, No. 6, pp. 604-612, 2012.

Reeves P.M., W.H. Pun and K.S. Chung, "Influence of Teacher Collaboration on Job Satisfaction and Student Achievement", *Teaching and Teacher Education*, Vol. 67, pp. 227-236, 2017.

Roberts S.M., E.Z. Pruitt, "Schools as Professional Learning Communities: Collaborative Activities and Strategies for Professional Development, *Corwin, Thousand Oaks*, CA., 2003.

Rone, B.C., T*he Impact of the Data Team Structure on Collaborative Teams and Student Achievement*, Ph.D., Lindenwood University, 2009.

Ronfeldt M., S.O. Farmer, K. McQueen and J.A. Grissom, "Teacher Collaboration in Instructional Teams and Student Achievement", *American Educational Research*

Journal, Vol. 52, 2015.

Roth W.M., G.M. Bowen, "Mathematization of Experience in A Grade 8 Open-Inquiry Environment: an Introduction to the Representational Practices of Science", *Journal of Research in Science Teaching*, Vol. 31, No. 3, pp. 293-318, 1994.

Roth W.M., "Problem-Centered Learning or the Integration of Mathematics and Science in a Constructivist Laboratory: a Case Study", *School Science and Mathematics*, Vol. 93, pp. 113-122, 1993.

Sanders M., "STEM, STEM Education, STEMmania", *Technology Teacher*, Vol. 68, No. 4, pp. 20-26, 2009

Scribner J.P., K.S. Cockrell, D.H. Cockrell and J.W. Valentine, "Creating Professional Communities in Schools through Organizational Learning: An Evaluation of a School Improvement Process", *Educational Administration Quarterly*, Vol. 35, No. 1, pp. 130-160, 1999.

Senge P., "The Fifth Discipline", *Doubleday*, New Mexico, 1990.

Shakenova L., "The Theoretical Framework of Teacher Collaboration", *Khazar Journal of Humanities and Social Sciences*, Vol. 20, No. 2, pp. 34-48, 2017.

Smetser, F., *Samenwerken in Teams, Een Vanzelfsprekendheid' Een Onderzoek Naar Condities Die Het Samenwerken Van Professionals In Teams Beïnvloeden*, Ph.D. Thesis, Radboud Universiteit Nijmegen, 2007.

Sigurgardottir A., "Studying and Enhancing the Professional Learning Community for School Effectiveness in Iceland. Unpublished Doctoral Essay", *The University of Exeter*, UK, 2006.

Sparks D., "Leading for Transformation in Teaching, Learning and Relationships", *On Common Ground: The Power of Professional Learning Communities*, pp. 155-175, 2005.

Stoll L., R.R. Bolam, A. McMahon, M. Wallace, S. Thomas, K. Hawkey and M. Smith, *Creating and Sustaining Effective Professional Learning Communities*, 16^{th} International Congress for School Effectiveness and Improvement, Sydney, Australia, 2003.

Takahashi S., "Co-Constructing Efficacy: a Communities of Practice Perspective", *Teaching and Teacher Education*, Vol. 27, No. 4, pp. 732-741, 2011.

Tessier, S., "From Field Notes, to Transcripts, to Tape Recordings: Evolution Or Combination' International", *Journal of Qualitative Methods*, Vol. 11, pp. 446-460, 2012.

Toole J.C., K.S. Louis, "The Role of Professional Learning Communities in International Education from the book International Handbook of Educational Leadership and Administration", *Kluwer Academic Publishers*, Dordrecht, 2002.

Tschannen-Moran M., A.W. Hoy and W.K. Hoy, "Teacher Efficacy: Its Meaning and Measure", *Review of Educational Research*, Vol. 68, No. 2, pp. 202-248, 1998.

Vangrieken K., F. Dochy, E. Raes and E. Kyndt, "Teacher Collaboration: a Systematic Review", *Educational Research Review*, Vol. 15, pp. 17-40, 2015.

Vangrieken K., I. Grosemans, F. Dochy and E. Kyndt, "Teacher Autonomy and Collaboration: a Paradox' Conceptualising and Measuring Teachers' Autonomy and Collaborative Attitude", *Teaching and Teacher Education*, Vol. 67, pp. 302-315, 2017.

Vescio V., D. Ross, A. Adams, "A Review of Research on The Impact of Professional Communities on Teaching Practice and Student Learning", *Teaching and Teacher Education*, Vol. 24, pp. 80-91, 2008.

Villegas-Reimers E., "Teacher Professional Development: An International Review of the Literature", *UNESCO: Paris- missing information*, 2003.

Wang H.H., T.J. Moore, G.H. Roehrig and M.S. Park, "STEM integration: Teacher perceptions and practice", *Journal of Pre-College Engineering Education Research*, Vol. 1, No. 2, pp. 1-13, 2011.

Wiggins K.C. *and D.S.J. Survivors or Friends' et al.*, "A Framework for Assessing Effective Collabortion", *Teaching Exceptional Children*, Vol. 38, No. 5, pp. 49-56, 2006.

Woodland R.H., "Evaluating PK-12 Professional Learning Communities: An Improvement Science Perspective", *American Journal of Evaluation*, Vol. 37, No. 4, pp. 505-521, 2016.

Woodland R., M.K. Lee and J. Randall, "A Validation Study of the Teacher Collaboration Assessment Survey", *Educational Research and Evaluation*, Vol. 19, No. 5, pp. 442-460, 2013.

Yarbrough, M., *Efficacy Of Professional Learning Communities and Their Impact Upon Student Academic Outcomes As Perceived By Local School Administrators And Teachers*, Ph.D. Education Department Of Educational Leadership 2010.

Zito M.F., *Is Working Together Worth It' Examining the Relationship Between the Quality of Teacher Collaboration Instruction and Student Achievement*, Ph.D. University of Massachusetts Amherst, 2011.

APPENDIX A: EXAMPLE CONSENT AND RELEASE FORM

``INVESTIGATION OF COLLABORATION ON PROFESSIONAL LEARNING COMMUNITIES OF SCIENCE, TECHNOLOGY AND MATHEMATICS TEACHERS" PARTICIPANT CONSENT and RELEASE FORM

Dear Colleague:

My name is Utku Oztekin, as you know, I am working in your school as a teacher. Meanwhile, I have completed all the requirements for a master of science coursework in Secondary School Science and Mathematics Education. I am at the thesis stage and seeking assistance from you to complete my research.

I am conducting a research study called ``Investigation of Collaboration On Professional Learning Communities Of Science, Technology And Mathematics Teachers". With respect to current literature, collaborative working skills are the foremost priority for a structured STEM Education. Recent actions show that STEM Education integration is a popular topic in our school. That is to say, ``Advisory Committee on Technology and Innovation Policy" and ``Innovation Center" focus on making STEM Education use of for our school. Within this setting, I want to find out variables effective on collaborative attitude of STEM fields teachers in a professional learning community (PLC).

During the research study, I will focus on school-wide collaborative work throughout the year.

Taking part in this study involves completing two surveys and one rubric.

- Descriptive Analysis Teacher Questionnaire (DATQ) (Part 1 and 2) and School Professional Staff as Learning Community Questionnaire (SPSLCQ) (Part 3) will be submitted online.
- Teacher Collaboration Assessment Rubric (TCAR) will be filled hard-copy.

Figure A.1. Example Consent and Release Form 1.

All the instructions and directions will be made and the researcher will always be available to answer your questions.

Identifying information including your name and background information will be collected. ID related data will be used to relate different instruments to each other. Data will be quantized via IBM SPSS and all ID information will be deleted when the data transfer completed. So the analysis of the study will be completely anonymous. Also, raw data will not be shared with public, only summarized data will be presented at meetings or in publications. Electronic data will be stored on a password-protected computer. Signed consent forms and paper copies SPSLCQ will be stored in a locked file cabinet in my home. Data will be deleted and shredded at the end of the research, approximately August 31st, 2019.

Your participation is completely voluntary. You may withdraw from the study at any time where practicable, for any reason, and without explanation. If you would like to review and potentially make changes to your submission, you may withdraw up to two weeks from the time of being provided a copy of your form submission. If you choose to withdraw from the study, all the information you provided during the process would be withdrawn from the study and destroyed.

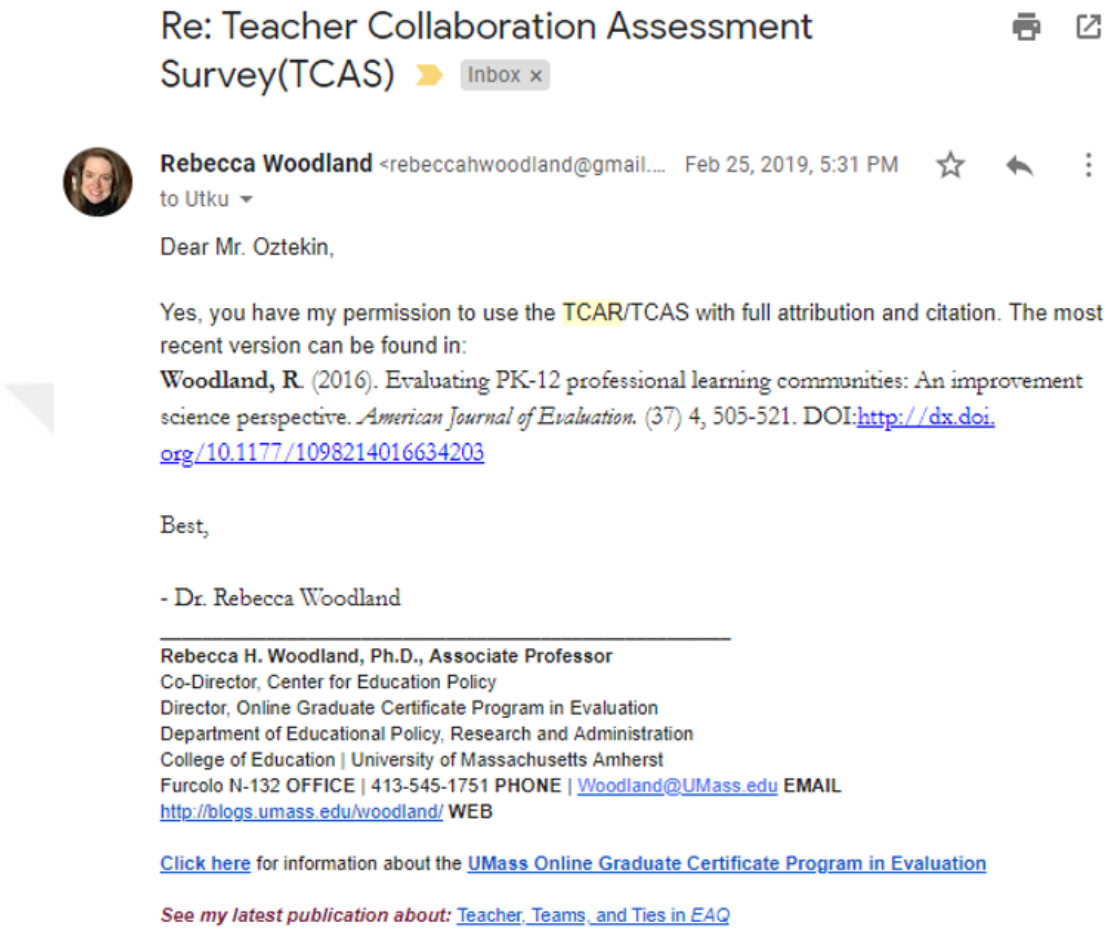
If you have any concerns or questions about your participation please contact me via utkuoztekin@gmail.com

I have read and understand the information provided above, and hereby consent to participate in this research under the above conditions:

Participant Name _____ Participant Signature _____

Figure A.2. Example Consent and Release Form 2.

APPENDIX B: PERMISSION TO USE TCAR/TCAS



Re: Teacher Collaboration Assessment Survey(TCAS) Inbox ×

Rebecca Woodland <rebeccahwoodland@gmail.... Feb 25, 2019, 5:31 PM

to Utku

Dear Mr. Oztekin,

Yes, you have my permission to use the TCAR/TCAS with full attribution and citation. The most recent version can be found in:
Woodland, R. (2016). Evaluating PK-12 professional learning communities: An improvement science perspective. *American Journal of Evaluation.* (37) 4, 505-521. DOI:http://dx.doi.org/10.1177/1098214016634203

Best,

- Dr. Rebecca Woodland

Rebecca H. Woodland, Ph.D., Associate Professor
Co-Director, Center for Education Policy
Director, Online Graduate Certificate Program in Evaluation
Department of Educational Policy, Research and Administration
College of Education | University of Massachusetts Amherst
Furcolo N-132 **OFFICE** | 413-545-1751 **PHONE** | Woodland@UMass.edu **EMAIL**
http://blogs.umass.edu/woodland/ **WEB**

Click here for information about the UMass Online Graduate Certificate Program in Evaluation

See my latest publication about: Teacher, Teams, and Ties in *EAQ*

Figure B.1. Permission to Use TCAR/TCAS.

APPENDIX C: SEDL PERMISSION FOR SPSLCQ

AIR
AMERICAN INSTITUTES FOR RESEARCH®

AGREEMENT FOR PERMISSION TO REPUBLISH — PRINT & ELECTRONIC

Please fill out, sign, and return copy to American Institutes for Research, Attn: Copyright and Permissions Help Desk, Publication and Creative Services Department, 1120 E. Diehl Road, Suite 200; Naperville, Illinois 60563; copyright_PS@air.org.

American Institutes for Research (hereinafter called the "Grantor") grants the undersigned, Utku Öztekin, Fizik Öğretmeni, Hisar Okulları (hereinafter called the "Applicant"), nonexclusive license to reprint the following (hereinafter called "the Selection"):

Title and Credit Line: Hord, S. M. (1996). *School Professional Staff as Learning Community Questionnaire*. [Survey instrument]. Austin, TX: Southwest Educational Development Laboratory.

The undersigned agrees:

1. To give full credit in every copy printed; on the copyright page or as a footnote on the page on which the Selection begins; or, if in a magazine or a newspaper, on the first page of each Selection covered by the permission, exactly as indicated in this Agreement.
2. To make no deletions from, additions to, changes to, or electronic manipulation of the content without the written approval of the Grantor.
3. That permission granted herein is nonexclusive and nontransferable.
4. That permission applies, unless otherwise stated, solely to **use the Selection in a research study and reprint it in a thesis titled *Assessing Teacher Concerns Regarding a History of Rapid Curriculum Change***, in all languages and forms and subsequent revisions in the United States and internationally.
5. That translation into another language shall be specifically approved as a use in Clause 4 above and preserve a sufficient amount of the original language and context to convey the author(s)' intended meaning, thus enabling an independent assessment of the appropriateness of the translation.
6. That the permission shall automatically terminate at the end of the business day of **March 1, 2021**.
7. This permission does not extend to any copyrighted material from other sources that may be incorporated within the Work in question—nor to any diagrams, illustrations, charts, or graphs—unless otherwise specified.
8. That the Work containing Grantor's Selection may be reproduced in alternate formats (such as Braille, large type, and sound recordings) for individuals with disabilities, provided no charge is made for the Work.
9. That unless the agreement is signed and returned within three months from the date of issue, the permission shall automatically terminate.

Date: 12/05/2019 **Signature of Applicant:**

Printed Name: UTKU ÖZTEKİN

Address: Bahçelievler mah. Elvan Sok. No:2 Vefa Konakları B blok Daire 5 İstanbul / TURKEY

Permission on the foregoing terms
American Institutes for Research

Date: May 13, 2019 **By:** Helen Sacco

Figure C.1. SEDL Permission for SPSLCQ.

APPENDIX D: TCAR QUESTIONNAIRE

DIALOGUE Circle one box per row			
	2	1	0
a	An agenda for team dialogue is pre-planned and accessible to all in advance of every team meeting.	A written agenda for group dialogue is provided for most team meetings.	There is no pre-planned agenda for group dialogue/team meetings.
b	The team meets regularly and all meetings are attended by all members.	The team meets with some regularity and most meetings are attended by all members.	The team meets sporadically, or full attendance at team meetings is rare.
c	Team meetings are always structured. Protocols are used to facilitate and guide team dialogue.	Team meetings are somewhat structured. Occasionally protocols are used to facilitate, and guide team dialogue.	Team dialogue/meetings are generally improvisational, unstructured, and not purposefully facilitated.
d	Team dialogue consistently addresses essential questions of practice, instructional quality, and student learning.	Team dialogue occasionally addresses essential questions of practice, instructional quality, and student learning.	Team dialogue does not address essential questions of practice, instructional quality and student learning.
e	Inter-professional disagreements about issues of practice are typical - these disagreements are expected, openly examined and thoughtfully discussed.	Inter-professional disagreements about important issues are not typical, often go unexamined, or remain addressed.	The group avoids conflict, tends to confirm present practices, or inter-professional disagreements are said not to exist.
f	Team members participate equally in group dialogue; there are no hibernators or dominators.	Most team members contribute to the dialogue, but there are some hibernators and dominators.	Team members contribute unequally to the dialogue; there are regular dominators and hibernators.
g	An accurate record of team dialogue, decisions, and subsequent actions is recorded and accessible to all members.	A record of team dialogue, decisions, and intended actions exists.	No accurate or accessible record of team dialogue, decisions, and subsequent actions exists.
		Dialogue Total /14	

DECISION MAKING Circle one box per row			
	2	1	0
a	Team members regularly identify and determine specific actions that they will take to improve instructional practice and student learning.	Team members occasionally identify and determine actions that they will take to improve instructional practice and student learning.	Team members do not identify or determine specific actions that they will take to improve instructional practice and student learning.
b	The team uses a specific process for every decision it makes (e.g. consensus, majority, or some other decision-making structure).	The team occasionally uses a process for making decisions (e.g. by consensus, majority, or some other decision-making structure).	The team does not use specific processes for making decisions.
c	Decisions made by the team are clearly and directly related to the improvement of instructional practice and student learning.	Decisions made by the team are occasionally related to the improvement of instructional practice and student learning.	Teams decisions are not related to the improvement of instructional practice and student learning.
d	The team regularly makes decisions about what specific instructional practices it will initiate, maintain, change and discontinue.	The team occasionally makes decisions about what specific instructional practices it will initiate, maintain, change or discontinue.	The team does not make decisions about instructional practices to initiate, maintain, change and/or discontinue.
e	All team decisions are informed by full group dialogue.	Most team decisions are informed by some level of group dialogue.	Team decisions are not informed by group dialogue.
f	All team decision-making is transparent; each member knows what the decisions are/were and how and why they were made.	Decision-making is somewhat transparent; members are aware of team decisions and how they were were made.	Group decision-making is not transparent; members are not aware of how group decisions were made.
g	The team regularly determines what specific instructional practice and student learning information it intends to obtain and analyze.	The team occasionally decides what specific instructional practice and student learning information it needs to obtain and analyze.	The team does not determine instructional practice and student learning information it needs to obtain and analyze.
		Decision-Making Total /14	

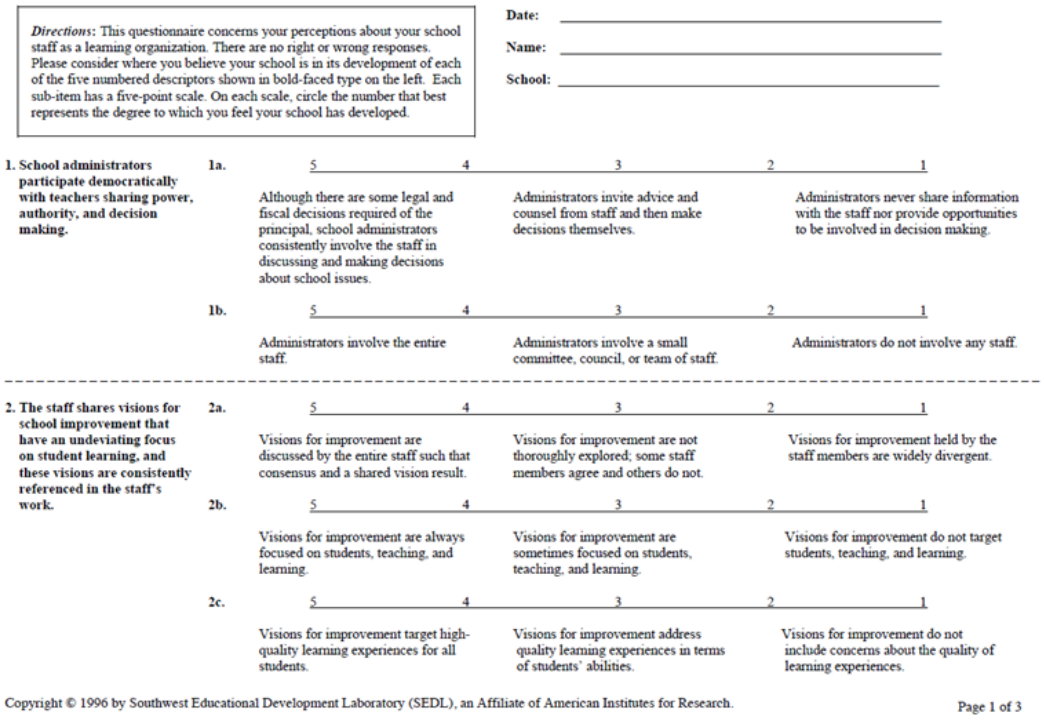
Figure D.1. TCAR Questionnaire 1.

ACTION - Circle one box per row Circle one box per row			
	2	1	0
a	Team members know the specific individual actions that they should take as a result of group dialogue and decision-making.	Most team members know the specific individual actions that they should take as a result of group dialogue and decision-making.	Team members are unaware of specific actions that they should take as a result of group dialogue and decision-making.
b	Intended actions to be taken by team members are high leverage (i.e. team members believe their actions will directly improve instructional practice).	Intended actions are somewhat high leverage (i.e. team members believe their actions could contribute to the improvement of instructional practice).	Intended actions are not high leverage (i.e. team members don't know how or if their actions will improve instructional practice).
c	Team members actions are specific and measurable/observable.	Team members actions are specific or measurable/observable.	Team members actions are not specific, nor measurable/observable.
d	Team member actions are coordinated and interdependent.	Team member actions are coordinated or interdependent.	Individual team member actions are independent and coordinated with one another.
e	Action-taking is equitable among members (i.e. every member acts to improve individual instructional practice and group performance as a result of team decision-making.)	Action-taking is somewhat equitable (i.e., most members regularly take steps to improve individual instructional practice and group performance.)	Action-taking is not equitable (i.e., some members take most of the action, some take very little or none.)
f	The group has clear, continuous, and accessible documentation of the instructional practices that they have stopped, started and/or changed over time.	The group has some documentation of the instructional practices they have stopped, started and/or changed over time.	Little, if any, documentation exists of the practices that the group has stopped, started and/or changed over time.
		Action Total /12	

EVALUATION Circle one box per row			
	2	1	0
a	Team members collect/have access to data about the quality of their instructional practices and their students' learning.	Team members collect some/have some access to data about their instructional practices and their students' learning.	The team does not have access to data about quality of their instructional practices and/or student learning.
b	The team regularly analyzes the quality of their students' actual work (i.e. work completed by their students in response to their instruction).	The team infrequently examines the quality of their students' actual work (i.e. work completed by their students in response to their instruction).	The team does not examine the quality of their students' actual work (i.e. work completed by their students in response to their instruction).
c	The team regularly analyzes the quality of their classroom-based instructional practice.	On occasion the team will analyze the quality of their classroom-based instructional practice.	The team does not analyze the quality of their classroom-based instructional practice.
d	Team members regularly observe each other's classroom instructional practices, either in person or indirectly via technological means.	Team members occasionally observe each other's classroom instructional practices, either in person or indirectrly via technological means.	Team members do not observe each other's classroom instructional practices, either in person or indirectly via technological means.
e	The team consistently generates targeted, specific, and timely feedback for team members about how to improve instructional practice and student learning.	The team occasionally generates some ideas for how team members might improve quality of instructional practice and student learning.	The team does not generate targeted, specific, and timely feedback about quality of instructional practice and student learning.
f	The group has clear, continuous, and accessible documentation and substantiation of how their instructional practice affects their student's learning.	The group has some documentation of how their instructional practice affects their student's learning.	The team does not document or substantiate the effects of their actions on student learning.
		Evaluation Total /12	

Figure D.2. TCAR Questionnaire 2.

APPENDIX E: SPSLCQ QUESTIONNAIRE



Directions: This questionnaire concerns your perceptions about your school staff as a learning organization. There are no right or wrong responses. Please consider where you believe your school is in its development of each of the five numbered descriptors shown in bold-faced type on the left. Each sub-item has a five-point scale. On each scale, circle the number that best represents the degree to which you feel your school has developed.

Date: _____

Name: _____

School: _____

1. School administrators participate democratically with teachers sharing power, authority, and decision making.

1a. 5 — 4 — 3 — 2 — 1

5: Although there are some legal and fiscal decisions required of the principal, school administrators consistently involve the staff in discussing and making decisions about school issues.

3: Administrators invite advice and counsel from staff and then make decisions themselves.

1: Administrators never share information with the staff nor provide opportunities to be involved in decision making.

1b. 5 — 4 — 3 — 2 — 1

5: Administrators involve the entire staff.

3: Administrators involve a small committee, council, or team of staff.

1: Administrators do not involve any staff.

---

2. The staff shares visions for school improvement that have an undeviating focus on student learning, and these visions are consistently referenced in the staff's work.

2a. 5 — 4 — 3 — 2 — 1

5: Visions for improvement are discussed by the entire staff such that consensus and a shared vision result.

3: Visions for improvement are not thoroughly explored; some staff members agree and others do not.

1: Visions for improvement held by the staff members are widely divergent.

2b. 5 — 4 — 3 — 2 — 1

5: Visions for improvement are always focused on students, teaching, and learning.

3: Visions for improvement are sometimes focused on students, teaching, and learning.

1: Visions for improvement do not target students, teaching, and learning.

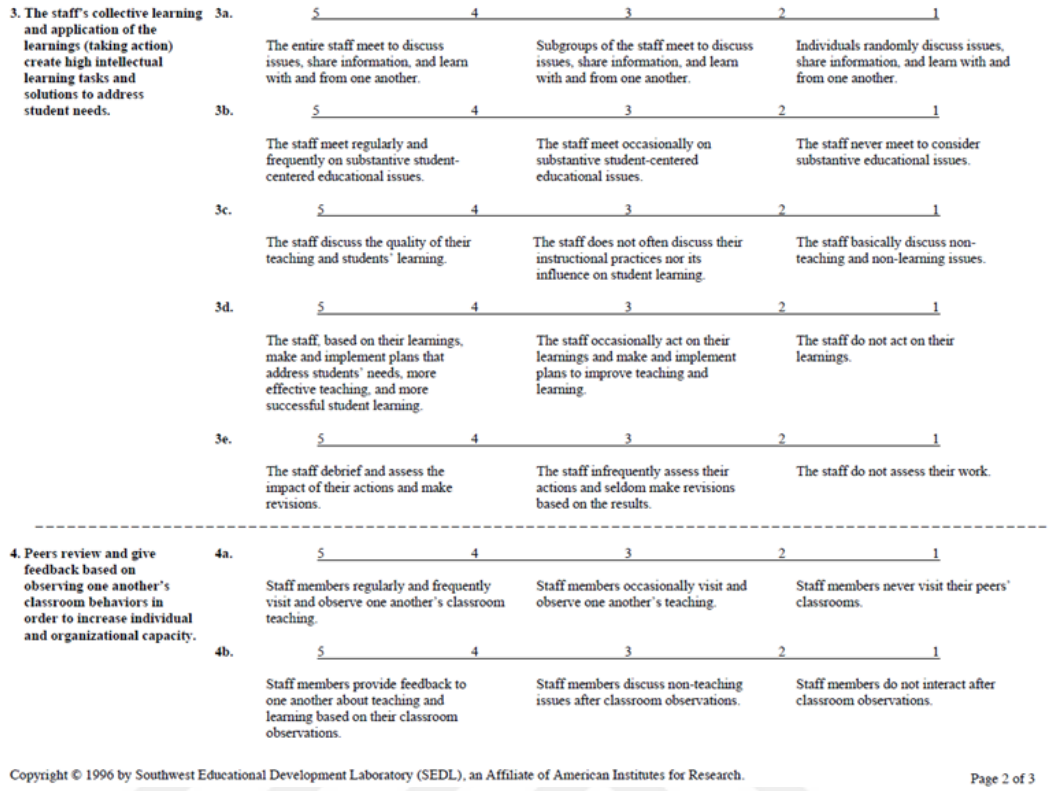
2c. 5 — 4 — 3 — 2 — 1

5: Visions for improvement target high-quality learning experiences for all students.

3: Visions for improvement address quality learning experiences in terms of students' abilities.

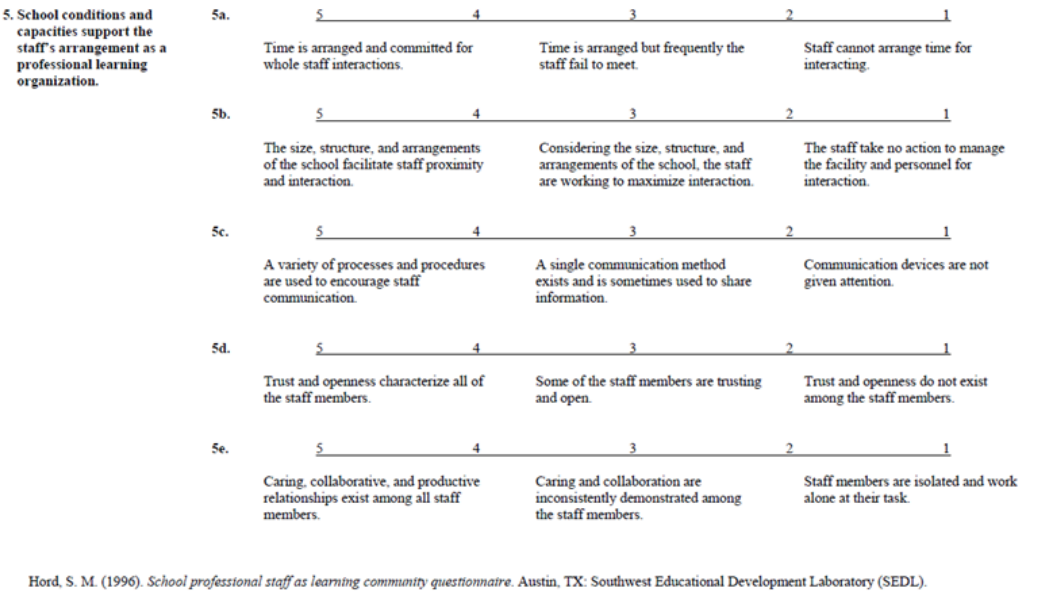
1: Visions for improvement do not include concerns about the quality of learning experiences.

Figure E.1. SPSLCQ Questionnaire 1.



		5	4	3	2	1
3. The staff's collective learning and application of the learnings (taking action) create high intellectual learning tasks and solutions to address student needs.	**3a.**	The entire staff meet to discuss issues, share information, and learn with and from one another.		Subgroups of the staff meet to discuss issues, share information, and learn with and from one another.		Individuals randomly discuss issues, share information, and learn with and from one another.
	3b.	The staff meet regularly and frequently on substantive student-centered educational issues.		The staff meet occasionally on substantive student-centered educational issues.		The staff never meet to consider substantive educational issues.
	3c.	The staff discuss the quality of their teaching and students' learning.		The staff does not often discuss their instructional practices nor its influence on student learning.		The staff basically discuss non-teaching and non-learning issues.
	3d.	The staff, based on their learnings, make and implement plans that address students' needs, more effective teaching, and more successful student learning.		The staff occasionally act on their learnings and make and implement plans to improve teaching and learning.		The staff do not act on their learnings.
	3e.	The staff debrief and assess the impact of their actions and make revisions.		The staff infrequently assess their actions and seldom make revisions based on the results.		The staff do not assess their work.
4. Peers review and give feedback based on observing one another's classroom behaviors in order to increase individual and organizational capacity.	**4a.**	Staff members regularly and frequently visit and observe one another's classroom teaching.		Staff members occasionally visit and observe one another's teaching.		Staff members never visit their peers' classrooms.
	4b.	Staff members provide feedback to one another about teaching and learning based on their classroom observations.		Staff members discuss non-teaching issues after classroom observations.		Staff members do not interact after classroom observations.

Figure E.2. SPSLCQ Questionnaire 2.



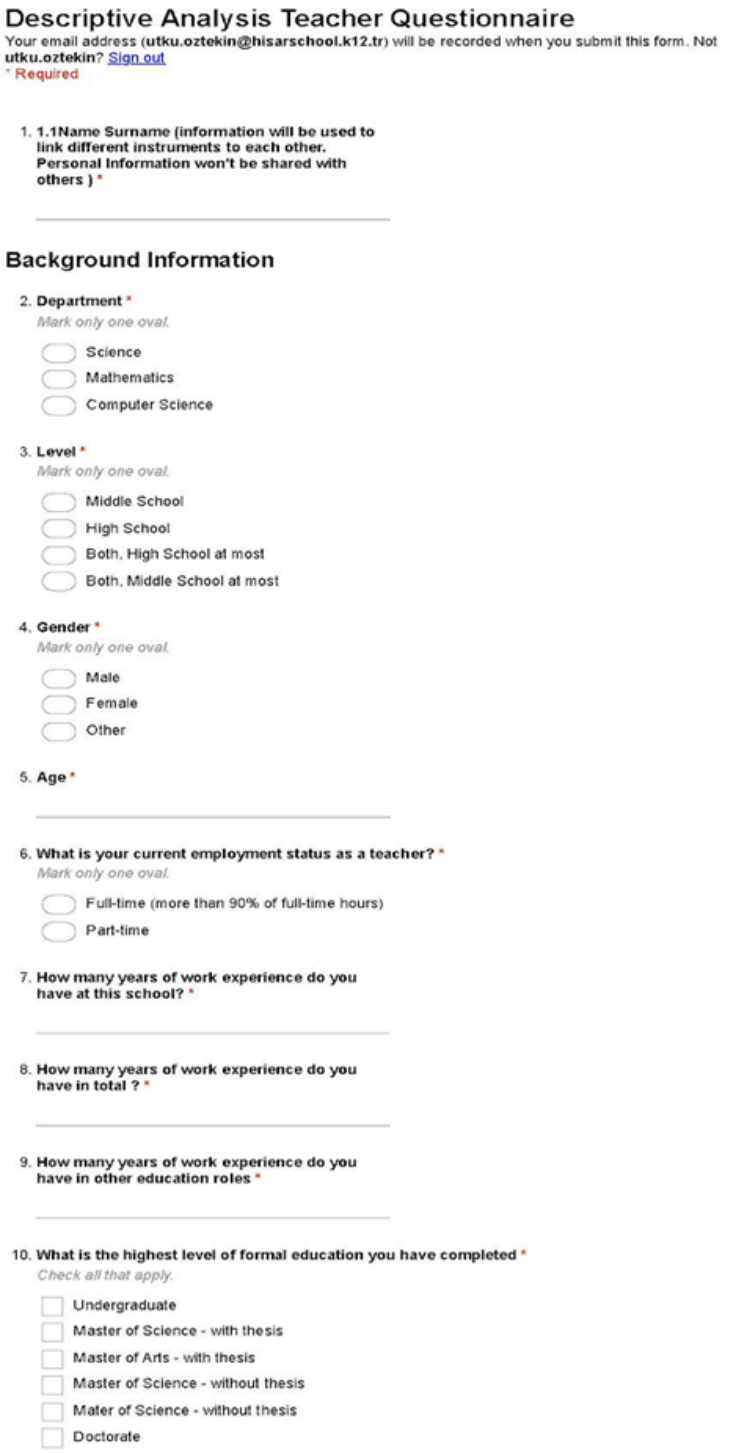
		5	4	3	2	1
5. School conditions and capacities support the staff's arrangement as a professional learning organization.	**5a.**	Time is arranged and committed for whole staff interactions.		Time is arranged but frequently the staff fail to meet.		Staff cannot arrange time for interacting.
	5b.	The size, structure, and arrangements of the school facilitate staff proximity and interaction.		Considering the size, structure, and arrangements of the school, the staff are working to maximize interaction.		The staff take no action to manage the facility and personnel for interaction.
	5c.	A variety of processes and procedures are used to encourage staff communication.		A single communication method exists and is sometimes used to share information.		Communication devices are not given attention.
	5d.	Trust and openness characterize all of the staff members.		Some of the staff members are trusting and open.		Trust and openness do not exist among the staff members.
	5e.	Caring, collaborative, and productive relationships exist among all staff members.		Caring and collaboration are inconsistently demonstrated among the staff members.		Staff members are isolated and work alone at their task.

Hord, S. M. (1996). *School professional staff as learning community questionnaire*. Austin, TX: Southwest Educational Development Laboratory (SEDL).

Available by permission from:
American Institutes for Research
Library–License Agreements
4700 Mueller Blvd.
Austin, TX 78723
www.sedl.org/about/copyright_request.html

Figure E.3. SPSLCQ Questionnaire 3.

APPENDIX F: DEMOGRAPHIC ANALYSIS TEACHER QUESTIONNAIRE



Descriptive Analysis Teacher Questionnaire

Your email address (**utku.oztekin@hisarschool.k12.tr**) will be recorded when you submit this form. Not **utku.oztekin**? Sign out

* Required

1. **1.1Name Surname (information will be used to link different instruments to each other. Personal Information won't be shared with others) ***

Background Information

2. **Department ***
   Mark only one oval.
   - Science
   - Mathematics
   - Computer Science

3. **Level ***
   Mark only one oval.
   - Middle School
   - High School
   - Both, High School at most
   - Both, Middle School at most

4. **Gender ***
   Mark only one oval.
   - Male
   - Female
   - Other

5. **Age ***

6. **What is your current employment status as a teacher? ***
   Mark only one oval.
   - Full-time (more than 90% of full-time hours)
   - Part-time

7. **How many years of work experience do you have at this school? ***

8. **How many years of work experience do you have in total ? ***

9. **How many years of work experience do you have in other education roles ***

10. **What is the highest level of formal education you have completed ***
    Check all that apply.
    - Undergraduate
    - Master of Science - with thesis
    - Master of Arts - with thesis
    - Master of Science - without thesis
    - Mater of Science - without thesis
    - Doctorate

Figure F.1. Demographic Analysis Teacher Questionnaire 1.

11. **In your teaching, to what extent do you feel prepared for the elements below?** *
Mark only one oval per row.

	Not at all	Somewhat	Well	Very well
Content of the subject(s) I teach				
Pedagogy of the subject(s) I teach				
Classroom practice in the subject(s) I teach				

12. **As a teacher of this school, during your most recent complete calendar week, how many 60-minute hours did you spend** *
Scroll right for more hours. A 'complete' calendar week is one that was not shortened by breaks, public holidays, sick leave, etc. Also include tasks that took place during weekends, evenings or other off classroom hours. Round to the nearest whole hour. Also include tasks that took place during weekends, evenings or other off classroom hours. Please exclude all time spent teaching as this was recorded in the previous question. Rough estimates are sufficient. If you did not perform the task during the most recent complete calendar week, write 0 (zero).
Mark only one oval per row.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
During a regular week, approximately in total on teaching, planning lessons, marking, collaborating with other teachers, participating in staff meetings and on other tasks related to your job at this school?																											
Of this total, how many 60-minute hours did you spend on teaching ?																											
On "Individual planning or preparation of lessons either at school or out of school" ?																											
on "Team work and dialogue with colleagues within this school " ?																											
on "Marking/correcting of student work " ?																											
on "Students counseling (including student supervision, virtual counseling, career guidance and delinquency guidance)"?																											
on "Participation in school management " ?																											
on "General administrative work (including communication, paperwork and other clerical duties you undertake in your job as a teacher)"?																											
on "Communication and co-operation with parents or guardians" ?																											
on "Engaging in extracurricular activities (e.g. sports and cultural activities after school)"?																											

Figure F.2. Demographic Analysis Teacher Questionnaire 2.

13. **Are you currently involved in any mentoring activities?** *

This question refers to mentoring by or for teachers at your school. It does not refer to students within the teacher education who are practising as teachers at school.Please mark one choice in each roW

Mark only one oval per row.

	Yes	No
I presently have an assigned mentor to support me.	◯	◯
I serve as an assigned mentor for one or more teachers.	◯	◯

14. **During the last 12 months, did you participate in any of the following professionaldevelopment activities, and if yes, for how many days did they last?** *

Mark only one oval per row.

	Yes	No
Courses/workshops (e.g. on subject matter or methods and/or	◯	◯
Researchers present their research results and discuss educational researchers present their research results and discuss educational issues	◯	◯
Observation visits to other schools	◯	◯
Observation visits to business premises, public organisations, non-governmental organisations	◯	◯
In-service training courses in business premises, public organisations, non-governmental organisations	◯	◯

15. **If you choose Yes for any item above, pleases pecify the number of days spent on the activity** *

Please sum up the activities in full days (a full day is 6-8 hours). Please include activities taking placeduring weekends, evenings or other off work hours.

16. **During the last 12 months, did you participate in any of these activities?** *

Mark only one oval per row.

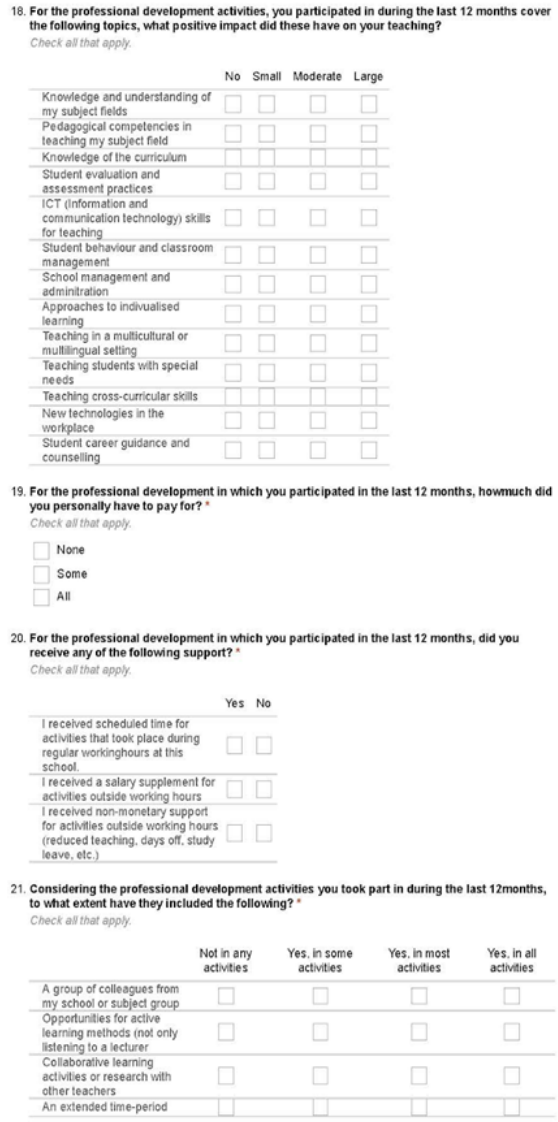
	Yes	No
Qualification programme (e.g. a degree programme)	◯	◯
Participation in a network of teachers formed specifically for the professional development of teachers	◯	◯
Individual or collaborative research on a topic of interest to you professionally	◯	◯
Mentoring and/or peer observation and coaching, as part of a formal school arrangement	◯	◯

17. **Did the professional development activities you participated in during the last 12 months cover the following topics?** *

Check all that apply.

	Yes	No
Knowledge and understanding of my subject fields	☐	☐
Pedagogical competencies in teaching my subject field	☐	☐
Knowledge of the curriculum	☐	☐
Student evaluation and assessment practices	☐	☐
ICT (Information and communication technology) skills for teaching	☐	☐
Student behaviour and classroom management	☐	☐
School management and administration	☐	☐
Approaches to indivualised learning	☐	☐
Teaching in a multicultural or multilingual setting	☐	☐
Teaching students with special needs	☐	☐
Teaching cross-curricular skills	☐	☐
New technologies in the workplace	☐	☐
Student career guidance and counselling	☐	☐

Figure F.3. Demographic Analysis Teacher Questionnaire 3.



18. **For the professional development activities, you participated in during the last 12 months cover the following topics, what positive impact did these have on your teaching?**
Check all that apply.

	No	Small	Moderate	Large
Knowledge and understanding of my subject fields	☐	☐	☐	☐
Pedagogical competencies in teaching my subject field	☐	☐	☐	☐
Knowledge of the curriculum	☐	☐	☐	☐
Student evaluation and assessment practices	☐	☐	☐	☐
ICT (Information and communication technology) skills for teaching	☐	☐	☐	☐
Student behaviour and classroom management	☐	☐	☐	☐
School management and adminitration	☐	☐	☐	☐
Approaches to indivualised learning	☐	☐	☐	☐
Teaching in a multicultural or multilingual setting	☐	☐	☐	☐
Teaching students with special needs	☐	☐	☐	☐
Teaching cross-curricular skills	☐	☐	☐	☐
New technologies in the workplace	☐	☐	☐	☐
Student career guidance and counselling	☐	☐	☐	☐

19. **For the professional development in which you participated in the last 12 months, howmuch did you personally have to pay for?** *
Check all that apply.

- ☐ None
- ☐ Some
- ☐ All

20. **For the professional development in which you participated in the last 12 months, did you receive any of the following support?** *
Check all that apply.

	Yes	No
I received scheduled time for activities that took place during regular workinghours at this school.	☐	☐
I received a salary supplement for activities outside working hours	☐	☐
I received non-monetary support for activities outside working hours (reduced teaching, days off, study leave, etc.)	☐	☐

21. **Considering the professional development activities you took part in during the last 12months, to what extent have they included the following?** *
Check all that apply.

	Not in any activities	Yes, in some activities	Yes, in most activities	Yes, in all activities
A group of colleagues from my school or subject group	☐	☐	☐	☐
Opportunities for active learning methods (not only listening to a lecturer	☐	☐	☐	☐
Collaborative learning activities or research with other teachers	☐	☐	☐	☐
An extended time-period	☐	☐	☐	☐

Figure F.4. Demographic Analysis Teacher Questionnaire 4.

22. **For each of the areas listed below, please indicate the degree to which you currentl yneed professional development.** *

Check all that apply.

	No need at present	Low level of need	Moderate level of need	High level of need
Knowledge and understanding of my subject fields	☐	☐	☐	☐
Pedagogical competencies in teaching my subject field	☐	☐	☐	☐
Knowledge of the curriculum	☐	☐	☐	☐
Student evaluation and assessment practices	☐	☐	☐	☐
ICT (Information and communication technology) skills for teaching	☐	☐	☐	☐
Student behaviour and classroom management	☐	☐	☐	☐
School management and adminitration	☐	☐	☐	☐
Approaches to indivualised learning	☐	☐	☐	☐
Teaching in a multicultural or multilingual setting	☐	☐	☐	☐
Teaching students with special needs	☐	☐	☐	☐
Teaching cross-curricular skills	☐	☐	☐	☐
New technologies in the workplace	☐	☐	☐	☐
Student career guidance and counselling	☐	☐	☐	☐

23. **How strongly do you agree or disagree that the following present barriers to your participation in professional development?** *

Check all that apply.

	Strongly disagree	Disagree	Agree	Strongly agree
I do not have the pre-requisities (e.g. qualifications, experience, seniority)	☐	☐	☐	☐
Professional development is too expensive/unaffordable	☐	☐	☐	☐
There is a lack of employer support	☐	☐	☐	☐
Professional development conflicts with my work schedule	☐	☐	☐	☐
I do not have time because of family responsibilities	☐	☐	☐	☐
There is no relevant professional develoment offered	☐	☐	☐	☐
There are no incentives for participating in such activities	☐	☐	☐	☐

Teaching In General

24. **We would like to ask about your personal beliefs on teaching and learning. Please indicate how strongly you agree or disagree with each of the following statements** *

Please mark one choice in each row.

Check all that apply.

	Strongly disagree	Disagree	Agree	Strongly agree
My role as a teacher is to facilitate students' own inquiry	☐	☐	☐	☐
Students learn best by finding solution to problems on their own.	☐	☐	☐	☐
Students should be allowed to think of solutions to practical problems themselves before the teacher shows them how they are solved	☐	☐	☐	☐
Thniking and reasoning processes are more important than specific curriculum content	☐	☐	☐	☐

Figure F.5. Demographic Analysis Teacher Questionnaire 5.

25. **On average, how often do you do the following in this school?** *

Please mark one choice in each row.
Check all that apply.

	Never	Once a year or less	2-4 times a year	5-10 times a year	Once a week or more
Teach jointly as a team in the same class	☐	☐	☐	☐	☐
Observe other teachers' classes and provide feedback	☐	☐	☐	☐	☐
Engage in joint activities across different classes and age groups.	☐	☐	☐	☐	☐
Exchange teaching materials with colleagues	☐	☐	☐	☐	☐
Engage in discussions about the learning development of specific students	☐	☐	☐	☐	☐
Work with other teachers in my school to ensure common standards in evaluations for assessing student progress	☐	☐	☐	☐	☐
Attend team conferences	☐	☐	☐	☐	☐
Take part in collaborative professional learning	☐	☐	☐	☐	☐

26. **In your teaching, to what extent can you do the following?** *

Please mark one choice in each row.
Check all that apply.

	Not at all	To some extent	Quite a bit	A lot
Get students to believe they can do well in school work	☐	☐	☐	☐
Help my students value learning	☐	☐	☐	☐
Craft good questions for my students	☐	☐	☐	☐
Control disruptive behaviour in the classroom	☐	☐	☐	☐
Motivate students who show low interest in school work	☐	☐	☐	☐
Make my expectations about student behaviour clear	☐	☐	☐	☐
Help students think critically	☐	☐	☐	☐
Get students to follow classroom rules	☐	☐	☐	☐
Calm a student who is disruptive or noisy	☐	☐	☐	☐
Use a variety of assessment strategies	☐	☐	☐	☐
Provide an alternative explanation for example when students are confused	☐	☐	☐	☐
Implement alternative instructional strategies in my classroom	☐	☐	☐	☐

School Climate and Job Satisfaction

27. **How strongly do you agree or disagree with these statements as applied to this school?** *

Please mark one choice in each row.
Mark only one oval per row.

	Strongly disagree	Disagree	Agree	Strongly agree
This school provides staff with opportunities to actively participate in school decisions	◯	◯	◯	◯
This school provides parents or guardians with opportunities to actively participate in school decisions.	◯	◯	◯	◯
This school provides students with opportunities to actively participate in school decisions.	◯	◯	◯	◯
This school has a culture of shared responsibility for school issues	◯	◯	◯	◯
There is a collaborative school culture which is characterised by mutual support	◯	◯	◯	◯

Figure F.6. Demographic Analysis Teacher Questionnaire 6.

28. **How strongly do you agree or disagree with these statements about what happens in this school?** *

Please mark one choice in each row.
Mark only one oval per row.

	Strongly disagree	Disagree	Agree	Strongly agree
In this school, teachers and students usually get on well with each other.				
Most teachers in this school believe that the students' well-being is important				
Most teachers in this school are interested in what students have to say.				
If a student from this school needs extra assistance, the school provides it.				

29. **How strongly do you agree or disagree with the following statements?** *

Please mark one choice in each row.
Mark only one oval per row.

	Strongly disagree	Disagree	Agree	Strongly agree
The advantages of being a teacher clearly outweigh the disadvantages				
If I could decide again, I would still choose to work as a teacher				
I would like to change to another school if that were possible				
I regret that I decided to become a teacher				
I enjoy working at this school				
I wonder whether it would have been better to choose another profession				
I would recommend my school as a good place to work				
I think that the teaching profession is valued in society				
All in all, I am satisfied with my job				

30. **How strongly do you agree or disagree with the following statements concerning your personal attitudes?** *

Please mark one choice in each row.
Mark only one oval per row.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I always listen carefully to students.					
I am confident about my judgements about students					
I have doubts about my ability to succeed as a teacher					
I have always been honest with myself about my teaching qualities					
I feel threatened by teachers who are very successful					
I have said things that hurt colleagues' or students' feelings					
I feel angry when colleagues express ideas different from my own.					
I help students and colleagues in toruble					
I admit when I do not know something if a student asks a question in class					
I am irritated by students who ask for favours					

Figure F.7. Demographic Analysis Teacher Questionnaire 7.

APPENDIX G: SEMI-STRUCTURED INTERVIEW QUESTIONS

Time of Interview:

Date:

Place:

Interviewer:

Interviewee:

Questions:

1. Shared and Supportive Leadership
    a. Can you describe the structure of the decision making mechanism in the school?
        i. How do you and the teachers define yourselves in that mechanism?

2. Shared Beliefs, Values and Vision
    a. How can you describe the vision of the school?
        i. How do you and the teachers contribute to formation of that vision? How that vision is arose?
        ii. What is the importance given to that vision? What are your thoughts about the implementation and absorption of that vision by you and the other teachers?
        iii. What kind of evaluation is made concerning the compatibility of behaviors and the activities of the teachers to that vision?

Figure G.1. SEMI-Structured Interview Questions 1.

3. Collective Learning and Its Applications
    a. Can you tell us about the teams formed inside the school?
        i. How often do you meet with these groups?
        ii. What are the objectives of the formation of these groups? Do the results match with the objectives?
        iii. In terms of implementation, how practical are these results? What do you do to assess the quality of these results?
    b. In the groups that you are a part of, what do you share to better meet the needs of student and to promote more effective teaching methods?
        i. Excluding your performance, how do you evaluate the performances of the group that you are a part of?

4. Shared Personal Practice
    a. What kind of system is used for the class activities and effectiveness of the teachers?
        i. In this system, how do teachers share information?
        ii. How does the feedback system work?
        iii. How does the relationship between two teachers proceed? Are class visits made?

5. Supportive Conditions
    a. How is the time management process is designed for collaborating with other teachers?
        i. For disciplinary scale?
        ii. For interdisciplinary scale?
        iii. How do you evaluate your proficiency? What would you do if you have more time?

Figure G.2. SEMI-Structured Interview Questions 2.

b. How do you evaluate the administration's efforts in order to promote collaboration among teachers?
    i. What can be done?
    ii. What do you need?
c. Which methods and tools do you use to support collaboration and to improve communication among teachers?
d. According to you, what are the thoughts of administration and teachers about the collaboration?

6. Dialogue
    a. With regards to department works
        i. Who calls for a meeting and how is it done? What do you think about the participation?
        ii. What are the steps that you follow during the meeting?
        iii. What is the focus of the meetings?

7. Decision Making
    a. How does the decision making mechanism of your team works? How do you resolve disagreements?
    b. What is the general context of decisions taken in the meetings? (improving instruction practice, student learning, reducing workload, taking less responsibility, etc.)
    c. How do you evaluate the sustainability of the educational methods?
        i. Is the activity dependent on teacher who organizes it or is it applicable without that teacher?
8. Evaluation
    a. How do you evaluate the results of the implementation of the decisions that are taken by your team?
    b. How do you make your analysis?
    c. How does the observation and feedback processes work?
    d. How do you maintain sustainability of that process?

Figure G.3. SEMI-Structured Interview Questions 3.

9. With respect to analysis of the data for the research study, middle school teachers have relatively high percentage than high school teachers for almost all aspects of collaboration. What do you think about that?

10. What is your opinion about the difference between middle school and the high school?
    a. What are the practices of administration to facilitate the collaboration?

11. What kind of difference do yo notice when you compare the disciplinary and interdisciplinary studies?
    a. What do you think about the necessity of these studies? Why?
    b. What complicates the process?
    c. What kind of administrational measures can be taken?

12. When the evaluation dimension of the collaboration is analyzed, results show a relatively low score than the others. What are the reasons of that according to you?
    a. What are the benefits of increase in the collaboration between STEM teachers?
    b. What can be done to increase the collaboration?
    c. What are the obstacles for these studies?

13. If you prepare an action plan for increasing collaboration, what would be the top five items?

Figure G.4. SEMI-Structured Interview Questions 4.

APPENDIX H: CODEBOOK ANALYSIS FORM

Category		Detail	A 0-5	B 5-10	C 10-15	D 15-20	E 20-25	F 25-30	G 30-35	H 35-40	I 40-45	J 45-50	K 50-55	L 55-60	Notes for Interpretation Code	Comment
Effective Collaboration	1	Joint teaching														
	2	Observe other teachers														
	3	Take part in collaborative professional learning														
	4	Engage in interdisciplinary joint activities														
	5	Other														
Fundamental Collaborative Skills	1	Echange Teaching Material														
	2	Working with other teachers for standards														
	3	Others														
Shared Leadership	1	Group Formation														
	2	Management Style														
	3	Other														
Collective Learning	1	Group Types														
	2	Focus of groups														
	3	Other														
Shared Practice	1	Sharing Content														
	2	Sharing Mechanism														
	3	Management of sharing process														
	4	Other														

Figure H.1. Codebook Analysis Form 1.

Category		Detail	A 0-5	B 5-10	C 10-15	D 15-20	E 20-25	F 25-30	G 30-35	H 35-40	I 40-45	J 45-50	K 50-55	L 55-60	Notes for Interpretation Code	Comment
Supportive Conditions	1	Scheduling Management for Disciplinary Purposes														
	2	Scheduling Management for Interdisciplinary Purposes														
	3	Administrative Support for Collaboration														
	4	Other														
Dialogue	1	Departmental Meeting Structure														
	2	Participation Management														
	3	Pre-planning/ preperation														
	4	Focus of Meetings														
	5	Other														
Decision Making	1	Mechanism for decisions														
	2	Conflict Resolution														
	3	Focus of Decisions														
	4	Other														
Action	1	Acting Strategy														
	2	Distribution of Duty														
	3	Fairness														
	4	Coordination Mechanism														
	5	Other														

Figure H.2. Codebook Analysis Form 2.

Category		Detail	A 0-5	B 5-10	C 10-15	D 15-20	E 20-25	F 25-30	G 30-35	H 35-40	I 40-45	J 45-50	K 50-55	L 55-60	Notes for Interpretation Code	Comment
Evaluation	1	Evaluation Focus														
	2	Evaluation Purpose														
	3	Structure of Evaluation														
	4	Focus of Feedback														
	5	Impact of Feedback														
	6	Frequency of Feedback														
	7	Other														
Hindering Factors	1	Personal Characteristics														
	2	Group Characteristics														
	3	Organisational Characteristics														
	4	Structural Characteristics														
	5	Other														

Figure H.3. Codebook Analysis Form 3.

Category		Detail	A 0-5	B 5-10	C 10-15	D 15-20	E 20-25	F 25-30	G 30-35	H 35-40	I 40-45	J 45-50	K 50-55	L 55-60	Notes for Interpretation Code	Comment
Facilitating Factors	1	Personal Characteristics														
	2	Group Characteristics														
	3	Process Characteristics														
	4	Organisational Characteristics														
	5	Structural Characteristics														
	6	Guidance (PD)														
	7	Other														

\+ : positive contribution

\- : negative contribution

O : neutral

V : Yes

X : No

Figure H.4. Codebook Analysis Form 4.

APPENDIX I: QUALITATIVE ANALYSIS CODEBOOK WITH DEFINITIONS

Table I.1. Qualitative Analysis Codebook with Definitions.

Category	No	Detail	Description or/and Example
Effective Collaboration	1	Joint teaching	Teaching together for the same class
	2	Observe other teachers	Class visits, department head observations, etc.
	3	Take part in collaborative professional learning	UbD groups, project studies, PD activities
	4	Engage in interdisciplinary joint activities	Project studies, afterschool studies
	5	Other	
Fundamental Collaborative Skills	1	Exchange Teaching Material	
	2	Working with other teachers for standards	Level based, discipline based or interdisciplinary sharing
	3	Others	
Shared Leadership	1	Group Formation	Invitation, voluntarily, specification based, focus group, etc.
	2	Management Style	Leader's choice, consensus, majority
	3	Other	
Collective Learning	1	Group Types	School-wide, disciplinary, interdisciplinary, etc.
	2	Focus of groups	Program development, student learning, assessment, etc.
	3	Other	
Shared Practice	1	Sharing Content	Material, PD tools, content, etc
	2	Sharing Mechanism	Cloud, directly, by department head, public release, etc.
	3	Management of sharing process	Independent small groups, supervision of department head, etc.
	4	Other	
Supportive Conditions	1	Scheduling Management for Disciplinary Purposes	Random, in case of need, weekly, daily
	2	Scheduling Management for Interdisciplinary Purposes	Random, pre-planned, mandatory, etc.
	3	Administrative Support for Collaboration	Scheduling, less responsibility, payment, etc
	4	Other	
Dialogue	1	Departmental Meeting Structure	Manager's choice, random, weekly, etc.
	2	Participation Management	Mendatory, volunteer, passive, active
	3	Pre-planning/ preperation	Agenda sharing, agenda formation
	4	Focus of Meetings	Studen's learning, future planning, etc.
	5	Other	
Decision Making	1	Mechanism for decisions	Head's choice, majority, consensus, etc.
	2	Conflict Resolution	Win-win, authority, no solution, etc
	3	Focus of Decisions	Student's learning, less working, etc
	4	Other	

Table I.2. Qualitative Analysis Codebook with Definitions (cont.).

Category	No	Detail	Description or/and Example
Action	1	Acting Strategy	Pre-planning, group acting, personal focus, etc.
	2	Distribution of Duty	Voluntarily, mandatory,
	3	Fairness	Equal responsibility, fair payment
	4	Coordination Mechanism	Freedom of choice, managerial support,
	5	Other	
Evaluation	1	Evaluation Focus	Acts, decisions, student output, learning output, etc.
	2	Evaluation Purpose	Criticism, feedback, improvement, elimination, etc.
	3	Structure of Evaluation	Structured, informal, pre-planned, etc.
	4	Focus of Feedback	Content, pedagogy, teaching strategy, etc.
	5	Impact of Feedback	Low, high, mandatory, effective, etc.
	6	Frequency of Feedback	Weekly, monthly, yearly, random
	7	Other	
Hindering Factors	1	Personal Characteristics	Vulnerability, negative attitude for teaming, lack of PD, isolation, resistance to sharing, etc.
	2	Group Characteristics	Fault lines, leadership issues, communication, lack of structure, etc.
	3	Organizational Characteristics	Isolation based school culture, norms of autonomy, etc.
	4	Structural Characteristics	Lack of time, scheduling, resources, reward mechanism,.
	5	Other	
Facilitating Factors	1	Personal Characteristics	Willingness to team, positive communication skills, evaluation skills, etc.
	2	Group Characteristics	Student centered leadership, team size, teamwork skills, etc.
	3	Process Characteristics	Professional autonomy, attention for individual needs, focus on improving instructional quality, etc.
	4	Organizational Characteristics	Leader's support, monitoring system, school culture, performance alignment, commitment.
	5	Structural Characteristics	Staff continuity, consistent meeting times, regulation possibilities, etc.
	6	Guidance (PD)	Training possibilities, effective feedback system, team support
	7	Other	