THE CASE OF PLANNING AND IMPLEMENTING MATHEMATICS AND SCIENCE INTEGRATION IN THE 8TH GRADE IN A PUBLIC MIDDLE SCHOOL

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ABSTRACT

THE CASE OF PLANNING AND IMPLEMENTING MATHEMATICS AND SCIENCE INTEGRATION IN THE 8TH GRADE IN A PUBLIC MIDDLE SCHOOL

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The aim of this study was to investigate one mathematics one science teacher's planning and implementation processes of mathematics and science integration. Specifically, the study focused on existing situation of teacher's practice in terms of integration, their planning of integrated lesson plans, their implementation of the plans, and their evaluation of the processes.

One mathematics and one science teacher working at the same public middle school were selected as voluntary participants by using purposive sampling. Observations were conducted to understand the teachers' practice in terms of integration. The teachers decided topics to be integrated and prepared integrated lesson plans together. Planning of the lessons was audio recorded and the plans were documented. Science teacher implemented the integrated science plans and mathematics teacher implemented the integrated mathematics plans. The implementations of the plans were video recorded. After the implementations, interviews were conducted with the teachers. Content analysis was used to analyze the data.

Findings indicated that science teacher and mathematics teacher considered several critical issues such as determining objectives, students’ prerequisite knowledge, and aim of using integration. The teachers had several problems such as lack of content knowledge, trivializing content, and lack of confidence during planning and implementations. Mathematics teacher had difficulties especially in science content. Although science teacher claimed that she was using integration in lessons before the study, she had difficulties in mathematics content during the processes as much as mathematics teacher. Suggestions for Ministry of National Education, teacher education programs, and science and mathematics teachers were presented.

Keywords: Science and mathematics integration, planning and implementation, middle school science and mathematics teachers, critical issues, problems.

ÖZ

BİR DEVLET ORTAOKULUNDA 8. SINIF DÜZEYİNDEKİ MATEMATİK VE FEN ENTEGRASYONUNUN PLANLANMASI VE UYGULANMASI DURUMU

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Bu çalışmanın amacı, bir matematik ve bir fen öğretmeninin matematik ve fen entegrasyonunu planlama ve uygulama süreçlerini incelemektir. Özel olarak, bu çalışma bir matematik ve bir fen öğretmeninin uygulamalarının entegrasyon açısından mevcut durumuna, öğretmenlerin entegre dersleri planlamalarına, öğretmenlerin entegre edilmiş ders planlarını uygulamalarına ve öğretmenlerin planlama ve uygulama süreçlerini nasıl değerlendirdiklerine odaklanmıştır.

Aynı devlet ortaokulunda birlikte çalışan gönüllü bir matematik ve bir fen öğretmeni amaçlı örneklem metodu yoluyla seçilmiştir. Öğretmenlerin derslerinde fen ve matematik entegrasyonu açısından var olan durumlarını anlayabilmek için sınıf içi gözlemler yapılmıştır. Entegre edilecek matematik ve fen konularına öğretmenler karar vermişler ve entegre edilmiş ders planlarını birlikte hazırlamışlardır. Ders planlarının hazırlanma sürecinde ses kaydı alınmış, hazırlanan planlar yazılı döküman haline getirilmiştir. Fen öğretmeni entegre edilmiş fen ders planlarını, matematik öğretmeni de entegre edilmiş matematik ders planlarını derslerinde uygulamıştır. Planların uygulanma süreci araştırmacı tarafından video kaydına alınmıştır. Uygulamalar sonrasında öğretmenlerle ayrı ayrı mülakatlar gerçekleştirilmiş. Verilerin analizinde içerik analizi kullanılmıştır.

Bulgular, fen öğretmeninin ve matematik öğretmeninin ders kazanımlarının belirlenmesi, öğrencilerin ön bilgileri, ve entegrasyonu kullanım amaçları gibi kritik noktaları gözönünde bulundurduklarını göstermiştir. Ayrıca öğretmenlerin entegre edilmiş derslerin planlama ve uygulama süreçlerinde içerik bilgisi eksikliği, içeriği önemsizleştirme ve güven eksikliği gibi problemler yaşadıkları görülmüştür. Matematik öğretmeni özellikle fen içeriği ile ilgili sıkıntı yaşamıştır. Fen öğretmeni de entegrasyonu daha önce derslerinde kullandığını belirtmesine rağmen, süreç içerisinde matematik içeriği ile ilgili problem yaşamıştır. Çalışmanın bulguları doğrultusunda önemli sonuçlara ulaşılmış ve bu doğrultuda Milli Eğitim Bakanlığı'na, öğretmen yetiştirme programlarına ve fen ve matematik öğretmenlerine önerilerde bulunulmuştur.

Anahtar Kelimeler: Fen ve matematik entegrasyonu, planlama ve uygulama, ortaokul fen ve matematik öğretmenleri, kritik noktalar, problemler.

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TABLE OF CONTENTS

PLAGIARISM iii
ABSTRACT iv
ÖZ iii
DEDICATION viii
ACKNOWLEDGEMENTS ix
TABLE OF CONTENTS xi
LIST OF TABLES xvii
LIST OF FIGURES xviii
LIST OF ABBREVIATIONS xix
CHAPTER
1. INTRODUCTION 1
  1.1 Purpose of the Research 6
  1.2 Significance of the Study 8
  1.3 Definitions of the Important Terms 12
2. LITERATURE REVIEW 16
  2.1 Curriculum Integration 16
  2.2 Relation between Science and Mathematics Instruction 22
  2.3 Definition of Science and Mathematics Integration 25
    2.3.1 Positive Effects of Science and Mathematics Integration 28
    2.3.2 Problems and Barriers Related to Science and Mathematics Integration 28
  2.4. Models for Integrated Science and Mathematics Education 30
  2.5 Studies Conducted with Teachers about the Implementation of Science and Mathematics Integration 39
  2.6 Studies Conducted in Turkey about Integration of Science and Mathematics 45
  2.7 Summary 48
3. METHODOLOGY 50
  3.1 Research Design 51

3.2 Participants of the Study 53
3.2.1 Mathematics Teacher (MT) 54
3.2.2 Science Teacher (ST) 54
3.3 The Research Context 55
3.4 Integrated Lesson Plans 56
3.5 Data Collection Procedure 57
3.5.1 Data Collection Tools 61
3.5.1.1 Classroom Observations 61
3.5.1.2 Documents (Students' Notebooks) 62
3.5.1.3 Teachers' Definitions of Mathematics and Science Concepts 62
3.5.1.4 Interviews 63
3.5.1.5 Video Records 63
3.6 Data Analysis Procedure 64
3.6.1 Coding 64
3.6.2 Researcher Role 66
3.6.3 Trustworthiness of the study 66
4. FINDINGS 69
4.1 Findings of the Pre-study 70
4.1.1 Observations 70
4.1.2 Students' Notebooks 72
4.1.3 Teachers' Descriptions of Mathematics or Science Concepts 74
4.2 Findings of the Main Study 77
4.2.1 Planning of the Integrated Lessons 77
4.2.1.1 Critical issues 78
4.2.1.1.1 Determining the objectives 79
4.2.1.1.2 Checking for students' prerequisite knowledge 80
4.2.1.1.3 Using teaching methods, and materials 81
4.2.1.1.4 Aim of using integration 82
4.2.1.1.4.1 Integration for reminding previous/recent mathematics/science concepts 82
4.2.1.1.4.2 Integration for introducing new topic/concept/procedure 84

4.2.1.1.4.3 Integration for explaining topics/concepts by connecting mathematics and science 85
4.2.1.1.4.3.1 Connection science to mathematics (S-M) 86
4.2.1.1.4.3.2 Connection mathematics to science (M-S) 89
4.2.1.1.4.3.3 Connection science to mathematics to science (S-M-S) . 90
4.2.1.2 Factors affecting the planning 90
4.2.1.2.1 Problems about content knowledge 91
4.2.1.2.1.1 Lack of content knowledge in mathematics and/or science .. 91
4.2.1.2.1.2 Trivializing content 95
4.2.1.2.2 Teachers' collaboration and communication 96
4.2.1.2.2.1 Support 96
4.2.1.2.2.2 Suggestions 98
4.2.1.2.2.3 Persuasion 99
4.2.1.2.2.3.1 Persuasion in disagreements 100
4.2.1.2.2.3.2 Persuasion in Hesitations 101
4.2.2 Implementation of the Integrated Lessons 102
4.2.2.1 Integrated science plans 102
4.2.2.1.1 Plan1 (Inheritance-Probability) 103
4.2.2.1.1.1 Critical issues in Plan1 103
4.2.2.1.1.1.1 Checking for students' prerequisite knowledge: 103
4.2.2.1.1.1.2 Integration for reminding previous/recent concepts: 104
4.2.2.1.1.1.3 Integration for introducing the new topic/concept/procedure: 105
4.2.2.1.1.1.4 Integration for explaining topics/concepts by connecting mathematics and science 106
4.2.2.1.1.1.4.1 Connection science to mathematics (S-M) 106
4.2.2.1.1.1.4.2 Connection mathematics to science (M-S) 109
4.2.2.1.1.1.4.3 Connection science to mathematics to science (S-M-S) 109
4.2.2.1.1.2 Problems affecting the implementation of Plan1 111
4.2.2.1.1.2.1 Lack of content knowledge 111

4.2.2.1.1.2.2 Trivializing content 115
4.2.2.1.1.2.3 Teaching related problems 116
4.2.2.1.1.3 ST's evaluation of Plan1 117
4.2.2.1.2 Plan2 (Buoyancy- Ratio and Proportion) 118
4.2.2.1.2.1 Critical issues in Plan2.. 119
4.2.2.1.2.1.1 Checking for students' prerequisite knowledge 119
4.2.2.1.2.1.2 Integration for reminding previous/recent concepts...... 119
4.2.2.1.2.1.3 Integration for introducing the new topic/concept/procedure 122
4.2.2.1.2.1.4 Integration for explaining topics/concepts by connecting mathematics and science 123
4.2.2.1.2.1.4.1 Connection science to mathematics (S-M) 123
4.2.2.1.2.1.4.2 Connection mathematics to science (M-S) 124
4.2.2.1.2.1.4.3 Connection science to mathematics to science (S-M-S)... 124
4.2.2.1.2.2 Problems affecting the implementation of Plan2................. 125
4.2.2.1.2.2.1 Lack of content knowledge 125
4.2.2.1.2.2.2 Teaching related problems 125
4.2.2.1.2.3 ST's evaluation of Plan2 127
4.2.2.1.3 Plan3 (Heat and Temperature- Line Graph) 128
4.2.2.1.3.1 Critical issues in Plan3.. 129
4.2.2.1.3.1.1 Checking for students' prerequisite knowledge 129
4.2.2.1.3.1.2 Integration for reminding previous/recent concepts...... 130
4.2.2.1.3.1.3 Integration for introducing the new topic/concept/procedure 132
4.2.2.1.3.1.4 Integration for explaining topics/concepts by connecting mathematics and science 132
4.2.2.1.3.1.4.1 Connection science to mathematics (S-M) 132
4.2.2.1.3.1.4.2 Connection mathematics to science (M-S) 133
4.2.2.1.3.2 Problems affecting the implementation of Plan3................. 134
4.2.2.1.3.2.1 Lack of content knowledge 134

4.2.2.1.3.2.2 Teaching related problems 136
4.2.2.1.3.3 ST's evaluation of Plan3 136
4.2.2.2 Integrated mathematics plans 138
4.2.2.2.1 Plan4 (Probability-Inheritance) 138
4.2.2.2.1.1 Critical issues in Plan4 139
4.2.2.2.1.1.1 Checking for students' prerequisite knowledge 139
4.2.2.2.1.1.2 Integration for reminding previous/recent concepts 140
4.2.2.2.1.1.3 Integration for introducing the new topic/concept/procedure 143
4.2.2.2.1.1.4 Integration for explaining topics/concepts by connecting mathematics and science 144
4.2.2.2.1.1.4.1 Connection science to mathematics (S-M) 144
4.2.2.2.1.1.4.2 Connection mathematics to science (M-S) 145
4.2.2.2.1.2 Problems affecting the implementation of Plan4 145
4.2.2.2.1.2.1 Lack of content knowledge 145
4.2.2.2.1.2.2 Trivializing content 147
4.2.2.2.1.2.3 Teaching related problems 148
4.2.2.2.1.3 MT's evaluation of Plan4 149
4.2.2.2.2 Plan5 (Volume of geometric objects- Buoyancy) 151
4.2.2.2.2.1 Critical issues in Plan5 152
4.2.2.2.2.1.1 Checking for students' prerequisite knowledge 152
4.2.2.2.2.1.2 Integration for reminding previous/recent concepts 152
4.2.2.2.2.1.3 Integration for introducing the new topic/concept/procedure 154
4.2.2.2.2.1.4 Integration for explaining topics/concepts by connecting mathematics and science 154
4.2.2.2.2.1.4.1 Connection science to mathematics (S-M) 154
4.2.2.2.2.1.4.2 Connection mathematics to science (M-S) 155
4.2.2.2.2.2 Problems affecting the implementation of Plan5 155
4.2.2.2.2.2.1 Lack of content knowledge 155
4.2.2.2.2.2.2 Teaching related problems 157

4.2.2.2.2.3 MT's evaluation of Plan5 158
4.3 Summary of the Findings 159
5. DISCUSSION AND CONCLUSION 166
5.1 Discussion and Conclusion 166
5.1.1 Initial Situations 167
5.1.2 Critical Issues for Planning and Implementation 169
5.1.3 Affecting Factors of Planning and Implementation 173
5.1.4 Teachers' Evaluation of Their Teaching 178
5.2 Suggestions and Implications 178
5.3 Recommendations for Future Studies 182
5.4 Limitations of the Study 183
REFERENCES 185
APPENDICES
APPENDIX A 197
APPENDIX B 199
APPENDIX C 200
APPENDIX D 203
APPENDIX E 204
APPENDIX F 207
APPENDIX G 229

LIST OF TABLES

TABLES

Table 3.1 Mathematics and science teachers' demographic information...................54

Table 3.2 Properties of the 8th graders in the school..55

Table 3.3 Integrated topics of the plans and their implementation order...................56

Table 3.4 Timeline of data collection activities...61

Table 3.5 The research questions and the data collection tools..................................62

Table 4.1 Topics and numbers of related questions connected to science concepts in students' mathematics notebooks..73

Table 4.2 Topics and numbers of related questions connected to mathematics concepts in students' science notebooks...73

Table 4.3 Information about the integrated plans and their implementation order...79

Table 4.4 The frequencies of different usage of connections for each prepared plan...86

Table 4.5 The frequencies of the problems for each plan for planning process..92

LIST OF FIGURES

FIGURES

Figure 2.1 Example about obtaining unit of heat in science…………………………...24

Figure 2.2 Example about obtaining unit of y in mathematics……………………...24

Figure 2.3 Continuum of integration of mathematics and science concepts/activities……………………………………………………………...32

Figure 2.4 Flowchart of theme-based, interdisciplinary, integrated curriculum…….33

Figure 2.5 Mathematics/science continuum………………………………………...34

Figure 2.6 CSM Continuum of mathematics and science correlation………………36

Figure 2.7 Content for the Balanced Model…………………………………………37

Figure 4.1 Implementation order of Plan1..104

Figure 4.2 Implementation order of Plan2..120

Figure 4.3 Implementation order of Plan3..130

Figure 4.4 Implementation order of Plan4..140

Figure 4.5 Implementation order of Plan5..153

LIST OF ABBREVIATIONS

STEM	Science Technology Engineering and Mathematics Education
NCTM	National Council of Teachers of Mathematics
MoNE	Ministry of National Education
ST	Science Teacher
MT	Mathematics Teacher
SIMCI	Science Intensive Mathematics Connected Integration
MISCI	Mathematics Intensive Science Connected Integration
S-M	Connection science to mathematics
M-S	Connection mathematics to science
S-M-S	Connection science to mathematics to science

CHAPTER I

INTRODUCTION

Innovation and productivity growth are necessary in order to enhance human living standards (Council of Canadian Academies, 2015). At this point Science, Technology, Engineering, and Mathematics (STEM) skills have been put into the focus of advancing innovation. Countries which want to improve their economical situations also place a great emphasis on advancing STEM skills (Council of Canadian Academies, 2015). Improving students' success in STEM fields is critical with the purpose of competing in terms of economic growth in the world (Wang, Moore, Roehrig, & Park, 2011). Students might obtain significant tools through STEM skills which help them having chance to select a variety of education fields for their future (Council of Canadian Academies, 2015).

Integration of a combination of knowledge, skills and beliefs of at least two STEM disciplines form the components of STEM education (Corlu, Capraro, & Capraro, 2014). STEM education is also described as an interdisciplinary approach including an integration of science, technology, engineering, and mathematics. STEM integration, moreover, aims to make the boundaries between the four STEM subject areas barely visible (Wang, et al., 2011).

There are connections between STEM disciplines in which the boundaries are not strict. For instance, Berry, Chalmers, and Chandra, (2012) presented an example of ratio concept in mathematics in order to indicate this connection. They stated that ratio is a mutual concept between the STEM disciplines, in science as concentration of solutions, in technology as “mixing ingredients in a healthy meal” and in engineering as “the exploration of different concrete mixes” (Berry, et al., 2012, p.

225). Berry, and et al. (2012) also emphasized that all STEM fields want individuals to combine their ideas and thinking in order to reveal real life products. They indicated designing and construction of a bridge example for this situation. According to this example; the STEM disciplines' people should work in collaboration and integrate the knowledge by the purpose of creating the best bridge. When this relation was considered, the reflection of the relation and the process to the classrooms has become an important issue.

Among the disciplines of STEM education, the relation between mathematics and science has been accepted and investigated for a long time. In each level of elementary, middle and high school, mathematics and science courses are mostly considered important in order to be successful (Tian, Wu, Li, & Zhou, 2008; Tyson, Lee, Borman, & Hanson, 2007; Uzun, Bütüner, & Yiğit, 2010). However, every student may not obtain remarkable achievement in mathematics and science and for some students, to be successful in both can require more efforts (Li & Li, 2008). In this regard, curricula of science and mathematics can be considered as vital for students' learning. Many national agencies or foundations responsible for curriculum development such as Turkish Ministry of National Education (MoNE, 2006; 2009; 2013a; 2013b), National Council for Teacher of Mathematics (NCTM, 2000), and National Research Council (1996), have reformed their related curricula (science or mathematics) for the purpose of improvement of students' learning of school mathematics and science. As Wang (2005) pointed out, these foundations accepted the importance of interdisciplinary approach for science and mathematics.

Turkish Ministry of National Education have stressed in elementary and middle school mathematics curriculum (MoNE, 2011a) and science and technology curriculum (MoNE, 2011b) that both curricula should aim to help students achieve certain common objectives such as critical thinking, creative thinking, investigation and questioning, problem solving skills, and use of informational technologies. In the middle school mathematics curriculum, interdisciplinary connections has been mentioned in the part of skills pertain to domain especially with science domain. For example, when the 8^{th} grade students learn the concept of slope in science course, they have to know trigonometric ratios in mathematics in order to understand and internalize the concept of slope (MoNE, 2011a). On the other hand; middle school science and technology curriculum (MoNE, 2011b) also stressed the importance of the connection between science and other disciplines, especially mathematics. It can be said that several topics in mathematics and science constitute pre-requisite knowledge for each other, which reveals the importance of connection between mathematics and science and both curricula support this relation. At this point, it may be deduced that students may need to learn science and mathematics concepts in schools consecutively and in relation to each other, and teachers should teach subjects of science and mathematics in a harmony.

NCTM (2000), emphasized the relation between mathematics and science by stating a long history of close ties between them and placed a great importance to make connections between mathematics and science, social studies and art in contents of geometry, measurement, data analysis and probability domains. They also stated that the connection between the two disciplines was evident across both contents and processes of mathematics and science. NCTM (2000) underlined that scientific problems generate mathematical notions. On the other hand; using science content and processes gives opportunity to students to gain insight for problem solving and its applications in mathematics. Beyond mentioning the relation between mathematics and science, NCTM (2000) and other curricula (Koestler, Felton-Koestler, Bieda, & Otten, 2013) recommended mathematics teachers to make connections between mathematics and especially science and to make collaboration with science teachers in order to avoid misconceptions or misunderstanding related to science. Mathematics teachers were also suggested that they provided students to encounter mathematical situations in daily life and used science context for making mathematical explorations (NCTM, 2000). Finnish National Board of Education (n.d.) also stated the importance of multidisclinary cooperation network to enhance students' schooling and well being (p.30). Basista and Mathews (2002) also indicated the relation between mathematics and science. They stressed that science provides rich context and concrete phenomena for mathematical patterns and relations and mathematics contribute to understanding of science concepts and applications as a language and tools. At this point, mathematics and science can be evaluated as inseparable parts of a comprehensive whole.

Mathematics and science integration is important because a better performance in one seem to be related to a better performance in the other. International organizations have conducted comparison studies in order to see and evaluate students' mathematics and science achievements. They additionally assessed whether there was a relationship between students' mathematics and science achievements. Trends in International Mathematics and Science Study (TIMSS) study is one of them. TIMSS has assessed 4^{th} and 8^{th} grade students' academic performance in mathematics and science with questions of various domains of mathematics and science in accord with cognitive levels from participant countries (Bayraktar, 2010). In the literature, there are several studies which were conducted with TIMSS data and which aimed to reveal students' science and mathematics achievement levels by using some variables such as; gender, attitude, homework, and education level of parents. (Uzun, Bütüner, & Yiğit, 2010; Wang & Santos, 2003; Wang, 2005; Webster, Young, & Fisher, 1999). A comparative study found that there was a positive linear relationship between 8^{th} grade students' mathematics and science achievements among participating nations in TIMSS 1995 and 1999 (Wang & Santos, 2003). Wang (2005) also stated that there was a strong positive correlation between students' achievements in science and mathematics in TIMSS data and this result supported the previous one.

The related literature about the connection between science and mathematics emphasizes science and mathematics integration which dates back to the beginning of the 20^{th} century (Berlin & White, 2001). The studies related to integration generally have mentioned that integration helps to develop more positive perceptions, views and attitudes towards science and mathematics and increases achievements in science and mathematics (Berlin & White, 1999). Victor, Kellough and Tai (2008) also underlined that the science and mathematics programs should be in accordance with each other for making students' understandings and achievements in both disciplines better. They stated that a curriculum development should intend a common endeavor which aims to strengthen the connections between disciplines, by means of integrating mathematics and science.

Mathematics and science integration has been considered important by many researchers (Berlin & White, 1994; Haigh & Rehfeld, 1995; Lehman, 1994; Lederman & Niess, 1998; NCTM, 2000; Temel, Dündar, & Şenol, 2015; Wang, 2005). They have indicated that integration would result in an increase in students' achievements in both courses, production of meaningful learning as a result of concepts that were learned by using the connection in both disciplines, and an increase in attitudes and motivations of students towards mathematics and science. McBride and Silverman (1991) discussed the necessity of integrated science and mathematics by the help of related literature. First, they addressed the natural relation between mathematics and science in real life. Therefore, they claimed that science provides benefits for mathematics in terms of providing abstraction of mathematics and enhancing students' mathematical learning. Similarly, mathematics provides benefits for science in terms of enhancing students' science understanding and relationships. Last, students' motivation for mathematics is improved by the help of science activities.

Efforts for science and mathematics integrated instructions started in the beginning of 21th century and recently increased (Lehman, 1994). Reform movements have also affected the view of curriculum integration especially for mathematics and science (Lederman & Niess, 1998). These efforts were based on the assumption that students' mathematics and science achievements will increase by integration of mathematics and science (Haigh & Rehfeld, 1995; Lehman, 1994).

To sum up, although integration of science and mathematics is not a new concept, this topic is still valid (Lee, Chauvot, Vowell, Culpepper, & Plankis, 2013) because of the relationship between the two disciplines and the belief that the integration of them will increase students' achievements in both mathematics and science and positively affect their attitudes towards both disciplines (Berlin & White; 1999;

Lehman, 1994). Additionally, detailed planning and building for how to implement the integration process have become vital to explore the integration's real effect on students' learning. At this point teachers' planning and implementations of integrated plans prepared by them can be important for successful and effective science and mathematics integration.

1.1 Purpose of the Research

A mathematics teacher can ignore to mention concepts related with science when teaching mathematics but a science teacher cannot skip the mathematical concepts related with the science topics (Frykholm & Meyer, 2002). Moreover, mathematics takes part intensively in different science areas. While there are many mathematical concepts in physics, this is not the same for biology. This situation may give a view that mathematics and science are not related mutually, only science contains some mathematical pre-learning and concepts, and mathematics does not need scientific concepts. However, as it can be seen in Turkish science and mathematics curricula, science is considerably related with daily life and mathematics includes many daily life concepts (MoNE, 2011a; 2011b). Therefore, it can be deduced that the relation between science and mathematics is not one sided. As it was mentioned before, many researchers (Basista & Mathews, 2002; Berlin & White, 1994; Haigh & Rehfeld, 1995; Lederman & Niess, 1998; Lehman, 1994; NCTM, 2000; Wang, 2005) have supported mutual relationship and that this relation should be used for integrating mathematics and science for students' better understanding and conceptualization of both mathematics and science concepts by combining the related concepts, such as density in science and volume in mathematics. At this point, an instruction that integrates science and mathematics may be useful for students in each grade.

The new considerations of integration that can result in positive results can be achieved through the implementation and experience of the teachers in real classrooms (Mason, 1996). Kıray (2012) presented a balance model for science and mathematics integration. He put the content knowledge at the center and he claimed that skills, the process of teaching and learning, affective characteristics, and measurement and assessment are the other important parts of the model. Seven dimensions were determined on the balance model for the content knowledge. Intensity of integration was increasing as move to the middle of the continuum in this model. These dimensions were mathematics, mathematics-centered science-assisted integration, mathematics-intensive science-connected integration, total integration, science-intensive mathematics-connected integration, science-centered mathematics-assisted integration and science. In this regard, considering that in-service teachers are the real implementers of science and mathematics teaching, revealing how they put planning and implementation of integration into practice can contribute to understand the integration in the school environment. Within these aims, following questions guided this study:

1. How do one middle school science teacher and one middle school mathematics teacher practice integration in their existing teaching?

2. How do one mathematics teacher and one science teacher plan the integrated lessons?

    2.a. What are the critical issues that the teachers considered during planning?

    2.b. What are the influencing factors in planning process of integrated plans?

3. How do one mathematics teacher and one science teacher implement the integrated lessons?

    3.a. To what extend the teachers implement the integrated plans?

    3.b. What are the problems that they encounter while implementing the integrated plans?

4. How do the teachers evaluate the integration process in terms of their teaching?

This study sought the answers of these questions through observing one science teacher and one mathematics teacher during an academic semester by the purpose of analyzing what they were doing related to integration of science and mathematics. After this long observation, the teachers planned and implemented integrated lesson plans in the same school and classes. The planning and implementation process was deeply investigated in order to respond to the research questions. The teachers participated in this study used Kıray (2012)'s the balance model phases of mathematics-intensive science-connected integration (MISCI) and science-intensive mathematics-connected integration (SIMCI) dimension during their planning and used the plans they developed in the implementation of the study in their classes.

1.2 Significance of the Study

Science is defined as a system which aims to understand the natural phenomena by the help of observation and experimentations (Catalano, 2014). Science education is necessary for people to think and overcome difficulties about the problems which could affect their lives (Uzun, Bütüner, & Yiğit, 2010). On the other hand, mathematics is an international language which is necessary for all sciences and every individual needs mathematics for handling the problems in daily life (Işık, Çıltaş, & Bekdemir, 2008). Mathematics education provides people of all ages with lifelong learning (Clements & Ellerton, 1996). Mathematics education aims to help them gain them creative thinking, reasoning, problem solving, and critical thinking skills (Baki, Güç, & Özmen, 2012).

Besides the necessity of mathematics and science education, the relation between them is not negligible (Basista & Mathews, 2002). It is believed that the integrated instruction that can increase students' achievement and it can develop positive attitudes towards mathematics (Wang & Santos, 2003; Webster, Young & Fisher, 1999). In addition, for science and mathematics that affect each other in many situations, using this integration with daily life examples can be useful for students. Students can be more successful in both mathematics and science and this meaningful learning can contribute students' future education and can affect their lives positively (Lederman & Niess, 1998; Lehman, 1994). Despite its importance, how integration is implemented in the real school environment is not clear (Kıray, Önal, & Demirel, 2007).

Teachers could be considered the main agents of integration. Science and mathematics teachers are important because implementing integrated lessons effectively in classrooms is in their power and responsibility (McBride & Silverman, 1991). It is more important to determine how to teach integrated lessons rather than what will be integrated because teachers have inadequate background related to science and mathematics integration (Steen, 1994). Judson (2013) emphasized the probable difficulties that teachers can encounter while preparing and implementing integrated lesson plans. These problems were summarized as extra time for planning, requirement of team work for planning, content knowledge problem in both science and mathematics, and need of relevant curricula. Kıray and Kaptan (2012) suggested that training should be given to both preservice and in-service teachers so that they could close the gap in their content knowledge and skills in both science and mathematics.

It is asserted that integration would result in better learning outcomes for mathematics and science, however; not much had been done to understand the effect of integration because integration has not been implemented much (McBride & Silverman, 1991). Because, integration is not easy to implement and it requires more efforts in terms of support, time, resources and materials (McBride & Silverman, 1991). Pang and Good (2000) stated that teachers' teaching is affected by variables such as their subject matter knowledge, pedagogical content knowledge, and beliefs. According to them, if the teachers have sufficient content knowledge and internalize the connections between the disciplines, integrated curriculum could be implemented successfully. Temel, Dündar and Şenol (2015) stated that students have difficulties in understanding the related mathematics and science concepts since these relations are not emphasized enough. They also suggested that these difficulties could be overcome by using the relationships in science and mathematics topics. Additionally, they recommended planning the instructions including the relations and preparing suitable materials for this purpose, and more studies which develop materials and activities related to the integration should be conducted.

Mathison and Freeman (1997) discussed the importance of the several questions for interdisciplinary teaching which were not clarified. One of these questions was about the situation of the real classroom environment during integrated instruction. Kurt and Pehlivan (2013) suggested developing integrated instructions which will last long time in order to see the effectiveness of the program. Hurley (2001) recommended future researches that would focus on the need to the implementation of integrated curriculum in different forms. Pang and Good (2000) suggested to focus on revealing the challenges during the implementation of integrated instructions and identifying the solutions for the teachers' limitations for integration for any grade level. Frykholm and Glasson (2005) also recommended examining teachers' planning and implementations of connected science and mathematics instruction in the classrooms.

In the light of the related literature, it could be inferred that many researchers suggested investigating the planning and implementation processes in a long duration although it is a difficult process. On the other hand, only few researchers have explored teachers' implementation of integrated lessons in the real classroom environment. There are also few studies which reveal the problems that the teachers encountered during integrated teaching. Therefore, understanding teachers' preparation and implementation processes of integrated lessons might provide information about their teaching, possible difficulties and needs that the teachers face during the process as well as the requirements for successful implementation.

Considering the importance of teachers in the mathematics and science integration, studying how mathematics and science teachers plan and implement integration becomes important. There are few studies in the integration literature conducted with in-service teachers, which investigated what they did in their teaching related to integration and the whole process of integration prepared and conducted by the teachers in collaboration. The findings of the present study might provide an understanding of the big picture of integration processes, from teachers' planning to implementation of the integrated lessons. At this point, this study may illuminate and encourage teachers and researchers about the integration and its applications.

Additionally, Temel, Dündar and Şenol (2015) also indicated that little research has been done on science and mathematics integration in Turkey; thus, they suggested examining the integration to raise attention to the importance and the necessity of the integration. For this reason, this study will contribute to the integration literature in Turkey.

In this study, one mathematics teacher and one science teacher collaborated for preparing integrated lesson plans for mathematics-intensive science-connected integration (MISCI) and science-intensive mathematics-connected integration (SIMCI) for 8th grade classes as a team in a public middle school in Ankara. Although importance of the interaction between science and mathematics was emphasized in many studies, it's reflection to curriculum and teaching in real classrooms is still not clear (Kurt & Pehlivan, 2013). Implementing integrated science and mathematics in real classroom and real school environment with real students (Czerniak, Weber, Sandman, & Ahern, 1999) and observing classroom environment in order to see the reflection of the teachers' integrated conceptions on their teaching (de Araujo, Jacobson, Singletary, Wilson, Lowe, & Marshall, 2013) are suggested as a research outlet for integration. This study closely observed the two teachers, one science teacher and one mathematics teacher through a semester. Then, they planned five integrated lesson plans together collaboratively and implemented the plans in their classes on their own through an academic year. Both planning and implementation processes were also observed to investigate the process in depth. Therefore, the findings of the study might provide the literature not only with depth, but also breadth of the integration process.

The researchers studying integrated instruction (Jacobs, 1989; Meier, Nicol, & Cobbs, 1998) recommend several issues for planning and implementing the lessons. These are working as a team with at least two teachers, common planning time, teaching the same students, teachers skilled in professional collaboration, consensus building, and curriculum development. Additionally, the researchers present several barriers and problems for successful integration such as time constraint, classroom management, lack of administrative support, teacher knowledge, and teacher beliefs.

This study may be important in terms of controlling some of these problems before starting the integration process. First of all, permission was given by the administrator of the school for using all opportunities of the school. Second, since the teachers participated in the study were experienced teachers, classroom management problem was not expected. Third, the planning of the integrated lessons were prepared by the teachers in collaboration during the seminar term of the beginning of the academic year thus, they had no time constraint in the planning phase. Last, the teachers participated in the study voluntarily and they had positive ideas about the effectiveness of the integration. Moreover, when related literature was examined, it can be seen that barriers to integration were generally discussed and evaluated in literature review studies. In this sense, this study may also provide opportunity to see the teachers' real experiences and difficulties during the planning and implementation of integration directly.

The present study may provide teachers with the awareness of the critical issues for integration. Additionally, the findings of this study may present guidance to MoNE for in-service teacher training which was suggested in integration literature mostly, by examining the teachers' integration processes and determining the needs for integration. Besides, the study may help school administrations for ideas about presenting opportunities for successful integration process. This study can also contribute to the teacher education programs for designing their instructions about integration for preservice teachers.

1.3 Definitions of the Important Terms

Integration of Mathematics and Science: Integration is an act or instance of combining into an integral whole. A recombination event in which a genetic element is inserted (Retrieved from http://dictionary.reference.com/browse/integration?s=t). In the literature there is not a clear definition of integration stated by the researchers (Huntley, 1998). For example according to Huntley (1998), integration can be defined as a tool which helps students in terms of developing well organized and interconnected knowledge. He discussed the meaning of integration in several situations, such as in problem solving in mathematics, using mathematics as a tool in science or in making connections between science and mathematics. Additionally, Berlin and White (1994) stated that for determining whether an instruction has integrated mathematics and science or not, if someone cannot distinguish the class is mathematics class or science class it can be said that that class is an integrated class. According to Furner and Kumar (2007), instruction of integration of certain disciplines deal with students' best acquired knowledge, learning process, the teaching subject, and cooperation of students and teachers in the process. Therefore, it may be said that there is not an agreement about what the definition of integration is, although the number of studies related to integration has increased (Kıray, Önal, & Demirel, 2007). In this study, integration was considered as Huntley (1998) and Furner and Kumar (2007) stated as a tool for connecting the disciplines for meaningful learning and bringing students in best knowledge, providing being active and enabling cooperation of students and teacher in the integrated learning process.

Kıray (2012)'s Balance model was taken as a base in order to form integration process in terms of contents. According to this model's phases, this study specifically focused on two parts of the model which could be more applicable for the current middle school science and mathematics curricula. These phases were explained below.

Mathematics intensive science connected integration (MISCI): In related literature, there are dimensions similar to MISCI dimension of the Balance model. For example; 'mathematics focus' dimension in Lonning and DeFranco (1997)'s "Continuum Model of Integration" and as 'math with science' dimension in Huntley (1998)'s "Mathematics/Science Continuum" model are two of them. Both Lonning and DeFranco (1997)'s and Huntley (1998)'s models emphasized that mathematics is the primary purpose and science concepts and activities are used in mathematical problems or situations in these dimensions. Kıray (2012) describes MISCI dimension as a mathematics course which includes transferring appropriate science content. This lesson approaches to science and thus, the mathematical boundaries of the class are not strict.

Science intensive mathematics connected integration (SIMCI): As in MISCI, there are similar dimensions respectively 'science focus' and 'science with math' in Lonning and DeFranco (1997)'s and Huntley (1998)'s models. Both of these dimensions indicated that mathematics is used as a tool for science learning. Mathematical concepts and activities support science. Similar to MISCI, SIMCI is defined as a science course including appropriate mathematics content transfer. It also approximates to mathematics course by making the science course's boundaries rather transparent (Kıray, 2012).

Integrated plans: Integrated plans are the science and mathematics plans which were prepared by one middle school science teacher and one middle school mathematics teacher depending on MISCI and SIMCI for this study.

Middle school: Middle school is an education period which starts at the end of the primary school education. The school type, elementary school, in which the participant teachers work, was separated into two as primary and middle schools soon before the data collection process of the study. Middle schools include the students from 5th, 6th, 7th and 8th grades.

Mathematics teacher: Mathematics teacher is a teacher who teaches mathematics in line with the curriculum directed by MoNE. In this study, mathematics teacher is a teacher who teaches in 5th, 6th, 7th and 8th grades.

Science teacher: Science teacher is a teacher who teaches science in line with the curriculum directed by MoNE. In this study, science teacher is a teacher who teaches in 5th, 6th, 7th and 8th grades.

Trivializing: Trivializing was exemplified by Mason (1996) as "a poem about photosynthesis may not help one understand photosynthesis as a process, or poetry as a genre" (p. 266). Mason (1996) also stressed the importance of using activities and tasks which would prevent trivializing of concepts while integrating curriculum. In this study, trivializing content indicated the teachers' use of statements which were irrelevant to the content and out of the aimed objectives and may have the potential to direct students’ attention to unrelated issues during the class.

CHAPTER II

LITERATURE REVIEW

The purpose of the study was to examine science and mathematics integration in terms of the teachers' preparation and implementation processes. In this chapter, a general view of mathematics and science integration, and several theoretical models for integrated mathematics and science education were presented respectively.

2.1 Curriculum Integration

Curriculum integration has a long history and it is accepted as an educational philosophy which aims to reveal the connections between disciplines and the wider context by establishing practices for distinct topic or theme (Badley, 2009). DeZure (1998) also implied that interdisciplinarity is a very old term. As an example, he stated that sociology and geography are accepted as interdisciplinary disciplines for many years.

To get attention to the need for curriculum integration, Beane (1991) related students' learning in schools within the current curriculum to giving a pile of jigsaw puzzle and asking to make them one whole without giving the picture of it. He stated that subject areas or disciplines formed by academic scholars have specific boundaries and these boundaries prevent to reach more extensive knowledge. He also criticized the school curriculum by indicating the real life situation in which people do not differentiate mathematics, science, history, when they encountered a problem. He emphasized that we do integration by ourselves and it helps us to gain meaningful learning by composing interaction with the environment. Additionally, he stresses the need for integration and pointed out two important points to be careful about. The first one was that integration refers to 'wholeness and unity' and does not support ‘separation and fragmentation’. As the second issue, he claimed that curriculum integration could be done if the students encounter questions related to their experiences in a meaningful way. He also explained that there were attempts to make revisions in middle school curriculum for providing better school climate and block class system and collaboration among teachers from different disciplines. Moreover, he stressed that middle school students’ questions reflect personal versions of larger world questions. He also stated that the integrated curriculum is based on constructivism and teachers and students also could construct new meanings.

Many research recommends using integration for reaching knowledge (Beane, 1996). Beane (1996) emphasized that the more knowledge is unified, the more it is brain-compatible therefore, more accessible for learning. Real life problems do not require using only one discipline’s knowledge. Thus, students need to benefit knowledge from different subject areas for placing the problem in a meaningful base (Beane, 1996).

DeZure (1998) also defended curriculum integration and classified six reasons to advocate interdisciplinarity. First, he stated that life includes problems that can be solved by the help of more than one disciplines. Second one was the request coming from students and foundations for more connected curriculum instead of the one which separates knowledge. Third, business world needs graduates who have multidisciplinary knowledge. Fourth, administrators are also voluntary for preparing materials in order to make use of them across the disciplines. Fifth, by the fast change of knowledge, limits of the disciplines are tending to lose and new fields has revealed. And last, technology and internet have important role in the situation of blurring the boundaries of disciplines.

Besides, to make coherent explanations about integration, Badley (2009) put his definition of integration as “Integration involves curriculum or instruction that combines, draws upon or encourages students to see connections between the contents of two or more academic disciplines” (p.115). On the other hand, Beane (1996) defined curriculum integration by explaining four elements. First point was that teachers and students should collaborate for planning problems and issues related to real world in order to establish the curriculum. Second, learning experiences are arranged by ignoring the disciplines' boundaries to integrate related knowledge. The third one was that "knowledge is developed and used to address the organizing center currently under study rather than to prepare for some later test or grade level, or to accumulate specific facts or skills from some state or district list" (p.6). And last, projects and activities which require using knowledge practically are given importance by the purposes of giving opportunities to students to experience integrated curriculum and providing students to be involved in problem solving processes. He also stated that this definition suits multidisciplinary approach. However, he presented differences between integration and multidisciplinarity. Subject area content is located at the beginning and end of the multidisciplinary approach however, problems and issues are important at the beginning and end of the integration for providing meaningful knowledge. The sequence of the knowledge is important for multidisciplinary approach since it focuses on content and skill. On the other hand, integration uses the sequence in line with the problem that was focused on.

Loepp (1999) stated a metaphor considered by people who accepts astronomy, biology, chemistry, geology, and physics as separate courses, assess a general science course as a step through integration. This metaphor includes marble cake and layer cake to indicate the different levels of integration. For the layer cake, each discipline shows its own properties in a general science course. Since the disciplines preserve the boundaries, it is accepted as more interdisciplinary. However, marble cake is based on problems and each science discipline supports and makes contribution for the solution. He stated that interdisciplinary and integrated curriculum can be much related to each other; however, this relation does not stress the importance of whether a curriculum is interdisciplinary or integrated. According to Loepp (1999), the important thing is to create relevant, standards based and meaningful curriculum and to make students encounter challenging real life problem situations. Curriculum can be related to the other disciplines by benefitting the other disciplines' knowledge and skills. However, he points out that every integrated curriculum does not indicate the relevancy.

On the other hand, Coffey (2012) described interdisciplinary teaching as using 'methods and language' of several subject areas by the purpose of understanding an issue, question, problem, or topic. He also stated that the methods in interdisciplinary teaching are used to make connections between disciplines such as sciences, mathematics, social studies, and English language. Interdisciplinary curriculum was also defined by Jacobs (1989), prominent of researchers in interdisciplinary approach, as "a knowledge view and curriculum approach that consciously applies methodology and language from more than one discipline to examine a central theme, issue, problem, topic, or experience" (p. 8).

There are many concepts that are used for integration in the literature such as thematic teaching, integrated day, multi-disciplinary, transdisciplinary and interdisciplinary (Badley, 2009). Mathison and Freeman (1997) also stated that there are many terms such as interdisciplinary, core, fusion, integrated, crossdisciplinary, correlated, integrative, and trans-disciplinary. But they did not prefer to define all these terms. Instead, they emphasized the clarification of the interdisciplinary term. They categorized all the terms in three approaches as interdisciplinary, integrated, and integrative. They defined interdisciplinary approach as connecting more than one subject areas in a planned way without losing their own properties. Critical thinking skills and a comprehensive content are important elements of interdisciplinary approach and the teacher follows the curriculum. For integrative approach, there is a purpose of reaching more combined, comprehensive and real knowledge by moving beyond the limits of the disciplines. This approach is inquiry oriented and theme based. The role of the teacher is to determine the activities and lead the students through the purpose. Besides content and skill, processes are also important for composing the aims of this approach. On the other hand, integrative approach requires interaction and negotiation that are established from students' and teachers' ideas. Moving beyond the disciplines occurs by considering coherence and meaning.

Another categorization was made by Fogarty (1991). He suggested ten models for integrated curriculum to educators. He categorizes these models as within single disciplines (fragmented, connected and nested), across several disciplines (sequenced, shared, webbed, threaded, and integrated) and within and across learners (immersed and networked). He stated that these models can be selected by teachers to create their own integration style in their teaching.

Loepp (1999) noted that there is a trend of using “interdisciplinary” for elementary schools and “integrated curriculum” for high schools and colleges when implemented. He presented three general integrated curriculum models as interdisciplinary model, problem based model and theme-based model. In interdisciplinary model, the subject areas are distributed by school as time blocks and a group of teacher teaches the curriculum to the students. By this model, the teachers can collaboratively work and teach a certain number of students. This model is also not very separated from traditional curriculum since it has flexibility in terms of programming time. Besides, this model has limitations, for instance, since the teachers need to design the curriculum, it lacks standards based integrated curricula across the disciplines. Its implementation can also be limited to a small part of the curriculum since planning of it takes a long time. In problem-based model, technology education has an important role in the curriculum. By focusing on a technological problem, other disciplines contribute to the solution of the problem. The problems in this model have relevancy and provide motivation for the students. However, students at a certain grade level can have difficulties since this model tries to ensure national standards. Last, in the theme-based model, the teachers easily make connection between the curriculum and national standards and state frameworks. Students can also use connections in different disciplines’ objectives. The disadvantage of the model can be that if there is a little relation between the theme and a discipline, it can cause superficial or not related learning.

Mathison and Freeman (1997) came up with three approaches as interdisciplinary, integrated, and integrative. All these approaches aim students to obtain meaningful learning by connecting disciplinary knowledge and real world context. They also emphasized that these models do not only focus on connecting the disciplines. Using inquiry, hands-on approaches, and connection to the real life are also important factors for them. Interdisciplinary models aim to connect discipline to increase students' learning in these disciplines. Additionally, they give opportunity to understand the relation among the disciplines and the real world. Integrated models seemed to be a bridge between interdisciplinary and integrative models. In integrated studies, 'discipline-transcending concepts' and problems are the focus. However, Mathison and Freeman claim that although integrated model is accepted as beyond interdisciplinary approach, when one thinks it is in an interdisciplinary framework, it shows similarity to interdisciplinary approach. In integrated studies, students are active. Teachers guide students as a team with a collaborative work by using their own expertise. Similar to the integrated model, in integrative model, themes and issues are in the center. However, integrative model presents a different role as being partner to teachers and students while the curriculum is creating. Additionally, when compared to the two models, it stresses the importance of students' "personal interest, and cultural and affective nature" (p.17).

DeZure (1998) pointed out that students should have opportunity to do the task by themselves, model the task, and evaluate it from positive and negative sides in order to be involved in creative tasks by integrating different disciplines. Moreover, Brophy and Alleman (1991) stressed that integrated curriculum should be a tool in order to reach educational purposes. They criticized that activities proposed for successful integration and their implementation are doubtful for serving the goals. The activities not prepared according to students' background can result in serious difficulties for students. They suggest integration should be used in necessary and suitable situations and the prepared activities should be in line with the educational purpose, and they should not be implemented superficially.

Classifying curriculum integration in several different categories may reveal different ideas about the definition. However, when related literature about curriculum integration is examined, it can be said that the main purpose of curriculum integration is identified as providing students opportunities to make strong relations among different disciplines since the students will not separate the problems they encountered as discipline by discipline in real life. In the following part, since this study focused on specifically science and mathematics integration, the relation between science and mathematics was presented in order to see how this relation was emphasized in the literature.

2.2 Relation between Science and Mathematics Instruction

The common and basic purpose of the mathematics and science curricula is providing student's meaningful learning (Temel, Dündar, & Şenol, 2015). The relation between mathematics and science instruction has been a subject for many research. The examples of these studies are also seen in recent decades. For instance, Güleç and Alkış (2003) investigated the relation among primary students' academic achievement levels in different courses such as Turkish, mathematics, social sciences and science. They collected data from 1000 students from grades 1 to 5 by obtaining students' grades for each course at the end of the academic year. According to the results, in general, students' grades indicated strong positive relations between the courses. Specifically, while researchers examining the relation between mathematics and the others, they found the strongest positive relationship between mathematics and science achievement levels, for 4^{th} and 5^{th} grades. Besides, for the relation between science and the others, they found stronger relation between science and social science (correlation coefficients respectively were 0,88 for 4^{th} grades and 0,90 for 5^{th} grades) than relation between mathematics and science (correlation coefficients respectively were 0,83 for 4^{th} grades and 0,84 for 5^{th} grades). They concluded that this result is interesting since the relation between mathematics and science is stressed more. They explained this with the connection between social science course at first three grades and science and social science courses at 4^{th} and 5^{th} grades.

Wang (2005) also examined the relation between mathematics and science achievement of 8^{th} grade students according to the Third International Mathematics and Science Study (TIMSS) and the repetition of the TIMSS project (TIMSS-R) data. He illustrated the linear model by using scatterplots and showed linear correlation coefficients belong to different countries indicating the relation between mathematics and science achievements of the students. Consequently, the researcher suggested performing instructional efforts which are concluded to moderate correlation between mathematics and science in terms of student achievement.

Çetin (2013) determined undergraduate students' ideas about the role of mathematics in science in his study. He collected data from 345 undergraduate students in science education. He used three structured open ended questions. According to the results, 81% of the students stated that a student who is successful at mathematics, will also be successful at science. Nearly half of the students claimed that this situation is because of using mathematics in science. Additionally, nearly 20% of them stated that both science and mathematics are numerical courses and connected to each other.

Temel, Dündar, and Şenol, (2015) conducted a case study which aims to find out science teachers' mathematical difficulties, their solutions to these difficulties and the reasons for the necessity of mathematics and science integration. They conducted semi structured interviews with six in-service science teachers working in different middle schools. They concluded that science teachers' mathematical difficulties stemmed from conceptual and computational difficulties. The teachers' efforts for handling these difficulties were individual efforts and collaboration with others. The teachers emphasized the necessity of science and mathematics integration for three reasons. First, science and mathematics are related to each other. Second, both of them are related to daily life. And third, science and mathematics integration makes students' learning easier.

Beauford (2009) investigated 12 middle school textbooks (8 mathematics and 4 science texts) in order to reveal connections and disconnections between science and mathematics instruction. She focused on the usage of mathematics/science in the science/mathematics text in terms of quantity and quality of references to the other discipline. The researcher detected similar and different strategies, tools and topics. As a result, five titles were obtained namely, data gathering and analysis, probability, graphs and graphing, measurement, unit analysis. For example, in unit analysis topic, she found that although science and mathematics have the same way of obtaining the unit of a magnitude, the unit issue was ignored in mathematics. She gave an example from science that includes calculating the heat by using mass of the water, specific heat capacity of water, and temperature difference and showed how to reach the unit of heat as joule as in Figure 2.1 below.

$$heat = 4{,}184 \text{ J/kg.}\,^{\circ}\text{C} \times 0.2 \text{ kg} \times (80^{\circ}\text{C} - 25^{\circ}\text{C})$$

$$heat = \frac{4{,}184\, J}{\cancel{kg} \cdot {}^{\circ}\cancel{C}} \times 0.2 \text{ kg} \times 55^{\circ}\cancel{C}$$

$$heat = 46{,}024\, J$$

Figure 2.1 Example about obtaining unit of heat in science (Beauford, 2009, p. 47)

The same situation was explained in mathematics as in the following example in Figure 2.2 below.

$$y = \frac{4{,}184\, a}{\cancel{b}\,\cancel{c}} \times 0.2\cancel{b} \times 55\cancel{c} = 46{,}024\, a$$

Figure 2.2 Example about obtaining unit of y in mathematics (Beauford, 2009, p. 47)

She concluded that to make students benefit from the two disciplines efficiently and consistently, mathematics and science teachers should have awareness of what is happening in the other course related to their course. She also suggested science teachers to increase the collaboration with mathematics teachers and to form a common language in order to improve the translation of knowledge between science and mathematics for better student learning.

Consequently, it could be deduced from the studies which investigated students' achievements in science and mathematics, the preservice and in-service teachers' ideas about science and mathematics, and the relation between science and mathematics in textbooks, that there is a relation that cannot be ignored between science and mathematics and this relation influences the students' achievement in both. In line with this relation, the following part explained how the science and mathematics integration was defined.

2.3 Definition of Science and Mathematics Integration

Students have been taught in separate discipline areas although we do not use subjects separately for our actions in real life (Park-Rogers, Volkmann, & Abell, 2007). Since mathematics and science is integrated naturally in daily life, to support teaching of concepts that could be integrated is a sound action. Science and mathematics integration is possible by using a bridge that will close the gap between the two by clear, related and significant natural links for teachers and students (Johnston, Ní Ríordáin, & Walshe, 2014). Many researchers stated that although integration is not a new issue, there is still no clear definition of the integrated science and mathematics as a basis for developing, implementing and assessing the results of research. (Czerniak, Weber, Sandman, & Ahern, 1999; Judson, 2013; Kurt & Pehlivan, 2013). Davison, Miller, and Metheney (1995) claimed that few educators are aware of the need of cross-disciplinary curriculum and in contrast, many of them believe that the place of the integration in the projects about interdisciplinary is not obvious. Moreover, they emphasized that many different definitions were revealed by different researchers.

For instance, Lonning and Defranco (1997) explained integration via the term interdisciplinary. They stated that curricular integration is related to the nature of the relationship between the concepts of different disciplines. Integration can be performed by using this relation and the activities including concepts of at least two different disciplines. Besides, they considered the interdisciplinary curricula as including the integration and stated that interdisciplinary curricula can present integrated activities from different disciplines but it is not an obligatory.

Kurt and Pehlivan (2013) asserted that many terms were used in the literature interchangeably instead of the term integration. These are "blended, connected, correlated, core, cooperation, coordinated, cross-disciplinary, fused, immersed, integrated, integrative, interactions, interdependent, interdisciplinary, linked, multidisciplinary, nested, networked, thematic, threaded, trans-disciplinary, sequenced, shared, unified and webbed" (p.116). Berlin (1991) stated that these terms indicate different levels of integration including "mathematics taught as a prerequisite tool for science, mathematics applied to science problems, science phenomena translated into mathematical terms, and science and mathematics taught in concert in a real world, problem-solving context" (p.12). Kurt and Pehlivan (2013) also concluded that their literature review showed that most of the attempts for integration are based on science activities including related mathematics concepts. The situation of having many different synonym terms has caused emerging different definitions of science and mathematics integration. However, Kıray (2012) claimed that if the terms that Kurt and Pehlivan (2013) stated are used for integration of science and mathematics, all the other terms including interdisciplinary should be in the category of integration.

Vasques-Mireles and West (2007) stated that integration of science and mathematics has been defined as "using mathematics to teach science" (p.47) in general. They exemplified this definition as using chemical equations in chemistry shows integrating mathematics. They compared the correlation and integration. According to this comparison, correlated mathematics and science lesson cannot be distinguished by another person for whether that lesson is science or mathematics. However, in integrated science lesson one can understand that it is a science lesson which uses mathematics as a tool including integrated activities.

Some researchers draw analogies in order to clarify the meaning of integration. For example Lederman and Niess (1997) used a metaphor of tomato soup and chicken noodle soup. The tomato soup does not show any granules since it is homogeneous. Similar to tomato soup, they defined integration as a blend of science and mathematics which cannot be seen separately. On the other hand, they considered interdisciplinary on chicken noodle soup. One can distinguish science and mathematics in interdisciplinary with meaningful connections like the particular in chicken noodle soup. Another metaphor was stated by Loepp (1999). He stated that scientists, who think that the different fields of the science such as astronomy, biology, chemistry, geology refer to a phase of integration, indicated the level of the integration by using marble and layer cake examples. These scientists considered that each science preserves their discipline boundaries in a general science course like a layer cake. However, if sciences support the other science in a problem based situation for reaching the final solution, it is like a marble cake. The scientists claimed that layer cake seems more interdisciplinary compared to marble cake.

Hurley (2001) identified five integration forms by investigating 31 studies related to science and mathematics integration. These were namely, sequenced, parallel, partial, enhanced, and total. In sequenced, there is a sequence between science and mathematics for planning and teaching. In parallel, parallel concepts are used in order to plan and teach science and mathematics at the same time. In partial, the two are learned separately but partially together in the same classroom. In enhanced, one of them is in the center of the teaching and the other discipline is revealed during the instruction. In total, both science and mathematics are taught equally together. To make generalizations about the positive effects of integration on student learning, a clear, operationalized definition is necessary as a prior condition (Czerniak, Weber, Sandman, & Ahern, 1999). Judson (2013) also pointed out that it is a difficult task to explain the quality and definition of integration as a yes/no answer. He stated that discussing a lesson is whether integrated or not and using many other terms for integration show integration has been as an uncertain term. In parallel with this idea, the researcher claimed that even if a broad definition of integration is given to the teachers, they will not hesitate about how to plan their teaching. Considering the related literature about integration, one can see there is still lack of a detailed and clear definition of integration. At this point, it might be more important to not to focus on whether the curriculum is integrated or interdisciplinary or else. Instead, Loepp (1999) suggested to develop curriculum which has relevant, standard-based and meaningful for students and present them challenging situations regarding the daily life.

2.3.1 Positive Effects of Science and Mathematics Integration

Many researchers stated that science and mathematics integration has affected students' learning positively. For example; Kurt and Pehlivan (2013) indicated that empirical studies related to integrated science and mathematics program signed positive effects. Processes and skills such as inquiry, problem-solving, and higher-order thinking skills can be enhanced by science and mathematics integrated instruction (Berlin & White, 2001). Science and mathematics integration is seen as an encouraging way by the educators since 1900's in order to increase students' science and mathematics understandings performance and attitudes (Berlin & White, 1999). West, Tooke, and Muller (2003) claimed that using manipulatives efficiently for understanding the connections between disciplines can enhance students' motivation and interest. However, they stated that there were not sufficient empirical studies yielding positive effects of a totally interdisciplinary integrated instruction and they pointed out that the important point was where these connections should be used.

Czerniak, Weber, Sandman, and Ahern (1999) emphasized that curriculum integration is an important element in terms of centering on determining and satisfying the students' need and interest. They stated that many researchers supported curriculum integration to make students' understanding deeper, to provide opportunity for them to see the whole picture, to make them aware about related concepts from different disciplines, and to enhance their interest and motivation. They considered that by the help of integration, connections among ideas could be established. Additionally, they stressed that integration is promoted since existing curricula were not proper for students in terms of presenting real life problems.

2.3.2 Problems and Barriers Related to Science and Mathematics Integration

As there are studies that indicate positive sides of science and mathematics integration, the researchers also emphasized the problems and barriers for successful integrated science and mathematics instruction. For example; Lee, Chauvot, Vowell, Culpepper, and Plankis (2013), asserted that using methods of mathematics in science or using science examples and methods during mathematics teaching is a common thread about science and mathematics integration. Kurt and Pehlivan (2013) indicated that empirical studies conducted with preservice teachers showed that teachers mostly had stumbling block in their content knowledge and pedagogical content knowledge. Another barrier was presented as lack of experience of integrated instruction.

West, Vásquez-Mireles, and Coker (2006) also summarized the barriers to integration in their literature review study. They emphasized lack of content knowledge as a handicap. Additionally, planning integration as a team, time limitation, lack of instructional models and appropriate materials, issue of student assessment were stated as other barriers that teachers deal with. Lack of integrated teaching training and experience were emphasized as other barriers for successful integration. The researchers also stated that sequential structure of mathematics can limit integration. Similarly, the difficulties of maintaining conceptual continuity and cohesiveness for mathematics and science may result in gaps or trivializing the contents (Basista & Matthew, 2002).

Meier, Cobbs and Nicol (1998) investigated the integration literature and identified the implementation issues as benefits and barriers. They ordered the obstacles as content barrier, teacher knowledge barrier, teacher belief barrier, school structure barriers, and the assessment and curriculum barriers. For content barrier, they signed differences and similarities of the nature of mathematics and science. They stated that in both secondary and elementary teacher education programs, teachers were not educated for an integrated curriculum as necessary. Additionally, secondary teachers are prepared for specializing in only one area such as mathematics, chemistry, and physics. Moreover they mentioned the difficulty of integrating the science areas and stressed that integrating more than one discipline is more difficult. On the other hand, they remarked that preservice elementary teachers have additional problems. They have high mathematics anxiety and less confidence for mathematics and science skills. Meier, et al. (1998) indicated that not only preservice and in service teachers', but also faculty members' beliefs in teacher education programs about integrated curricula should be considered. They explained the school structure barrier through curriculum adoption which occurs differently and independent in science and mathematics. They indicated assessment for integrated curriculum is a problem as well as a problem in science and mathematics separately. They pointed out that the important thing is forming items which are appropriate to the curriculum and desired outcomes for both mathematics and science.

West, Vásquez-Mireles, and Coker (2006) presented some suggestions for overcoming these barriers. These were to determine the correlations between science and mathematics concepts, to constitute common planning time for science and mathematics teachers to form common explanations, to enhance content knowledge in both, to form a method course about integrated science and mathematics for preservice teachers, and to make students more active and leave teacher directed instruction. They also indicated that more effective methods are required for integrated science and mathematics. Berlin and White (2012) also suggested peer collaboration and team teaching for handling the barriers of the integration. Meier, Cobbs and Nicol (1998)'s suggestion to overcome content barrier for teachers was taking both similarities and differences of science and mathematics into consideration instead of focusing on one. Basista and Matthew (2002) also recommended collaboration of the educators of both science and mathematics.

As mentioned before, although integration of science and mathematics is not a new issue, it still has no agreed-upon definition. Benefits of integration of science and mathematics have been emphasized many times; however, the problems and barriers are gaining attention in the studies especially stated in literature review researches.

2.4. Models for Integrated Science and Mathematics Education

Because the researchers could not have an agreement about the definition of integrations, the studies which presented several models that aimed to clarify the meaning of the science and mathematics integration were seen in the integration literature after 1990's. Some of these studies were presented in the following.

Lonning and Defranco (1997) proposed a theoretical model by the purpose of both explaining the definition of integration and guiding the integrated curricula's development and analyzing processes. They first explained the key terms about the model. They considered that integration means making the disciplines together by involving activities which are meaningful and appropriate to the students' grade level. Their model aimed to show the relation between science and mathematics as a continuum from independent science/mathematics to independent mathematics/science, a balanced part in the middle as seen in Figure 2.3. Independent science or independent mathematics parts do not need or indicate integration of science and mathematics. Mathematics focus dimension showed that the mathematics content is appropriate for curriculum and the objectives are in the center, and science concepts are included from different grades. Science focus part was similar to the mathematics focus part on the continuum model. Lonning and Defranco explained the balanced mathematics and science part of the model. If both mathematics and science content for a particular grade level are meaningfully included in the curriculum, these activities are called balanced mathematics and science on the continuum model. They claimed that the continuum model can help to see the relations between the science and mathematics concepts, objectives and activities. The researchers also questioned some points which were key issues for integration. They first stated that increasing student understanding of science and mathematics concepts is a condition for achieving the integration. Second, they indicated that integration can be meaningful if its relation with science and mathematics curricula in use is established. Last, they pointed out that integration should not be the focus and the important thing is providing students' meaningful understanding of concepts.

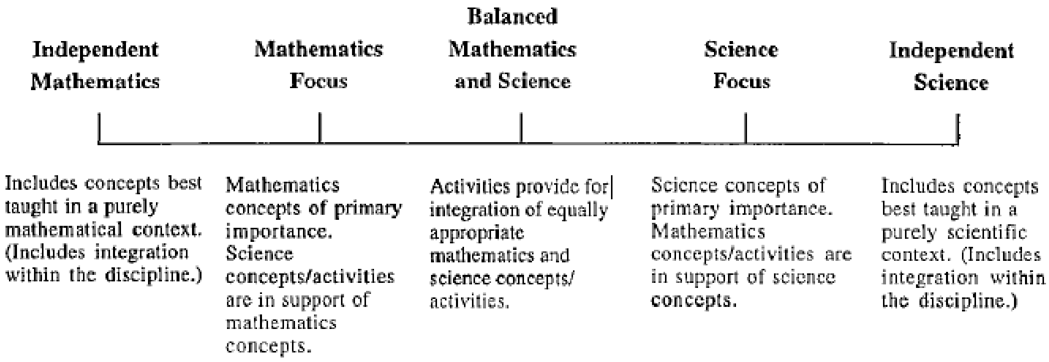

Figure 2.3 Continuum of integration of mathematics and science concepts/activities (Lonning & Defranco, 1997, p. 213)

Lonning, Defranco and Weinland (1998) presented a model, including two steps as theme creation and activity refinement, which aims to develop theme-based, interdisciplinary, integrated curriculum. They based their model on the previous model created by Lonning and DeFranceo (1997). The authors defined the theme, interdisciplinary and integrated terms for explaining the model. Theme refers to "a topic, concept, problem, or issue providing both a focus and organizing framework that guide the development and implementation of a cohesive, interrelated series of lessons or activities" (p.312). They used Jacob's (1989) definition of interdisciplinary: "a knowledge view and curriculum approach that consciously applies methodology and language from more than one discipline to examine a central theme, issue, problem, topic, or experience" (p.313). They additionally described integrated term as "Integrated is used to describe the nature of the relationship between two or more disciplines which are included in an interdisciplinary unit" (p.313). They stated that this model was not a list that would be followed. They indicated that it could help to see and enhance the process. In the development of theme phase, concepts, objectives, materials which are appropriate to the grade level and school's curriculum are examined (see Figure 2.4). By this, certain themes are formed. These themes could contain interdisciplinary and integrated activities. Then, the theme is assessed in terms of its appropriateness and importance for the disciplines, whether the activities enhance the learning of the concepts, and provide a perspective for understanding the issues widely. The theme is revised by controlling these criteria in zooming process which can be cycling process up to reach the potential theme. In the activity refinement process, by connecting the determined theme, interdisciplinary activities are developed. Then, the degree of the integration is evaluated by using the continuum stated in Lonning and DeFranceo (1997)'s model by the teacher team. They aim to create activities appropriate to balanced integration phase of the continuum as much as possible. This process is repeated until the best activity is obtained. They pointed out that having theme is very crucial to make the instruction relevant for students and being a team, collaboration and communication are important for development of well-designed themes and activities.

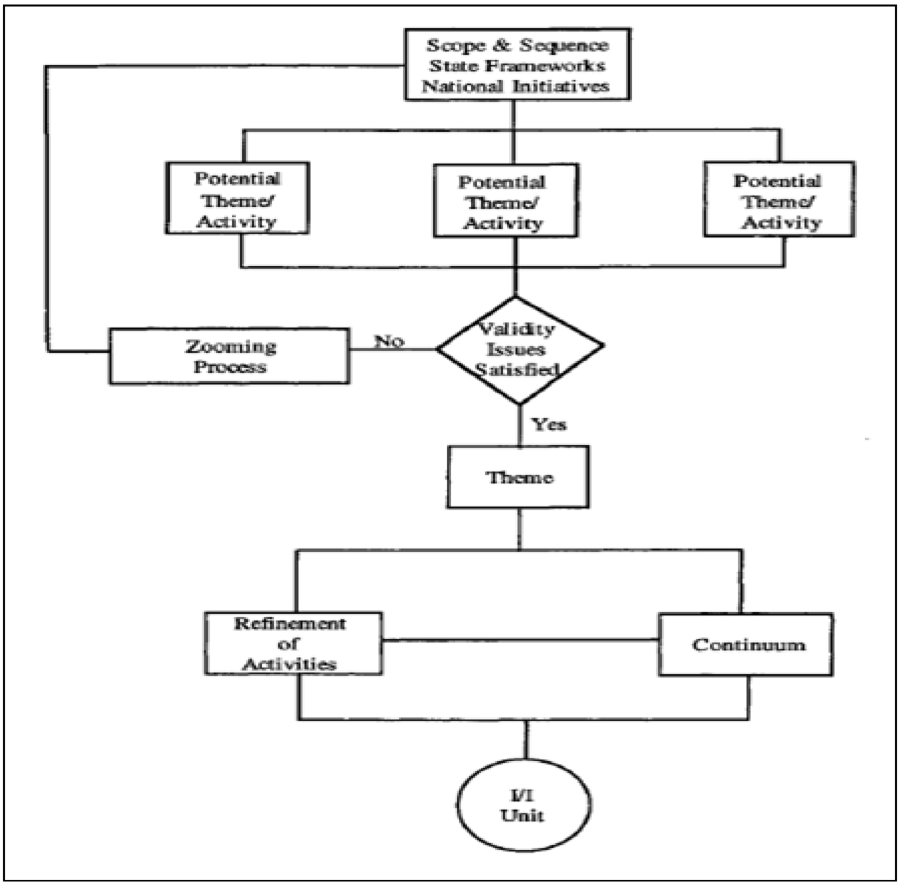

Figure 2.4 Flowchart of theme-based, interdisciplinary, integrated curriculum (Lonning, Defranco, & Weinland, 1998, p. 314)

Another continuum model was developed by Huntley (1998), namely Mathematics/Science continuum. Huntley defined the terms intradisciplinary, interdisciplinary, and integrated. Intradisciplinary refers to an instruction which focuses on only one discipline's curriculum. Interdisciplinary means that there is a discipline in the center, however; it is supported by another discipline. On the other hand, integrated is defined as a curriculum which the teachers implement by internalizing concepts of different disciplines equally in a harmony. Similar to the Lonning and DeFranco (1997)'s continuum model, Huntley (1998) also used the continuum which shows the degree of integration by moving to the center of the continuum. However, Huntley indicated the degree of overlapping parts of the disciplines in the model as in Figure 2.5. Similarly, the center of the model refers to the integrated mathematics and science in which they support each other and a synergy occurs between the two that is more than connecting them. Huntley showed mathematics as a blue circle with horizontal stripes and science as a yellow circle with yellow stripes. Then, the middle of the continuum appeared as a green circle which mathematics and science circles overlapped.

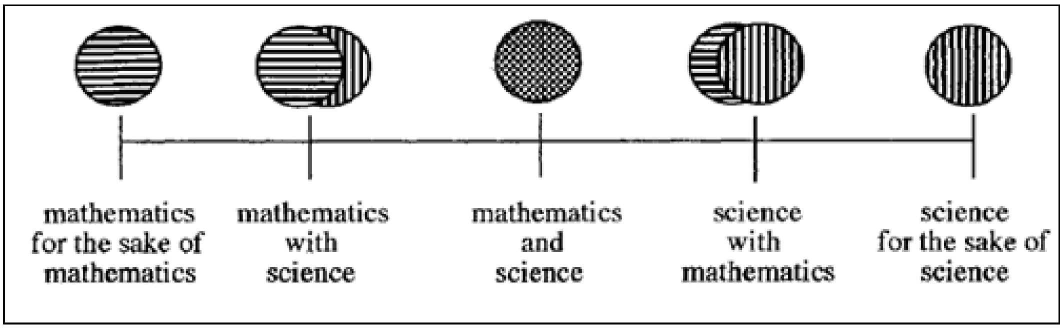

Figure 2.5 Mathematics/science continuum (Huntley, 1998, p. 322).

As the time passed, the researchers have moved away from focusing only on the content of science and mathematics integration. They also gave importance to the processes and skills, teaching strategies, and attitude and belief dimensions of the integrated science and mathematics instruction. As an interpretive theory, Berlin and White (2001) presented a model called The Berlin-White Integrated Science and Mathematics Model (BWISM) to describe the science and mathematics integration and to ensure a conceptual based guide for developing resources and materials to be utilized integrated science and mathematics instructions. This model has six dimensions namely, ways of learning, ways of knowing, content knowledge, process and thinking skills, attitudes and perceptions, and teaching strategies. By ways of learning dimension, they emphasized the importance of students' being active during instruction based on constructivist approach. Ways of knowing indicates that cyclical relationships between inductive-deductive and qualitative-quantitative views of the world which should be empowered by integrated science and mathematics instruction. Content knowledge dimension states that parallel and overlapping ideas for forming integrated contents should be used. Process and skills regarding inquiry, problem-solving, and higher-order thinking skills can be enhanced by the integration of science and mathematics. Attitudes and perceptions of the students are considered important to assess the integration. Teaching methods are also an important issue for integrated science and mathematics since it provides a wide content and requires using inquiry, problem solving, and gives opportunity to benefit from laboratory tools and materials and appropriate technological devices.

Browning (2011) developed a model for professional development of teachers about correlated science and mathematics. The author claims that the model provides integrating science and mathematics more extensively than the other models. She determined seven basic aims for teaching the disciplines. These are: "(a) teaching for conceptual understanding, (b) using each discipline's proper language, (c) using standards-based learning objectives, (d) identifying the natural links between the disciplines, (e) identifying language that is confusing to students, (f) identifying the parallel ideas between the disciplines when possible, and (g) using 5E inquiry format in science and mathematics when appropriate" (p.63). These aims were proposed for the center of the integrated curriculum as in Figure 2.6.

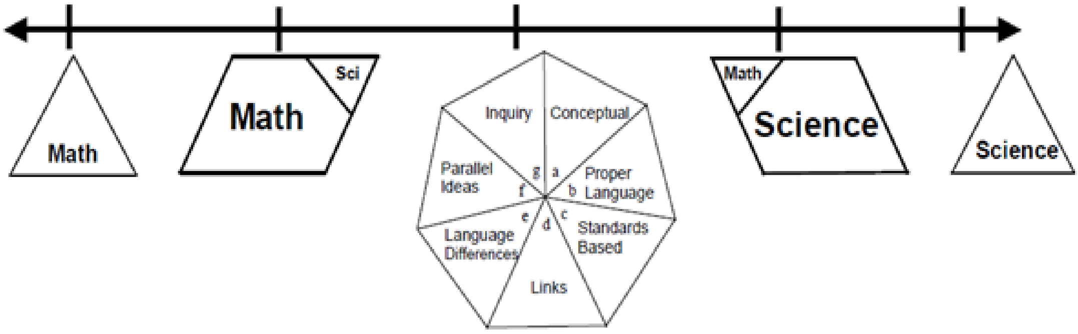

Figure 2.6 CSM Continuum of mathematics and science correlation (Browning, 2011, p. 63)

The author stated that this model can be implemented by a team including a science expert and a mathematics expert who have comprehensive knowledge in both science and mathematics. They develop lessons for the aim of the models. Then, they implement the model with the science and mathematics teachers as a team. Browning stated that this model can be helpful for teacher teams in terms of integrated science and mathematics instruction.

Besides, Kıray (2012) suggested a science and mathematics integration model namely the balance model, which is appropriate for Turkish science and mathematics curricula and background of the teachers. He stated that many countries including Turkey have used a discipline based curriculum. He also explained that Turkey's curriculum is influenced by national examinations in terms of the content. The dimensions of the balance model were given as content, skills, the teaching-learning process, affective characteristics, measurement and assessment. According to the model, content is in the center of the integration. He pointed out that balance between science and mathematics should be taken into consideration because the model aims to provide long term implementation. The model does not limit the content part to the activities as in the previous models; in contrast, it includes the entire course. The content of the model has seven dimensions including mathematics, mathematics-centered science-assisted integration (MCSAI), mathematics-intensive science-connected integration (MISCI), total integration (TI), science-intensive mathematics-connected integration (SIMCI), science-centered mathematics-assisted integration (SCMAI), and science as illustrated in Figure 2.7.

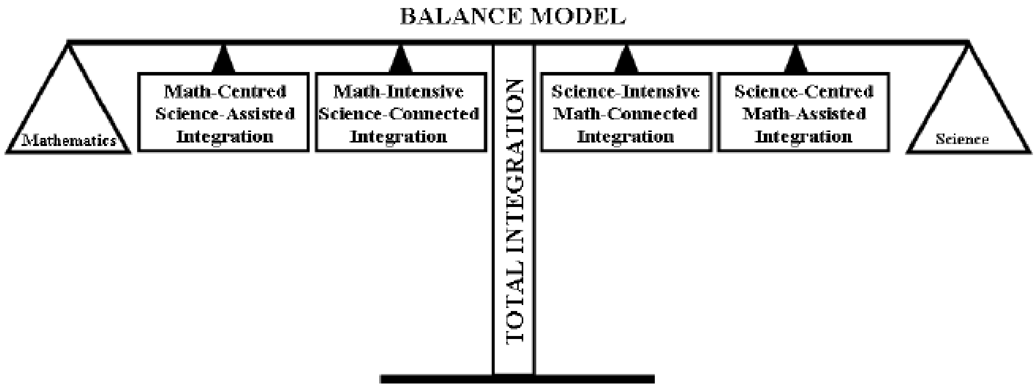

Figure 2.7 Content for the Balanced Model (Kıray, 2012, p. 1185)

In mathematics part, mathematics is in the focus of the course. Integration can be done by daily life activities and science concepts can be transferred into mathematics. During this transfer teacher does not need to pay attention to science curriculum. Improving science concepts is not preliminary purpose here.

In mathematics-centered science-assisted integration (MCSAI), mathematics is still in the focus; however, science is a helping discipline where there is an organization showing parallelism in order to make students to transfer the science and mathematics topics. In mathematics-intensive science-connected integration (MISCI), mathematics is still in focus; however the course is closer to science with connections. Both mathematics and science prerequisites are important for making transfers. The major aim of the course is achieving the mathematical objectives. Science content is intense however; it does not have the purpose of covering all science outcomes. When it comes to balance or the total integration (TI), it is important to include both science and mathematics equally in the curriculum. Students should get all the objectives for both science and mathematics. Any person who sees the course cannot distinguish whether the lesson is a mathematics or science. In science-intensive mathematics-connected integration (SIMCI), similar to the MISCI, science course shows closeness to mathematics through connections but the aim for the students is to gain science outcomes. In science-centered mathematics-assisted integration (SCMAI), similar to MCSAI, mathematics is a helping discipline to science and the focus is in science course. Last, science part indicates the focus of the content as science. Transfers can be done by using mathematical concepts into science and it does not require paying attention to science concepts in the curriculum attention. Integration with daily life examples can be used. Kıray stated that the content of the model shows the stated forms moving in the intervals.

The second dimension of the balance model was skills. By considering the science and mathematical skills of the national curricula for 6th, 7th, and 8th grades and NCTM, the author categorized the skills for integration in two parts as primary and secondary common skills. All mathematical skills and frequently used science skills were determined as primary common skills (connections, problem solving, reasoning, reaching conclusions and interpreting, organizing the data and formulating models, comparison-classification, measurement, collecting information and data, estimation, making inference, prediction, recording the data, communication, and observation). These skills were considered as appropriate for SCMAI and MCSAI. All mathematical and scientific skills were collected under the heading of secondary common skills and these were appropriate for MISCI, TI, and SIMCI content parts.

The third dimension of the balance model was teaching and learning process. Teaching and learning process in integration was based on constructivism. Each course's teaching learning process influences the other one. The methods, techniques and strategies are considered according to content and skills which are transferred or the courses are totally integrated. The students should be active in this process. First, content and skills of the instruction are fixed and then, the methods appropriate for constructivism are determined.

Affective characteristics are another dimension of the model. Affective variables related to both science and mathematics can influence the success of the integrated science and mathematics instruction positively or negatively. For example, negative attitude towards mathematics can affect the attitude towards science and integration process. The model suggests that teachers should be aware of students' affective characteristics before the integrated instruction.

The last dimension of the model was measurement and assessment. In line with constructivist approach, the model suggests to execute the measurement and assessment for both content and process. According to the focused content parts of the model, the measurement and assessment can be changed. The author claimed that the model is appropriate for students who were teaching in a curriculum including national examinations. Thus, it is also approved by the parents and educators since the content was not left aside.

When related models were investigated it could be inferred that the models have become more detailed and focused on all the teaching and learning process for successful integration of science and mathematics. Kıray (2012)'s balance model has also considered all these important points. Additionally, this model is more appropriate for Turkish curricula which are based on constructivist approach and considered the national examinations and anxieties of parents and administrators about these examinations. Thus, this study benefited from Kıray (2012)'s balance model during teachers' planning and implementation processes of integrated science and mathematics. Specifically, the integrated plans were prepared according MISCI and SIMCI dimensions were considered by the participating teachers during planning and implementation processes.

2.5 Studies Conducted with Teachers about the Implementation of Science and Mathematics Integration

There are many studies about science and mathematics integration which were conducted with preservice teachers generally in order to understand their perceptions towards integration. For example; Koirala and Bowman (2003) investigated 35 preservice teachers' development and implementation processes of integrated science and mathematics instruction for 5-8 middle school students as teams including three groups in a method course. They used modelling, team teaching and the learning cycle approach as appropriate for constructivism in the method course. They collected data through course materials, student works, field notes, observations, and interviews. They obtained three main theme namely, appreciation of integration, tension in integration, and absence of integration about preservice teachers' perceptions about integration. As conclusion, the researchers found that preservice teachers were pleased about practicing integration since they noticed the natural sides of the integration in topics such as ratio, graphing, data analysis during the course. In some cases where integration was not obvious and natural, the preservice teachers did not notice integration. Being aware of integration and practicing as a team were considered as important elements of student teaching.

Frykholm and Glasson (2005) also conducted a study to investigate preservice secondary mathematics and science teachers' knowledge, attitudes and beliefs in terms of science and mathematics integration. They examined the preservice teachers' perspective, lesson planning, and teachings in an innovative preparation program. A total of 65 students were separated into five groups including different disciplines. The groups worked for projects as designing units or lesson plans which would aim to connect science and mathematics concepts after giving an instruction and encouragement. Audiotaped records of class discussions, collaborations, presentations, observations, field notes, and documents were the data and these data were analyzed by qualitative ways. The researchers concluded that although all the participants considered the connection between science and mathematics as important, they had concerns which stemmed from their negative experiences in their education and awareness of their lack of content knowledge. The participants shared their knowledge, and their collaboration influenced the project in terms of making connections. They were also surprised that working as a team was a good experience. The researchers suggested determining the prerequisite knowledge bases and necessary experiences for preservice teachers such as increasing the amount of mathematics and science content coursework.

Berlin and White (2010) investigated change in perceptions and attitudes of preservice science and mathematics teachers after a program related to integration program for 7-12 grades in a longitudinal study. They collected data from 81 preservice teachers by using both semantic differential questionnaire and open ended questions. The results indicated that the preservice teachers' perceptions and attitudes about the value of science, mathematics and technology integration did not change. However, the participants' attitudes and perception about the difficulty of the integration increased after the program since they noticed the challenges and barriers during designing lesson plans and field experiences.

Besides studies investigating the preservice teachers' perceptions, attitudes, and beliefs towards integration, there are studies which aim to compare preservice and in-service teachers' perceptions. For example, Lehman (1994) compared 161 preservice teachers' and 60 in-service teachers' perceptions about science and mathematics integration by using ten-item questionnaire. They concluded that in-service teachers considered that they had more background in science and mathematics curricula. Most of the preservice teachers stated that integrating science and mathematics is an appropriate way for teaching instead of teaching them separately. The researchers emphasized that integration is not adding science and mathematics, and it should give meaningful instruction by forming integral parts of them.

When science and mathematics integration literature was examined in terms of studies conducted with teachers, many studies can be seen. For example; Browning (2011) investigated the effect of Correlated Science and Mathematics (CSM) training (as explained in models part) on the science and mathematics teachers' content knowledge in physics and mathematics and how CSM training affected the teachers' planning and implementation of integrated science and mathematics lessons. The participants of the study were twenty middle school teachers (ten science and ten mathematics). Data were collected by both quantitative (pre-tests and post-tests) and qualitative ways (observations and interviews). CSM training lasted two weeks. During the training, the teachers had opportunity to work together as teams and prepare lessons including science and mathematics concepts. Each participant conducted the plans in their classes and at least two lessons were observed by the researcher. The results showed that the teachers' content knowledge in both physics and mathematics increased after two weeks of CSM training with large effect size in physics and medium effect size in mathematics. The qualitative data indicated that the teachers' abilities of preparing and teaching integrated lessons and using appropriate language for both science and mathematics enhanced. Additionally, the teachers stated that although they did not teach an integrated science and mathematics lesson before the training, they taught many times after the training. Moreover, the teachers foresaw that they can use the plans they taught once more in the following years, since their teaching were better than they expected. The researcher concluded that CSM model can help teacher teams to teach integrated science and mathematics successfully.

Baxter, Ruzicka, Beghetto, and Livelybrooks (2014) formed a professional development project in order to enhance elementary in-service teachers' teaching by connecting science and mathematics. The researchers used a Likert-scale, open ended questionnaire and observations in order to determine possible differences on the teachers' confidence and practice before and after participation in the projects and to understand how they connect mathematics and science,. Forty-one teachers participated in the project. Field notes of the project workshops, online survey related to teachers' confidence in science and mathematics, and selected response questions related to teachers' instruction change were used in order to collect data. They used paired sample t test for comparing teachers' pre and post test results in terms of confidence in teaching science and mathematics. Teachers' confidence was increased after participation in the project. Selected response questions and open ended questions were asked to the teachers to see the change in teachers' instructional practices. According to results, many teachers indicated that they used some mathematics in science when connecting mathematics and science. They felt confident in reflecting the changes that they formed in their science and mathematics teaching. The researchers concluded that teachers' confidence and practice was influenced positively by the professional development program for connecting science and mathematics. The researchers additionally, determined two types of connection opportunities as infusion and transfer in the teachers' connections. They explained infusion as using mathematics which the situations not frequently used and accepted in mathematics. For example; addition of 20 and 30 is equal to 40 in physical properties of various soil materials topic. This could show a way to scientist for the aim of a science investigation. They explained transfer as mathematics concepts and process which helps to explain the science inquiry, for instance; “data analysis and algebraic reasoning, are transferred to the science context to identify patterns in the data” (p.111).

Johnston, Ní Ríordáin, and Walshe (2014) conducted an exploratory year-long case study for the purpose of preparing, implementing and evaluating science and mathematics integration by utilizing the technology as a handled graphic calculator in three secondary schools in Ireland. The schools and the teachers were selected by purposive sampling according to the technology support provided by the schools. The science and mathematics teachers in the schools collaborated and implemented the lessons including distance, speed and time unit by the help of the calculator for integrating the disciplines. A national center helped for training the teachers for using technology, and for teachers’ implementation in the classes. The authors designed the integrated distance, speed and time unit by taking support and feedback from the participant teachers. The qualitative data were collected through journals, lesson observations and focus group interviews. The results of the study indicated that students appreciated the integrated instruction which occurred through the collaboration of the teachers in order to increase the effectiveness of the teaching. The authors concluded that technology could be helpful for a successful integration if the teachers feel comfortable in using technology. They added that science and mathematics integration was also influenced by the teachers’ pedagogical content knowledge in mathematics and science language using. They suggested giving opportunity to the teachers in designing and developing the integrated mathematics and science units by the help of technology.

Based on an online graduate program for Integration of Science, Mathematics and Reflective Teaching (iSMART); Lee, Chauvot, Vowell, Culpepper, and Plankis (2013) investigated the iSMART team members’ and teachers ‘conceptualizations of integrated science and mathematics. iSMART teachers were 25 middle school science and mathematics teachers who worked collaboratively in groups including four or five colleagues. The teachers focused on integrated science and mathematics lessons to analyze, write and implement. The teachers examined and discussed the related models and theories about integrated science and mathematics while they were not said whether a model was suggested or not. They were asked to constitute their own understanding of integrated science and mathematics. Data were collected by the help of interviews from iSMART team members, and survey data from the teachers. Results of the study showed that both iSMART team members and the teachers considered the importance and the positive sides of the integrated science and mathematics. However, the teachers focused on the content of mathematics and science, while iSMART team members considered the inquiry process including the contents of the two disciplines.

Sherrod, Dwyer and Narayan (2009) reported the development of 24 integrated science and mathematics activities by the teachers for middle school graders in a study. The researchers conducted a pilot study for three of the activities by observing the teachers in the classes and took feedbacks from the teachers. They claimed that these activities enable students making predictions by using their prerequisite knowledge, examining science situations and calculating and analyzing data, encouraging recording the data obtained from observations. The researchers considered that these activities could be helpful for science teachers with lack of mathematical skills which would affect their confidence about mathematics.

Offer and Vasquez-Mireles (2009) conducted a study which aims to identify middle school teachers' beliefs about the correlation and the problems they encountered through a Mix It Up program. During the program, teachers participated in the professional conferences and correlating science and mathematics model were presented to them. They had opportunity to design their own instruction collaboratively as a team. They were observed when they were teaching the lessons in their classes. Data of the study gathered with a survey for identifying 30 teachers' initial beliefs. Data related to teachers' content knowledge were collected by using a survey conducted before and after the program. Daily reflections of the teachers were also gathered as data. The results of the study showed that the teachers believe the positive effects of the correlating mathematics and science in terms of enhancing student content knowledge, closing the gap between the two disciplines, and increasing both students' motivation and problem solving skills. The teachers noticed their lack of content knowledge after the program. Additionally, they explained the problems about the correlated science and mathematics teaching as, time, coordinating students, team planning, student assessment, lack of models and materials, communication, exposure to the correlation, content knowledge. In the following section, the studies conducted in Turkey related to science and mathematics integration was presented.

2.6 Studies Conducted in Turkey about Integration of Science and Mathematics

Related to the call for more empirical studies for understanding the effect of science and mathematics integration for students' learning, several studies were conducted in Turkey. For instance; Kaya, Akpınar and Gökkurt (2006) aimed to understand the effect of science and mathematics integration on 7^{th} grade students' achievements. They formed two group of students as control and experimental group. While experimental group was taught by lesson plans including objectives, activities and materials for teaching science and mathematics together in the same lesson, control group was taught in line with the existing science and mathematics curriculum. An achievement test including pressure unit from science and ratio and proportion and percentage unit from mathematics was implemented to the students before and after the implementation. The implementation of the integrated lessons lasted five weeks. For analyzing data t-test was used. The results indicated that there was a significant difference between experimental and control groups in favor of experimental group in terms of the post test results.

Deveci (2010) also conducted an experimental study in order to understand the effect of science centered mathematics assisted integration on 6^{th} grade students' science achievements and on the students' knowledge's permanence. Sixty one students in the same elementary school in Hatay participated in the study. Science achievement test was implemented to both experimental and control groups before and after five weeks implementation. Four weeks later, the test was again implemented for understanding the permanence of the knowledge. According the results, the experimental group's achievement was higher than control group's achievement. However, this was not a significant difference. On the other hand, there was a significant difference in favor of experimental group in permanence scores. The author concluded that science centered integration had a positive effect on students' achievement.

Another study that focused on the effect of the integration was conducted by Kıray and Kaptan (2012). They investigated the effect of a science centered mathematics assisted integration (SCMAI) program on students' achievement. Participants of the study were 90 8^{th} grade students in a middle school in Ankara. Mixed method design was used for the study. Two classes for experimental groups and one class for control group including 30 students in each were formed. They developed a SCMAI test for measuring students' achievements about the cell division and inheritance unit and graphics, determination of probable events, types of events and types of probabilities units. They also conducted interviews with teacher and the students related to the implementation. There was no significant difference among the three groups in terms of pretest results. However, the researchers found significant difference when they compared the post test results in favor of experimental groups. Additionally, student interviews showed that lack of mathematics knowledge was a factor for science learning. They also concluded that teachers had difficulties about mathematics content. Consequently, the authors indicated that integration increased the students' achievement. However, teachers' lack of content knowledge and skills is a factor that could affect students' achievement in integration process negatively.

Kıray (2010) investigated an integrated instruction's effects on 8^{th} grade students' achievements based on balance model that he developed in his dissertation study. Ninety students from an elementary school in Ankara participated in the study. The students were randomly assigned to experimental and control groups including 30 students in each as two experimental groups and one control group. The researcher developed integrated lesson plans based on the four dimensions of the model and these plans were implemented in the experimental groups. Data were collected by multiple choice tests which were developed by the researcher. Additionally, the researcher conducted semi structured interviews with 35 students from experimental groups and the teachers to evaluate the integrated lessons. The results indicated that the students showed better performance in integrated questions compared to not integrated science and mathematics questions. The researcher found significant difference between experimental groups and control group for four dimensions of the instructions. Most of the students stated that they liked the integrated program and the program made science and mathematics topics easier. The author also interviewed the teachers. He found that while the teachers thought that there was no need for integration, they thought that there is a need for integration but total integration was not still necessary after the implementation. The researcher also found that the teachers asked questions to each other; however, their collaboration was not efficient.

Kıray, Gök, Çalışkan and Kaptan (2008) conducted a study by the purpose of revealing the middle school science and mathematics teachers' perceptions about the need for relation and integration. Data were gathered ay using an open ended questionnaire and through semi structured interviews. Nine teachers including four mathematics and five science teachers from two elementary schools in Ankara were the participants of the study. For data analysis, content analysis was used. The authors analyzed the teachers' perceptions by focusing on input, process and output phases of the program. The results of the study showed that science and mathematics teachers accepted that science and mathematics have influenced each other in terms of student achievement. Additionally, they thought that science and mathematics topics should be related and science and mathematics teachers should be in collaboration.

Başkan, Alev and Karal (2010), examined in-service teachers' ideas about necessary mathematics topics for physics and necessary physics topics for mathematics to provide meaningful student understanding. Besides the necessary topics, the researchers focused on the teachers' views about relating or integrating the disciplines. They collected data from three physics teachers and three mathematics teachers from secondary schools in Trabzon by conducting semi structured interviews. Mathematics teachers considered that the relation could be established by using questions and concrete examples regarding to the two disciplines. On the other hand, science teachers perceived using the relation as giving the necessary mathematical knowledge before the physics topics that would be taught. All mathematics teachers stated that integration or relating mathematics with physics would provide a great benefit for students' understanding mathematics meaningfully. They suggested in-service and preservice trainings for clarifying the interdisciplinary curriculum.

Bütüner and Uzun (2010) conducted a survey research for identifying science teachers' ideas about mathematical based problems in science teaching. Eleven science teachers from eight elementary schools participated in the study. Data were collected through interviews. According to qualitative data analysis; the authors found that the teachers had more mathematical difficulty in force and motion unit. These mathematical difficulties were about ratio and proportion, finding the unknown variable, unit conversion, reading and drawing graphs, and computations. The teachers stated that these difficulties resulted in losing time, decrease in performance, lack of understanding of science topics, and decrease in motivation. The teachers suggested to teach the science and mathematics topics in a parallel way and to collaborate science and mathematics teachers to overcome these problems.

2.7 Summary

When science and mathematics integration studies were examined, it can be seen that most of them focused on teachers' collaboration and being a team including at least four teachers for integration design and implementation. However, these studies generally aimed to reveal the change of variables such as confidence level, belief, and attitudes of the teachers in terms of integration. Although these studies suggested giving opportunity to teachers to design and implement science and mathematics integration, examination of the whole integration process including planning and implementing was not much focused. This study aimed to close this gap in the literature in the Turkish education context. Additionally, the literature gave information about the problems and barriers for integration through review studies and few studies showed that the teachers were aware of the problems of integration. However, neither literature review studies documented these encountered problems for planning-implementation processes, nor other studies indicated how these problems were reflected on these processes. Therefore, this study can also contribute the integration literature from this perspective.

Integration of science and mathematics literature in Turkey indicated that the number of the studies about this subject increased in recent years. However, in general, these studies were conducted by the purpose of seeing the effect of the integration on students' learning, revealing the beliefs or perceptions of the teachers about integration, and illustrating the relation between science and mathematics. Studies examining teachers' integration process was not encountered in Turkish literature. At this point, it can be said that there is also a gap in Turkish literature in terms of the nature of integrated science and mathematics. This study can contribute also to Turkish literature in terms of science and mathematics integration by focusing one science teacher and one mathematics teacher's planning and implementation processes of integrated science and mathematics instruction collaboratively.

CHAPTER III

METHODOLOGY

The main purpose of this study was to investigate one mathematics teacher and one science teacher's planning and implementation processes of mathematics and science integration. Specifically, the study focused on (a) teachers' integration practices in their existing teaching, (b) the teachers' planning of integrated lesson plans, (c) the teachers' implementation of the integrated lesson plans, and (d) the teachers' evaluation of the processes. In this sense, the following research questions were explored:

1. How do one middle school science teacher and one middle school mathematics teacher practice integration in their existing teaching?

2. How do one mathematics teacher and one science teacher plan the integrated lessons?

   2.a. What are the critical issues that the teachers considered during planning?

   2.b. What are the influencing factors in planning process of integrated plans?

3. How do one mathematics teacher and one science teacher implement the integrated lessons?

   3.a. To what extend the teachers implement the integrated plans?

   3.b. What are the problems that they encounter while implementing the integrated plans?

4. How do the teachers evaluate the integration process in terms of their teaching?

This chapter explained the method of the present study. The chapter was divided into three main parts as research design, data collection, and data analysis.

3.1 Research Design

Qualitative research focuses on individuals' interpretations and making meaningful inferences about their experiences and their constructions of their own worlds (Merriam, 2009). It seeks meanings constructed by individuals and researchers try to evaluate the parts of these meanings by the purpose of composing a general idea by using their interpretations (Merriam, 2009). Creswell (2007) explained qualitative research as a research methodology that tries to clarify and explore phenomena, a situation or a problem of an individual or groups in their natural settings "when the problem needs to be explored, when a complex, detailed understanding is needed, when the researcher wants to write in a literary, flexible style, and when the researcher seeks to understand the context or settings of the participants" (p.51).

In qualitative research, researchers have face to face communication with participants in their natural environments (Creswell, 2009). Participants act the same as in their daily lives and there is no interruption to the settings they experienced. The researcher needs to be in the natural setting of the individuals to understand their real behaviors (Merriam, 1998).

Merriam (1998) explained that qualitative researchers utilized themes, categories, concepts that come from data for composing the findings. Additionally, qualitative research includes descriptions that come out of investigating the processes, meanings and understandings. Researchers prepare and conduct their instruments on their own for exploring the phenomenon (Creswell, 2009).

In this study, qualitative research methodology was employed in order to understand in detail how the mathematics and science integration processes occur during mathematics and science teachers' mutual planning and implementing. To obtain deeper understandings of the integration processes, “how” and “what” questions were used as research questions. Data were collected with multiple data collection tools such as observations, interviews, and video records, in the school environment (classes, teachers’ room, meeting room, archive room) by spending a considerable amount of time together with the teachers.

In this study, case study was used as a research methodology for the purpose of investigating the teachers’ integration processes in detail. There are several case study definitions in the literature. Merriam (1998) stated that case study aims to obtain deeper insight for a situation, and focuses on “process rather than outcomes, context rather than a specific variable, and discovery rather than confirmation” (p.19). Creswell (2007) accepted case study as a research methodology that a researcher examines a case or cases in detail for a period of time by using multiple data collection tools (such as observations, interviews, and documents) and it can be used to study routes, happenings, and actions. Yin (2009) defined a case as an empirical inquiry which “investigates contemporary phenomenon in depth and within its real life context, especially when the boundaries between phenomenon and context are not clearly evident” (p.18).

The case study was appropriate for the current study, since it indicated a case of planning and implementing mathematics and science integration in the 8^{th} grade by one mathematics and one science teacher in a public middle school through 2013-2014 academic year. Specifically, this case study can be named as observational case study as Bogdan and Biklen (1992) and Merriam (2009) stated. Bogdan and Biklen (1992) explained that the interest is on a certain organization such as school, rehabilitation center or a specific place in the organization such as classroom, teachers’ lounge, or laboratory in the observational case study. A group of people in the organization and certain activities of the organization such as curriculum planning can also constitute the foci of the observational case studies. Merriam (2009) also emphasized that observational case study can be interested in a specific place in an organization, a certain group of people, or a specific activity. In the current study, one science teacher and one mathematics teacher (a specific group of people) working in the same school (in a specific place) and teaching the same students were the focus. Additionally, the teachers tried to plan and implement integrated science and mathematics instruction (a particular activity) during an academic year. The case of this study was planning and implementing of integration process by one mathematics teacher and one science teacher in a public school.

Bogdan and Biklen (1992) stated that participant observation is mostly used as data collection tool and it can be supported with formal or informal interviews or documents. Since science and mathematics integration is a new issue for teachers' teaching and the study focused on the process of the integration, it was necessary to be a participant observer in the process. For this reason, after giving a brief training for informing about the integration of science and mathematics and the Balance model, I observed the teachers' planning and implementation processes as a participant observer. I took observation notes and audio recorded the meetings of planning, and video recorded the classes during the implementation of the integrated plans. I also conducted several interviews in addition to the observations.

3.2 Participants of the Study

Purposive sampling strategy was used in the study to select the participants. When a researcher uses purposive sampling, he/she studies with individuals that are both available and can give rich information, and tries to examine the case deeply (Frankel & Wallen, 2006). The participants of the study were one mathematics teacher and one science teacher who were working in the same school and teaching the same 8^{th} grade students in the selected middle school in Ankara. To be volunteer for participation and to accept making collaboration with the colleague were other conditions for the selection of participants. The teachers accepted to be participants of the study. They were also colleagues in the same school and good friends that they also had a communication out of school. After they decided to participate in the study, they filled the voluntary participation form (See Appendix B). In order to observe the mathematics and science teachers' classes, first I asked to the teachers whether they wanted to participate to the study or not and then, I explained my purpose to the school principal. After he agreed that the teachers could participate in the study, and the teachers accepted to participate in the study, first I took necessary permission from the Research Center for Applied Ethics at Middle East Technical University. With this permission I applied for permission from Ministry of National Education (MoNE). The permission taken from MoNE was given in Appendix A. After I took the permissions I started to the study. Table 3.1 below presents demographics of the teachers.

Table 3.1

Mathematics and Science Teachers' Demographic Information

Demographics	Mathematics Teacher	Science Teacher
Gender	Male	Female
Age	30	35
Program of Study	Elementary Mathematics Education	Biology
Education level	Undergraduate/Master student	Undergraduate
Experience in Teaching	6 years	15 years
Experience in the current school	3 years	4 years
Undergraduate minor	Science education	-

The characteristics of the teachers were explained in the following parts.

3.2.1 Mathematics Teacher (MT)

MT graduated from a public university's Elementary Mathematics Education program in 2007. He was also a master student in Elementary Science and Mathematics Education program of the same university at the time of the study. He had an undergraduate minor in science education; however, he did not have any kind of integrated instruction or course about integration in his university education. He did not take any methods of teaching science course. He had been teaching as a mathematics teacher for 6 years and had no experience in science teaching. He has taught students from 6, 7, and 8th grades.

3.2.2 Science Teacher (ST)

ST graduated from a public university's Biology department in 1998. She had no undergraduate minor. Additionally, she did not have any kind of integrated instruction or course about integration in her university education and did not take any methods of mathematics teaching course. She had a teaching experience for 15 years as science teacher and she had no experience in mathematics teaching. She has taught students from all middle school grades (grades from 5 to 8).

3.3 The Research Context

A public middle school in Integration District (pseudonym) of Ankara was chosen for the study since the selected and volunteer teachers were working in this school. There were both primary and middle school students in the school at the time of the study. While middle school students (5^{th}, 6^{th}, 7^{th}, and 8^{th} graders) were attending the school in the morning, primary school students (1^{st}, 2^{nd}, 3^{rd}, and 4^{th} graders) were attending in the afternoon. There were approximately 1200 students in the school. In the middle school part, there were four classes for each grade level and more than 600 students in total at the time of the study. According to the headmaster of the school, the students of the school were from rather low socioeconomic status families. Since ST and MT were teaching the same 8^{th} grade as common classes and the topics that the teachers selected for integration were from 8^{th} grade level, their teaching were observed in all 8^{th} grade clasesses in the school. Table 3.2 shows the number of male and female students in these 8^{th} grade classes.

Table 3.2

Properties of the 8^{th} Graders in the School

Class	Females	Males	Total
8/A	22	23	45
8/B	22	21	43
8/C	22	22	44
8/D	20	24	44
Total	86	90	176

These four 8^{th} grade classrooms had a computer on the teachers' desk and a projector on the ceiling in each classroom. Different from other classrooms, 8/C had an aquarium on a bookshelf.

3.4 Integrated Lesson Plans

The aim of the study was to examine the planning and implementation of integrated mathematics and science lessons by focusing on one mathematics teacher and one science teacher's lesson plans, and implementation of these plans. There were five integration plans prepared by the teachers according to the Balance Model developed by Kıray (2012) explained before in the literature chapter.

Three of the plans were Science-Intensive Mathematics-Connected Integration (SIMCI) plans and two were Mathematics-Intensive Science-Connected Integration (MISCI) plans. The number of the plans was determined based on the selected topics by the teachers in the mathematics and science curricula and the nature of connections in the 8th grade level. The plans were prepared by the teachers collaboratively in the seminar term before the 2013-2014 academic year started. The aim of their preparations was to understand what was happening during their collaboration. They were the ones who best knew the students and the culture of the school, thus, their preparation was also crucial for this perspective. MT and ST consulted with each other when they had confusion during the planning phase. These five integrated lessons were conducted in certain time intervals and none of the implementations overlapped. The implementation order and integrated topics of the plans were given in Table 3.3.

Table 3.3

Integrated Topics of the Plans and Their Implementation Order

Type of integration	The teacher that implemented the plan	Mathematics topic	Science topic
SIMCI-Plan1	ST	Probability	Inheritance
SIMCI-Plan2	ST	Ratio-proportion	Buoyancy
MISCI-Plan4	MT	Probability	Inheritance
SIMCI-Plan3	ST	Line graphs	Heat-temperature
MISCI-Plan5	MT	Volumes of geometric shapes	Buoyancy

The order of the plans was formed according to the mathematics and science curricula in 8th grades. For instance, since “inheritance” was the first topic in science, it was planned and implemented first in four 8th grade classes. The implementation order in classes was determined according to lesson schedule of ST. The implementation took place in a similar way for the mathematics lessons. Plan4 was given as an example of the plans prepared by the teachers in Appendix A.

3.5 Data Collection Procedure

In qualitative research, multiple data collection tools are utilized in order to reveal the phenomenon such as; observations, interviews, and documents (Creswell, 2009). Similarly, in this study, several data collection tools were used. The tools were explained in detail in the following sections. Below, an overview of the data collection procedure was given.

At the beginning of the data collection process, both teachers’ 7th and 8th grade classes were observed by the researcher to understand to what extent and how they made connections between mathematics and science concepts. These observations were used to guide the study during the planning of the integrated lesson plans. In addition to this, with the purpose of analyzing teachers’ activities for the possible connections between these disciplines in the 2012-2013 academic year, four students’ mathematics and science notebooks from 7th and 8th grades were collected and examined.

MT and ST were asked about definitions of science and mathematics concepts respectively in order to understand teachers’ readiness for integration. Then, they made connections between mathematics and science concepts/units/objectives without knowing what the other one did.

Beauford (2009) stressed the need for the teachers to notice the common parts of mathematics and science. In this study, the teachers had decided on which parts of mathematics and science could be integrated. Since all concepts of science and mathematics could not be integrated (Lonning & DeFranco, 1997), the researcher wanted the teachers to decide which concepts could be focused for integration. After the teachers decided which topics to be integrated by evaluating their previous connections, first, the researcher explained common aims (critical thinking, creative thinking, investigation and questioning, problem solving skills, and use of informational technologies) in the science and mathematics curricula determined by MoNE (2011a; 2011b). Then, the researcher presented important issues based on the integration literature (e.g. Furner & Kumar, 2007; Lonning & Defranco, 1997; West, Tooke, & Muller, 2003; Zemelman, Daniels, & Hyde, 2005) for guiding the teachers. These issues were listed as in the following and explained to the teachers before starting the planning:

> Integration should focus on which content of mathematics and science overlapped. The instruction should be student centered. Students should be active and they should be included in each content through hands on and concrete experiences. Hands on materials should be used to make the content concrete and connect to daily life. Students' thinking and understanding about mathematics and science should be considered. Students' experiences in classroom and daily life should be connected by the help of instructional strategies. Determining mathematics and science concepts that will be used in the activity and their meaningfulness in terms of curricula is crucial for placing the relation between mathematics and science. Discussion, inquiry and questioning should be used. Problem solving approach should be used. Problem based activities should be used for process skills. The content or learning skills in mathematics and science should complete each other. Conceptual understanding of mathematics and science concepts should be in the center besides process skills of mathematics and science. Process skills such as reading, writing, reporting, research, problem solving, mathematical application, data analysis, should be considered for students' motivation. Students should be supported to connect new knowledge and skills from mathematics and science meaningfully in a constructed lesson. Technology can be a support for integration. Measurement and assessment should be used for controlling the students' learning. Students' beliefs and feelings about mathematics and science should be considered.

After this general information was given, the researcher presented two integrated models to the teachers. The first one is Berlin-White Integrated Science and Mathematics Model (BWISM) which aims to characterize the science and mathematics integration and to give a conceptual-based guide for developing resources and materials to be utilized for integrated science and mathematics instructions. Since BWISM did not indicate how the teachers will perform integration, the researcher explained the Kıray (2012)'s Balance Model. The balance model was appropriate for Turkish educational system since it took into consideration national examinations, parents' concerns, and school environment. The model included five dimensions as content, skills, the teaching-learning process, affective characteristics, measurement and assessment as mentioned in the literature part in detail. The teachers were wanted to consider all these dimensions during the planning and implementation phases of the study. Constructivism was the base of the Balance model thus; the teachers stated that they were not unfamiliar with the approach since the national curriculum was based on constructivism. The balance model was clearer thus, it helped the teachers to have idea and discuss the determined integrated topics to be prepared. After sharing their ideas, the teachers concluded that science and mathematics curricula were not giving the opportunity of preparing the integrated plans according to the "total integration" dimension of the model. Therefore, the plans were formed by the teachers according to content part of the SIMCI and MISCI dimensions. Kıray (2012) explained the content about SIMCI and MISCI dimensions as in the following (p.1186).

> "In Mathematics-Intensive Science-Connected Integration (MISCI), mathematical outcomes are dominant. The connections between the content outcomes make the mathematics course closer to the science course. In terms of the transfer of content into the mathematics course, not only the prerequisites of the mathematics course but also those of the science course are taken into consideration. The outcomes that are to be learned simultaneously are identified. If the outcomes are suitable, the courses are simultaneously combined. During the planning phase, whether or not the mathematics outcomes to be acquired are the prerequisites of the future science outcomes is carefully considered. One of the aims of the course is the full acquisition of the mathematical outcomes at the end of the teaching-learning process. However, although the scientific content of the course is intense, the aim is not the students' acquisition of the full outcomes of the science unit.
>
> In Science-Intensive Mathematics-Connected Integration (SIMCI), the focus is the outcomes of the science course. The science course becomes closer to the mathematics course through the connections between the content outcomes. Both the scientific prerequisites and the mathematical prerequisites are taken into consideration through their transfer into the science course. The outcomes to be learned simultaneously are identified. If the outcomes are suitable, the courses are simultaneously combined. During

> the planning phase, whether or not the science outcomes to be acquired are the prerequisites of the future mathematics outcomes is carefully considered. One of the aims of the course is the full acquisition of the scientific outcomes at the end of the teaching learning process. However, although the mathematical content of the course is intense, the aim is not the students' full acquisition of the outcomes of the mathematics unit."

After understanding MISCI and SIMCI, the researcher wanted the teachers to prepare pilot lesson plans. Ratio-proportion topics from mathematics and mass-weight topics from science were selected from 6^{th} grade curricula by the researcher as a warm-up for preparing integrated pilot plans according to both MISCI and SIMCI phases of the model. After warm up, the researcher showed an example plan which was developed and implemented by Kıray (2010) based on the same model. They discussed and compared the warm up plan and Kıray's plan. Then, teachers' summer break started and communication with teachers continued via telephone and e-mails. The researcher sent mathematics resources such as mathematics teacher guide book to ST and science resources to MT during the summer break to make them think the topics, keep the selected topics in their mind and prepare for planning and implementing integrated plans.

Before the academic year started, during the seminar term in which teachers were prepared for the academic year, the teachers discussed and prepared lesson plans of determined units for both MISCI and SIMCI. Planning meetings were audio-recorded. The plans were reviewed by the researcher and discussed by the teachers. After the discussion, the parts which the teachers approved and did not write on the draft plans during the discussions, were added by listening to the audio records. Last versions of the plans were shared with the teachers and their confirmations were taken. After lesson plans were completed, MT implemented MISCI plans and ST implemented SIMCI plans in their classes in the 2013-2014 academic year. The implementation processes were also video-recorded and observed by the researcher. After each implementation, MT and ST's feedbacks were asked and the processes were evaluated. The timeline of the data collection procedure of the study was summarized in the Table 3.4 below.

Table 3.4

Timeline of Data Collection Activities

Date	Activity
March 18- May 31 2013	Observation of Teachers' classes
May 27 2013	Collection of students' mathematics and science notebooks
May 27- May 31 2013	Definitions of mathematics and science concepts
May 27- May 31 2013	Connecting mathematics and science concepts/units/objectives
June 18 2013	Deciding grade level and the mathematics and units to be integrate
June 24-25 2013	Informing training for integration
(Seminar term)	Pilot plans (Warm up) (Mass-Weight & Ratio-Proportion)
July 1- September 2, 2013	Communication with teachers through e-mails and phone
September 2-13, 2013 (Seminar term)	Preparation of the decided integration plans
September 30-October 9 2013	Implementation of Inheritance- Probability Integration Getting feedback from science teacher and discussion
November 4- November 8 2013	Implementation of Buoyancy- Ratio-Proportion Integration Getting feedback from science teacher and discussion
December 2- December 6 2013	Implementation of Probability- Inheritance Integration Getting feedback from mathematics teacher and discussion
March 18- March 21 2014	Implementation of Heat and Temperature- Graphs Integration Getting feedback from science teacher and discussion
May 5- May 8 2014	Implementation of Volume of Geometric Shapes- Buoyancy Integration Getting feedback from mathematics teacher and discussion

3.5.1 Data Collection Tools

The data were collected through observations, documents, and interviews. Table 3.5 indicates the data collection tools according to the research questions of the study.

These data collection tools were explained in this section in the following.

3.5.1.1 Classroom Observations

Marshall and Rossman (1990, p.22) stated that observation of a situation in its natural environment was a preferred beginning point for qualitative research. In order to understand the extend of teachers' use of mathematics and science connections in their regular lessons, 7th and 8th grade classes taught by both MT and ST were observed for two and half months. During the observations, notes were taken by the researcher in terms of how both teachers implemented their regular lesson plans, and the degree that MT used science concepts and ST used mathematics concepts in their lessons. Classroom observations helped the researcher to see the general situation related with integration in mathematics and science lessons. They also provided a base for the actual study design.

Table 3.5

The Research Questions and the Data Collection Tools

The Research Questions	The Data Collection Tools
1. How do one middle school science teacher and one middle school mathematics teacher practice integration in their existing teaching?	Classroom observations Documents (Students' notebooks) Teachers definitions of the concepts
2. How do one mathematics teacher and one science teacher plan the integrated lessons?	Audio-records of the planning process Mini-interviews with teachers
3. How do one mathematics teacher and one science teacher implement the integrated lessons?	Video-records of the implementations Classroom observations Mini-interviews with teachers
4. How do the teachers evaluate the integration process in terms of their teaching?	Interviews at the end of each the implementation

3.5.1.2 Documents (Students' Notebooks)

The researcher observed participating teachers' lessons during the last two and half months of the academic year. Since the limited observation conducted by the researcher would not fully indicate the teachers' teaching in terms of mathematics and science connections, four students' mathematics or science notebooks from 7^{th} and 8^{th} grades were selected. These notebooks were suggested by the teachers because they reflected the class activities the most. Students' notebooks were copied and investigated in detail for mathematics and science connections in order to understand teachers' practices better.

3.5.1.3 Teachers' Definitions of Mathematics and Science Concepts

Since MT and ST worked together in planning of mathematics and science integrated lesson, it was important to know mathematics teacher's science knowledge and science teacher's mathematics background for the study. Therefore, definitions of basic science concepts in science units, which could be used in mathematics lessons, were asked to MT. Similarly; definitions of basic mathematics concepts in mathematics units, which could be used in science lessons, were asked to ST. This definition step helped in understanding to what extent teachers have knowledge of mathematics and science concepts before the integration process.

3.5.1.4 Interviews

There were several interviews conducted with MT and ST. They prepared the integration plans together and, the teacher responsible from the main part of integration plan implemented the plan in his/her lessons. When there was a need to learn more about an issue during the implementation process, small-scale interviews were conducted to address the need. After each implementation, the researcher discussed the planning and implementation processes with the teacher and received feedbacks from her/him in order to improve the implementation of the integration (Appendix B). All interview questions were prepared by the researcher and the questions were revised through the experts' opinions. One of the experts was a researcher in mathematics education and had studies related to mathematics and science integration. The other expert was a PhD student in science education field who was about to complete her dissertation and interested in science and mathematics integration.

3.5.1.5 Video Records

The researcher video recorded teachers' implementations of the integrated lessons. Since the researcher spent a long time, approximately one and half year, in the same school and the classes and with the teachers, all the 8^{th} grade students knew her. Presence of her did not seem to have any effects on teachers and the students during the video-recording of mathematics and science classes. Duration of the records was changed depending on the duration of the designed plans and the implementation in the class. Video camera was placed at the most appropriate place differently in each class. The researcher generally sat and took notes. When the teacher moved around the classroom the researcher changed the position of the camera in order to have rich records. The researcher also put an audio recorder on the teachers table to not to lose any data.

3.6 Data Analysis Procedure

In the study, content analysis was used to analyze the data. Content analysis is conducted in order to obtain concepts and relations that clarify the data set (Yıldırım & Şimşek, 2008). Krippendorf (2004) defined content analysis as "a research technique for making replicable and valid inferences from the text to the context of their use" (p.18). According to Elo and Kyngäs (2008) qualitative and quantitative data can be analyzed in inductive or deductive ways by using content analysis method. Additionally, they stated that when previous studies did not give sufficient information about the context, inductive content analysis would be suitable and the categories could be obtained from the data set by inductive way.

In this study, there were four classes and five integrated plans with different implementation durations from two to five hours. Planning of the integrated lessons was conducted in collaboration with the teachers. The audio records of the planning processes were transcribed. For implementations of the integrated plans, transcribing video records of all implementations for all classes was a very demanding work. Thus, the researcher initially transcribed the class in which the implementation was started the first. The video records of other classes were also watched and different points from the first class such as, teacher's difficulties, teacher's questions, and unexpected events were transcribed.

3.6.1 Coding

Since there was no clear and usable framework for planning and implementation of the integration processes in the accessible literature, a code book was formed by utilizing the related literature and in the light of the research questions. Then, participating teachers' planning and implementation processes were coded. First, inheritance-probability SIMCI plan's and probability-inheritance MISCI plan's planning transcripts were coded by the researcher. After these plans' implementation transcripts were coded, the initial codes were discussed with a researcher experienced in qualitative analysis.

Merriam (2009) stated that determining unit of analysis is a starting point for data analysis. She explained the unit of analysis as the smallest meaningful part of the data which serves to answer the research question of the study and describe the phenomenon. In this study, the teachers' planning and implementation records were examined in terms of science and mathematics integration. A sentence, several sentences, a conversation, or a paragraph which gave meaningful data were determined. Thus, the unit of analysis was chosen as a chunk which consisted meaningful expressions.

For providing inter-rater reliability, 10% of the all data were considered as sufficient in order to interpret the consistency between the researcher's and second coder's coding (Neuendorf, 2002). First, the researcher gave the inheritance-probability SIMCI plan and probability-inheritance MISCI plan's planning transcripts to the second coder who completed her PhD in science education and studying mathematics and science integration. This second coder was about to complete her dissertation when she helped as an expert for the interview questions used for the study. The agreement between the researchers was calculated (Miles & Huberman, 1994) as 94%. Second, the same plans' implementation transcripts and videos were given to another researcher who was a doctoral student in mathematics education for coding. The agreement between the researchers was calculated as 97%. All the percentages were more than the suggested value of at least 80% by Miles and Huberman (1994). The points that we did not come to an agreement were discussed and an agreement was reached. These transcripts composed 40% of the all planning and implementation transcripts which were more than the suggested ratio by Neuendorf (2002).

3.6.2 Researcher Role

Creswell (2009) stated that qualitative research has an interpretative view and he pointed out the importance of the researcher role in qualitative research. He stressed that researchers should give information about their personal background, past experiences, biases, connections between participants, and ethical permissions. I was familiar to the middle school environment because I had two years teaching experience as a mathematics teacher in a middle school. As a researcher, I gave general information about important issues based on the integration literature and then, explained the features of SIMCI and MISCI during planning of the lessons to the teachers. I asked questions to clarify the unclear points while they were discussing the plans. I tried not to lead them and to select questions objectively. I led them to discuss and collaborate for each point. At the end of the lessons, I was with the teacher and tried to spent time with them. This gave me the opportunity to ask each question about the lesson to the teachers and to have a good communication with them. During lessons, when the teacher needed help and looked at me for approval, I did not change my position and gesture and did not answer their questions in order to see how they overcame the situation.

I went to the school like a teacher of the school for one and half year continuously, thus; I communicated with all people in the school from the students to the all teachers and the administrators. Moreover, the school headmaster wanted me to participate several meetings with the teachers since he accepted me as a teacher of the school and I knew the school's structure. Additionally, I participated a picnic activity with the teachers and the administrators.

3.6.3 Trustworthiness of the study

For any types of research, validity and reliability are crucial issues since they influence the study's conceptualization, data collection, data analysis and creation of the findings. There are several strategies for ensuring the validity and reliability for qualitative research (Merriam, 1998). Guba (1981) presented four criteria as credibility, transferability, dependability, confirmability for the validity and reliability of the study.

Internal validity is about how consistent the research findings are with reality (Merriam, 1998). The coherence between the aim of the researcher and the acts of the researcher for the data of the study is important. Six basic strategies were presented by Merriam (1998) to enhance internal validity. These were triangulation, member checks, long term observation, peer examination, participatory or collaborative modes of research, and researcher biases. Internal validity was tried to be ensured by using triangulation, long term observation and peer examination in this study.

Triangulation refers to using multiple data sources (at least two sources), different investigators, different perspectives and different methods (questionnaire, interview, documents) in order to validate the data (Guba, 1981). Several data sources were utilized in order to obtain rich and detailed data such as video records, audio records, interviews, observations for enhancing the internal validity in this study. In addition, Merriam (1998) suggested long term observation as another way for increasing internal validity. Long term observation means observing the same phenomena at the research site and collecting data through a long time period. For the current study, the researcher was in communication with the participant teachers from March-2013 to May-2014 and she spent almost three academic semesters at the school. Peer examination was another way for validity suggested by Merriam (1998). During this study, the researcher asked the researchers who studied science and mathematics integration for their comments about the findings of the study.

Dependability means the replicability of the research findings in the same context, with the same methods and with the same participants, and getting similar results (Merriam, 1998; Shenton, 2004). For enhancing the dependability, it is necessary to explain the process of the study in order to give the opportunity of repeating the study by other researchers. For this, the researcher gave the information about the properties of the participants, the data collection tools, the data collection processes in detail. Triangulation also indicates a way for ensuring the dependability (Merriam, 1998). Since the researcher used multiple data sources as explained before in this section, dependability of the study has been ensured. Additionally, establishing an audit trail was recommended by Guba (1981) and Shenton (2004). An audit trail gives the other researchers an outline to trace the processes of the study. In this study, audit trail was established and a researcher from Elementary Education Department followed the research process and checked the findings step by step.

CHAPTER IV

FINDINGS

This study aimed to investigate one mathematics teacher and one science teacher's planning and implementation processes of mathematics and science integration. For this purpose, the following research questions were examined:

1. How do one middle school science teacher and one middle school mathematics teacher practice integration in their existing teaching?
2. How do one mathematics teacher and one science teacher plan the integrated lessons?
   2.a. What are the critical issues that the teachers considered during planning?
   2.b. What are the influencing factors in planning process of integrated plans?
3. How do one mathematics teacher and one science teacher implement the integrated lessons?
   3.a. To what extend the teachers implemented the integrated plans?
   3.b. What are the problems that they encountered while implementing the integrated plans?
4. How do the teachers evaluate the integration process in terms of their teaching?

This chapter included two main parts. First, pre-study findings that aimed to reveal the existing situation in the school in terms of science and mathematics integration were given. Then, the main study's findings that indicated the planning and implementation processes of integration were explained in detail. All excerpts were translated by the researcher and the translations were controlled by the supervisors of the study.

4.1 Findings of the Pre-study

The pre-study included observations of classes of both mathematics teacher and science teacher, students' mathematics and science notebooks, mathematics and science teachers' definitions about mathematics and science concepts, the teachers' connecting objectives in mathematics and science units. Findings of the pre-study were important because it directly shaped the main study's design and content. Therefore, the findings of the pre-study are presented in order to provide a better understanding of the study and its findings. All names are pseudonym.

4.1.1 Observations

The main purpose of the observations of mathematics and science teachers' classes was to understand to what extend they were using the connections between mathematics and science topics in the middle school grades.

There were four classes for each of the 6^{th}, 7^{th}, and 8^{th} grades in the school at the time of the study. However, mathematics and science teachers' common classes were 7^{th} and 8^{th} grade classes. Thus, I observed each of the 7^{th} and 8^{th} grade's units separately in mathematics and science lessons in order to see if the teachers referred to mathematics or science topics that the other teacher was teaching. Due to the time of the permission of the Ministry of National Education (MoNE) for the study, I started to observe at the beginning of April 2013 and the observations lasted approximately two and half months until the beginning of June. When mathematics and science teachers' classes overlapped, I chose the new or appropriate unit in mathematics or science to observe. The observations were analyzed unit by unit for each of the teacher's lessons.

Mathematics teacher's teaching process can be explained in the following way. He first revised the previous lesson briefly in the first 2-3 minutes in each class. Then, he explained concepts and definitions of the new topic. In general, his questions were from easy to difficult and sometimes he reflected the questions to the board by using projection device. When he decided that all types of questions which could be encountered were solved in the classroom, he assigned questions in student workbook as homework.

For the 7th grade, measures of central tendency and dispersion, area in quadrilaterals, and volume of cylinder topics were observed when mathematics teacher was teaching them. Solids, perspectives of objects, and trigonometry were observed in the 8th grade classes. In both of the 7th and 8th grades' mathematics classes, no concepts of or reference to science were used to make connections between the two disciplines. The teacher was giving examples from daily life, but they were not related to science topics.

Similar to the mathematics teacher, science teacher was also repeating the previous lesson shortly and controlling students' prerequisite learning about the new topic. She asked the definitions of the concepts first to the students, and then she explained them. She wanted students to give examples from daily life related to the topic. After these examples were discussed, she selected a student to read the explanations of the topic in the textbook. She asked her own questions to the students. Unit evaluation questions were given as homework and these questions were discussed in the next class. These steps were the same for each unit in her lessons.

In the 7th grades classes, "light", and "human and environment" units were observed for the connectivity of mathematics and science topics. In the light unit; the science teacher asked what the condition was for a light ray to go from air to water. Then, she explained that when the light ray goes more intensive setting, it will be close to the normal and she added that angle of the light ray will become smaller when it reflects. The teacher used "angle" many times while teaching this topic. In another unit named "human and environment", while she was stating water contamination and global warming issues, she expressed 90% of the world consisted of water and stated that 3% of this percentage was drinkable water and 2% of it was in poles. She clarified this as “Let’s think 60 liters; 40 liters of it are in poles.” She used “percentage” frequently in her lessons.

Units of “electric current and magnetism”, and “natural processes” were also examined during the observations in the 8th grade classes. In electric power topic, the science teacher defined “electrical power” as the amount of energy saved in unit time by electrical devices. She emphasized the unit of electrical power was watt second. After these explanations, she solved problems that required converting unit. In the same topic, she reminded that there was a direct proportion between the number of turn and the electric current. In a graph question, they used direct proportion. In the same topic, another question was asking how much liras would be added to the electric bill when a drill with 400watt worked for 3 hours. First, they converted watt to kilowatt, then they multiplied 0,4kw and 3 hours, and again multiplied the result by 0,2liras. While multiplying, students had difficulties in understanding how decimal numbers were multiplied. The science teacher wrote the computation to the board and explained the computation step by step.

For the observations of the mathematics teacher’s last three units and the science teacher’s last two units; it can be concluded that the science teacher used more mathematics in her lessons than the mathematics teacher’s using science in his lessons. The mathematics teacher did not refer to any science topic, although mathematics curriculum emphasized the relationship between mathematics and science. The reason for the science teacher’s using more mathematical expressions could because of the nature of the science topics. For instance, in the “light” unit, it was necessary for students to know ray and angle concepts to understand what a light ray is and how it reflects in different positions. Thus ST’s using more mathematics in this topic could because of the nature of the light unit.

4.1.2 Students’ Notebooks

At the end of the 2012-2013 academic year, I took four different students’ science and mathematics notebooks from both the 7th and 8th grades. Since both of the teachers carried out their teaching by using questions, the connections between mathematics and science in students' notebooks was found in the questions. In the mathematics notebooks, a total of nine questions related to science concepts, including speed and Archimedes Principle, were identified. Table 4.1 below shows the references to science concepts in mathematics notebooks.

Table 4.1

Topics and numbers of related questions connected to science concepts in students' mathematics notebooks

Mathematics Topics		Related Science topics and numbers of them
7th grade	Ratio Proportion	Speed (2 questions)
	Geometric Solids	Archimedes Principle (1 question)
8th grade	Probability	Inheritance (1 question)
	Cylinder	Archimedes Principle, The States of Matter (3 questions)
	Slope	Speed (2 questions)

Students' science notebooks included many mathematical expressions such as direct or indirect proportions, graphs, ratio and proportion, and probability. Table 4.2 below shows the references to mathematics concepts in science notebooks.

Table 4.2

Topics and numbers of related questions connected to mathematics concepts in students' science notebooks

Science Topics		Related Mathematics topics and numbers of them
7th grade	Systems in our body	Bar graph (1 question)
	Springs	Direct proportion (4 questions)
	Work and Energy	Formulas (3 questions)
	Kinetic Energy	Direct proportion (2 questions)
	Potential Energy	Formulas and line graph (2 questions)
	Simple Machines	Formulas and inverse proportion (7 questions)
	Friction Force	Direct Proportion (1 question)
	Electric Current	Direct Proportion, Formulas and Fractions (14 questions)

Similar to the observation findings, students' notebooks illustrated the intensive mathematics usage of science teacher while mathematics teacher used few science related situations in his lesson.

Science Topics		Related Mathematics topics and numbers of them
8th grade	Mitosis Division	Formulas and Exponents (2 questions)
	Inheritance Crossings	Percentage and Probability (1 question)
	Mendel's Crossings	Percentage, Ratio and Probability (2 questions)
	Genetic Disease	Percentage and Probability (2 questions)
	Blood Types	Percentage and Probability (2 questions)
	Meiosis Divisions	Exponents and Line graphs (2 questions)
	buoyancy of fluids	Formula and Direct proportion (13 questions)
	Pressure	Formula and Direct proportion (4 questions)
	Chemical reactions	Equations and Algebra (2 questions)
	The states of matter and heat	Inverse proportion, line graph and formulas (9 questions)
	Photosynthesis	Line graph (5 questions)
	Electric	Formula (2 questions)

4.1.3 Teachers' Descriptions of Mathematics or Science Concepts

In order to understand the level of the mathematics teacher's knowledge about science concepts and the science teacher's knowledge about mathematics concepts, mathematics and science concepts that could be connected in the middle school grades were asked to the teachers. Science concepts that could be used in mathematics and connected to mathematics were given to the mathematics teacher and he was asked to define and/or explain these concepts. He had difficulties in defining many science concepts. For example, he tried to explain mass and gravity by using their units. He stated that these were related to each other and gravity had an effect of gravitational acceleration. He could not define work and energy; however he was able to distinguish potential and kinetic energy. He could explain what the simple machines and their functions were, and the friction force. He got confused in remembering the factors that affected buoyancy, density of object, submerged volume of the object, or density of fluid. However, after two minutes he remembered. He also could not clearly define density. He only stated it depended on mass and volume of the object. He had another difficulty in pressure concept. He emphasized that pressure depended on surface area of the object and hesitated whether it depended on density or not.

Concepts about matter's structure were unclear for the mathematics teacher. He could only remember the definition of atom clearly. He explained this situation as; he was generally bad at chemistry in his life. He could not differentiate element, compound, molecule, mixture, ions, acid and base easily. The mathematics teacher stated that heat and temperature were generally confusing terms. While he expressed temperature by its units, he could say heat as a kind of energy. Moreover, he could explain easily specific heat, melting, freezing, evaporation, and condensation. In electric concepts, he used some units for definition of concepts such as resistance and current. However, he was able explain connection in series and parallels. He could not define electrical power.

The mathematics teacher was able to clearly define concepts in light unit such as; reflection, incident ray, reflecting ray, normal, limiting angle, and total reflection. Furthermore, he had no difficulty in defining biology concepts such as cell, tissue, organ, system, organism, DNA, chromosome, inherit, mitosis and meiosis divisions. He even gave several examples for each.

Similarly, mathematics concepts that could be related to science were asked to the science teacher and she tried to define these concepts. For example, the science teacher stressed that fraction, decimal and percentage concepts all indicated the same ratio. When she wanted to exemplify direct and indirect proportions, she used concept of buoyancy from force and motion unit. By reminding the formula of buoyancy, she expressed that there was direct proportion between buoyancy and submerged volume of an object, and there was an indirect proportion between submerged volume of an object and density of the fluid. Additionally, she emphasized that if there was a multiplication sign between the magnitudes, there would be an indirect proportion between them. When she was asked about extremely small numbers, she used the example of height of organelles in the cell. She did not mention anything about scientific notation.

Science teacher had difficulty in explaining the difference between line and line segment. She described line as the smallest line between the two points and added that line segment had a starting and an end point. She had another difficulty in defining what the angle was. She stressed an angle had two rays and it was necessary to cross them. Additionally, she was able to describe the types of graphs, but she did not know the definition of histogram.

When mathematics teacher's explanations about science concepts and science teacher's explanations about mathematics concepts were evaluated together, it could be concluded that science teacher had more knowledge of mathematics concepts than the mathematics teacher's knowledge about science concepts. It could be said that it was expected because observations of the science teacher's classes and students' science notebooks included many more mathematical expressions. Thus, the science teacher could define many mathematical concepts because she used them in her lessons. In contrast, the mathematics teacher had difficulty in defining science concepts because he could remember the science concepts only from his university education. This finding was consistent with observations of the teachers' classes and students' notebooks.

According to findings of the observations of the classes; while MT did not use any science related concept or issue in his lessons, ST used mathematics concepts such as percentage, proportion, unit conversion many times in her lessons. Since the observations were limited to several units of the mathematics and science curricula, the students' science and mathematics notebooks were examined. According to analyzes of the notebooks; while the science notebooks included many mathematical concepts, the mathematics notebooks included few science related issues. In addition, both of the teachers had difficulty while defining the science/mathematics concepts. However, ST was more comfortable in defining mathematics concepts when compared to MT's defining science concepts. While ST stated that she used mathematics in her lessons many times, MT explained that he remembered the science concepts from his university education.

4.2 Findings of the Main Study

The main study included the teachers' planning and implementation processes of integrated lessons. In this part, the findings were explained according to the research questions respectively for planning and implementation processes.

4.2.1 Planning of the Integrated Lessons

There were five integrated plans prepared by the teachers including three science intensive and two mathematics intensive integration. For preparation of the lesson plans, the teachers prepared drafts, and tried to write integrated questions to ask in the classes before they worked together. While the science teacher prepared the science intensive drafts, the mathematics teacher prepared the mathematics intensive drafts because they implemented those plans in their classes. In the beginning of the planning sessions, they explained the drafts to each other. Then, the other teacher tried to understand the plan, asked when he/she got confused, added some extra information, or made certain corrections in the plans.

Before planning the final plans, a warm up session was conducted for planning integrated lessons including mass-weight and ratio-proportion topics from 6^{th} grades. They identified a way they would follow for planning of the plans. The following conversation indicated the teachers' ideas about the procedure of planning.

> **MT:** When we considered the balance model, we have to consider the objectives for both MISCI and SIMCI plans. In MISCI, mathematics objectives should be more intensive. We should also consider science objectives. Science prerequisite knowledge of the students is very important.
> **ST:** Similarly, we should focus on science objectives in SIMCI but mathematics objectives are also important. We have to benefit from mathematics objectives. Students' mathematical prerequisite knowledge is another important thing that we should consider. It is necessary because if we do not do we cannot transfer mathematics to science. We should first decide common objectives.
> **MT:** Hımm, yes. For example we should examine the mathematics objectives in detail first then, identify the correspondence science objectives.

ST: Then we should identify prerequisite knowledge from both science and mathematics.
MT: We should consider which methods and materials will be used. And, while constructing the content, we focus on how and which content will be connected.
ST: Yes, I agree. It is good. We can follow this way.

This conversation gave the clues of the critical issues for planning of integrated lessons that the teachers considered. The second research question of this study was investigated in terms of the two main points, namely critical issues that teachers considered during planning and factors affecting the planning process. The findings were presented respectively below.

4.2.1.1 Critical issues

Critical issues that the teachers considered were determined in teachers' planning processes for integrated lessons. These critical issues were categorized as determining the objectives, checking prerequisite knowledge, using teaching methods and materials, and aims of using integration. The following Table 4.3 shows teachers who prepared and supported the plans and the integrated topics.

As ST explained that she always used integration in her lessons, there were necessary mathematical concepts that could not be ignored during teaching in some science units such as probability use in inheritance, ratio-proportion in buoyancy, and graphs in heat-temperature as the selected topics to be integrated by the teachers. ST had asked only the probability value in inheritance questions in her teaching before however, in addition to the calculation of the probability value, the probability types were also integrated in to inheritance topic in Plan1. ST had also used ratio-proportion in buoyancy topic and line graphs in heat-temperature in her lessons in previous years. The objectives selected by the teachers for integrating were from 7th grade objectives. Different from ST's previous teaching, in Plan2 and Plan3 there were more detail explanations and questions related to the objectives of ratio-proportion and line graphs. As a result, ST had to emphasize more mathematical concepts in integrated science plans.

Table 4.3

Information about the integrated plans and their implementation order

Plans	The teacher who prepared the plan	The teacher who supported the plan	Type of Integration	Mathematics Topic	Science Topic
Plan1	ST	MT	SIMCI	Probability	Inheritance
Plan2	ST	MT	SIMCI	Ratio-proportion	Buoyancy
Plan4	MT	ST	MISCI	Probability	Inheritance
Plan3	ST	MT	SIMCI	Line graphs	Heat-temperature
Plan5	MT	ST	MISCI	Volumes of geometric shapes	Buoyancy

The situation was different for MT's integrated mathematics plans. Because MT's previous teaching of probability included only a few questions about inheritance. However, more questions about inheritance were used in Plan4. Additionally, inheritance content was integrated to probability types in line with the objectives. Similarly, MT did not use buoyancy before while teaching volume of geometric shapes. Thus, his teaching in Plan5 would be different from his previous lessons. Consequently, while intensity of ST's use of mathematical concepts was increased compared to her previous lessons, MT's teaching changed in terms of his method and content at the end of the planning phases of integration.

While explaining the critical issues and factors affecting the planning, examples from the teachers' statements and conversations between the teachers during planning phases were given.

4.2.1.1.1 Determining the objectives

The teachers decided the topics that would be integrated in the study. They first focused on the objectives that could be used and integrated in the plans. They selected the objectives individually and the other teacher accepted them.

When ST's plans were examined, it was seen that she first focused on the science objectives. Then, she identified the mathematics objectives. For example, in the

Plan2, after ST stated the science objectives about buoyancy, she added the following statement:

> Related mathematics objectives are, to be able to explain the relation between quantities for direct and indirect proportions, and solve problems about direct and indirect proportions. These objectives are from 7th grade mathematics.

When MT's plans were examined, he first focused on science objectives for Plan4 of probability and inheritance topics. However, he wrote mathematics objectives first for Plan5 including volume and buoyancy topics. For example, in Plan4, after MT stated the science objectives, he hesitated to determine the objectives and consulted ST about the correctness of them:

> I decided these are related to mathematics….Do you want to add something related objectives? I could see these, that is, such as mitosis, meiosis, mutation, I am not sure.

When the focuses of determining the objectives were compared, it could be seen that ST had a focus of the objectives that would be integrated. On the other hand, MT had no certain focus of the objectives. Since he had encountered integration for the first time, he attended mostly to the science objectives for Plan4 and consulted to the ST about the correctness of them. However, in Plan5 he decided the objectives and did not question the appropriateness.

The only matching topics were probability and inheritance. Plan1 was science intensive and Plan4 was mathematics intensive for these topics. There was one common science objective and three common mathematics objectives for these plans. The teachers decided these objectives and stated it was meaningful to use these common objectives.

4.2.1.1.2 Checking for students' prerequisite knowledge

The second critical issue that ST and MT considered was prerequisite knowledge of students for the integrated science and mathematics topics. They both took prerequisite knowledge into consideration in their planning for each plan. The following statements indicated examples of ST's and MT's determining the prerequisite knowledge of students.

For Plan1 ST:

> Students have to know science related things such as structure of cell, duties of nuclear and structure of nuclear. They have to know calculating probability and calculating percentage related to mathematics.

For Plan2 ST:

> Students have to know direct and indirect proportion, density concepts and of course four operations.

For Plan5 MT:

> For mathematics prerequisite knowledge, students have to know computing the volume of rectangular prism because they learnt it at the 6^{th} grade. And as related to science, they have to know computing density and buoyancy. They have to know these science concepts since they had learnt in science class before.

4.2.1.1.3 Using teaching methods, and materials

The teachers took teaching methods into consideration while preparing the integrated plans. They stated which teaching methods they would use in their lessons. They did not mention the teaching methods for mathematics and science separately while they were trying to integrate mathematics and science topics. They wrote the teaching methods for the full plan. As observed during pre-study, they had used mostly questioning, lecture, discussion, and cases in their lessons. This situation continued for the integrated plans. They used activity and/or experiments, and some materials in their lessons for Plan1, Plan2, and Plan4.

For Plan1, ST decided to use problem solving, lecture, brainstorming, and cases as teaching methods and techniques. She prepared an activity for integrating probability computations and experimental probability in inheritance topic:

> We can conduct an activity. By this activity students make probability computations while trying different variations of inheritance characters and evaluating the results. They both conduct experiments and see crossings visually, and we can emphasize experimental probability here.

The other plan that ST used experiment was Plan2. She wrote discovering, lecture, experimentation, questioning, problem solving as teaching methods into the plan. She explained the experiments that she planned to use as the following:

> We perform mini experiments about the factors that affect buoyancy. We use objects and dynamometer. For example, we sink some part of the object, it means we sink its' volume, then we measure its' weight by dynamometer. We increase the submerged volume and again measure the weight. As the submerged volume increases, we observe the weight is changing continuously.

In Plan4, MT wrote case, problem solving, connecting, and discovering as teaching methods. He used an activity including an experiment in the middle part of the plan. He explained the purpose of the activity as the following:

> I designed an activity that will be conducted after probability types are given in order to provide students to understand better. The activity will also include inheritance. In the activity, students will learn by practicing and experimenting. The students will experiment by groups including two students. Each group's results will be noted and evaluated at the end.

4.2.1.1.4 Aim of using integration

In planning processes of the integrated lessons, the teachers tried to integrate science and mathematics. They made explanations about the purpose of their actions of integration. These purposes were collected under three titles as reminding previous/recent mathematics/science concepts, introducing new mathematics/science topic/concept/procedure, and explaining topics/concepts by connecting mathematics and science.

4.2.1.1.4.1 Integration for reminding previous/recent mathematics/science concepts

The teachers used integration by the purpose of reminding previous/recent mathematics and/or science concepts in their plans. For example, in mathematics intensive lessons, MT used integration for reminding science concepts. They sometimes reminded both mathematics and science concepts.

In Plan1 and Plan3, ST used integration for reminding for different purposes. She used reminding for mathematics concept in Plan1. She wrote a question into the Plan1 related to inheritance of eye color character and made connection to the subjective probability by considering the different answers that would come from students:

> Here, since I stated my opinion about the answer, we remind subjective probability concept.

At the end of the Plan1, ST also stated that it was important to understand both the science and mathematics concepts:

> At the end of the lesson, students should get all inheritance concepts by the questions and calculate probability. Again these concepts could be repeated. Additionally, subjective, theoretical, and experimental probabilities are reminded.

Different from Plan1, ST used integration for reminding science concepts in Plan3:

> Then, we remind straight lines are points that show phase changes and the temperature does not change at these points in the given graph. This is very important for us. In the graph, especially it is reminded to the students again that constant temperature values are observed in phase change ranges.

When MT's plans were examined in terms of using integration for reminding, it could be seen that he used reminding for both science and mathematics concepts, and for only science concepts. The following statement was an example of MT's reminding for both science and mathematics concepts such as calculating the volume of the prism and buoyancy in Plan5:

> Here, I formed a question related to both calculating the volume of the prism and buoyancy. We can remind the buoyancy formula at the beginning of the plan.

MT's using integration by reminding for science concept could be noticed in both Plan4 and Plan5. For Plan4, MT stressed the meaning of 'inheritance' by using the following statement:

> I will ask a question as why family members are not the same; I mean what is the reason of diversity. I think students' answers will be inheritance, gene, DNA. Then, I will ask whether there is a probability of a child with blue eyes of parents with brown eyes. This is also for the purpose of reminding. … When the students say the answer as inheritance I will also ask he definition of inheritance for reminding.

In a similar way, MT used question in order to remind prerequisite knowledge for buoyancy and density of the fluid as a factor of buoyancy:

> At the beginning of the lesson, I planned to ask a question in order to remind prerequisite knowledge. The question is 'Have you ever swum in the sea or pool? Which is easier in terms of staying on the water without sinking, in the sea or pool? Why?' Through these questions, students will remember density and buoyancy.

4.2.1.1.4.2 Integration for introducing new topic/concept/procedure

The second aim of teachers' using integration was identified as introducing new mathematics/science topics/concepts/procedures. The teachers wanted to start the lesson by asking a remarkable question in general. ST used integration for introducing the course for only Plan3 of heat and temperature and graphs topics. Her explanation for this aim was given below.

> First state changes of the matters are mentioned. At what temperature the matters change states? Or what happens to the temperature of the matters through changing states? The answer is constant. Then, given information is transferred to graph. I give examples about heating and cooling curves then, the students transfer these to the graphs. For instance we have ice then, we heat it and it becomes steam. The changes occurred in the process are transferred to the graph. Before constructing line graph, it is very important that students interpret it. Thus, I stress the horizontal and vertical lines and which quantities they will contain. That is, students should interpret what will change in the horizontal and vertical lines. I will introduce lesson by this way.

On the other hand, MT thought that using integration for introducing the lesson was a necessity since he considered that science related examples get the students' attention to the lesson. Thus; he used it in both Plan4 and Plan5. In Plan4, MT asked a question related to both daily life and science:

> I wanted to introduce by asking students what the probability of one's having a twin in the world was. I think different answers from students will come. That is, some of them will say 0%, some of them 100% or 20 % may be. I considered that this can be an example related to both science and mathematics. But I will not mention subjective probability in here. We are just introducing to the lesson.

In Plan5 of volume and buoyancy topics, MT could not decide how he would start to the lesson because he pushed himself to make connection between mathematics and science at this part. The following statements indicated his thoughts about this issue and his final decision:

> Actually, I cannot introduce to the lesson by buoyancy. Hımmm buoyancy and volume of the prisms. I thought how I can connect them. I think I cannot mention buoyancy while teaching volume of prisms....I think, it will not like inheritance and probability plan. It was easier to connect while introducing in that plan....Hımm, ok, I can connect by using questions. Do you know why I limited myself? I feel that I have to introduce to the lesson always with science. I had no difficulty in probability topic.

After these explanations, MT used integration in introducing the lesson by the following statements:

> I have asked which one is easier to stay on the water without sinking, pool or sea. I expect student answers will be as density and buoyancy. Then, to introduce mathematics, I will ask to students, to which geometric object a pool resembles. The students will answer as prism. Then, again I will ask them when you think a pool like this classroom, how can you calculate the amount of water it could contain. I provide them introduction of volume topic by these questions.

4.2.1.1.4.3 Integration for explaining topics/concepts by connecting mathematics and science

The teachers tried to make connections between science and mathematics by several ways during planning integrated lessons. They used different forms of connections such as science to mathematics (S-M), mathematics to science (M-S), and science to mathematics to science (S-M-S). For instance, when the teacher made connection from science to mathematics she/he started with and example related to the science concept and then made transition to mathematical situation through that example or situation. Table 4.4 below indicated the frequencies of these different usages of connections for each plan.

Table 4.4

The frequencies of different usage of connections for each prepared plan

		Frequencies of connections			
Plans		S-M	M-S	S-M-S	Total
Science plans	P1	13	0	4	17
	P2	6	3	0	9
	P3	4	5	0	9

	All	23	8	4	35
Mathematics plans	P4	7	0	0	7
	P5	2	9	0	11
	All	9	9	0	18
Total		28	17	4	-

The different usages of these connections were explained below respectively.

4.2.1.1.4.3.1 Connection science to mathematics (S-M)

As seen in Table 4.4 the most used connection was S-M. This type was also the most used one for Plan1 by ST. She started with science and then connected it to mathematics specifically in the following statement by making transition by connecting Mendel's crosses to probability.

> Then, I will mention about Gregor Mendel who first studied about inheritance and his studies. This is my third objective that addresses the importance of his studies. The probability concept is engaged in here first. Thus, it is important. At this point, identifying situation of characters of offspring from parents' characters, that is probability comes here.
>
> According to Mendelian laws; for F1 offspring obtained from different homozygote individuals crossings, inheritance probability of individuals are calculated in terms of phenotype and genotype. After parents' genotypes are identified, we cross the genes, and then we calculate the ratio, the probability for the offsprings.
>
> After we give the genotypes of two individuals, we ask what the obtained offsprings are and how many of them could be as the determined genotype, and then we ask the definition of the probability. By this way, we have been connected to probability.
>
> For example, I ask what the probability of a child with blue eyes from parents with brown eyes is. In the following parts of the topic, by giving the inheritance properties of parents or child offspring, the probability of the event is calculated. At the moment, to calculate the probability is important and we have emphasized it.
>
> It can be asked to students what the probability of a boy with blue eyes from a mother with blue eyes and a father with heterozygote brown eyes is. At this point I

> say for example, in my opinion it is 50%, I mean according to me. I ask what kind of probability this is. From here, they learn subjective probability.

In Plan2, ST mostly used S-M connection. For this plan, she explained the factors affecting the buoyancy such as submerged volume of the object and the density of the fluid, and then made transition to indirect proportion. The statements related to this explanation were given below:

> Students know the relation between submerged volume of the object and the density of the fluid. Then, we say if the influencing buoyancies to the objects are equal, we want them to compare the submerged parts of the objects in different fluids. Then, we say there is indirect proportion between the two when their buoyancies are equal.
>
> That is, it means that the more the density decreases, the more submerged part of the object increases. If the question gives two situations for the same object and the object sinks more in the one according to the other, students use indirect proportion when we want them to compare the density of the fluids. They will say that for example, if the submerged part of the volume of the object is bigger, it means the fluids' density is smaller than the other one because there is indirect proportion between them.

ST also used S-M connection for Plan3 in heat and temperature topic:

> After the students have learned at which temperatures matters change their states or what happens to the matters' temperatures during state changing. The answer is it remains constant; they have to know this. Then, this information is transferred into the graph. A state changing, a heating or cooling example is given and then, students transfer it in to the graph.
>
> Students will compose a heating curve including from ice at -5 Celsius degree to steam at 110 Celsius degree. There is certain information for melting point for water, we give it. We want them to transfer these into the graph.

When MT's plans were examined, it can be seen that although he did not use S-M connection as much as ST, he used this form many times in both of his plans. He prepared similar questions with ST. Two of these questions that he stated were given below:

> Aysel and Mehmet have a daughter and three sons. What is the experimental probability of the fifth child to be a girl? What is the theoretical probability of the fifth child to be a girl?

MT's use for this form of connection was also seen in Plan5 as given below:

> Since the questions will be through density topic, I wanted to bridge how the density will be calculated to prisms.... They learn density in science lessons and I tried to include prisms in it.

The teachers sometimes used S-M connection by making it double. For example, they started with science than combined to mathematics. Then, again they connected to science and then, used the mathematics concept to make connection to science one more time. Both teachers made this connection. ST used it for Plan2, for instance, by stating factors that affected buoyancy, and then explained direct and indirect proportions. She again stressed the volume factor and passed to direct proportion. The following statements showed this issue:

> We have only one formula. The factors that affect buoyancy are certain. However, when some of the factors were held steady, we explain how the other two change by direct and indirect proportions. We ask students what happened to buoyancy when the submerged part increased in the same fluid. Students will say it will increase because of the experiments they learned. I ask what kind of change it is, what kind of proportion. They will probably answer as direct proportion.

> While calculating an object's density especially in Archimedes principle, I use proportion. I explain that an object's density is calculated by using the formula which indicates mass divided by volume. That is, if you know mass and volume of the object, you can find the density. Or you can find mass if you know density and volume. Again, I repeat direct and indirect proportion for this formula.

When MT's plans were examined, making S-M connection double can be seen in both Plan4 and Plan5. For instance in Plan4, MT gave the information about crossing result. Then, he wanted students to find parent's genotypes and calculate the probability of obtaining certain individual type. There was a step after crossing including ratio use. The following statements indicated this in Plan4 and Plan5 respectively:

> There is another question. There are 60 black and 20 white rabbits as the result of crossing of black and white rabbits. According to this, determine the crossing parent rabbits' genotypes and calculate the probability of obtaining heterozygote black rabbit. I asked by this way. It is somehow difficult compared to others. It requires going reversely.

> A cube is full of water and its volume is $1000m^3$. If a marble, its density is $5gr/cm^3$ and mass is 40gr, is put into the cube and then removed, how much water level will decrease in the cube? The question is like this. I considered that the amount of water is equal to the volume of the marble. I gave density and mass and they will find volume. The volume of the displaced water will be calculated. Then, they will

find displaced water will decrease water level in the cube. What will happen? They will say 10x10xh =8. The answer will remain as fraction.

4.2.1.1.4.3.2 Connection mathematics to science (M-S)

The form of teachers' another connection was identified as M-S where they started with mathematical idea and then combined it with science. According to Table 4.4, this form was used less than 'from science to mathematics'. Both ST and MT did not prefer to use this form for 'inheritance and probability' topics in Plan1 and Plan4. ST used this form in Plan2 as given in the following:

> If they know while a magnitude increases and the other decreases, we say there is indirect proportion between the two. I especially emphasize this here in my lessons. While interpreting the buoyancy formula if there is equal sign between the magnitudes, there is direct proportion between the magnitudes under the condition that the other magnitude is constant. That is, when one of them increases, the other also increases. If there is multiplication sign, there is indirect proportion between the two magnitudes that we examine under the condition that the other magnitude is constant. The student reaches to the result that while one increases the other decreases for the factors of buoyancy by this way.
>
> Proportion helps students to conceptualize, because buoyancy is not an easy subject. In order to answer the questions they should know many things that are related. To interpret the formula by looking the equal sign and multiplication sign is the simple way. If they know these ratios, if they know the changes with direct and indirect proportions, they could solve easily which factors and how they affect buoyancy. My experiences over the years showed this to me.

For Plan3, ST used M-S connection more than for Plan2. She generally took the interpretation of the line graph as starting point, and then she explained the heating or cooling curve over line graph. The following statements of ST indicated this issue:

> Students should differentiate heating and cooling curves according to decrease and increase on the lines of graph. They also should know state changes occurring in the constant points, the important point is this for me.
>
> We give a graph to the students. According to this graph, we ask them a matter's melting point, boiling point, freezing point, or the state at 35 Celsius degree. We want them to interpret these all according to the information in the graph.

When MT's use of M-S connection was examined, it can be said that he used this form for only Plan5 although they prepared mathematics intensive integrated plans. The following statements indicated MT's use of this form:

> For the first question a right triangular prism is drawn on the board. 2/9 of this prism is full of fluid. The amount of the fluid is 32 gr. Calculate what the density of this fluid is. They will both calculate the volume of the prism and fractions will be involved in and they will calculate what part of the whole, and density.
>
> We have a square prism block. The lengths of the base are 3 and 3, the height is 4cm. When the prism put on the container, it sinks into the water its' ¾. The question is that calculate the buoyancy influencing to the square prism. I asked this. The other question. When a container, with 30gr mass, is full of its half with water, it is 114gr. When an object with 8gr mass and $3cm^3$ volume put into this container, what is the position of the object in the fluid? …First they will find the mass of the fluid because they know when half of the container is full it is 114gr. Then, they will calculate the volume and density respectively. … they will find the volume of the object. Since I gave the mass and volume they will find the density. Last, they will compare the two densities in order to say the position of the object.

4.2.1.1.4.3.3 Connection science to mathematics to science (S-M-S)

There was another connection form that teachers used which was starting with science and connected with mathematics, then again connected with science concepts. This form was named as S-M-S connection. This form was used by only ST for Plan1 and MT did not use this form. ST generally used this form in her questions. She started with crossing, and then asked the genotypes. Between crossing and genotypes there was a need to benefit from probability. The following questions that ST prepared for her Plan1 indicated this issue:

> There will be several types of questions. There are 500 wrinkled pees of 2000 pees as the result of crossing two individuals in terms of seed shape character. How should crossed individuals' genotypes be?
>
> The phenotype ratio was observed as 3:1 as the result of crossing two individuals. According to this information, which one is correct about the genotypes of the parents?
>
> There is 25% probability of being a baby with blue eyes of parents with brown eyes. According to this information, which one is correct about the genotypes of the parents?

4.2.1.2 Factors affecting the planning

Through the research question 2, factors that affected the planning processes of integrated plans were investigated. These factors were categorized in two as, 'problems about content knowledge' and 'teachers' collaboration and communication'. The factors were explained below respectively.

4.2.1.2.1 Problems about content knowledge

Planning processes of integrated lessons were influenced by lack of teachers' content knowledge in several instances. Only for Plan3 (line graph - heat and temperature integrated plan), no teacher deficiency about content knowledge was detected. The frequencies of these problems for other plans were reflected on the Table 4.5 below. The numbers in the table indicated the teachers' statements related to lack of knowledge and trivializing content problems during planning of integration process.

Table 4.5 illustrated that there were problems about teachers' content knowledge that affected the planning of the plans with equal numbers in science and mathematics plans. These problems were 'lack of content knowledge in mathematics and/or science and trivializing content'. These problems were explained below.

Table 4.5

The frequencies of the problems for each plan for planning process

		Frequencies of problems according to the plans	
		Lack of content knowledge in mathematics and/or science	Trivializing content
Science plans	P1	4	1
	P2	11	1
	P3	0	0
	All	15	2
Mathematics plans	P4	10	2
	P5	7	0
	All	17	2
	Total	32	4

4.2.1.2.1.1 Lack of content knowledge in mathematics and/or science

Content knowledge in mathematics and/or science was emerged as an important teacher weakness in planning integrated plans. Nearly in all plans, content knowledge came up as the most repeated problematic issue as seen in the Table 4.5. While in some plans, only one teacher's content knowledge deficiency was seen, in some of them both mathematics and science teachers had lack of content knowledge. Plan1 was influenced by ST's lack of mathematical content knowledge. ST made a faulty definition of the subjective probability:

> For example, I ask the probability of having a blue eyed son of blue eyed mother and heterozygote brown eyed father. Here, I say in my opinion this is 50%, it means up to me. I ask what kind of probability it is. The students learn subjective probability in here. We call subjective probability as 'up to me'

Additionally, ST used a mathematical concept, which she composed by three different mathematical concepts:

> After evaluating the theoretical probability, I ask what the *ratio of experimental probability* is and I give this concept. That is, how can we do it experimentally?

ST sometimes hesitated during preparation of the Plan1, and asked the correctness of her statements to MT. MT approved her explanation without any correction. Since MT approved her 'ratio of experimental probability' statement, it can be said that MT had also lack of content knowledge here.

It appeared that Plan2 was influenced by ST's lack of content knowledge. ST's statements indicating direct or indirect proportion showed that she used these concepts in the way that could encourage students to memorize the mathematics concept:

> If there is multiplication sign between the magnitudes (in the buoyancy formula), we say that there is indirect proportion between them that we observed, under the condition that the other magnitudes are constant.

ST did not seem to have any thoughts about how ratio and proportion topics were taught in mathematics lesson:

> I think you solve ratio and proportion as formula don't you? Can you give an example of ratio and proportion problem? What kind of problems do you use, for instance, is it work problem?

Teachers' lack of content knowledge influenced the preparation of Plan4. ST did not have much knowledge about topics in probability concept, although she taught inheritance as the first topic of academic year and used probability in inheritance topic:

> In which month will you teach this topic? If you teach after I did, it is ok. Do the students learn calculation of probability in 6th and 7th grades?

Another instance for ST's lack of mathematical content knowledge was in the topics of dependent or independent events. For example, she could not be sure whether the event was dependent or independent when she encountered the case of calculating the probability of having blue eyed daughter of a couple. Similarly, there were instances where MT did not have sufficient science content knowledge. First, he could not decide the objective to be connected in terms of relatedness of probability and the other science concept, and he asked to ST to be sure during the planning:

> Do you want to add extra objectives related to inheritance? I could find these objectives. I am not sure, whether mitosis, meiosis or mutation can be added to the objectives.

Another situation that MT was confused about was the science concept. He could not differentiate the character or gene to use in the question:

> The students will make crossing as in the activity. Here, again dominant and recessive characters are important. Is it character or gene?

MT also had difficulty in mathematical concepts. He discussed the dependent and independent events although he did not put them in Plan4. The following statement indicated MT's confusion about dependent events:

> For instance, think that there is a vector colorblind mother and healthy father. When we think the probability of their daughter's being colorblind, is there a dependent event here? There is, isn't it? Why? If they will have daughter, does the gene affect the other one? Is it dependent event?

As seen in above instances, MT had difficulty because of lack of science and mathematics content knowledge. MT's lack of science content knowledge was also seen during the preparation of Plan5 in the following conversation between ST and MT:

> **ST:** If the object is sinking, its ¾, it has buoyancy as much as its' weight. The students should find the weight.

> **MT:** What's weight? Wait a second. Let me explain. The formula of buoyancy was multiplication of density of fluid and submerged volume of the object, wasn't it?

In Plan5, both ST and MT also revealed science content knowledge deficiencies. They both used weight and mass as the same term, although they could define weight and mass in pre-study before.

During planning processes, teachers had lack of confidence in teaching mathematics and/or science as a result of lack of content knowledge in mathematics and/or science. There were instances that they did not feel comfortable and hesitated. ST's statements in below for Plan1 and Plan2 respectively indicated that she was not sure about her mathematical knowledge and she needed the approval of MT about integrating crossing and probability topics:

> Then, we make crossing. When we calculate the crossing result, I think it is theoretical probability, isn't it?

> While interpreting over the buoyancy formula, if there is equal sign between the magnitudes under the condition of the other one is constant, there is direct proportion between the two magnitudes. It means as one increases, the other one increases. Is it right?

MT showed similar behavior with ST in Plan5. He also could not be sure to connect buoyancy and volume in the questions that he prepared on his own. Thus, he asked ST's opinion several times. MT first explained a question that he prepared for the Plan5 then, he stated his hesitation about the complexity of the question. ST appreciated him for using integration by using good connections however, she suggested him to use simple questions, not complicated ones:

> **MT:** I explain the students that the volume of the marble is equal to the displacement fluid. They will calculate the volume of the marble. I gave the density and mass. They will find the volume of the displacement fluid. Then they will find how much the fluid decreased. They will reach 10x10xh=8. They will find h. Is this question complicated? They can understand I think, can't they? Should I add some easy steps in to the question?
> **ST:** If you ask easier questions it will be better. Actually you will understand while you are teaching. But the questions are so good; you made good connections between mathematics and science.

After Plan1 and Plan4's planning, the teachers sometimes discussed issues about connecting the concepts and avoided to use it. To avoid using the connection seemed to be related to lack of confidence and lack of content knowledge. For instance in Plan4, they discussed dependent and independent events, and disjoint and mutually exclusive events, and both ST and MT avoided putting these concepts into Plan1 and Plan4. While ST connected her idea about not to use dependent and disjoint events to duration of the plans, MT connected it to difficulty of science and claimed that Plan4 is enough.

> **ST:** I will not mention such as disjoint or dependent event. If I do, my plan becomes longer.
> **MT:** Why science is more difficult than mathematics? Look at the science objectives, there are a lot of things. Anyway, these are enough for my plan, I will not mention any more.

4.2.1.2.1.2 Trivializing content

The second lack of teacher knowledge observed during planning integrated plans was identified as in composing meaningful content. This lack of knowledge could be also considered as trivializing the content. Plan3 and Plan5 did not reveal this kind of weakness. Trivializing content was detected when teachers tried to add some concepts and lost the main focus of the lesson while integrating. For instance, ST stressed that four operations were also included in a different type of crossing question:

> We can ask such type of a question. How many of the peas are wrinkled in 2000 peas, obtained as a result of a crossing, which has genotype ratio 1:3? If I add this kind of question, four operations are also involved in.

In this case, both ST and MT considered that to put four operations into the science context is sufficient for integration. For this reason, MT did not object for this statement. This instance can also be considered as a trivializing content issue. For Plan2, although ST prepared the plan, MT suggested an issue which was another indicator of trivializing the content issue. The following instance indicated MT's trivialization:

> It can be emphasized that the more submerged part of the object increases, the more fluid level increases. I am not sure this is in formula but it can be said.

MT prepared a question for Plan4 which addressed the similar situation in Plan2. The question was about DNA chain and the probability of continuing as in the other part of the chain. This question was not directly related to the objectives of Plan4. Although there was an error, he insisted and put into the plan by revising it. ST did not say anything about this issue.

4.2.1.2.2 Teachers' collaboration and communication

The teachers were friends and colleagues at the same school for 3 years. In planning processes of integrated plans, MT and ST worked together. They made arrangements before they came together. They were in communication and they collaborated for the preparation of all plans. Their collaboration and communication were coded in three main issues: support, suggestion, and persuasion.

4.2.1.2.2.1 Support

The teachers supported to and approved each other's ideas by making additional explanations through planning. This support was sometimes one way and sometimes mutual. The most repeated action between ST and MT was supporting each other during integrated lesson planning.

In Plan1, MT made additional explanation and supported ST when she used a definition for subjective probability by her own words:

> **ST:** I say students "in my opinion it is 50%", that is up to me. I ask what kind of probability this is. They will learn subjective probability by this way.
> **MT:** That is, changing person to person.

MT made extra explanations for clarifying the difference between theoretical and experimental probability. ST had difficulty to connect Mendel's experiment to experimental probability and asked MT. He tried to explain as seen in the conversation below.

> **ST:** Mendel conducted experiments about crossing. He grew peas with different genetic properties. Is it experimental probability here?
> **MT:** If an experiment was conducted before, inferences can be made according to the results of that experiment. I mean, it is theoretical, not experimental probability.

MT also needed to approve ST and ST needed to be approved during Plan1 preparation. The following conversation showed this situation:

> **ST:** Here, since I stated my own idea, we remind subjective probability concept.
> **MT:** Yes, it is subjective probability.
> **ST:** Then, we make crossing. I think it is theoretical probability that we obtained.
> **MT:** Yes, correct.

The only plan that teachers supported to each other was Plan2. While MT approved ST's explanations, ST explained some points about buoyancy to clarify the topic for MT. The conversation between MT and ST below showed these instances respectively:

> **ST:** Even if the densities of fluids are different, the buoyancy of them is equal to the object's weight.
> **MT:** Hımm, ok. Can we explain by another way?
> **ST:** It changes according to the position, the submerged volume is changing.
> **MT:** The formula was multiplication of density of fluid and submerged volume of the object.
> **ST:** Yes.
> **MT:** If the buoyancy is 12 and the object's submerged part is 2v in the first fluid and v in the second fluid.
> **ST:** Ok, there is two folds ratio.
> **MT:** Does the buoyancy change?
> **ST:** It does not.
> **MT:** When we consider according to the formula, ok, I understood.
> **ST:** It makes sense.

During Plan4's preparation, ST supported MT's statements and approved several times. When MT got confused, ST interrupted and explained the context. The following conversations illustrated ST's support for the objectives and inheritance concept:

> **MT:** Do you want to add other objectives to these?
> **ST:** No, the same.
> **MT:** I could take these. I am not sure, mitosis, meiosis, mutation?
> **ST:** There is no probability calculations related to that concepts. You don't need others, they are enough.
> **MT:** They will make crossing as in the activity. Here, again recessive and dominant characters, character or gene?
> **ST:** Character.
> **MT:** They should know recessive and dominant characters.
> **ST:** I also use this kind of questions, they can do this.

Additionally, ST approved MT's questions related to science concepts as in the following conversation:

> **MT:** When the students answered the question as inheritance, I will ask what the inheritance is.
> **ST:** If I were you, I will do the same.

MT also supported ST during Plan3's preparation about the types of graphs as in the following conversation:

> **ST:** I will ask students which graphs they use except line graphs to remind the graphs. For instance bar graphs, what else hımm?
> **MT:** Pie chart
> **ST:** Yes.

In Plan5, ST supported MT as much as in Plan4. Besides making explanations in order to prevent MT's confusion, ST appreciated MT's questions in terms of integration since he prepared the plan on his own. The following conversations indicated this situation:

> **MT:** The students will both calculate the volume of the prisms and density….Since I will give the mass and volume, they will find the density. They will compare the two densities. I wanted to address different objectives.
> **ST:** Yes, it does. The questions are very good. They are totally connected in terms of mathematics and science.

4.2.1.2.2.2 Suggestions

The teachers also suggested ideas for each other's plans in order to integrate mathematics and science for better understanding of students in a meaningful way. It can be said that ST suggested ideas to MT, more than MT did for ST. They suggested each other ideas about preventing a misunderstanding of the concepts, how to introduce to the lesson, different question types, emphasizing important points, and simplifying the questions' level.

In order to prevent a misunderstanding of and confusion about theoretical and experimental probability, MT suggested the following ideas to ST in Plan1:

> In my opinion, you can omit experimental probability for this example, they calculate this theoretically.

MT made suggestion in order to emphasize direct and indirect proportions for integration in Plan2.

> There are direct and indirect proportion concepts. You can emphasize direct and indirect proportions through their definitions and the buoyancy formula verbally. I took some notes. For example, as the object's submerged volume increases, the affecting buoyancy increases. This can be asked as 'what is the relation between these or what kind of proportion is it?' to the students.

As mentioned before, ST's suggestions were more than MT's suggestions. ST suggested different question types for Plan4. First, she stressed that the questions that MT asked were the questions that she usually used. Then, she suggested MT to focus mathematics objective as in the following:

> I will have solved these kinds of questions before you did. Until you explain, they solve at that moment. I feel that you should focus on mathematics concepts and objectives. These questions are the ones that I use generally.

ST also presented suggestions for Plan5. The purpose of these suggestions was to help MT to introduce the lesson and connect volume of prisms and buoyancy. Her suggestion was given below.

> For example, you can want students to calculate a rectangular prism's volume, ok? Then, you put this rectangular prism in to a container including fluid with $2gr/cm^3$ density. And you give the mass of the rectangular prism. Last, you ask them to state whether the prism sinks or floats. They can connect by this way.

Additionally, although ST liked MT's questions that he prepared before, she expressed that the questions can be difficult and she suggested the following.

> If you put the simple questions or simplify the harder questions, it can be better. You will understand the level of students while teaching, I think.

4.2.1.2.2.3 Persuasion

The third collaboration and communication part was identified as persuasion of the teachers. It can be inferred that persuasion efforts of the teachers were more in the mathematics plans compared to the science plans. ST and MT tried to persuade each other for two main purposes. The first one was for reaching agreement in disagreements. The second one was revealed as clarifying the hesitated points. These purposes were explained respectively below.

4.2.1.2.2.3.1 Persuasion in disagreements

The teachers were in communication and they collaborated continuously through integrated plan preparation process. Sometimes they had different ideas. In such cases, they tried to persuade each other and reach agreement on the plan. These disagreements were mostly revealed in mathematics plans. There was only Plan2 as science plan that the teachers had disagreement and persuaded each other.

The disagreement in Plan2 was about the difference related to style of using ratio and proportion between science and mathematics topics. The conversation of this disagreement and persuasion was given below.

> **MT:** When we explain direct and indirect proportions we use that kind of problems (referring worker problems). However, when we encounter a problem as there is indirect proportion between x and y, and direct proportion between x and z, we don't use 'if there is equal sign' or 'if there is multiplication sign' statements. These are for university entrance examination level, not for high school (entrance) examination level.
> **ST:** But this is very important for me. By this way the students differentiate thus, I have to state this. It also makes easier students to comprehend proportion; otherwise it is not an easy topic to understand. Proportion is very much connected to buoyancy; they have to know everything to answer the questions. This is (referring equal sign and multiplication sign) just the easy way for them.

MT did not object ST's explanation thus ST persuaded him and put the proportion by her own way in to the plan.

One of the teachers' disagreements in Plan4 was on the question of DNA in which MT had aimed students to calculate probability over bases on the given DNA chain. This question did not make sense to ST. She insisted to understand but she got confused. The conversation about this question was given below.

> **ST:** What is your purpose here, what will they calculate? I don't ask such a question in my lessons.
> **MT:** I asked the probability of continuing the second part on the chain as in the first part. What are the choices? AT, TA, SG, GS.
> **ST:** You think that there are four bases and any one of these four can be, don't you?
> **MT:** Yes
> **ST:** Do you think, it depends on these bases?

MT: No, without any logic, when they see four bases, they can answer as ¼. I gave three of them, did not give one of them. I will add another and there are five bases on the chain, now it is ok I think.

...

ST: Will the students look at the combination here? This question is complicated.

MT: No, it is not related to combination. I don't mention combination in probability here. I want them to say that there are four kinds and for example, the probability of writing A base here, is ¼.

ST: That is they should know there are four bases. They need to know prerequisite knowledge about DNA then, to say the probability. It is not important to say which base will come to the other part of the chain.

Although ST stressed that this issue was not important for students' learning, MT insisted and ST accepted to put it in to the plan.

In Plan5, ST opposed to MT about a question type, since she had a foresight as the students could have difficulty to understand it. MT accepted her explanation. This situation was given in the conversation below.

MT: We have a prism shaped container. I will give its' measures and the weight of the fluid in the prism. What will they do? Additionally, I will give another object's density that we put it in to the prism. I will ask the position of the object in the fluid. The students will calculate the volume of the fluid in the prism. The mass of fluid was given. After they find the volume they will calculate the density of the fluid. Then they will compare the two densities.

ST: It can be challenging for the students. I will say another but similar thing. You may want them to calculate the object's volume. Then you give the weight and they calculate the density of it. You put the object into a fluid with certain density. They can interpret by this way easier.

MT: Hımm, ok."

4.2.1.2.2.3.2 Persuasion in Hesitations

The teachers also persuaded each other in order to clarify the hesitated points during the planning. This persuasion generally occurred by making explanations and convincing each other. The number of frequency for the persuasions in hesitations was equal for mathematics and science plans.

When ST hesitated in connecting Mendel's crossing to experimental probability, MT persuaded her by the following statement in Plan1.

If an experiment was conducted before, it can be inferred according to the results of the experiment. I mean it is theoretical probability. Here we make crossing and

> we calculate theoretical probability since we make crossing. It is not composed by an experiment. We only calculate it. We do not perform the experiment.

Similar situation occurred in Plan2 for ST. When MT could not understand how the different fluids could apply buoyancy to the same object, ST persuaded him by the help of figures as in the following statement.

> It is about this. If the object is floating or maintaining its position at a certain depth without hitting the base, the buoyancy is always equal to the object's weight. It's submerged volume changes but the buoyancy is always as much as the weight.

4.2.2 Implementation of the Integrated Lessons

In this part, in line with the research question 3, examination of ST and MT's implementations of integrated science and mathematics plans in the 8th grade classes were presented. The focus was to understand how they performed the plans according to the critical issues they considered during the planning. Additionally, affecting the implementation of the plans was investigated. Teachers' evaluations about their own teaching of integrated plans after the examinations of implementations were given for each plan. ST and MT prepared integrated science plans together according to SIMCI part of the Balance Model. Similarly, they prepared integrated mathematics plans together according to MISCI part of the model. They implemented the plans on their own in their classes. Implementations of the integrated science plans and integrated mathematics plans were examined below respectively.

4.2.2.1 Integrated science plans

After the preparation phase of the plans, ST implemented Plan1 (Inheritance - Probability), Plan2 (Buoyancy - Ratio and Proportion), and Plan3 (Heat and Temperature - Line Graph) in four 8th grade classes. Each plan was examined respectively below.

4.2.2.1.1 Plan1 (Inheritance-Probability)

Plan1 included inheritance and probability topics from 8th grade science and mathematics curricula. ST implemented this plan in four 8th grade classes for four lesson hours. The implementation was performed first in 8/D class. The summary of implementation with the order of implemented sections is given in Figure 4.1.

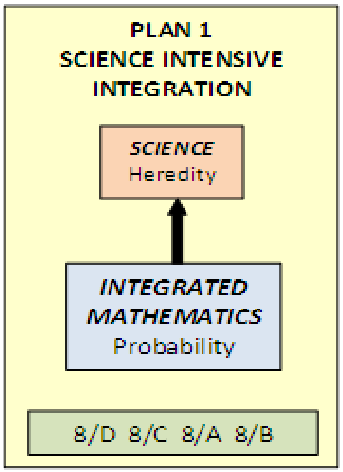

Figure 4.1 Implementation order of Plan1

4.2.2.1.1.1 Critical issues in Plan1

In this part, critical issues observed in the implementation of Plan1 were explained in order to understand how the teacher implemented the integrated plan. Critical issues revealed in planning phase of the Plan1 were considered while analyzing the implementation of Plan1.

4.2.2.1.1.1.1 Checking for students' prerequisite knowledge:

ST started the lesson by controlling students' prerequisite knowledge for science and mathematics based on the teachers' plan. She controlled science prerequisite knowledge for science concepts related to inheritance such as, gene, DNA, structure of chromosomes, homozygote offspring, and heterozygote offspring in all classes by questioning. She asked the definitions of these terms to the students. Although ST controlled 8/D class students' prerequisite knowledge of the probability concept which was identified as prerequisite knowledge for mathematics, she did not attempt to understand the students' knowledge about probability in the other three classes. When the reason of this was asked, she stated that she decided that the students knew what the meaning of probability was.

4.2.2.1.1.1.2 Integration for reminding previous/recent concepts:

While planning, ST had used integration for the purpose of reminding probability concept by using a science question that asks the probability of obtaining a certain genotype at the beginning of the lesson, however; she only reminded definition of the probability in 8/D class at the beginning of the lesson. Although the teachers had decided to remind both science concepts related to inheritance and mathematics concepts about types of probability at the end of the lesson in planning, ST did not remind these concepts in any of the classes.

During the implementation, ST also used integration for the purpose of reminding the types of probability. For example, in 8/D class, after she explained the subjective and theoretical probability, she stated that they would conduct an experiment and name that probability experimental probability. Then, she asked how many types of probability there were. The following conversation took place in 8/C when she asked a question and used integration for reminding the types of probability:

> **ST**: A couple will have a straight haired baby with the probability of 25%. According to this information, how can the genotypes of the mother and father be?
> **Student**: 50% or 75%.
> **ST**: Do not speak with subjective probability, tell me with theoretical probability.

Another example related to integration for reminding took place in 8/C. After she explained the theoretical probability, she repeated the subjective probability, and again explained theoretical probability as in the following:

> If we say it is 20% by stating personal idea, it will be subjective probability. But we calculate it, so it is theoretical probability.

When ST's controlling prerequisite knowledge and reminding concepts of science and mathematics were examined, it could be said that she gave more importance to implement the plan exactly in 8/D class since it was the first class that the plan was implemented. In the other classes, for instance, ST omitted to ask the definition of probability although she did plan. ST's attention to following the plan decreased as she approached to the last class most probably because ST developed a self-confidence about teaching according to the integration plans in the previous classes and also about teaching mathematics topics in her classes before. Thus, her self-confidence might have caused to not to give attention to these points in her classes.

4.2.2.1.1.1.3 Integration for introducing the new topic/concept/procedure:

ST used integration for introducing a new mathematical concept/concept/procedure. For example she used probability types, which the students encountered first before they learned in the mathematics course. While teachers did not mention any purpose for introducing a new concept in planning, ST frequently used integration to introduce a new topic during explaining the probability types. For example, while she was trying to move on to subjective probability in 8/D class, she asked the question below:

> If I say, in my opinion, the probability of curly haired parents' having curly haired child is 100%, if I say this kind of probability, is it true?

While stating theoretical and experimental probability, she also used integration for the purpose of introducing these new concepts. The example statement in 8/D was given below:

> The result that we calculated here is theoretical probability. According to Mendel's crossing laws we calculated and found. Since it depends on a theory, it is theoretical probability. Now we will do it by animating. We will conduct an experiment. We will calculate the result we found before as experimental and name it experimental probability.

In 8/C class, ST also explained subjective and theoretical probability for introducing purpose. She tried to compare the two types of probability and make them clear by the following explanation:

> When I say probability, for example I say heterozygote curly haired parents have curly haired children with the probability of 80%. For who, I say? By doing

> nothing, if everyone say differently or estimate for instance say 90%? Is it a probability? Yes. But I say this in my own way. In Turkish, for instance we name these kinds of sentences as subjective. Similarly, my probability estimation is subjective probability. But if I calculate this with crossing, if this probability depends on information or theory, it is theoretical probability. If I say 80% by myself, it is subjective. But the one that I calculated on the board, 75%, is theoretical probability.

4.2.2.1.1.1.4 Integration for explaining topics/concepts by connecting mathematics and science

As it was explained before, the teachers used integration in forms of different connections. There were three kinds of connections namely, science to mathematics, mathematics to science, and science to mathematics to science in the implementation of Plan1. ST conducted science to mathematics connection more intensively than the others. The connections were explained in the following part in detail below.

4.2.2.1.1.1.4.1 Connection science to mathematics (S-M)

This type connection indicated ST's usage of integration by starting a science concept. After ST started with a scientific situation, she connected it with mathematical concepts. ST used this type of connection many times during her teaching the integrated plans. For instance, she started with a crossing context and then she connected it to finding the probability value. ST's statements about this connection in 8/D class were given below:

> The issue of being heterozygote is related to having different chromosomes. If they are different, dominant character is involved in. Then appearance shows the feature of the dominant character. Thus, the child is curly-haired. There is no probability of being straight haired, you know.
>
> Let's say that we have an individual with a certain genotype. Does it mean that there will be a child having that genotype or the first child will have that genotype? No. We find types in there, we calculate the probability of the situation.

ST also connected genotype and phenotype concepts to ratio, percentage and probability concepts. She generally used the ratio of genotype and phenotype, and then connected them to the stated mathematics concepts. In 8/D class, she used this connection as in the following statement:

> When we say genotype, we will consider homozygote and heterozygote issues. If the genotype of the individuals obtained from crossing of two pure breeding is one kind, the genotype ratio is 1. In terms of the phenotypes, these individuals are curly haired, thus ratio is again 1. If we get its percentage, I mean, calculate the probability, we say the individuals are curly haired with 100% and heterozygote with 100%.

Another example, for connecting genotype and phenotype concepts to ratio, percentage, and probability concepts, was formed in 8/C class as given below:

> Here, we find the probability of these parents' children's hair types. If phenotype is one kind and we get its percentage, the ratio is 100%.
>
> We will say the first child is curly haired with …% probability or straight haired with …% probability. We will decide it from the phenotype and genotype ratios. Phenotype ratio was 3:1. If we transform it into percentage, the child will be curly haired with 75% probability and straight haired with 25% probability. The child is homozygote curly haired with 25% probability, heterozygote curly haired with 50% probability, and straight haired with 25% probability. The ratio is this. For the first, second and third child, the probability of having curly hair for all is 75%. This gives us the probability.

Another example for this type of connection was seen as from crossing to subjective probability. For example in 8/D, ST tried to explain students the subjective probability first by using a crossing example as in the following:

> If I say curly haired parents have curly haired baby with 100% probability, is it a type of probability? Is it my opinion, isn't it?

On the other hand, in 8/C and 8/B classes, ST explained the subjective probability by using subjective sentences although there were not any statements in the planning phase. She also did this by the help of the connection S-M. The explanations of ST in 8/C and 8/B classes were given respectively below:

> When we say probability, for instance I say that heterozygote curly haired parents' child has curly haired with the probability of 80%. According to who, I say this? Without doing something, if everybody says different sayings or estimates as 90%? Is this a probability? Yes. But I say this in my own way. For example in Turkish, we name these kinds of sentences as subjective sentences. The probability estimation is also subjective probability. If we estimate from the beginning, it is subjective.
>
> Let's think about the probability of homozygote curly haired mother's and heterozygote curly haired father's having straight haired child. In my opinion the probability is 0%, but it can also be 25%. If I say 50%, is there something we based on? We only estimate. Is that a kind of probability, what do you think? For

> example I say, the probability of having a rainy weather today is 0%, but another person say it's 70%. Is this a probability? There are objective and subjective opinions in Turkish. We name this probability as subjective probability.

ST connected crossing also with theoretical probability concept by using this type of connection after connecting the subjective probability. For example, in 8/C and 8/B she explained as in the following respectively.

> For example, when we consider the probability of heterozygote curly haired parents' child having curly hair, if we calculate this with crossing, it depends on an information or theory, and this probability depends on a theory, it becomes theoretical probability. Your mathematics teacher will also explain this again.

> Homozygote curly haired mother's and straight haired father's child have heterozygote curly haired genotype. The phenotype ratio is 1, and genotype ratio is 1. If we transform them in to percentage, both of them become 100%. Now we calculated the probability and it depends on a theory, Mendel's laws. We name this kind of probability as theoretical probability.

ST followed the order of subjective, theoretical, and experimental probability in her teaching as in the plans. She connected crossing to theoretical probability through the connection S-M in all classes. ST used three baby dolls and attached stickers to them in an activity and explained experimental probability in 8/C as in the following:

> If we calculate the probability that we find through crossing, by trying or help of an experiment, what is that? It is experimental probability. The mother's genotype is homozygote curly haired and the father's genotype is heterozygote curly haired. And this is their child. The child can take mother's curly and father's curly, mother's curly and father's straight, mother's curly and father's curly, and mother's curly and father's straight hair. Thus, the child can be homozygote curly haired, or heterozygote curly haired, or homozygote curly haired, or heterozygote curly haired. Did I say straight haired? No, the probability of having straight hair is 0%. This probability is experimental probability.

After completed explaining all types of probability, ST connected these types through connecting from crossing to the types in all classes. Although she did not state this connection in planning, she used it in her teaching. ST's same statement in 8/D and 8/B was given in the following:

> Okey then, let me ask a question. In terms of their hair types; what is the probability of homozygote curly haired mother's and heterozygote curly haired father's child having straight hair as percentage? Is the result that you will obtain subjective, theoretical, or experimental probability?

4.2.2.1.1.1.4.2 Connection mathematics to science (M-S)

Connection mathematics to science was identified when ST used integration by starting with mathematics and then connecting the situation to science context. ST used this connection at least once in all classes, although teachers did not plan the situations that indicated this connection. She used this connection generally in questions after the topic was completed. In only 8/C, ST used connection F-M-S while explaining the example situation as in the following statement:

> We transform the genotype ratio (3:1) into percentage, the child is curly haired with the probability of 75% and straight haired with the probability of 25%. And homozygote curly haired 25%, heterozygote curly haired 50%, and straight haired 25%. The ratio is this. All the children, first, second etc. have curly hair with the probability of 75%.

ST used the same form of questions with different context. While she used eye color in 8/C, she used hair style and form of pea in 8/A, and 8/B. These contexts that ST used were given below respectively in ST's statements:

> A family has nine brown-eyed and three green-eyed children. What kind genotypes the parents can have? What is the probability of obtaining green-eyed child in the options? For this question, we will consider this. The numbers are important here. We should obtain the ratio of 3 to 1 for brown and green-eyed. If Yy x Yy is crossed, we obtain the ratio. Thus Yy x Yy is the true genotypes. (8/C)
>
> According to a crossing result, 3000 circle peas and 1000 wrinkled peas were obtained. What can be the genotypes of the crossed individuals? The ratio of 3 to 1 should give an idea. Which genotypes' crossing gives us this ratio? We will think this. (8/A and 8/B)

4.2.2.1.1.1.4.3 Connection science to mathematics to science (S-M-S)

This type of connection includes three phases science to mathematics to science. For this, ST started with a situation related to science, then she connected it to a mathematical situation or concept. And then, she connected to a science related issue. This means that mathematical situation has a transitional mission in this connection type. ST preferred to use this type of connection in the last lessons of the classes. For example in 8/D, ST stressed the crossing rules through a situation, then she stated the phenotype and genotype ratios. After the ratios were given, she calculated the probability of obtaining a certain individual's feature. Then, she again showed all the individual's properties that would be obtained as a result of the crossing. Thus, three phases of this connection were applied. ST's explanation was given in the following:

> The crossing rules are these. The result shows us this. The children of pure breeding curly haired mother and straight haired father are the same kind in terms of hair style. That is, only one kind in terms of both phenotype and genotype. There is no another probability. That is, 1 means whole. When we transform it into percentage, all the children of them will be heterozygote curly haired with 100% probability. That means that even if they have 10 children, all of them will be heterozygote curly haired.

A question that was used in the other classes as a connection M-S, was explained in 8/D class by using a connection S-M-S. This may be because of two reasons. One of them might be that 8/D was the first class which the implementation of Plan1 was conducted, thus ST might have given more importance to make connection. The second reason might be the effort of ST to teach the plan in detail. The conversation indicating this connection in 8/D was given below:

> **ST:** As a result of peas with unknown genotypes, there are 3000 circle peas and 1000 wrinkled peas. Which of the following can be the genotypes of the crossed peas? Circle is dominant.
> a.SS x ss
> b.SS x SS
> c.Ss x ss
> d.Ss x Ss
> Which options do we eliminate first? a and b, why? We have wrinkled peas. Recessive character reveals if both mother and father have it. In these options they have no, thus we say it could not be. According to what will we interpret? Why did I give you these numbers?
> **Student:** To see the ratio.
> **ST:** Yes. What is the ratio? 3 dominant, 1 recessive. When does this situation occur?
> **Student:** When both of them are heterozygote.
> **ST:** Or, let's do with crossing. We eliminated A and B, since there is no recessive. If you know, you say directly. How many times? 3 times. When did we find 3 curly haired and 1 straight haired?
> **Student:** When both of them are heterozygote.
> **ST:** You will remember that ratio or you will cross. In Ss and ss, what is the ratio? 1 to 1 that means 2000 to 2000 should be. Do the d option. Ss and Ss, the ratio is 3 to 1. This is true option.

There were several situations similar to this conversation about the connection S-M-S in different examples stated in the other classes not different from 8/D.

4.2.2.1.1.2 Problems affecting the implementation of Plan1

Problems that were observed during the implementation were analyzed by the help of the literature about the barriers to integration. The encountered problems were identified as lack of content knowledge, trivializing content, and teaching related problems. Lack of content knowledge and teaching related problems were observed in all implementations of the plans. The problems were explained in the following respectively.

4.2.2.1.1.2.1 Lack of content knowledge

Through teaching the integrated Plan1, although ST was rather relaxed, problems related to content knowledge in mathematics were observed. ST stated several times at both planning and implementation processes that she always taught her lessons by using integration with mathematics. Thus, she believed that she wasn't a stranger to this process and it was easy for her. She also emphasized that she had sufficient mathematics knowledge to integrate and use in her teaching. During ST's teaching the integrated Plan1, she showed content knowledge deficiencies in mathematics topics many times. This problem was explained by examples from the classes during the implementation of Plan1 below.

ST used contradictory statements for the definition of subjective probability. For example, she described subjective probability by using a daily life concept, weather forecast. She frequently defined the subjective probability as "the probability which is up to me" instead of the probability which changed from person to person. This situation first took place in 8/D class. She continued to use the subjective probability in the same way in the other classes although she spoke with MT and he explained it again at breaks. ST's statement related to this situation was given below:

> **ST:** I say 'up to me', you can say 'it is not up to me'. For instance, there are clouds in the air, so I say that it is going to rain with 50% probability. Is there that kind of probability?
> **Student:** Yes, there is.
> **ST:** What is its name? We name it as subjective probability. We name the probability that is up to me as subjective probability.

Another content knowledge problem related to mathematics in ST's teaching was about definition of theoretical probability. She defined theoretical probability as the probability depending on a theory. Such explanations were observed in 8/D and 8/C. The explanations of ST in these classes were given below respectively:

> The result that we found with the help of crossing here is theoretical probability. We calculated the probability according to Mendel's rules. Since this probability depends on a theory, it is theoretical probability.
>
> If I calculate the probability that I said as subjective, with the help of crossing, if it depends on knowledge or a theory, then it becomes theoretical probability. If I say 80% according to 'in my opinion', then it is subjective probability. However, 75% that I calculated on the board is theoretical probability.

ST generally connected the new concepts with the concepts she taught before. For example, she tried to explain theoretical probability by reminding and connecting subjective probability. However, she used the same incorrect definition for subjective probability in 8/A by the following statement:

> What is the probability of homozygote curly haired mother and crossbreed curly haired father's children having straight hair as percentage? If I say, in my opinion, then it is subjective probability. If I calculate, then it is theoretical, isn't it?

Another controversial issue similar to this definition challenge occurred when ST tried to give the comparison of theoretical and experimental probability. She also had content knowledge problem for definition of the experimental probability. The example occurred in 8/A was given below:

> When tossing up, the probability of tails is theoretical probability. Supposing that you tossed up, it becomes experimental probability.

Different from the definitions of mathematical concepts, ST had some misusage of and confusing statements during integration. First, she generally used the probability as percentage and she asked the value of probability as percentage. An example for this situation was happened in 8/A as stated below:

> Let's say, mother is heterozygote curly haired and father is crossbreed curly haired. Evaluate all the probabilities. And tell me probability with percentage. 75% curly, 25% straight, 25% homozygote curly, 50% heterozygote curly, and 25% homozygote straight.

ST's use of probability as only the percentage of something caused several cases which could lead students to misconceptions and confusions related to mathematical concepts such as ratio, percentage and probability. She used the terms percentage, ratio, probability and kind with different combinations in several cases. She used percentage, ratio and probability in the same statement together in 8/C and 8/D classes as below:

> 25% probability means ratio of 3 to 1. When do we have this ratio? When we look to the options, we eliminate b and d options because to be straight haired, both of the characters have to include straight gene. b and d have no. What percentage of ratio will the others be?
>
> Now we found the ratio, let's say it as percentage. The whole contains four parts, how many corresponds to each part? 25. Then, we can say 75% curly haired and 25% straight haired. They will ask you like that. They will ask for example, the probability of the child's having straight hair. How will you find it? By the help of crossing you will find the ratio and get its percentage, ok?

ST used a combination of kind, probability, and percentage. In 8/D, she used this combination several times as given in her explanations below.

> We have found the genotypes of the children. Is there a probability of having straight haired child of this family? No. If there was, then we would find as a result of crossing. Since we found only heterozygote curly hair type, all children of the family have heterozygote curly hair. There is no another chance. The purpose of the crossing is that. We have to calculate probability in here. How many kinds of hair types can be? Only one. If we transform it into percentage, it means that all children of this family will be curly haired with 100% probability.
>
> The children's hair style of pure breeding curly haired mother and straight haired father is definitely one kind. It means that it is one kind in terms of phenotype and genotype. There is no other choice. I mean, one means the whole. When it is transfer into percentage, the children will be heterozygote curly haired with 100% probability.

ST used ratio, probability, kind and percentage in the same explanation inheritance context in 8/C and 8/D. The examples from 8/C and 8/D were given respectively in the following:

> We find here the probability of having hair style of this family's children. If the phenotype is only one kind and we transform it into percentage, the ratio is 100%. If two pure breeding are crossed, the children will be heterozygote curly haired with 100% probability. What does 100% probability mean? It means certain. They will definitely be curly haired but we say with probability.

> When we consider genotype we will look heterozygote or homozygote. If there is one kind of genotype in the crossing of two pure breeding, the genotype ratio is one. In terms of phenotype, these children will be curly haired, so the ratio is again one. When we transform this into percentage, that is, when we calculate the probability, we say they will be curly haired with 100% and heterozygote with 100%.

In addition to her usage of terms, ST stated the ratio as describing a "certain" situation. The example of this situation was given for 8/D class below:

> If the child could be straight haired, it would be in the crossing result. This ratio is certain. That is, if you find the ratio is one, the child is definitely 100% curly haired.

Another different usage of ST which indicated the content knowledge problem in mathematics was the use of ratio instead of probability in a question. Additionally, she used dependent probability although the teachers removed it from the objectives in planning phase. This situation happened in 8/B as in the following excerpt:

> What is the ratio of heterozygote brown-eyed parents' having blue-eyed son? Both father and mother is heterozygote. The child can have blue eye in the ratio of one fourth. And the child will be a boy. It is ½. Then, two in one, you will multiply them. We find 1/8. If it asks brown-eyed daughter, it will be 3/8. How do we name this? Is it compound hımm, no no. We name it as dependent probability.

ST did not explain the difference of usage of ratio in inheritance and in mathematics. There were ratios such as 1:2:1 in her statements about genotype and phenotype ratios, which were used in science concepts but not in mathematics concepts. The students did not know such a ratio in mathematics. Additionally, a student asked whether the order of the numbers was important or not in phenotype and genotype ratios. ST stated that it was not important, although she wrote the ratios according to the order of the individual properties in the crossing result. This issue happened in 8/D as below:

> **ST**: We saw that the child is straight haired or curly haired in phenotype. How many curly? 3. How many straight? 1. Then, we write 3:1. In genotype? We will look at how many homozygote curly haired, heterozygote curly haired and straight haired there are. We write according to this result as 1:2:1.
> **Student**: Is the order important?
> **ST**: No. If you do as I explained, it is better.

ST's lack of content knowledge caused lack of confidence in teaching mathematics concepts. In general, she was confident through the process as she stated in every situation. However, it appeared that she did not trust herself about dependent probability concept in 8/B as explained before. She was not sure about her explanation for the probability that whether it was compound or dependent. She looked for approval from the researcher and waited for a few minutes for approval although she taught her lessons quite fast. The researcher did not change her position and did not approve or disapprove ST's explanations. Then, ST moved on to another question quickly without clarifying.

4.2.2.1.1.2.2 Trivializing content

ST generally asked multiple choice questions about the topics with four options. This might be due to familiarizing students for the national examination for entrance in high schools. However, ST's use of the options without a preparation could affect the quality of the problem. While ST was teaching the integrated plan1, she used some explanations which were not related to the integrated concepts and the topics. She used options as in multiple choice questions, and irrelevant statements were revealed in the options that ST thought and said at that moment. For example, she asked a question that required an interpretation of crossing with probability in 8/D. One of the four options that ST presented to the students was the one that the students would not think about it and would eliminate directly since it was an irrelevant option. This question was given below:

> Parents with brown eyed had blue eyed child. How can you explain this situation?
> A) Parents confused the child with another in the hospital. We see every day in Turkey. (She is laughing.)
> B) Mother is pure breeding brown eyed.
> C) Father has recessive character.
> D) Mother and father are both heterozygote.

ST tried to explain the question by stressing in which condition a blue eye could be revealed through considering the probabilities. She stated that the first option should be directly eliminated. Thus, the first option had no important role for students' questioning the situation.

A similar situation happened in 8/C class in a similar question. For this question ST used two irrelevant options as 'The child was misplaced at the hospital' and 'The child was adopted.'

4.2.2.1.1.2.3 Teaching related problems

There were certain behaviors that ST had during her teaching which seemed to limit meaningful learning in the classroom. For example, it was observed that ST had pedagogical problem because of her speed of teaching. When she asked a question, she did not give sufficient time to students for inquiry. She answered the question immediately. An example for this was seen in 8/D class in the following question. She asked the question and let the students read carefully. Then, she explained the correct answer without waiting for the students' answers as below:

> The probability of having a blue eyed child of a mother with unknown genotype and heterozygote brown eyed father is 25%. Which of the following can be the mother's genotype? Read the question carefully.
> 1. AA
> 2. Aa
> 3. aa
>
> What is our criterion for obtaining recessive phenotype? Both mother and father have to recessive character.

ST sometimes ignored the students' questions since she thought that she explained before, although she did not. For example in 8/A, she did not answer the student's question as below:

> **Student:** I found the genotype ratio as 2:2, is it incorrect?
> **ST:** Write another question. We explained it before.

ST made sharp transitions from mathematics to science or vice versa. She did not make connection in a meaningful way between the concepts. For example in 8/D, after she explained the subjective probability, she moved on fast without any connection to crossing topic as in the following statement:

> We name this kind of probability as subjective probability. If we say 'in my opinion' it is called subjective probability. We made an introduction for crossing. We explained why we use it.

4.2.2.1.1.3 ST's evaluation of Plan1

ST stated that all the issues stated in SIMCI phase of Balance model was considered and reflected on the plan. ST had the idea that she used integration most of the time in her teaching for many years. She added that the implementation of Plan1 was the best form of the lesson she taught this topic up to now.

About the implementation, ST stated that all the points in planning was conducted in implementation successfully and as she expected. It was observed that she was comfortable during the teaching of Plan1. She expressed that her comfort depended on two reasons. She stated that science included mathematics and that she used integration continuously in her teaching.

ST also emphasized that students first heard probability types from her and this caught their attention to a mathematics topic. However, she remarked that students forgot everything fast thus, they would also forget both science and mathematics that she taught.

ST stated that she tried to teach the plan in each class in a similar way during the implementation of Plan1. However, she added that she made several mini changes in some classes such as increasing the number of questions and using more detailed questions according to understanding level of the class.

When the problems about implementation were asked, ST expressed that she hesitated about how to start the lesson in the first class and then, she found the solution by the help of a daily life context. She also stated that she did not reflect her hesitation to the students and handled it successfully. However, she was unaware of the problem related to dependent and independent events which were explained before in the influencing problems part. When whether this issue confused students' mind or not was asked to ST, she objected and claimed that the students understood clearly:

> Before the implementation we removed dependent/independent events from the plan with MT. I used it in the situation of the probability for having both blue-eyed

and daughter. Students understood the situation including the two at the same time easily.

ST claimed that she might not have sufficient knowledge about dependent and independent events and thus, she said she did not define these concepts during her teaching.

ST lastly suggested that by including objectives related to dependent and independent events, a new and more detailed plan could be prepared and implemented. However; she stressed that this was in MT's power and he should think this issue although she had the idea that it would be better.

4.2.2.1.2 Plan2 (Buoyancy- Ratio and Proportion)

Plan2 included buoyancy topic from 8th grade science curriculum and ratio-proportion topic from 7th grade mathematics curriculum. ST implemented this plan in four 8th grade classes for four lesson hours. The implementation was performed first in 8/C class. The summary of implementation with the order of implemented sections was given in Figure 4.2.

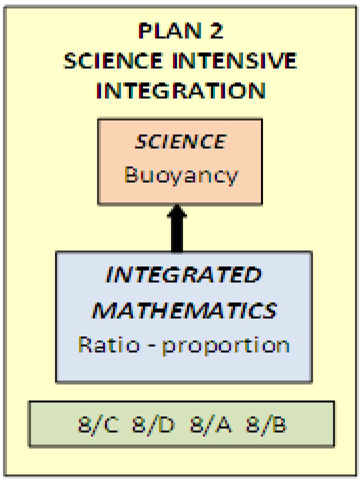

Figure 4.2 Implementation order of Plan2

ST implemented Plan2 in line with its planning. She followed the same order in all classes. There were no significant differences among classes in terms of ST's teaching from the first class to the last class. Since there were no difference, Plan2 was analyzed through 8/C which was the first class ST implemented Plan2 similar to the Plan1.

4.2.2.1.2.1 Critical issues in Plan2

Critical issues revealed in the planning phase of the Plan2 were considered while analyzing the implementation of Plan2. These issues were presented below.

4.2.2.1.2.1.1 Checking for students' prerequisite knowledge

As the teachers planned, ST started with science prerequisite knowledge control. She asked students first the meanings of gravity, weight, and mass in all classes. She also controlled balanced and unbalanced forces by asking how a pencil box stayed on the table. Then, she used the following statement:

> We name this situation with balanced and unbalanced forces, do you remember? You have learnt in 6th grade. We have to use all we learnt, you don't learn in vain.

Additionally, she controlled the definition of density and the unit of density. Although the teachers planned to control prerequisite knowledge for mathematics, she did not control for prerequisite knowledge of ratio and proportion concepts.

4.2.2.1.2.1.2 Integration for reminding previous/recent concepts

ST used many times reminding purpose while teaching buoyancy. She explained the factors that affected buoyancy and the relation among them with the help of direct and inverse proportions. ST first mentioned the proportion concept while she was trying to explain the factors affecting the buoyancy. She tried to remind to students direct proportion as they learned in previous classes:

> As density of the fluid increases the buoyancy increases. In other words, the more density of a fluid, the more buoyancy reveals. So, how do they change each other? How proportional they change?

Another situation about ST's reminding purpose for integration was for volume concept. She took a rectangular prism object and divided it into three parts with a board marker. Then, she asked why she did this for. The explanation of ST was given below:

> **ST:** We have three different fluids with the densities as respectively d, 2d, 3d. And we have this object and I separated it into three parts. Why do you think I separated? What do you think I want to do (by separating)?
> **Student:** We will put it into the fluid.
> **ST:** I separated into volumes because I want to state how much of this object will sink into fluid. That is, I divided covered area into three equal parts.

While ST was explaining the relation among buoyancy, volume of the immersed part of the body in the fluid and density of the fluid, she used reminding purpose for integration. She first explained the volume of the immersed part of the body in the fluid and its symbol and then, she asked how buoyancy, the volume of the immersed part of the body in the fluid and density of the fluid would change with the help of direct and inverse proportions. The following conversation indicated this issue:

> **ST:** How do we symbolize buoyancy? F_B. What is the immersed part of the body in the fluid? We show the whole volume with V. The covered area of this stone is volume. Volume of the immersed part of the body in the fluid is shown as V_I. How do F_B and V_I change? I mean, as volume of the immersed part of the body increases?
> **Student:** With direct proportion.
> **ST:** Buoyancy increases. They change with direct proportion. You know, the magnitudes changes with direct proportion. When a magnitude increases, the other one increases or when a magnitude decreases, the other one decreases. And how do F_B and d_F change?
> **Student:** With direct proportion.
> **ST:** Yes, as the density of the fluid increases F_B increases, they change with direct proportion. What about d_F and V_I?
> **Student:** Decreases. With inverse proportion.**ST:** Yes, they change with inverse proportion. The reason for using direct and inverse proportion is that; soon I will give you the formula of the F_B that is force to the object by the fluid. Then you will make interpretations.

ST also used integration for reminding purpose after giving the formula of $F_{B.}$ She again emphasized the direct and inverse proportions for explaining the formula. By the help of a question including two objects with equal volumes of the immersed parts in two different fluids, she wanted to compare the magnitudes of the buoyancies. Her explanation about interpretation of the formula of F_B was given below:

ST: You will not consider volumes of the immersed parts, because they are equal. F_B and d_F have direct proportion. It means that if the density of the fluid is bigger it applies bigger $F_{B.}$ So, $F_{Bx} < F_{By.}$ Exactly we interpret through formula; we use direct and indirect proportions. Direct proportion means if one is bigger the other is bigger, and if one is smaller the other is smaller. Inverse proportion means if one is bigger the other is smaller. Do you remember this?
Student: Yes.
ST: The matters are different but volumes of the immersed parts are equal. If both are equal, we will close V_I s in the formula. We will look F_B and $d_{F.}$ They both change with direct proportion, thus we say the fluid which has bigger density applies bigger $F_{B.}$

Another reminding purpose for integration used by ST was about density concept. Density concept was used before in both mathematics and science courses in the previous grades. Thus, there was a reminding purpose of density concept definition and its formula. ST first explained the meaning, formula, and unit of density. After this explanation, she gave an example that aimed to calculate the density. The following excerpt of ST indicated this reminding purpose:

The mass of a matter for a unit volume is called as density. If there are the less granules, it means that matter is less dense. Density depends on mass and volume. We need whole volume for calculating density. That is, you divide mass to volume for density in order to find the mass in unit volume. For example, if a matter has 200gr mass and 50 cm^3 volume, its density is 200/50, 4 gr/cm^3. You divide gr to cm^3, thus the unit of density is gr/cm^3.

The last reminding issue was about the volume of geometric shapes. ST controlled the students' knowledge about geometric shapes and reminded how to find the volume of regular geometric shapes. The conversation between ST and students was given below:

ST: Do you know what this is?
Student: Cylinder.
ST: Can you calculate its volume?
Student: Yes.
ST: You learnt in mathematics. How?
Student: Base area.
ST: Area of circular region multiply with?
Student: Radius.
ST:?
Student: Height.

ST: Yes. You calculate the volume. The thing we named volume is covered area, it means the complete covered area of this. Do you know its volume? (showing a cone)
Student: We can calculate.
ST: You have not learnt yet. But you will this year. Can you find the volume of this cube?
Student: Yes.**ST:** These are regular shapes, regular geometric shapes. Thus, we can calculate their volume.

4.2.2.1.2.1.3 Integration for introducing the new topic/concept/procedure

As in Plan1, ST used integration for introducing purpose in Plan2. However, in this plan ST did not exactly use integration for introducing a new mathematical concept. Instead, she tried to introduce a new easy way for answering multiple choice examination questions correctly about the buoyancy topic. As she stated in the planning phase of Plan2, she first explained the relation among buoyancy, volume of the immersed part of the body in the fluid and density of the fluid, then she constructed the formula of buoyancy. While she constructed the formula, she used her previous explanations about direct and inverse proportions for the factors that influenced buoyancy. Her explanation about this issue was given below:

ST: For instance I want to calculate the buoyancy for this stone in the water. But I have no dynamometer. If I had, I could say the approximate value. Now, how can I calculate? For this I have to use a formula. My formula is that; F_B and V_I had direct proportion, we write $F_B=V_I$. Then, we close V_I and we ignore it. F_B and d_F also had direct proportion, so we write here $F_B=V_I\ d_F$. And finally gravity acceleration also has direct proportion with F_B. So we write the same place as $F_B=V_I\ d_F\ g$. However, V_I and d_F were inversely proportional. I tell you since 6^{th} grade that the formulas are important in direct and inverse proportions. You should put equal sign between magnitudes which are directly proportional. What about magnitudes which are inversely proportional?
Student: > < signs.
ST: If I will make computation here?
Student: Multiplication sign.
ST: Yes. We will multiply these $V_I\ d_F\ g$. And the formula of F_B is $F_B=V_I \times d_F \times g$. We have formed the formula.

The other issue that ST used introducing for integration was about volume of irregular shaped objects. She first asked students how an irregularly shaped object's volume could be calculated. Then, she explained as in the following conversation:

> **ST:** We can calculate the volume of regular geometric shapes mathematically. If the object is irregularly shaped, for example this stone, how will we calculate its volume? You cannot say base area multiply height. What do you think?
> **Student:** First we measure the volume of the water, then we put the stone into water.
> **ST:** The water level increases and we find the volume of the stone. Your friend says that we take a measuring glass and put some water into the glass. Then, we out the object in to the glass. We look how much the water level increased. The difference of water level gives us the volume of the irregularly shaped object.

4.2.2.1.2.1.4 Integration for explaining topics/concepts by connecting mathematics and science

In the planning of Plan2, the teachers had used two connection types as science to mathematics and mathematics to science. However, during the implementation, ST also used a third connection type as science to mathematics to science. These connections were explained in the following respectively.

4.2.2.1.2.1.4.1 Connection science to mathematics (S-M)

ST used this type of connection in both her plans and teaching many times. She generally first explained a science situation, such as the factors that affected buoyancy, and then, connected it to a mathematical expression or concept, such as proportion, in the Plan2. While she was explaining the relation between density of fluid and buoyancy, she used the following statement:

> The more a fluid has density, the more it applies buoyancy. So, how they change each other? How proportionally they change?

Similarly, ST used the same way for the relation between F_B and V_I , and V_I and d_F as in the following statement:

> How F_B and V_I change each other? As volume of the immersed part increases buoyancy increases. They change direct proportionally. What happens to V_I when d_F increases? It decreases, they change inverse proportionally.

ST also used science to mathematics connection when she explained the formula for buoyancy. She first explained the factors that affected buoyancy with the help of proportion and then, she constructed the formula via proportion. The following statement of ST indicated this type of connection.

> How much buoyancy is applied to this stone by the fluid? To find, I use formula. The formula is that; F_B is buoyancy applied to the object by the fluid, and it is directly proportional with $V_{I.}$ $F_{B=}V_{I.}$ (She closed $V_{I.}$) by ignoring this F_B is directly proportional with $d_{F.}$ $F_{B=}V_I$ $d_{F.}$ And F_B is directly proportional with gravity acceleration g. $F_{B=}V_I$ d_F g. However, V_I and d_F have inverse proportion.

4.2.2.1.2.1.4.2 Connection mathematics to science (M-S)

As in the planning phase, ST used connection M-S in her teaching twice. One of them was about the interpretation of buoyancy formula and the second one was about the volume of irregularly shaped objects. For example, for the interpretation of buoyancy formula, ST stated the following through this connection.

> You will focus on the formula. When the question comes, write the formula. We always ignore gravity acceleration, since it is equal in everywhere. If V_I s are equal, you will close it. We will think the magnitudes which are direct and which are inversely proportional. What does it mean? For instance, if the density of fluids is bigger buoyancy is bigger.

4.2.2.1.2.1.4.3 Connection science to mathematics to science (S-M-S)

ST used the connection S-M-S, although the teachers did not state this connection in the planning. After completing the explanations of key concepts especially for the questions, she summarized the issue through this type of connection. ST's explanation about a question, including a comparison of buoyancies, was given below:

> You will decide by looking at volumes of the immersed part. The fluids and densities are the same. So we close density on the formula. To what should we focus on? Volumes of the immersed parts and buoyancies. How do they change? Direct proportional. If the volume of the immersed part is more, it will apply more buoyancies. The meaning of having less volume of the immersed part is less buoyancy.

4.2.2.1.2.2 Problems affecting the implementation of Plan2

During the implementation of Plan2, problems that affected integrated teaching process were observed. These problems were explained in the following respectively.

4.2.2.1.2.2.1 Lack of content knowledge

ST experienced content knowledge problems related to mathematics concepts during her teaching of Plan2. One of the problems was about volume concept. While she was explaining volume, she stated that volume was an object's covered area as in the following statement:

> In order to determine how much of this object in in the water, I separated it into volumes. That is I divided its covered area in to three parts.

Another statement of ST about volume concept which she explained volume as covered area was seen below:

> **ST:** You will calculate the volume with the help of height of the object. The thing which we called as volume is covered area that is the whole area of this object. Can you calculate the volume of this object (a cone)?
> **Student:** Yes.
> **ST:** You have not learnt yet, but you will.

The last content knowledge deficiency of ST was related to how to find the volume of sphere. On a student's question about how to calculate the volume of circular region, ST corrected and asked if it was sphere. However, ST stated that she forgot the formula of the volume of the sphere. The conversation between the student and ST was given below:

> **Student:** Is the volume of circular region calculated?
> **ST:** Volume of sphere?
> **Student:** Yes.
> **ST:** Yes we can do, but I forgot how to calculate, forgot the formula.

4.2.2.1.2.2.2 Teaching related problems

Besides content knowledge problem, ST showed pedagogical knowledge problems during her teaching. ST generally used questioning in all her lessons as stated in the pre-study findings. However, her questions sometimes indicated a leading format and contained hint about the answer for the students. This situation did not give opportunities for students' inquiry. The following statement of ST indicated this situation:

> The more a fluid is dense, the more it applies buoyancy. I mean how they change? How proportionally they change?

ST also used leading question in explaining the buoyant formula. The explanation was given below:

> What does the inverse proportional change in buoyancy? What are the magnitudes which change by inverse proportional?

Another example for ST's pedagogical problem was about leading students to rote learning. She formed the buoyancy formula on the board; however, she did not make detailed explanation about why she put multiplication or equal sign between magnitudes. Since she generally moved through the topics fast and students could not think and ask about this situation. There were also leading questions in her explanations in this topic:

> **ST:** In order to find how much buoyancy is applied to this stone without a dynamometer, we use a formula. For forming the formula we use again direct and inverse proportions that we mentioned before. I always say you that formulas are important in direct and inverse proportions. We put equal sign between magnitudes which are directly proportional. Which sign should we put between magnitudes which are inversely proportional?
> **Student:** > < signs.
> **ST:** If I will calculate something here?
> **Students:** Multiplication.
> **ST:** Yes, correct. We multiply these V_I x d_F x g.

Similar to the Plan1, ST sometimes gave some rules that she accepted as a true in Plan2. She gave the questions in multiple choice format and she gave four options. While students were trying to understand and answer the question, she led them with some rules that would come up with a solution. An example of ST's leading was given below:

> I told you in 7th grade. If you confuse the options, you should select the highest or the lowest option. Between the two will not be the correct answer. Your friend said in the middle. It is not correct. Be careful while answering the questions, ok?

4.2.2.1.2.3 ST's evaluation of Plan2

Similar to Plan1, ST was happy about the implementation process of Plan2. She expressed that the plan reflected on her teaching in accordance with SIMCI phase of Balance model. ST stated that the plan was implemented successfully. Additionally, she claimed that the implementation had a positive effect on students' understanding and interpreting buoyancy by the help of proportion. She noted that students both explained the relation between magnitudes with direct and inverse proportional, and they used proportion by interpreting in science questions.

In terms of implementation differences among classes, ST was sure that there were no differences among classes. She stated that she taught the plan as the same in plan in all classes with same questions. Additionally, she stressed that she was very comfortable about teaching the plan and again mentioned that she was no stranger to proportion topic as to probability in Plan1. Moreover, she remarked that since students had learned ratio and proportion in 7th grade, they had no difficulty in remembering proportion and understanding buoyancy although it was a difficult topic.

About the problems about the implementation, ST stressed that there were no hesitation and problem related to her teaching. She also added that the plan and implementation were the best she taught up to now.

ST explained her ideas about the effect of the questions including proportion on students' understanding with the following sentences:

> The students knew what the direct and inverse proportions were, so their knowledge was sufficient. This situation was also effective in interpretation of science. Especially in the buoyant formula, equal and multiplication signs between magnitudes were important for me. This made it easier for students to understand the subject.

When suggestions to make better the plan were asked to ST, she had no suggestion because she believed that this was a perfect plan and teaching. She stated that she would not change anything if she implemented again by the explanation below:

> The questions that I asked in the lessons included paired comparisons of buoyancy, volume and density when one of them was given equal. My purpose here was to help students to have the idea strongly. If I implement again, I use the same questions.

Finally, ST indicated awareness about students' prerequisite knowledge about proportion. She compared the students' prerequisite knowledge of proportion with probability types in Plan1, and she stated that Plan2 was implemented easier than Plan1 since the students learnt the probability types first during the implementation of Plan1 and had no idea about them before in Plan1.

4.2.2.1.3 Plan3 (Heat and Temperature- Line Graph)

Plan3 included Heat and Temperature unit from 8th grade science curriculum and Graphs topic from 7th grade mathematics curriculum. ST implemented this plan in four 8th grade classes for two lesson hours. Plan3 was implemented first in 8/B class. The summary of implementation with the order of implemented sections is given in Figure 4.3.

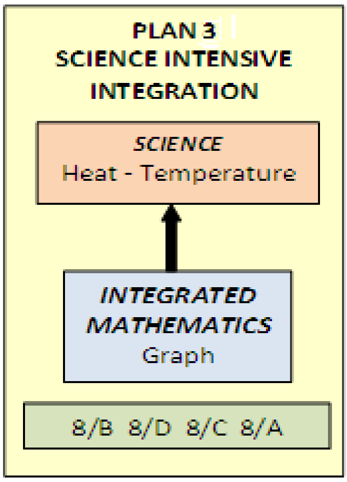

Figure 4.3 Implementation order of Plan3

ST implemented Plan3 in line with its design. She followed the same order in all classes. There were no significant differences among classes in terms of ST's teaching from the first class to the last class. Plan3 was analyzed through ST's teaching in 8/B since it was the first class she taught. The different situations occurred in the other classes were also indicated.

4.2.2.1.3.1 Critical issues in Plan3

As in both Plan1 and Plan2, implementation of Plan3 was analyzed by the help of critical issues considered in planning process. The critical issues revealed in implementation were given respectively below.

4.2.2.1.3.1.1 Checking for students' prerequisite knowledge

In the implementation of the Plan3, ST checked only students' mathematics prerequisite knowledge about graphs. She first explained the situation of the need for graphs by the help of science examples and wanted students to say 'graphs' by the following explanation:

> **ST:** While we are conducting an experiment or your observations can fill many pages while you are conducting an experiment in science. It can continue 3, 5 even ten pages. But you have to see the results clearly. How do you see the results of all observations clearly and in one? You did all the observations. You gave heat and the temperature has changed from -10 to -5 and then 0 degree. Or you got longer as years passed, for instance your height increased 2cm between these years. For these 10 years for example, where do you observe these results clearly?
> **Student:** In tables.
> **Student:** In graphs.
> **ST:** Yes, in graphs.

ST also checked students' knowledge about the reason of the need of using graphs. The conversation between ST and the students were given below:

> **ST:** Why do we use graphs in science?
> **Student:** To make interpretation.
> **ST:** Why are graphs necessary?
> **Student:** To see clear and correct.
> **ST:** To interpret clear, correct and in one we use graphs. I think you learnt graphs in 7^{th} grades.
> **Student:** In the 6^{th} grade.

ST: Ok. When you see a graph, what kind of results do you reach about it? About what do the graphs inform you?
Student: Increase or decrease of something.
ST: According to each other, isn't it? Actually graphs explain the relation among variables.

After ST explained the reason of the need for using graphs, she controlled students' knowledge of graph types. She asked what kinds of graphs they use in both science and mathematics, and in their daily lives. The conversation between ST and the students below indicated this issue:

ST: How many graphs do you know? In our daily lives or mathematics and science lessons?
Student: 2
ST: What are they?
Student: Bar and line.
ST: In recent times?
Student: Pie chart.
ST: Yes. For example, where pie charts are mostly used recently?
Student: In elections.
ST: It is preferred to explain the vote rate. We think that whose part (on the pie chart) is bigger, they win.

4.2.2.1.3.1.2 Integration for reminding previous/recent concepts

ST used integration by the purpose of reminding in Plan3 several times. Since the plan was prepared in line with the integration of line graphs, she first reminded interpretation of line graphs in heat context related to science. And she also connected the graphs to pressure topic of science from 7th grade. She reminded students that they used the previous year's hyperbolic lines in pressure topic. To indicate the issue clearly, the following conversation was given:

ST: How do we interpret line graphs? For example, if it goes to above?
Student: Increases.
Student: Its heat is increasing.
ST: If it goes to below?
Student: Decreases.
ST: It means that while one is increasing, the other is decreasing. What if it goes straight?
Student: It changes phase.
ST: It means that while one is increasing, the other is stable. We used this in pressure topic, do you remember? There were hyperbolic lines and curves instead of straight lines. For what did we use them?
Student: To see increase of pressure.

ST: How?
Student: It changes according to the surface of the container.
ST: Yes.

Another reminding purpose of ST was observed about constructing line graphs. She reminded how to draw a line graph in the context of temperature-time by questioning and explaining the procedure. She explained forming line graph as in the following:

> **ST:** Now we will convey the table to the line graph. What is the drawing strategy we use while drawing line graph?
> **Student:** First we write things starting with (-) to the corners. We write -20, 0.
> **ST:** We form the horizontal and vertical axes. What do we determine on these axes?
> **Student:** Temperature. We mark the temperatures with points.
> **ST:** We determine variables. It is important because you perceive how quantities change. You will decide by looking at the sides, what are the names of these sides? Is this graph enough for this table?
> **Student:** We have not put the numbers yet.
> **ST:** Okey. (She wrote 2, 4, 6, 8 to the time axis.) You should give equal intervals between the numbers. It is hard for me on the board. Is the graph finished?
> **Student:** No, we will place temperature values.
> **ST:** Temperature values start with -20.
> **Student:** We should write (-) values.
> We should take down some more y column because there are (-) values. It starts with -20, then go 0, 20, 40, 60 and 80. You put these values on the graph. Now we pass to draw. I think it is not necessary to explain how to draw lines. What will we do? It is -20 at the beginning. Where will we start to draw? (She put a point at -20.) At the second minute, it is 0 degree (She marked 0 degree). At the fourth minute, 20 degree. At the sixth minute, 40 degree. At the eighth minute, still 40 degree. At the tenth minute, 60 degree. And at the twelfth minute, 80 degree. If you take the intervals equal, it will be straight. On the board I could not do better. Lastly fourteenth minute, it will be still 80. How will I draw the graph?
> **Student:** Combine.
> **ST:** I will combine in lines. This line should be a straight line. Yes, here it remains stable and increases and then again it is stable.

ST used reminding for warning the students about interpretation of the graph besides drawing the graph. She especially paid attention to the inclination of the lines while interpreting the situation. She also stressed the equality of the interval for reminding. An example for this was given below:

> We have talked about what we take into account while drawing graph or interpreting the graphs. What will we consider specifically? There were phase changes in the lines remaining stable. For example, if there were two phase changes, we should consider in which phase the matter was at the beginning and what the phase change temperatures were.

4.2.2.1.3.1.3 Integration for introducing the new topic/concept/procedure

Different from both Plan1 and Plan2, ST did not use introducing purpose for integration in Plan3. This situation could be due to the selected mathematics topic, the graphs. She especially focused on line graphs through planning and implementation. Since the students learnt graphs from 5th grades to 8th grade each year, ST did not teach a new concept or issue for the students. There was mostly reminding purpose instead of introducing. Thus, any introducing purpose was observed for Plan3.

4.2.2.1.3.1.4 Integration for explaining topics/concepts by connecting mathematics and science

Similar to the planning process of Plan3, the implementation of Plan3 revealed two types of connection. ST used science to mathematics and mathematics to science with equal dense. These connection types revealed in Plan3 were explained below.

4.2.2.1.3.1.4.1 Connection science to mathematics (S-M)

ST's teaching indicated the connection S-M in two different situations. This connection type was seen in interpretation of line graphs and drawing line graphs.

ST used connection S-M in interpretation of line graph. She gave a line graph of a matter with two phase changes. Then she asked questions that required interpretation of temperature-time graph to the students about melting, freezing, and boiling temperatures. She first posed questions such as what the melting points of the matter was, and then she led students to interpret the graph and answer the questions. The following conversation illustrated this situation:

> **ST:** We see that the matter has two phase changes, how do we decide this?
> **Student:** From stable line.
> **ST:** From the point that temperature remains stable. We say that temperature points stable in graphs are phase change points. What is the melting point of this matter?
> **Student:** 40 degrees.
> **ST:** Boiling point?
> **Student:** 80 degree.

Another situation that ST's use of connection S-M was about a comparison of two heating graphs. ST drew two graphs and asked students whether these two graphs belonged to the same matter. Then, she remarked understanding of the graphs and deciding the answer of the question as given below:

> **ST:** Where do you consider in order to understand whether these graphs belong to the same matter?
> **Student:** At the melting temperature.
> **ST:** To the phase change temperature. If their phase change temperatures are equal, these matters can be same matters. So, what is the difference between these graphs?
> **Student:** Temperature and time. Their times are different.
> **ST:** Rating is different. Does it affect the result?
> **Student:** No.

ST's use of connection S-M was also observed in drawing line graph for heating and cooling situations of matters. For example, ST wanted students to draw temperature change of some water from 45 degree to -15 degree for cooling graph. The following explanations of ST showed use of the connection S-M.

> **ST:** We will start from 45 degree and reach to -15 degree. But before -15 what will we do? You will come to 0 degree and there will be phase change from liquid to solid. Then you will go to -15 degree.
> **Student:** What if we pull the line vertically?
> **ST:** No, you should not because it decreases by the time gradually. It becomes -10 etc. We should show this decrease. Your friend asks why we did not draw a vertical line above. But it does not increase suddenly to that degree. For example, if it will increase, it becomes 100, 101, and 102 gradually. It will not become 110 degree suddenly.

4.2.2.1.3.1.4.2 Connection mathematics to science (M-S)

ST also used connection M-S in teaching Plan3. Connection M-S was observed several times in ST's teaching about interpretation of the given heating or cooling graphs. The most distinct examples were given related to the connection M-S in interpretation of graphs. For example, ST questioned the situation of the line in graph and named the graph for whether it was heating or cooling as in the following:

> **ST:** Now, the line have to be straight. Here it remained stable, then increased and then again increased. Is it a heating or cooling graph?
> **Student:** Heating.
> **ST:** Why?

> **Student:** Because the temperature increased.
> **ST:** Yes. If it increases, it is heating graph.

Another example about interpretation of graph indicating connection M-S included sequential questions about the phase of the matter as below:

> **ST:** In which phase is this matter between zero and sixth minutes?
> **Student:** Solid.
> **ST:** Between sixth and eighth minutes?
> **Student:** Fluid, solid-fluid.
> **ST:** Solid-fluid because the matter is melting, so it is solid-fluid. Between eighth and twelfth minutes?
> **Student:** Fluid.
> **ST:** Between twelfth and fourteenth minutes?
> **Student:** Fluid-gas.
> **ST:** We say fluid-gas.

When ST asked students for a graph whether it was a heating or cooling graph, students could not decide. Then, ST first explained the graph and then reached the result of heating graph as in the following explanation.

> The temperature decreases from 100 to -10 degree. Starting point of the graph goes from above to below. Time starts from here and as the time goes the graph decreases to the below. So this is a cooling graph.

4.2.2.1.3.2 Problems affecting the implementation of Plan3

ST's teaching was influenced by several problems. These problems were similar to Plan1 and Plan2. Lack of content knowledge and teaching related problems were observed during the implementation of Plan3. These problems were explained below respectively.

4.2.2.1.3.2.1 Lack of content knowledge

ST had lack of content knowledge in explaining the interpretation of line graph. She asked how to interpret line graph by using leading questions in the context of heat-temperature. Her explanations were mostly indicating science content and lack of mathematical language. She did not need to stress the magnitudes on vertical and horizontal axes for the interpretation of the graph. She generally used "straight lines" in her expressions. There were ambiguities about what was increasing or decreasing in the interpretations. In this explanation, she also wanted to remind students "hyperbolic" concept which was used for pressure topic in the previous year. Here she emphasized using "hyperbolic lines and curves" instead of "straight lines". This explanation did not continue and was completed with ST's question. She continued with a different question after this. The conversation between students and ST that indicated these situations were given below:

> **ST:** How do you interpret a line graph? If the line goes up?
> **Student:** Increases.
> **Student:** The heat increases.
> **ST:** If it goes down?
> **Student:** Decreases.
> **ST:** It means that while one is increasing the other is decreasing. If it stays straight?
> **Student:** It is changing phase.
> **ST:** It means that while a magnitude is increasing the other one is not changing. Do you remember what we have used in pressure subject? We have used hyperbolic lines curves instead of straight lines. For what did we use them?

There was another explanation of ST which indicated her content knowledge problem and might reveal a misconception for students. After she explained the heating curves, she asked cooling curves' interpretation superficially and she again did not mention both the variables on the axes as in the following conversation:

> **ST:** What will be if the graph is a cooling graph?
> **Student**: It will go down.
> **ST:** The lines will go down. Because the temperature values will decrease.

A confidence problem related to ST's lack of content knowledge was revealed during her teaching while she was explaining a question requiring comparison of two heating graphs. The aim of the question was to make students notice whether those graphs belonged to the same substance by focusing the phase change temperatures. ST stated that those were the same substances; however, she had difficulty and could not be sure about explaining what kind of differences there were between the graphs. The following conversation indicated ST's hesitation:

> **ST:** If these substances' phase change temperatures are equal, they can be the same substances. So, what is the difference between the two graphs?
> **Student:** Temperature and time. I mean, their time is different.
> **ST:** The rating is different. Does it affect the result?

> **Student:** No.
> **ST:** No, it does not. I am not sure but I think it makes a difference on the inclination of the drawing. But we say they belong to the same substance.

4.2.2.1.3.2.2 Teaching related problems

As stated in content knowledge problem she had problems related to using mathematical language in her teaching. In addition to this, she acted as if all the students knew well how to draw a graph. She did not attempt to control whether the students knew drawing graph in practice or not. However, there were students that could not draw line graph correctly in the following lessons. ST's explanation about this was given below:

> Now you have processed the data on the graph, then we pass to drawing. I think it is not necessary to explain how to draw a graph to you.

4.2.2.1.3.3 ST's evaluation of Plan3

ST was sure that they prepared Plan3 with MT correctly and she implemented it correctly. She stated that the plan was appropriate for students' readiness levels. In addition to these she stressed that the students had sufficient knowledge about the graphs and they had no difficulty to use this knowledge in "heat-temperature" subject.

ST stated that she implemented the Plan3 by staying with the planning in line with the SIMCI phase of the Balance model. She claimed that the connections between science and mathematics were applied nested and successfully. About the mathematics objectives in the plan, ST stressed that the students had already known the graphs and she only reminded them during her teaching. Additionally, she stated that she handled all the objectives determined in planning completely.

There were minor differences among classes in which Plan3 was implemented. ST stated that she controlled the students' prerequisite knowledge by the same way in all classes. However, about the question which required to compare two graph and interpret whether they belonged to the same substance, she said that the questions she used were somehow different in 8/A and 8/D classes. She stated that while she interpreted the graphs by herself in these classes, the students did in the other classes. Additionally, she considered that she used fewer questions in 8/D than the other classes. However, she emphasized that it would be no problem because 8/D was a hardworking class.

Similar to the previous plans, ST stated that she had no hesitation about the quality of the implementation. She stated that the students had known graphs in the previous years and for this reason this topic was easy for her. She added that although she always stressed the interpretation of the graphs, she did not mention about graph types last year in this unit. Thus, this was the first time that she explained graph types.

About the questions that she used related to interpretation of line graphs, ST expressed that the students gained an awareness of interpreting the graphs. She stated that after this lesson, if she was a student she would remember phase change when she saw a straight line on a line graph in mathematics lessons.

ST believed that the plan was well implemented. When she was asked whether she had a suggestion to improve the plan, she emphasized that she focused on line graph in her teaching, but other graph types could also be used in plan in addition to line graph. She stated that recently, for instance, bar graphs were frequently used in science. Thus, bar graphs could also be another option for integration.

When ST compared the implementation of the plans which were prepared based on SIMCI phase of the Balance model, she stated that the implementation of Plan3 approached to “total integration” since all the objectives were performed. She explained that all the three plans were well prepared and she had no difficulty in implementation of them although they included different subjects. Moreover, she added that she had already tried to use and by the help of these plans she dwelled upon those mathematics subjects deeply. ST also reminded the limitations about mathematics in science curriculum. She stressed that the curriculum makers should explain how to teach those subjects without the help of mathematics to the science teachers. She stated that for this reason she did not take these limitations into consideration during her teaching. ST also emphasized her teaching experience and this experience showed mathematics was necessary for science teaching. Another reason of ST's ignorance of the limitation was that there was lack of trust for the examination system which was prepared by MoNE. She stated that there were always surprises about the question types thus she taught also by using mathematics.

4.2.2.2 Integrated mathematics plans

After the preparation phase of the plans, MT implemented Plan4 (Probability-Inheritance), and Plan5 (Volume of geometric objects-Buoyancy) planned in line with MISCI phase of the Balance Model, respectively in four 8th grade classes. Each plan was examined respectively below.

4.2.2.2.1 Plan4 (Probability-Inheritance)

Plan4 included probability and inheritance topics from 8th grade mathematics and science curricula. Plan1 which was implemented by ST had included the same topics, probability and inheritance. Since ST implemented Plan1 before MT, the students were familiar with the Mendel's rules and probability types (subjective, theoretical and experimental). MT implemented this plan in four 8th grade classes for four lesson hours. Plan4 was first implemented in 8/B class. Since MT followed the plan regularly in all classes and implemented the plan in a similar way in other classes, examination of the plan was performed through 8/B class. The summary of implementation with the order of implemented sections is given in Figure 4.4.

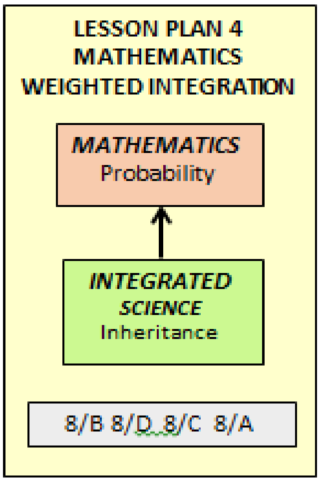

Figure 4.4 Implementation order of Plan4

4.2.2.2.1.1 Critical issues in Plan4

In this part, critical issues revealed in the implementation of Plan4 were given in order to understand how MT implemented the plan. Critical issues revealed in planning phase of the Plan4 provided a basis while analyzing the implementation of Plan4.

4.2.2.2.1.1.1 Checking for students' prerequisite knowledge

MT started the lesson as planned by checking the students' prerequisite knowledge about inheritance. However, his checking of science prerequisite knowledge remained only with asking questions. He repeated students' answers and responded questions with another question. He did not attempt to make detailed explanations related to science concepts. The following conversation indicated MT's controlling science prerequisite knowledge:

> **MT:** What might be the reason for different appearance of family members or the variety of family members' appearance?
> **Student:** Crossing over.
> **MT:** What is crossing over? Does it mean to go across the street? (He is laughing)
> **Student:** Part replacement.
> **MT:** Part replacement, hımm what else?
> **Student:** Meiosis.
> **MT:** What else, which terms can you mention?

Student: Each person has different DNA sequence. Because he/she takes one from mother, one from father, it is different for each person.
MT: What else it depends on, why?
Student: Probability.
MT: You say probability.
Student: Adaptation, mutation.
MT: Yes, what did your friends mention about? Crossing over, meiosis, DNA, gene. Even there are friends who said mutation. Now, another question.

On the other hand, MT controlled students' mathematics prerequisite knowledge in more detail. His gave some examples about probability while checking. The following conversation between MT and the students illustrated this situation:

MT: Probability. You have learned to calculate probability when you were at 6^{th} grade. You know probability.
Student: Yes.
MT: You can calculate the probability of obtaining heads, when you toss a coin. 50%.
Student: Weather conditions.
MT: Yes, weather conditions. For example, it may rain today. If I ask what the probability of this is?
Student: 50%. It is sunny or rainy. One of the two.
MT: Ayşe what do you think?
Student: Sunny, rainy, snowy, hail. Thus 25%.
MT: All your responses are different as you see. Did you hear probability types, what are they? Say without looking to your notebooks.

4.2.2.2.1.1.2 Integration for reminding previous/recent concepts

In planning of Plan4, MT decided to remind both science and mathematics concepts for integration. In implementation of the plan, first he tried to remind science concept about how to calculate the probability of obtaining a certain character by asking questions as in the conversation below:

MT: Is there a probability of brown eyed parents' having blue eyed baby?
Student: Yes.
MT: Let's look at in which situations this can be happened.
Student: When both parents are heterozygote.
MT: Yes, if they are heterozygote, the baby may have blue eyes.

MT reminded science related concepts through probability example types that he used in previous years. For example, he asked experimental and theoretical probabilities of having daughter of a couple who have 1 daughter and 3 sons. He reminded both crossing and chromosomes indicating gender by this way. However, the explanation was not sufficient. The following conversation shows this situation:

> **Student:** There are two options. Girl or boy. I write 2 to denominator. Since one of them will be obtained, I write 1 to numerator. Thus ½ equals to 50%.
> **MT:** What about chromosomes?
> **Student:** We have explained it in science lesson. For example, when the probability of having daughter of a couple who have 3 sons was asked, we also say 50% again. We can also think this.
> **MT:** I am waiting for another thing.
> **Student:** This is x and y, and this is x and x.
> **MT:** What does x y indicate?
> **Student:** Male individual.
> **MT:** xx?
> **Student:** Female individual. Then we write xx, xx, xy, xy. That is two fourths and it equals to 50%.
> **MT:** Yes. This is more explanatory. If you do by this way, it would be better. The theoretical probability of daughter is 50%.

MT also reminded who Mendel was and what he contributed to inheritance to students by questioning. He asked what kinds of peas Mendel used in his experiments in the following conversation:

> **MT:** Is there anybody who remembers what Mendel did?
> **Student:** He crossed the peas.
> **MT:** Which peas?
> **Student:** Wrinkled seeded, round seeded, yellow, what else.. hımm.
> **MT:** We only take wrinkled seeded and round seeded.

The teachers had planned an activity that would require peer-group study for Plan4. MT reminded genotype and phenotype, and explained how the students would perform the activity. He also used questions for this purpose. However, he did not attempt to explain what genotype and phenotype meant for reminding. The following conversation indicated this situation:

> **MT:** You have coins and 'S'and 's' are written in two faces of each coin. You will flip the coin twice. Let's say you flipped and S came. Again you flipped and s came. You will write here Ss. What is it's genotype of this?
> **Student:** Heterozygote.
> **MT:** Yes, what is its phenotype?
> **Student:** Round seeded.
> **MT:** Yes, did you understand?
> **Student:** Yes.
> ...

MT: Here, we cross two hybrids that is round or wrinkle. Thus we flip the coin twice. Is it correct?
Student: Yes.
MT: We have two peas with heterozygote round seeded, haven't we?
Student: Yes.
MT: We made pea crossing since round is dominant to wrinkle. Thus we flipped twice. The first time S or s, the second time S or s. We write to the table Ss, ss, or SS, ok?

MT did not attempt to ask and explain the definition of inheritance, although he had stressed that he would remind students the definition in the planning part.

At the end of the lesson, he asked students to summarize the lesson. He wanted students to say the concepts and topics they remembered by the purpose of getting attention to the integration he performed and providing to remind the integration. The following conversation indicated this situation:

MT: Who wants to summarize what we did today? Which concepts, topics do you remember?
Student: You asked questions and wanted us to look for probability. For instance you asked probability of having 0 blood group from A and B blood groups. We calculated the probability.
MT: You say probability.
Student: Yes, but you connected it with science, related with science.
MT: Perfect.
Student: First, we take subjective, theoretical and experimental probabilities. At the beginning we said probability but we connected it to science. Crossing, blood groups all we connected them with probability and passed to a bigger field.
MT: Very good. What else?
...
Student: We repeated science while learning probability in mathematics.
MT: Which concepts did we learn?
Student: Inheritance, crossing, peas, DNA, Mendel's law, blood groups.

After MT controlled students' awareness about his teaching, he asked about their ideas of the integrated lesson as in the following:

MT: Did you understand?
Student: To understand probability easily we spread in to science and we understood easily.
MT: Yes we tried to connect probability to science. Is there another topics which could relate science and mathematics?
Student: Buoyancy in force and motion unit. We used direct proportion and inverse proportion for buoyancy.
MT: We use ratio and proportion in buoyancy, correct?
Student: For the numbers in DNA, how many adenin, guanin?

MT: Is there a ratio?
Student: Yes. There are the same number of adenin and timin, and the same number of guanin and sitozin.
MT: Nice.
...
Student: We use exponents in mitosis and miosis. For mitosis, two cells are formed from one main cell. If it is divided four times we say 2^4.
MT: Exponents, hımm.
Student: We use mathematics in physics subjects more. Force and motion, or pressure topics. Only for inheritance we use mathematics in biology.
MT: Are you sure?
Student: Maybe more.
MT: Ok. Thank you all. You contributed to our lesson. (The lesson ended.)

4.2.2.2.1.1.3 Integration for introducing the new topic/concept/procedure

MT used introducing aim for starting the new topic, inheritance. He introduced the lesson by asking what the probability of having a twin in the world was to the students in order to make transition to inheritance. Another introducing purpose was observed when MT mentioned crossing as in the following:

> So, is there a probability of brown eyed parents' having blue eyed baby?

MT stated in planning that he would emphasize science topics that were related to mathematics at the end of the lesson. However, he spent considerable amount of time for this purpose at the beginning of the lesson for introducing the lesson in addition to the time he spent at the end of the lesson. At the beginning of the lesson, he controlled students' prerequisite knowledge and he tried to understand whether they noticed a difference in his teaching as in the following conversation:

MT: What are we talking about here? What do you think?
Student: Probability
MT: Yes, what else?
Student: Dependent and independent events.
MT: You say…
Student: Probability.
MT: Only probability?
Student: Science was mixed up with mathematics.
Student: Probability.
Student: Experimental probability.
MT: Experimental probability?
Student: Fractions.
Student: Theoretical probability.
Student: Science plus probability, because we mention about science.

> **MT:** Intensively what?
> **Student:** Probability.
> **MT:** Probability. Ok, we started probability topic.

4.2.2.2.1.1.4 Integration for explaining topics/concepts by connecting mathematics and science

The teachers used two different connections namely, connection science to mathematics (S-M) and connection mathematics to science (M-S) in planning phase of Plan4. In the implementation of the plans, the same connections were observed. The connections used by MT in implementation of Plan4 were explained respectively below.

4.2.2.2.1.1.4.1 Connection science to mathematics (S-M)

MT used connection S-M many times in the implementation of Plan4 as decided in planning. He used this connection generally in the questions that he asked to students. These questions first required using science knowledge and then connecting it to mathematics. The following question is an example of this connection:

> What is the probability of homozygote long eye lashed mother and homozygote short eye lashed father's child having long eye lash?

Similar to this question, the following conversation between MT and the students indicated the connection S-M by connecting crossing the characters to calculation of the probability:

> **MT:** What is the probability of homozygote curly haired mother and heterozygote curly haired father's having straight haired daughter?
> **Student:** Teacher, there will be no straight haired. (She crossed KK and Kk.)
> **MT:** Probability of straight haired daughter?
> **Student:** Zero.
> **MT:** We asked probability of straight haired daughter. Your friend said that there is no probability of having straight haired daughter. It means 0%. Ok? As a result, even girl or boy, none of them will have straight hair.

4.2.2.2.1.1.4.2 Connection mathematics to science (M-S)

MT also used connection M-S several times during the implementation of Plan4. Similar to connection S-M, he used connection M-S in the questions. His questions required first, using mathematics and then connecting science for this type of connection. One example question was as in below:

> As a result of the crossing of two rabbits chosen from black and white rabbits, 60 black and 20 white rabbits were obtained. According to this, find the probability of obtaining heterozygote black rabbit by determining the genotypes of the crossed rabbits. Black gene is dominant to white gene.

Another example for this connection was seen after a student's question after the activity about theoretical and experimental probability as in the following:

> **Student:** Can the experimental probability value and the theoretical probability value be equal?
> **MT:** Good question. Can it be? Yes, but the number of experiments has to be large. Mendel could find it by this way, could not he? As a result, he tried.

4.2.2.2.1.2 Problems affecting the implementation of Plan4

MT experienced many problems during implementation as in the planning. For Plan 4, lack of content knowledge, trivializing content, teaching related issues, and lack of confidence were observed as MT's encountered problems during the implementation. These problems were explained respectively below.

4.2.2.2.1.2.1 Lack of content knowledge

MT had lack of content knowledge related to science concepts and this was reflected on his teaching. He generally asked questions during his teaching. He mostly repeated students' responses when they answered a question. He did not make clear explanations about science concepts. For example, when he asked the probability of brown eyed parents' having blue eyed baby, he repeated the answer and asked another question without making interpretation of the response as in the following:

> **MT:** Is there a probability of brown eyed parents' having blue eyed baby?
> **Student:** Yes.
> **MT:** What is it?

Student: Since there is recessive gene in the family.
MT: One second, recessive gene?
Student: I mean, if the gene is dominant, it means that the person took the gene from his parents. Because they come together hımm.
MT: Good, your friend stated good points.
Student: If the gene coming from father is hybrid, the answer may be 25 %.
MT: What do you mean when you say hybrid?
Student: For instance, one blue eye gene and one brown eye gene come together.
MT: Any other ideas?
Student: For a person, brown eye is dominant character. If it is hybrid, there is another color character. When two hybrids are crossed, there will be another color with 25 %.
MT: What do you mean when you say hybrids are crossed?
Student: Do you say as computation?
Student: Two hybrids are crossed, when heterozygotes are crossed another color reveals with 25 %.
MT: Hımm, ok.

The explanation was sufficient for MT. His questions and repetitions indicated that he was unsure about the science concepts. Additionally, he used a confusing statement in the activity part of the lesson while explaining the reason of crossing. He said pea crossing instead of crossing the characters in terms of pea forms as in the following:

Since round is dominant on wrinkled one, we did pea crossing.

MT showed lack of confidence that points lack of content knowledge while mentioning science concepts. He did not attempt to make explanations about science concepts. He only stated short sentences. As mentioned before, he needed to repeat the students' answers. He generally looked like he was not sure and thinking. Additionally, he needed approval about his sentences and asked follow-up questions to the students in order to feel safe.

MT: What is the probability of homozygote long eye lashed mother and homozygote short eye lashed father's child having long eye lash? Who wants to explain?
Student: 100%
Student: Since mother is homozygote long eye lashed, she is KK. And father is homozygote short eye lashed, he is kk.
MT: One second, yes, ok. Continue.
Student: If we cross them, all individuals' phenotypes will be long eye lashed.
MT: All long eye lashed, you say.
Student: Yes, 100% long eye lashed.
MT: 100% long eye lashed hımmm.

Another example that indicated MT's need for approval was about the activity. While MT was explaining the activity, he needed approval several times as in the following conversation:

MT: We are crossing the peas, aren't we?
Student: Yes, the first one is wrinkled.
MT: Round or wrinkled? We are crossing these two hybrids. Thus we flip the coin twice, correct?
Student: Yes.
MT: Ok. Two heterozygote round. It is round, isn't it?
Student: Yes.
MT: Ok.

4.2.2.2.1.2.2 Trivializing content

MT had used some sentences which were not related to the topic and could cause students to loose attention to the lesson. For example when he asked what the probability of having a twin in the world was to the students in order to make transition to inheritance, the following conversation was observed:

Student: Impossible.
Student: Nobody resemble to anybody.
MT: You consider the song saying 'nobody resembles to you'

MT sometimes led students by asking questions which could cause to loose attention on the topic. For instance the following conversation, continuation of the previous one, indicated this situation:

MT: But there are for example maternal twins?
Student: Hımmm, you say them.
MT: Anyway, ok, we cannot endure one more you.

When MT asked the probability of brown eyed parents' having blue eyed baby, the correct answer came from a student. MT summarized the answer; however, one student was not persuaded about the explanation of the teacher. MT did not consider the students' confusion and answered with an unrelated statement as in the following conversation:

Student: When both the parents are heterozygote.
MT: Yes, when only in such a situation, there is a probability.
Student: No, but I did not understand. There is no probability.

MT: Ok, do not speak. Do not worry I give the baby to you. Another question.

4.2.2.2.1.2.3 Teaching related problems

MT used questioning frequently in his teaching. In general, he asked the question first, then listened the students' answer, repeated the responses, and then he closed the issue with a general sentence as given in the previous parts, such as the conversation given in lack of content knowledge part. In addition, for the question of the probability of brown eyed parents' having blue eyed baby, he had difficulty to handle classroom management. After he asked this question, the students spoke all at the same time and MT could not control them and got angry as in the following conversation:

Student: 25%
MT: How do you explain this? Why 25%?
Student: Both father and mother are hybrid but brown eye is dominant. Recessive eye comes from them.
Student: 1/16
MT: What?
Student: 1/16
MT: 1/16, hımm.
Student: I calculated 25% by considering if there is dominant and recessive.
(They are talking among themselves)
Student: Hybrid offspring.
Student: No, he did not say such a thing.
MT: What is happening there? Couldn't you share the baby? Why are you doing this? Do not speak. Sit down, ok?

MT hesitated in some situations during the implementation. For instance, in the question of experimental and theoretical probabilities of having a daughter of a couple who had 1 daughter and 3 sons, he tried to lead students with questions. However, he could not use clear sentences. The following conversation indicated this situation:

Student: There are two options, boy or girl. The answer is ½.
MT: What happens if we think through chromosomes?
Student: Already we will do. Even they have 10 sons; the probability of having daughter is 50%.
MT: But I am waiting for a different thing, hımm.

Another example of MT's not being able to use clear statements and questions, was revealed in the activity. At the end of the activity, he asked the result that would be inferred from the activity; however, students did not understand what he meant as in the following conversation:

> **MT:** Let's think that we flipped the coins for ten times. For example look 15th group's result. They found 5 round peas and 5 wrinkled peas. It means that if we flip ten times, the result will be 50% round and 50% wrinkled. But we did 200 times. To what our result is close to?
> **Student:** Round.
> **MT:** We will reach a conclusion here. Is there anybody to tell us?
> **Student:** The probability of obtaining round seeded peas is high when wrinkled and round seeded peas.
> **MT:** No, do not focus only that part, think general.
> **Student:** (No answer.)

4.2.2.2.1.3 MT's evaluation of Plan4

MT stated that the integrated plan had reached its target and was implemented successfully. He added that he noticed students had a comprehensive knowledge in science concepts and the students answered immediately when he asked. He claimed that this was an opportunity for him. He stressed that the students easily understood both probability and inheritance topics with his teaching.

MT evaluated the planning and implementation of Plan4, according to MISCI phase of the Balance model. He expressed that mathematics objectives were more intensive during the planning. However, the implementation of the plan went towards science intensive plan. He interpreted this situation as the plan included 60% science weighted.

In terms of the objectives in the plan, MT was sure that he implemented all of them without any problem. For both science and mathematics objectives, he stated that all important concepts were handled. Additionally, he accepted that he taught probability types superficially but he explained in detail by the activity. Additionally, he mentioned about the objectives related to dependent and independent events that the teachers removed from the plan before the implementation. He was sure that removing was a correct decision by the following instances:

> There were problems about how to integrate dependent and independent events with science subjects… The students get confused about examples related to these concepts. In addition we could not decide how to combine dependent and independent events. I also got confused… In mathematics examples, I sometimes cannot decide whether it is dependent or independent. I consider that these would not be related to science subjects… If we endeavor, we might, but it would be forcing. They would be confused.

MT stated that there were differences in terms of implementation of the plan, although he followed the plan almost the same in each classroom. He said that he was more comfortable in 8/D (which he considered as higher achieving class) than the other classes. He added that the students were surprised when he mentioned about science topics. MT also stressed that ‘crossing over’ was an unexpected response from students and remembered that ST and he did not consider it. In addition, he stated that the students’ interpretation after the lesson was as ‘you also learned something in this lesson’.

While evaluating his teaching, he stated that he hesitated about a science concept; however, he understood from the students’ interpretation. He said that the students did not notice this situation. He also expressed that he needed to communicate with somebody to be approved nearly in all steps of the plan. He stated that his was a different experience since he did not teach in such a way and he had hesitations about implementation. He explained these as in the following:

> Up to now, I did not reflect science to my lessons so much even they are related to each other. I had drawbacks at the beginning of the lesson in terms of both students and myself. I was thinking I had to have comprehensive knowledge about inheritance. Of course, there is difference between knowing and implementation. Different feedbacks, questions could have come from students. If I had encountered with these, maybe I would answer incorrectly and this would have affected students’ knowledge. But fortunately, the implementation was successful. I think I was good. I did not feel my hesitations in the first class, in the other classes. I could handle the students’ questions.

MT believed that the students enhanced their both science and mathematics knowledge. He stated that with his implementation of the plan, students who did not understand inheritance would be successful. He explained his ideas about the student benefits as given below:

> We helped the students who had difficulty in science. We repeated many concepts and by means of probability. We prevented students' forgetting of their learning. Actually we killed two birds with one stone.

MT considered that the questions prepared for the plan were good questions. He emphasized that he would use the activity for the next year. To improve the plan, MT suggested adding different types of questions. He also stated that instead of asking what the probability was to students, gaining their attention, preparing students for the subject, and connecting with daily life science subjects could be better for their learning.

4.2.2.2.2 Plan5 (Volume of geometric objects- Buoyancy)

Plan5 was about buoyancy topic from 8th grade science curriculum and volume of geometric objects topic from 8th grade mathematics curriculum. MT implemented the plan in four 8th grade classes for two lesson hours. The implementation was performed first in 8/B class. The summary of implementation with the order of implemented sections was given in Figure 4.5.

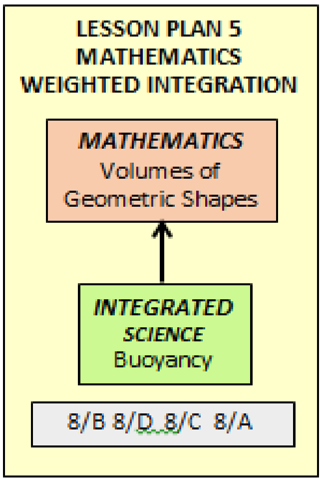

Figure 4.5 Implementation order of Plan5

MT implemented Plan5 in line with its planning. He followed the same order in all classes. There were no significant differences among classes in terms of MT's teaching from the first class to the last class. Thus, Plan5 was analyzed through 8/B, the first class in which the plan was implemented.

4.2.2.2.2.1 Critical issues in Plan5

Critical issues revealed in planning phase of the Plan5, were considered while analyzing the implementation of Plan5.

4.2.2.2.2.1.1 Checking for students' prerequisite knowledge

MT considered checking students' prerequisite knowledge at the beginning of the implementation of Plan5 in line with the plan. He asked questions to students about density concept through a comparison between water and salty water as in the following conversation:

> **Student:** The water in the sea is salty. Density of water in the sea and pool is different.
> **MT:** You say density of water in the sea and pool is different.
> **Student:** Sea water is salty water so, it increases the density of water. Since it is salty water, the buoyancy of objects becomes more. Since the water in the pool is normal and has less density, less buoyancy affects the objects.
> **MT:** What is density?
> **Student:** Closeness and distance of granules of the substance.
> **MT:** What else? How can we state density?
> **Student:** Mass divide by volume.
> **MT:** Let's write d=m/v, ok?

After MT controlled density concept, he asked buoyancy as indicated in the following conversation:

> **MT:** You said buoyancy. What is buoyancy, who will say?
> **Student:** Opposite force to weight of the object.
> **MT:** How do you symbolize it?
> **Student:** $F_{B.}$
> **MT:** F_B, what is next?
> **Student:** V_I x d_F x g. Volume of the immersed part of the object times the density of the fluid times the gravity.

MT also controlled students' mathematics knowledge about geometric objects and volume concept.

4.2.2.2.2.1.2 Integration for reminding previous/recent concepts

MT used many times reminding purpose for integration in Plan5. He wanted to explain density and buoyancy. Especially, he tried to remind the factors that affected buoyancy. He first reminded what the density was and how to calculate it with an example as in below:

> **MT:** What was density, who will say?
> **Student:** Mass divided by volume.
> **MT:** Ok, if you divide mass by volume?
> **Student:** ok.
> **MT:** Its mass is 32, volume is 16. So your friend found the density as 2. Understood?
> **Student:** Yes.

In addition, he reminded how to calculate buoyancy and gave the formula of buoyancy several times in the lesson. Both the students and MT focused on the symbols and the formula. They did not explain the factors when MT asked the definition of buoyancy as in the following conversation.

> **MT:** How do we find buoyancy?
> **Student:** V_I multiply with $d_{F.}$
> **MT:** Write on the board. Yes we can find buoyancy of an object by multiplying V_I and d_F.

MT also asked questions in order to be sure that students reminded buoyancy specifically, its formula, through a question given below:

> A right triangle prism with 6cm height was put into a container full of water and 120 cm^3 water overflew. According to this information, find the base area of the prism and buoyancy that affects the prism.

He explained the question to students by asking leading questions through buoyancy and volume of the prism formulas. The following conversation indicated this situation:

> **MT:** What was the buoyancy? (No answer) Yes, I will say these to your science teacher. Again I ask. What was the buoyancy? (No answer). How do we calculate buoyancy of an object?
> **Student:** We will multiply immersed object and density.
> **MT:** What of immersed object?
> **Student:** Density.
> **MT:** Whose density?
> **Student:** Fluid's.
> **MT:** We multiply density of fluid with?
> **Student:** Volume of the immersed part.
> **MT:** This object completely immersed so?
> **Student:** Complete volume of the object.

MT: Did I give the complete volume?
Student: No.
MT: What did I give?
Student: Height of the prism.
MT: 6cm.
Student: Yes.
MT: What will the volume of ebullient water be equal to?
Student: Volume of the object.
Student: Immersed volume.
MT: Yes. Ok.

4.2.2.2.2.1.3 Integration for introducing the new topic/concept/procedure

In Plan5, any introducing purpose for integration was not observed. Since buoyancy topic had been taught by ST before, the students had learned the concepts about buoyancy and they were familiar to these concepts. Thus, he did not attempt to introduce a new science concept during his teaching. He only used a daily life example by connecting to science at the beginning of the lesson as in the following:

MT: Have you ever swam in the sea or pool?
Student: Yeeess.
MT: Which one is easier?
Student: In the sea.
MT: Why? (No answer) Can it be because of the density of sea?

4.2.2.2.2.1.4 Integration for explaining topics/concepts by connecting mathematics and science

In the planning of Plan5, the teachers had used two connection types as science to mathematics, and mathematics to science. During the implementation, MT used the same connections. These connections were explained respectively in the following.

4.2.2.2.2.1.4.1 Connection science to mathematics (S-M)

The connection S-M was observed several times in MT's teaching. He generally used this connection for calculating buoyancy. He first explained how to find the buoyancy and applied the formula. The following conversation was an example of this.

MT: The buoyancy is V_I multiplied with d_F. What is volume of the immersed part? We found 36. What is 36? It is total volume of the object. But the ¾ of object was immersed.
Student: 27
…
MT: Yes, 27 is the volume of immersed part. V_I is 27, density of water is you know, 1. If you write, you will see the result is 27.

4.2.2.2.2.1.4.2 Connection mathematics to science (M-S)

MT used connection M-S more than S-M. He asked the questions in the plan. These questions generally indicated this connection. The plan started with a situation that required using volume of the prisms, and then connected it to calculating the density or buoyancy. The following two questions were examples of this connection used by MT in the implementation of Plan5.

> 2/9 of a right triangle prism container is full of a liquid. The mass of the liquid is 32 gr. What is the density of this fluid?
>
> When a square prism wood, as seen on the board, is put into a container full of water, ¾ of it sinks into the water. What is the buoyancy that affects this wood?

4.2.2.2.2.2 Problems affecting the implementation of Plan5

During the implementation of Plan5, influencing problems that affected MT's teaching process were observed as in Plan4. These problems were identified as lack of content knowledge and teaching related problems. These problems were explained in the following respectively.

4.2.2.2.2.2.1 Lack of content knowledge

MT had lack of content knowledge in buoyancy topic as in inheritance topic in Plan4. However, different from Plan4, his repetition of the student responses was less in Plan5. In addition, he had more comprehensive knowledge in buoyancy than in inheritance topic. MT and students discussed the following question:

> A right triangle prism with 6cm height was put into a container with full of water and 120 cm^3 water overflew. According to this information, find the base area of the prism and buoyancy that affected the prism.

MT asked questions to help students understand the question. However, it was observed that MT was still not able to make clear explanations to the students' responses. Additionally, he could not interfere the discussion between two students and had difficulty to manage the discussion. The following conversation is an example of a situation in which MT could not clarify the case for the students. He could not answer students' question, and finally ignored the question about the magnitude of the buoyancy as in the following:

MT: What will the volume of ebullient water be equal to?
Student: Volume of the object.
Student: Immersed volume of the object.
MT: Yes. Then, buoyancy of the object is 120.
Student: But it should be less than weight of the object.
Student: But it is totally sinking.
MT: Yeesss, okeyyy?
Student: But teacher you said that it totally sank.
MT: Yes, soo?
Student: Then it can be maximum 119.
MT: Why?
Student: It should be less than weight of it.
Student: We have said that buoyancy is equal to volume of ebullient water when we were learning buoyancy.
MT: Ok. We say the volume is 120, ok?

MT showed lack of confidence as a result of lack of content knowledge during Plan5 less than he had in Plan4. For example, he hesitated and needed an approval for the result of the question: 'When a wooden square prism, as seen on the board, is put into a container full of water, ¾ of it sinks into the water. What is the buoyancy that affects this wood?' The following conversation showed MT's hesitation:

MT: The buoyancy is V_I x d_F. We calculated the immersed part.
Student: 27 of 36 is immersed part.
Student: 27 is also buoyancy.
Student: But there is weight of object.
Student: I want to solve it.
MT: Did we do incorrectly?
Student: The computation is wrong.
Student: No, it is correct.
MT: Ok, it is correct.

4.2.2.2.2.2.2 Teaching related problems

MT used questions in all steps of the lesson. However, his questions were superficial and generally leading students to only focusing to the buoyancy formula. For example, he could not question deeply the definition of the buoyancy and gave the formula as the definition as in the following conversation:

> **MT:** What is buoyancy, do you know?
> **Student:** Opposite force.
> **MT:** How do you show it?
> **Student:** $F_{B.}$
> **MT:** Hımm, how does it continue?
> **Student:** V_I x d_F x g.
> **MT:** Yes, correct.

MT focused on the formula of buoyancy generally and he sometimes preferred to not to answer, and make students think about the answer. For example, although he did not express the unit of the buoyancy before, he asked the unit. A student answered correctly but MT did not approve and clarify. The following conversation indicated this situation:

> **MT:** What is the unit of buoyancy? (No answer)
> **MT:** Yes, volume of the immersed part is cm^3, what is density's unit?
> **Student:** gr divided by volume.
> **MT:** gr divided by volume?
> **Student:** gr/cm^3
> **MT:** The unit is (He wrote a question mark on the board). Another example.

A sharp transition from science to mathematics without a connection was observed in MT's teaching the Plan5. After he mentioned about buoyancy formula, he asked a question related to geometric objects as in the following conversation:

> **MT:** What is the formula of buoyancy?
> **Student:** V_I x d_F x g.
> **MT:** I think you have learned these. When?
> **Student:** First semester.
> **MT:** Ok. If we think our class as a pool, which geometric object does it resemble?

4.2.2.2.2.3 MT's evaluation of Plan5

Similar to Plan4, MT was glad about the implementation of Plan5. He stressed that the plan was successfully implemented as expected. He stated that the students had opportunity of using both buoyancy and density knowledge and volume of objects together, and they remembered their old learnings. MT also indicated that he followed the plan step by step and had no difficulty during the implementation. He emphasized that the plan was implemented in line with the MISCI phase of the Balance model. He could not be sure whether science or mathematics was intensively stressed during teaching. But, he decided mathematics was used more. In terms of the objectives, he emphasized that the objectives were performed as planned without any problem. He also stated that the plan was taught in different classes, and there were no difference among the four classes since he exactly followed the plan.

MT pointed out that he noticed the students' confusion at one point during his teaching and said this to ST. He explained this confusion as given below:

> The students have known that to find the buoyancy, volume of the immersed part of the object and density of the fluid should be multiplied. However, they have learned a different thing when the object totally sank. They thought that buoyancy should be less than the weight of the object. Something related to science remained unclear. Maybe they had forgotten because they learned buoyancy in the first semester. They have already had difficulty to say the formula of buoyancy. They remembered after some examples… Another problematic issue was that students generally had difficulty in the decimal computations in the questions.

MT evaluated his performance successful in general. However, he did not deny that he hesitated and asked ST the confusion of students given above, to be sure his idea was correct. He stated that after ST approved him, he did not make extra explanation to the students.

In terms of the effect of the plan on students' learning, MT was sure that the students understood both subjects better. He explained his ideas as in below:

> The students had learned to calculate volume at the 6^{th} grade. Thus, I gave more importance to buoyancy. They have known that buoyancy is directly proportional with V_I and d_F. I don't think. Most probably ST gave the volume of the immersed part directly in the questions. But here, I did not. They had to calculate the volume through density of the fluid. They did many exercises by this way. Their knowledge about buoyancy improved. They understood better.

MT also suggested some revisions for the plan although he thought that he prepared and implemented well. For example, he proposed that performing an experiment using a glass container and a marble could be meaningful while solving the questions. He claimed that this experiment might provide students a visual representation of the logic of the questions.

4.3 Summary of the Findings

Pre-study findings indicated that before starting integration planning and implementation, ST was more familiar to and ready for the integration and had more comprehensive mathematical knowledge and practice when compared to MT's readiness, science knowledge and practice.

In planning phase of the integrated lessons, the teachers initially considered the objectives that would be focused. Then, they took into consideration necessary prerequisite science and mathematics knowledge for students. They additionally explained how and why they planned the integrated plans. The findings showed that there were three main purposes for integration namely, reminding previous/recent mathematics/science concepts, introducing new mathematics/science new topic/concept/procedure, and explaining topics/concepts by connecting mathematics and science. They completed the planning phase by trying to construct meaningful content including rich connections between mathematics and science.

The teachers' implementations also indicated that the teachers checked the students' prerequisite knowledge for successful integrated lessons. When ST's implementation of integrated science plans were examined, it was observed that while ST gave more importance to check prerequisite science knowledge in Plan1 and Plan2, she did not focus on checking prerequisite mathematics knowledge. She only checked the definition of probability in only one class in Plan1. However, she checked students' mathematical knowledge about graphs in detailed during Plan3's implementation in the classes. While checking the students' knowledge she corrected students' wrong answers. When integrated mathematics lessons were evaluated, it was observed that MT tried to check students' both prerequisite science and mathematics knowledge in

Plan4 and Plan5. However, when MT asked science concepts to the students, he listened the students' answers and repeated the answers without any extra explanation or correction. In contrast, he explained the mathematics concepts and gave examples about them.

During her lessons ST tried to remind mathematical concepts by asking questions and explaining the answer related to types of probability in Plan1, the direct and inverse proportions for explaining the buoyancy formula, density formula and how to calculate the volume of regular geometric shapes in Plan2, and lastly, how to draw a line graph in the context of temperature-time in Plan3. However, she did not remind the mathematics concepts in all plans although they planned to do at the end of the lessons. On the other hand, MT was very careful about following the plan step by step while implementing the Plan4 and Plan5. Thus, he tried to remind all the science concepts that they planned without moving from the science concepts. For example, he emphasized the inheritance of a certain character and Mendel's pea experiments by asking questions in Plan4. He did not remind some concepts such as the definition of inheritance, genotype, phenotype but he stated that after he realized that the students knew those concepts, he did not need to remind them. In Plan5, MT tried to remind density, buoyancy, the factors that affects buoyancy, the formula of buoyancy formula of volume of the prism as they planned together with ST. However, while reminding these concepts he focused on the buoyancy formula without explaining the science concepts. Thus, the reminding purpose remained superficial.

ST integrated science and mathematics for introducing new topic/concept/procedure of mathematics. For example, she integrated the probability types to inheritance situations in order to present the probability types which the students learned first in Plan1. While comparing the subjective and theoretical probability, she used integration for introducing these concepts to make them meaningful for the students. However, ST integrated ratio-proportion with buoyancy for introducing a new procedure instead of presenting a new concept. While stating the relation among the factors that affect the buoyancy, she presented an easy way through the buoyancy formula by using direct and inverse proportion between the magnitudes (e.g. density of the fluid and volume of the immersed part). Different from both plans, there was no integration for introducing purpose in Plan3's implementation. The plan was including line graphs and heat-temperature topics. Since there was no new concept or procedure in terms of students' mathematical learning, this aim was not observed for Plan3. When MT's implementations were observed, integration for introducing purpose was seen in Plan4. MT tried to use integration for introducing the new topic of probability and its types by the help of inheritance situations and examples. Additionally, he emphasized the difference between his teaching and his previous teaching to get students' attention to the relation between science and mathematics at the end of both Plan4 and Plan5's implementations. Similar to ST's Plan3 implementation, no introducing purpose was observed in MT's Plan5 implementation because of the same reason that the students has learned the buoyancy topic that MT integrated to volume of geometric shapes topic. Instead, he benefited from daily life situations which were related to buoyancy while teaching volume of geometric shapes.

The teachers also used integration for explaining topics/concepts by connecting mathematics and science. This purpose was occurred in several connection ways. The first connection was S-M which indicates starting with science and bridging it to mathematics. In planning of the integrated lessons, this connection was the most used one for the plans. The teacher preferred to start with a science related issue then connected it to mathematics. When implementations of the plans were examined, it can be seen that both ST and MT used this connection many times in order to integrate the concepts in their teaching. For example in Plan1, ST connected genotype and phenotype concepts to ratio, percentage, and probability concepts in her teaching. For Plan2, she also used S-M connection for constructing the buoyancy formula by the help of the proportion between the factors that affect the buoyancy. For Plan3, ST used this connection in interpretation of line graphs and drawing line graphs. MT's teaching also included S-M connection. MT used this connection in Plan4 for connecting crossing the characters to calculation of the probability, which was the common usage of the probability in inheritance. MT also used this connection in Plan5 for calculating buoyancy by first explaining how to find the buoyancy and applying the formula.

The other connection was M-S that was considered by the teachers in planning and used in their teaching. M-S connection required to start with mathematical situation then connecting it to science. In planning phase the teachers did not use this connection in Plan1 and Plan4 which included inheritance and probability topics. ST used this connection by interpreting the line graph and then, explaining the heating or cooling curve over line graph in Plan2. MT also put this connection in Plan5. In implementation of the plans, ST used this connection for Plan1 although they did not plan. This connection was observed more in Plan3 in which ST questioned the situation of the line in graph and named the graph for whether it was heating or cooling in her lessons. MT also used this connection in his teaching. For example, in Plan5, he started with a situation that required using volume of the prisms, and then connected it to calculating the density or buoyancy.

The last connection that teachers used in planning and implementing of the plans was connection S-M-S. The teachers started with science and connected with mathematics, then again connected with science concepts in this connection. In planning, this connection was used for only Plan1. For example, they started with crossing, then calculating the probability to find the genotypes of the individuals. In implementation of the plans, only ST used this connection in Plan1 and Plan2 several times. ST used this connection although they did not plan for Plan2.

The teachers' collaboration and communication were also a factor that affected the planning of the integrated lessons. This was an important factor in order to see the teachers' harmony and benefit from each other to construct successful integrated plans and to prevent any misconception or misunderstanding. They mostly supported and approved each other by making additional explanations or clarifying the situations and concepts. Additionally, they presented suggestions to each other during planning. These suggestions gave idea to the teachers in terms of being aware of students' understandings about the other course, preparing the teachers for the implementation of the integrated plans, and being ready to the questions that might come from students. It was observed that ST presented more suggestions to MT than MT did. The teachers did not always have the same ideas. Sometimes they did not accept the suggestions or ideas and sometimes an ambiguity of the content caused to a persuasion situation. ST was the one who persuaded MT when there was a disagreement about the content. They also persuaded each other when a hesitation was occurred. This persuasion was done by explaining the context in detailed.

Planning and implementation processes of integrated lessons were affected by several problems. These problems were lack of content knowledge and trivializing the content.

In planning of the lessons, ST showed lack of mathematics content knowledge in Plan1 and Plan2. No problem was observed during Plan3's planning. In planning of integrated mathematics lessons, similarly MT had lack of science content knowledge; however, both ST and MT had also lack of mathematics content knowledge about dependent or independent events. Thus, MT showed both lack of science and mathematics knowledge during planning of Plan4. Similarly, both MT and ST showed lack of science knowledge in planning of Plan5 that they could not differentiate mass and weight and they used interchangeably. Teachers' lack of content knowledge also caused a lack of confidence during planning of the plans.

Although they collaborated and discussed the plans together, their lack of content knowledge problem was observed in implementation of the plans more than the planning of them. ST continued to define subjective probability as 'probability up to me' in the implementation of Plan1. Additionally, she did the similar misuse of definition of theoretical probability and comparison of theoretical and experimental probabilities. She used percentage, ratio, and probability interchangeably. Moreover, she did not make any explanations about the different use of ratio in mathematics and ratio for genotype and phenotype in science. In Plan2, ST stated that volume of an object was the covered area of that object. She could not remember how to find the volume of sphere while teaching Plan2. MT also had lack of content knowledge during his teaching of Plan4 and Plan5. In general, he implemented the plans by asking questions and only repeating the students' answers. He misused science concepts such as pea crossing instead of crossing the characters in terms of pea forms in Plan4. In Plan5, he could not answer students' question related to find the magnitude of buoyancy, Thus, he ignored the question. Lack of content knowledge also caused to lack of confidence while teaching for ST in Plan1 and Plan3, and MT in Plan4 and Plan5. In such situations, the teachers needed to be approved by the students or the researcher.

Trivializing content was another problem that the teachers experienced. For example in planning of Plan2, both of them considered that to put four operations into the science context and applying buoyancy formula was sufficient for integration. Since the teachers forced themselves to make connection by using statements unrelated to objectives, this was an example for trivializing content problem. Another trivializing issue was occurred in Plan4. MT insisted to put a question which was not related to the objectives of Plan4. Trivializing issue was reflected to the implementation of the plans. For example in Plan1, ST used unrelated options in her multiple choice questions that she constructed at that time. MT lost his focus and used some sentences which were not related to the topic and could cause students to loose attention to the lesson in Plan4.

Different from planning, there were other problems in terms of integration which were related to the teachers' teaching styles. For example, ST made sharp transition from mathematics to science without making any meaningful connection in Plan1. Similarly, MT made sharp transition from buoyancy formula to a question related to geometric objects without any connection. The teachers' speed of teaching, asking leading questions, and answering students questions superficially without conceptual explanations were other observed problems during the integrated lessons.

When the teachers' evaluations about the integrated lessons were examined, it was seen that both teachers were happy about their teaching. They suggested minor revisions for the plans and they stated that they would use the integrated plans in the following years. Additionally, they concluded that their teaching had positive effects on the students' achievements and attitudes related to science and mathematics.

CHAPTER V

DISCUSSION AND CONCLUSION

The purpose of this study was to investigate science and mathematics integration in terms of planning and implementation processes. A total of five integrated lessons were planned by one science teacher and one mathematics teacher collaboratively and implemented by them in their classes. In order to reflect the big picture of science and mathematics integration from pre-study to the planning of the plans and to the end of implementations of the plans, this chapter connected, summarized, and discussed the findings of the study. All the phases were related to each other since pre-study shaped the planning of the integrated lessons and planning was reflected on the implementations. Thus, discussion of the findings was made by focusing on the main issues of the study through the literature in the following parts. Suggestions and implications for educational practices, recommendations for further studies, and limitations of the study were also presented in this chapter.

5.1 Discussion and Conclusion

The findings of the study presented that it was important to understand how science and mathematics teachers working in public middle schools were collaborating in order to plan and implement mathematics and science integration, rather than focusing on student achievement. The study provided a snapshot of initial and intended practices of integration in school settings. It also clarified that simply expecting teachers to collaborate for integration without any support would probably not result in meaningful integration and increased student achievement. Even when the teachers were supported, as exemplified in this study, the integration process had several problems or issues to be improved in each phase of planning and implementation. These issues and problems were discussed below.

5.1.1 Initial Situations

The relation between science and mathematics is both natural and clear and moreover, integrating these two disciplines is more appropriate when considering the other fields (Koirala & Bowman, 2003; Kurt & Pehlivan, 2013). This relation has been emphasized in both Turkish mathematics and science curricula by stressing to connect science and mathematics during teaching (MoNE, 2011a; MoNE, 2011b). This study had initially focused on the existing situation in terms of participating teachers' science and mathematics integration practices. Science teacher's (ST) classroom observations and students' science notebooks illustrated that she used mathematical concepts and procedures many times in her lessons. However; science curriculum limited the teachers in terms of giving mathematical formulas in the directions of the beginning of the topics for the science teachers (Cebesoy & Yeniterzi, 2014), although the science curriculum supported making connection between science and other disciplines including mathematics (MoNE, 2011b). When ST was asked about those limitations, she emphasized that she could not explain science topics without the help of mathematics and ignored those limitations many times in her lessons. This situation shows a dilemma between the science curriculum's directions for science teachers and its practice. ST could explain many mathematics concepts because, she was familiar with the mathematical concepts and she could explain them easily.

On the other hand, mathematics teacher's (MT) classroom observations and students' mathematics notebooks did not contain connections to science much. Similar to the science curriculum, mathematics curriculum stresses the relation between mathematics and other disciplines including science (MoNE, 2011a). MT's practice did not reflect this relation sufficiently and thus, there was also a gap between the curriculum and its practice. Yeniterzi and Işıksal (2015) investigated teachers' guide book for the 7th grade mathematics published by MoNE in 2011 in terms of the relation between science and mathematics and identified many conceptual science usage and science examples related to daily life. Since there are many uses of science in mathematics textbooks and the mathematics curriculum stress the relation, it can be inferred that MT was not aware of this relation and did not put much emphasis to use it in his lessons. He ignored the relation and focused on mathematical concepts and procedures. Consistent with this, MT could not easily explain science concepts in the pre-study because he was not familiar and did not use them in his lessons.

As conclusion, it can be said that the current practice of the teachers and the existing curriculum could limit to carry out integrating mathematics and science successfully (Czerniak, Weber, Sandman, & Ahern, 1999; Hollenbeck, 2007; Lee, Chauvot, Vowell, Culpepper, & Plankis, 2013; Meier, Nicol, & Cobbs, 1998). Consistent with this, it can be said that although the science and mathematics curricula emphasize the relation between science and mathematics, this relation is not seen in science and mathematics teaching sufficiently and it is possible that the teachers' existing practice of the curricula can limit the integration process.

MT and ST came together and started to plan the integrated plans for science and mathematics topics identified for 8th grade level. The researcher only explained a list of important points for successful integration based on the related literature. This list included suggestions about using appropriate content, student centered teaching, hands on and manipulatives for concrete learning, discussion, inquiry, problem solving, questioning and benefitting technology for integration. Additionally, the list aimed to remind the teachers to give importance to conceptual understanding, process skills, measurement and assessment issues for checking student learning, and student beliefs and feelings towards science and mathematics. In addition to this, the teachers examined and discussed the Balance Model which was based on constructivist approach (Kıray, 2012) as the science and mathematics curriculum were, and they focused on its directions for SIMCI and MISCI parts for planning of the integrated plans. Both ST and MT stated that they were familiar these issues and they were teaching their lessons based on the constructivist approach as the curricula led them (MoNE, 2011a; MoNE, 2011b) before the implementation of the integrated plans.

5.1.2 Critical Issues for Planning and Implementation

One of the purposes of this study was identifying the critical issues that the teachers considered during planning and implementation processes. The teachers focused on objectives, students' prerequisite knowledge, teaching methods, and aim of using integration while planning the integrated lessons. Below, the findings of these issues were discussed.

Determining objectives

First of all, the teachers considered the objectives that could be connected from the matched topics in all plans and tried to construct the content according to these objectives in planning. This could be a reason for teachers' feeling safe by limiting themselves with the objectives. While determining the objectives, ST selected the science and mathematics objectives easier and faster than MT. MT spent more time while deciding the objectives. ST's focus was on science objectives however, MT's focus was on science objectives instead of mathematics objectives, for example, for Plan4. ST's easier determination of objectives could be due to her using mathematics integration before the study as it was observed in pre-study. On the other hand, MT's using more time for determination of the objectives and focusing on science objectives only for the first mathematics plan (Plan4) could be related to his first experience about science and mathematics integration as MT was not observed using science in his lessons in the pre-study.

Students' prerequisite knowledge

The other critical issue that the teachers considered was students' prerequisite knowledge. The importance of students' prerequisite knowledge could not be ignored (Mason, 1996) thus, the teachers tried to consider this issue. Similarly, Kıray and Kaptan (2012) found that lack of students' pre learning resulted in a negative effect on connecting between science and mathematics. Similarly, ST and MT were aware of the importance of the students' background knowledge necessary for gathering new knowledge about both science and mathematics in this study.

During planning, they were sensitive in checking prerequisite knowledge for the determined topics into the plans. During implementations, however, ST ignored to check prerequisite knowledge for mathematics in Plan1 (probability concept) and in Plan2 (ratio and proportion concepts). In contrast, MT was very careful for checking both science and mathematics prerequisite knowledge in implementation of both Plan4 and Plan5 and he did not omit any of them. The different situation between ST and MT might have stemmed from ST's self-confidence about using mathematics in her teaching in the previous years and MT's first experience that caused to be on the alert for each point in order to make integration well.

Teaching methods

Teaching methods were the other critical issue for the teachers during integration process. When observations of the teachers' lessons before the planning phase of the study were examined, it was revealed that they used only questioning and direct teaching in their lessons. The teachers stated that asking questions to the students during teaching indicated that they focused on student centered teaching. Their existing teaching methods were also reflected on their planning of the integrated plans. They both used questioning and direct teaching from the beginning to the end through their plans although they stated before that they would use discussion, inquiry, and problem solving.

Although the science and mathematics curricula are based on constructivism and the teachers prepared the integrated plans by considering constructivist approach, their existing teaching methods were dominant during integrated lessons' teaching. This can be a result of teachers' resistance to change in education as stated in literature (Al-Shalabi, 2015; Zimmerman, 2006). As concluded from pre study findings, the teachers still had resistance to practice related to constructivism. This resistance was also reflected on planning and implementation of integrated lessons. ST and MT generally started lesson with a daily life example and they stated the example as a problem situation. However, this problem situation did not contain a struggle for students to deal with and solve. Considering this situation and Furner and Kumar (2007)'s suggestion that stressed problem based learning has a crucial role for integration of science and mathematics, it can be concluded that the teachers' understanding of 'problem' term was problematic. This situation could result in problems for teachers' using problem based learning which was seen as an important way for achieving meaningful integration (Hurley, 2001; Kıray, 2012).

Aims of using integration

The last critical issue that the teachers considered was aims of using integration. From beginning to the end of the integrated plans, the teachers used integration for different purposes. These purposes were reflected on the plans to teaching in general. One of these aims was reminding previous/recent mathematics/science concepts. In planning, ST and MT stated that they used integration for reminding the concepts. In implementations, ST generally tried to remind previous/recent mathematics concepts in all science integrated plans; however, she forgot to remind mathematics concepts especially at the end of the lessons although she stated in the planning. When MT's teaching was examined, it was observed that MT used integration for reminding science concepts in both mathematics plans as he planned. Additionally, he asked questions to students about the lesson whether there was a difference between his teachings before and after and expressed the relationship between science and mathematics again at the end of the lessons.

The other aim of teachers' using integration was for introducing new mathematics/science topic/concept/procedure. In planning, ST only decided to introduce concepts by using integration in Plan3. However, MT tried to use integration by a science related question insistently in both plans. He stated that he felt obligated to introduce the lesson by using integration with science related question. He was able do this for Plan4; however, he had difficulty for such introduction in Plan5. After discussing with ST, MT could put the introducing purpose into Plan5. When implementations were examined in terms of using integration for the purpose of introducing, differences between planning and implementations were determined for ST. It was interesting that while ST did not use integration for introducing the lesson in Plan3 although she planned, she used integration for introducing in Plan1 and Plan2 although she did not. On the other hand, MT's teaching was consistent with his plans.

When the teachers' using integration for reminding and introducing purposes were evaluated together, it can be concluded that while ST was teaching the lessons by ignoring the points they decided for the plans, MT was trying to follow the plans word by word. This could be because of ST's having experience about integration in her lessons before the study which affected her teaching through integration. However, MT had no such an experience thus; he could be more careful for implementing the plans exactly in terms of the purposes of reminding and introducing as they planned.

The last aim of using integration was for explaining topics/concepts by connecting mathematics and science. Investigating the form of integration has been stressed (Hurley, 2001) and the study revealed that teachers used certain connection ways of integration for explaining topics/concepts. These connections were S-M (science to mathematics), M-S (mathematics to science), and S-M-S (science to mathematics to science). The most used connection in both planning and implementation was S-M. The teachers preferred to use science first and connect it to mathematical situations in a meaningful way. Consistent with this result, Frykholm and Glasson (2005) found that one of the prospective science and mathematics teachers in their study stated that starting with science ideas and seeking mathematics in it was more comfortable than vice versa. The reason of the teachers' mostly using S-M connection could be that it can be easier starting from science and connecting it to mathematics for them.

Teachers used connections in practice different than they planned. This could be resulted from their need to connect the concepts for better student understanding. Thus, they ignored the plans and connected as they saw necessary during their teaching. However, it could be inferred that the connections that the teachers made were not in detail and they remained superficial. Although the teachers stated that they aimed to use those connections to provide better conceptual understanding for both science and mathematics, it can be said that it did not serve as considered in mathematics integrated plans for science concepts and in science integrated plans for mathematics concepts due to their superficial nature.

When all the aims of using integration were considered, it could be said that using integration for different purposes could stem from the teachers' effort to not to move away from the integration aim and spreading the integration content to the entire lesson. If the teachers have awareness about why and how they use integration, this could help them to prepare their own integrated plans clearer and implement them easier and more consistently in all classes.

5.1.3 Affecting Factors of Planning and Implementation

The affecting factors were also investigated for planning and implementation of the integrated plans. Two main factors were determined as teachers' collaborations and communications in planning, and problems they encountered in both planning and implementation.

Teachers' collaborations and communications

Group members' characteristics, individual dominance, and blocking were barriers that should be handled for effective and successful group work (Gorse, McKinney, Shepherd & Whitehead, 2006). One of the most important factors that affected the planning of the integrated plans was teachers' collaboration and communication, and the group dynamics observed among them.

During planning of integrated plans, the teachers supported each other, they presented suggestions, and they persuaded each other when they disagreed or hesitated. Since the teachers were good friends for three years, this collaboration might be affected from this friendship positively and negatively. Form positive side, they might state each idea to each other without feeling any hesitations. However, this collaboration could be affected negatively from this friendship for several reasons. For example, because ST was more experienced than MT, MT might not have reacted to her ideas and might have accepted them immediately. They might have trusted each other's ideas without any questioning. The communication and collaboration might have been affected by one teachers' dominant behavior, lack of self-confidence in science/mathematics knowledge, ignoring the other teacher, and/or preventing others' action.

Problems in planning and implementation

Integration of science and mathematics can be accepted as an educational reform which would include problems and issues to cope with (Meier et. al 1998). At this point, another affecting factor was occurred as problems that the teachers encountered during planning and implementation of integrated plans.

In both planning and implementation processes, content knowledge problems for both science and mathematics were occurred. Lack of content knowledge was revealed as the most encountered problem during planning of the integrated plans. ST had lack of mathematics content knowledge and MT had lack of science content knowledge. However, MT also had lack of mathematics content knowledge. This result is consistent with several studies (Baxter, Ruzicka, Beghetto, & Livelybrooks, 2014; Koirala & Bowman, 2003; Stinson, Harkness, Meyer, & Stallworth, 2009) which indicated that the teachers had content knowledge problems also in their own field for a successful integration.

Although ST emphasized several times that she had sufficient mathematics background, she had lack of mathematics content knowledge during the implementations of the integrated science lessons. For example, in Plan1, she defined probability types incorrectly, used ratio, percentage, probability concepts interchangeably as they are synonyms, and did not explain the difference between the ratio in mathematics and ratio in science (e.g. genotype ratio as 1:2:1). Different use of ratio could cause problem for students' understanding. The need for common language of mathematics and science to integrate also emerged here. To lead the teachers to focus on not only the similarities but also differences between science and mathematics (McGinnis, McDuffie, & Graeber, 2006) could be helpful for successful integration.

Many researchers indicated the lack of teachers' content knowledge as a barrier for successful science and mathematics integration (Baxter et al., 2014; Frykholm & Glasson, 2005; Kıray & Kaptan, 2012; Koirala & Bowman, 2003; Meier et al., 1998), which were also observed in the present study. MT had lack of content knowledge problem during the implementation of the integrated mathematics plans. MT's lack of content knowledge was revealed in a different way from ST. ST's lack of mathematics content knowledge was clearly determined in her explanations. There were also MT's explanations which indicated his lack of science content knowledge. However, he generally repeated the students' answers, could not make clear and detailed explanations, did not interfere the conversation between the students and needed to be approved during his teaching. These behaviors could be accepted as indicators of his lack of content knowledge.

Lack of content knowledge caused lack of confidence in teachers' practices in this study. Lee et al. (2013)'s study also indicated that the teachers' content knowledge of other discipline and confidence level in integration affect each other. In their literature review study, Furner and Kumar (2007) remarked the importance of the teachers' confidence in science and mathematics teaching. They also stressed that while mathematics teacher can have confidence problem for teaching science and/or a science teacher can have confidence problem for teaching mathematics, science teachers' confidence level may be problem for all the science disciplines' (biology, physics, chemistry) teaching. At this point, it can be said that lack of confidence can cause meaningless connections and these meaningless connections can result in misuse and misconceptions of students about science and mathematics concepts. It should be noted that the participating teachers in this study did not receive any inservice training for integration, which is reported to be effective in making teachers more confident in meaningful integration (Baxter et al., 2014). Therefore, it could be the case that if the teachers had received training about integration before, they would most likely to be more self-confident in their practice of integration.

Trivializing was another problem which was encountered in planning and implementations. There were several points which indicated irrelevant content and could be accepted as trivializing problem in this study. In planning of Plan1, ST stated that when four operations were used in science, integration was achieved although the objectives were not related to achieving the four operations. Similar situation was valid for MT during the planning of Plan2 and Plan4. For Plan4, although ST noticed and tried to not to use irrelevant question, MT did not consider her concern.

Trivializing problem was also seen in implementations different from planning and in unexpected situations. For instance, ST used a multiple choice question including irrelevant choices and caused to trivializing problem while teaching Plan1. MT's teaching also had trivializing problem because of using irrelevant sentences about the topic and causing students to move away from the topic. Even if trivializing content problem was observed not more than lack of content knowledge problem, trivializing the content could result in other problems such as, not to be able to focus on the content, misuse of time, and not to be able to reach the objectives. The researchers also pointed out the trivializing problem in integration literature (Czerniak et al., 1999; Meier et al., 1998). However, Baxter et al. (2014) found that the teachers working as a team developed nontrivial and non-superficial connections between science and mathematics on the contrary of this study's findings. Therefore, it can be said that the collaboration between the ST and MT in the present study was not fully effective in terms of preventing the trivializing problem. It might be the case that teachers could not produce rather quality examples for integrated plans due to making such plans for the first time and focusing on the other content (science for MT and mathematics for ST) rather than the quality of the examples. It also might be that trivializing content problem occurred since the teachers were in research context and they pushed themselves to integrate science and mathematics even in unnecessary points.

There were also teaching related problems which were observed in implementations of the plans and related to teachers' teaching in general. For example, ST's speedy teaching, asking leading questions, not giving enough time for students' answers, and leading rote learning were the problems determined in ST's teaching. MT's teaching also included several teaching related problems such as not being able to direct the discussions, classroom management problem, not being able to make clear explanations, and asking superficial questions. Although teaching related issues seem not related directly to integration teaching, they could affect integrated lessons' quality as stated in literature (e.g. classroom management by Stinson et al., 2009).

The other problem was sharp transitions between science and mathematics. Sharp transition problem was observed in Plan1 and Plan5 by both ST and MT. This problem occurred when the teachers did not connect science and mathematics concepts but rather stated factual information about science and mathematics topics one after the other. This might be due to teachers' lack of experiences with integration. Although they planned the integrated lessons and tried to implement them as they were, they improvised from time to time, probably because they practiced such improvisation during their regular teaching without integration. Therefore, they might have considered a necessary connection, but could not go beyond sharp transition.

In this study, the teachers considered Kıray (2012)'s Balance Model for planning the integrated lessons. This model had focused on the points that would be considered for integration as content, skills, affective variables (for students), learning and teaching process, and measurement and assessment. This study determined that there were other factors which were about the teachers' knowledge and experiences that can be added to the model. According to this study's findings, it can be concluded that integration process is also influenced by the teachers' content knowledge in science and mathematics, their teaching experiences, their integration experiences, and their affect.

5.1.4 Teachers' Evaluation of Their Teaching

The teachers stated that they believed the integrated lessons were helpful for students' learning. They both were happy about the result. They considered that the integrated lessons had a positive effect on students' science and mathematics achievements and attitudes towards science and mathematics. On the other hand, MT accepted that he hesitated sometimes while ST did not think that she did during implementations. MT suggested some revisions for enhancing the plans; however, ST emphasized that the plans proceeded well.

Teachers in the present study were not aware of the problems that they encountered. In contrast, teachers and preservice teachers were found to be aware of the challenges of integration, such as lack of content knowledge, in previous studies (Frykholm & Glasson, 2005; Lee et al., 2013). Training for integration has been found to be effective in making inservice and preservice teachers aware of their lack of content knowledge (Berlin & White, 2010; Offer & Vasques-Mireles, 2009). In the present study, although the participating teachers did not attend a training program for integration, they experienced integration as a team through nearly an academic year. When the teachers evaluated their integration planning and teaching, ST generally stated that she was already integrating science and mathematics. For this reason, she showed more confidence during implementations compared to MT. Since this study was the first experience of MT related to integration, he was more cautiously proceeding in each phase of the planning and implementing. Because of this, his awareness could be higher than ST. Moreover, ST's awareness in terms of the problems that they encountered could be less than MT's, because of ST's over self-confidence.

5.2 Suggestions and Implications

ST did not consider the limitations of using mathematical formulas given in science curriculum and needed to use mathematics in science lessons. For this reason, the science curriculum could be revised in terms of the directions about using mathematics in science lessons. Similarly, the mathematics teachers' awareness about the science content in the mathematics curriculum and the mathematics textbooks could be increased and they could be guided to use this relation. By stressing the relation between science and mathematics in a powerful way and clarifying the degree of this relation in science and mathematics curricula, the importance of this relation could be understood by science and mathematics teachers.

This study investigated the integration process without a long training about integration. Teacher trainings could be given to both science and mathematics teachers together and separately, and these trainings could be given as stated in literature in a long duration (Kurt & Pehlivan, 2013) by teacher trainers and the researchers interested in this issue. In this study, the teachers planned the integrated lessons collaboratively as a team. This was important to observe their collaboration and communication in order to provide support to each of them for better integrated lessons. Team teaching is also another important issue as well as team planning. Several researchers emphasized the importance of team teaching (e.g. Steen, 1994; Loepp, 1999; Koirala & Bowman, 2003; Furner & Kumar, 2007; Browning, 2011). Training for integration should include team planning and team teaching which would most probably result in better integration at all phases of planning and teaching. Additionally, further research can focus on integration in team teaching of science and mathematics teachers.

This study also illustrated the critical issues that the teachers considered for planning and implementation of integration. For this reason, the content of teacher trainings, which will be designed for teachers' development for integration, can be constructed with the help of the findings of this study. The teachers had focused on only the similarities between science and mathematics during planning. If the teacher trainers construct a common language by considering not only the similarities but also the differences between science and mathematics, the content of the teacher trainings could lead the teachers to consider the differences besides similarities. Determining the common and uncommon use of science and mathematics concepts could also be taken into consideration while constructing the language. On the other hand, it was seen that the teachers focused on integrating content more than using common skills such as problem solving, reasoning, reaching conclusions and interpreting, organizing the data and formulating models, comparison-classification, measurement, collecting information and data, estimation, making inference, prediction, recording the data, communication, and observation of science and mathematics. However, it was suggested by several researchers (e.g. Steen, 1994; McGinnis, McDuffie, & Graber, 2006) to not to ignore common skills and methodologies of science and mathematics for the sake of integrating only content. Therefore, further studies can focus on this issue.

As seen from the findings of this study, it can be said that lack of content knowledge was the main barrier for achieving integration. Teachers' being aware of content knowledge gap for both science and mathematics is important for successful integration planning and implementation. As much as for content knowledge problem, the teacher should gain awareness for other problematic issues such as trivializing content, sharp transitions between science and mathematics concepts, and teaching related issues. These problems should be considered by teacher trainers and curriculum developers and the teachers should be supported for gaining awareness of these problems. If the teachers gain the awareness, they can be careful for overcoming these problems.

Using integration for different purposes could help the teachers to spread the other courses' content, to fulfill the all objectives, and to provide students with better understanding. Thus, if the teachers use different connection ways and increase the frequencies of using them, the students can understand the aimed concepts. The connections that will be used should be considered in detail and organized carefully in order to prevent possible misuse and misconceptions, and superficial connections.

Both ST and MT tried to plan the integrated plans. However, ST could not implement as expected because of her self-confidence. She implemented some unplanned things arbitrarily. However, MT tried to implement each point of the plans carefully but he was not comfortable while teaching and he had also encountered many problems. At this point, the role of other constructs such as self-confidence and even self-efficacy in teachers' planning and implementing integration can be also investigated.

The teachers' own planning of integrated plans could help them to internalize the plans and implement them easily. Thus, the opportunity of planning of the integrated lessons should be given them instead of giving them ready plans. In a similar way, Johnston, Ní Ríordáin, and Walshe (2014) also suggested to give opportunity of designing integrated lessons to the teachers by using technology. Balance model used for this study helped the teachers in planning the integration. However, criteria for better planning and implementing the integration should be clarified for guiding the teachers.

The participant teachers of this study did not consider when the other course's topics were taught. They should also have idea about this issue because the topics could construct the others' prerequisite knowledge for students. Therefore, future studies of integration should consider teachers' knowledge of other discipline's curriculum.

Participants of this study did not observe any practice of integration in their careers. Therefore, successful implementations could be video-taped and presented to the teachers to make integration. This can be also supported by university-school collaboration.

As explained before, MT had an undergraduate minor as science education. However, he did not take any course which integrated science and mathematics. Therefore, courses which the teacher candidates can use integration can be put into science and mathematics teacher education programs. These courses' content can include topics of other discipline and can focus on integration in separate classes. Additionally, there was an unclear point about the teachers' using teaching methods since they could not reflect the method they planned into the implementations. Therefore, teacher education program can also emphasize both science and mathematics teaching methods and the courses related to teaching can also revise methods for teacher education programs.

5.3 Recommendations for Future Studies

Since five different integrated lesson plans could be prepared and implemented in this study, all corresponding topics selected from science and mathematics could not be prepared and implemented for all plans except inheritance and probability plans. If mathematics integrated and science integrated plans of the selected two topics can be prepared and implemented by focusing on the same objectives, the teachers' teaching could be compared by focusing on these plans.

Additionally, replication studies can be conducted in private middle schools as well as other public middle schools. Since the school culture of private schools is different from public schools, integration process can take place differently in private schools with possible different critical issues and problems in planning and implementations.

In this study, the teachers did not start integration at the same point however, they took the same training. As a result of this study it can be concluded that they need more training for integration. Additionally, science teachers and mathematics teachers can need different training since their expectations are different. Although MT had an undergraduate minor as science education it did not really help him during the integration process. Studies can focus on the teachers who have undergraduate minor and have no undergraduate minor for investigating the integration process. Additionally, effect of undergraduate minor on the integration process can be investigated.

The participating teachers of this study stated that they would reuse and implement the integrated plans in their lessons in the following years. Their implementations can be investigated in order to see the permanence of the integration process by a longitudinal study. This study could be also conducted to for other grade levels besides 8th grade. It can be also important to use science and mathematics topics to be integrated from the same grade level which could not be done in this study because of the national examination of 8th graders. By this, teaching of the integrated plans can be easier in terms of students' remembering the related concepts.

By forming a teacher team including at least two science teachers and two mathematics teachers from at least two different schools, planning of the integrated lessons can be examined in detail by focusing on the communication and discussions among the teachers. In addition to this, by forming a team including one science teacher and one mathematics teacher who will teach the same plan at the same class together, implementation of the integrated plans can be observed and the process can be investigated.

Design based studies can be conducted since they will give opportunity to observe teachers' planning and implementation process by iterations and revisions during a long time. Additionally, they will help to reach more successful integration by solving the problematic points with more focus. Future phenomenology studies can also focus on how teachers experience integration. Lesson studies can also be conducted in order to understand students' and teachers' experiences.

5.4 Limitations of the Study

The aim of the study was to investigate one mathematics teacher and one science teachers' planning and implementation of the integrated lessons. The teachers collaborated in the planning process of the integrated lessons and they implemented the plans by themselves in their classes. The findings of the study revealed the teachers' initial practices related to mathematics and science integration, critical issues considered for the planning and implementation of the integrated lesson plans, the factors affected the planning and implementation of the plans, and the teachers' ideas about their teaching of the integrated lessons. These findings unearthed the science and mathematics integration's planning by in-service teachers experienced in own field at least five years and implementation of the plans in real classroom environment. However, this study also had some limitations. First, the participants of the study were one science teacher and one mathematics teacher in a public middle school in which the students were from rather low socioeconomic status families. ST had 15 years of experience and MT had 6 years of experience at the time of the study. They were working at the same school for 3 years. Thus, their teaching could be also shaped according to the school's features and students' profiles. Moreover, the teachers were good friends and they had a good communication both in and out of the school. This situation could affect their collaboration during the planning of the integrated plans. For example; since ST had more experience in teaching than MT, MT generally tended to accept ST's suggestions.

Since the teachers' common classes that they would teach were all 8^{th} grades in the school and the teachers determined the topics that would be integrated from 8^{th} grade topics, the content of the plans were limited to the topics from 8^{th} grade. Although they implemented the plans in 8^{th} grade, they put objectives from 7^{th} grade since they could not find any appropriate topic from 8^{th} grade. Moreover, the teachers usually focused on solving more questions in their lessons because 8^{th} grade students would take the national examination. This examination could have affected their teaching. Thus, the result of this study is limited to the 8^{th} grade classes.

In this study, five integrated plans were prepared and implemented because the teachers matched the topics and decided to plan them. Thus, this study is limited to these topics.

The other limitation of the study can be lack of team teaching in implementation of the integrated lessons. The school in which the study was conducted was a public middle school and the participant teachers were teaching four 8^{th} grade classrooms (for example while ST was teaching science 8/A, MT was teaching mathematics in a separate class hour 8/A). by changing respectively based on the course schedule prepared by administration. Thus, it was not possible to observe two teachers' team teaching in the same class for teaching integrated lessons.

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APPENDICES

APPENDIX A

PERMISSON OBTAINED FROM MINISTRY OF NATIONAL EDUCATION

ÖĞRENCİ İŞLERİ DAİRE BAŞKANLIĞI
REGISTRAR'S OFFICE

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SAYI:54850036-300 -3904-633 26.07.2013

EĞİTİM FAKÜLTESİ DEKANLIĞINA

Ankara Valiliği Milli Eğitim Müdürlüğü'nden alınan, İlköğretim Ana Bilim Dalı Doktora Programı öğrencisi Betül Yeniterzi'ye ait yazı ilgisi nedeni ile ilişikte sunulmuştur.

Bilgilerinize arz ederim.

Saygılarımla.

Nesrin ÜNSAL
Öğrenci İşleri Daire Başkanı

SSD/

24/07 29/07 E.U

T.C.
ANKARA VALİLİĞİ
Milli Eğitim Müdürlüğü

ÖĞRENCİ İŞLERİ
DAİRESİ BAŞKANLIĞI
Ev. Arş. Md. Saat :

Sayı : 14588481/605.99/1816885 19/07/2013
Konu: Araştırma İzni
(Betül YENİTERZİ)

ORTADOĞU TEKNİK ÜNİVERSİTESİNE
(Öğrenci İşleri Daire Başkanlığı)

İlgi : a) MEB Yenilik ve Eğitim Teknolojileri Genel Müdürlüğünün 2012/13 nolu genelgesi
b) 03.07.2013 tarih ve 007520 sayılı yazınız.

Üniversiteniz İlköğretim Ana Bilim Dalı Doktora Programı öğrencisi Betül YENİTERZİ"nin "Entegre Edilmiş Matematik ve Fen Öğretiminin Hazırlanma ve Uygulama Sürecinin İncelenmesi" konulu tez önerisi kapsamında 2013-2014 eğitim-öğretim yılında uygulama yapma isteği Müdürlüğümüzce uygun görülmüş ve araştırmanın yapılacağı İlçe Milli Eğitim Müdürlüğüne bilgi verilmiştir.

Anketlerin uygulama yapılacak sayıda çoğaltılması ve çalışmanın bitiminde iki örneğinin (CD ortamında) Müdürlüğümüz Strateji Geliştirme-1 Şube Müdürlüğüne gönderilmesini arz ederim.

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APPENDIX B

VOLUNTARY PARTICIPATION FORM

Bu çalışma, ODTÜ Eğitim Fakültesi İlköğretim Bölümü öğretim üyesi Yrd. Doç. Dr Çiğdem Haser danışmalığındaki Betül Yeniterzi tarafından doktora tez çalışması kapsamında yürütülmektedir. Bu çalışmada fen ve matematiğin entegre edilmesinin planlama ve uygulama süreçlerinin incelenmesi amaçlanmaktadır. Çalışmaya katılım gönüllülük esasına dayanmaktadır.

Katılımcı olmanız durumunda herhangi bir zarar görmeniz söz konusu değildir. Verdiğiniz bilgiler tamamen gizli kalacak ve çalıştığınız kurum ve çalışma arkadaşlarınızla kesinlikle paylaşılmayacaktır. Çalışma kapsamında derslerinizde video kayıtları ve sizlerle yapacağımız görüşmelerde izizn vermeniz halinde ses kaydı alınacaktır. Elde edilen veriler sadece bilimsel amaçla kullanılacak ve kimliğiniz gizli tutulacaktır.

Çalışma esnasında herhangi bir rahatsızlık hissederseniz çalışmadan çekilebilirsiniz. Çalışmaya katıldığınız için çok teşekkür ederiz. Çalışma ile ilgili bilgi almak için aşağıdaki iletişim bilgilerini kullanabilirsiniz.

Adres: Orta Doğu Teknik Üniversitesi, Eğitim Fakültesi, İlköğretim Bölümü

Betül Yeniterzi: E-posta: ybetul@metu.edu.tr, Oda no: EF-A 39, Tel: 2107506

Çiğdem Haser: E-posta: chaser@metu.edu.tr, Oda no: EF-A 105, Tel: 2106415

Bu çalışmaya tamamen gönüllü olarak katılıyorum. Çalışmadan istediğim zaman çekilme hakkım olduğunu biliyorum. Vereceğim bilgiler bilimsel amaçla kullanılabilir.

Adı Soyadı   Tarih   İmza

APPENDIX C

AN EXAMPLE OF INTEGRATED MATHEMATICS LESSON PLAN

Fen Entegre Edilmiş Matematik Ders Planı

Ders: Matematik (Matematik Ağırlıklı Fen Bağlantılı Entegrasyon)
Sınıf: 8 **Süre:** 2 ders saati
Konular:
Olasılık-Kalıtım
Ön Öğrenmeler:
Kesirlerle çarpma, olasılık hesaplama, örnek uzay, olay, kalıtım, gen, DNA, homozigot, heterozigot, eşey kromozomları.
İlgili Fen ve Matematik Kazanımları:
2.3. Mendel'in calısmalarının kalıtım acısından onemini irdeler.
2.4. Gen kavramı hakkında bilgi toplayarak baskın ve cekinik genleri fark eder.
2.5. Fenotip ve genotip arasındaki iliskiyi kavrar.
2.6. Tek karakterin kalıtımı ile ilgili problemler cozer.
Olasılık Çeşitleri
1. Deneysel, teorik ve öznel olasılığı açıklar.
6. sınıftan Olasılıkla ilgili temel kazanımlar
2. Bir olayı ve bu olayın olma olasılığını açıklar.
3. Bir olayın olma olasılığı ile ilgili problemleri çözer ve kurar.
Öğretim metotları:
Soru cevap, akıl yürütme, problem çözme, ilişkilendirme, tahmin etme.

<u>Dersin Başlangıcı</u>

Sizce yeryüzünde bir ikizinizin olma ihtimali nedir? Sorusu öğrencilere yöneltilerek farklı cevaplar gelmesi beklenir. Peki insanların ya da aile bireylerinin kardeşlerin mesela birbirinin aynısı olmamasının yani çeşitliliğin olmasının nedeni nedir? diye sorulur. Gelecek cevaplar (kalıtım, gen, DNA) olabilir.
Sizce kahverengi gözlü anne ve babanın renkli gözlü bir çocuklarının olma ihtimali var mıdır? Bunu nasıl açıklarsınız? Diye sorup kalıtım ve gen konularını hatırlatmayı amaçlanır. Sonra aşağıdaki sorular sınıfta tartışılır.
1) Kahverengi göz rengine sahip anne ve babanın mavi gözlü çocuklarının olma olasılığı var mıdır? Bu olasılık nelere bağlıdır?
2) Homozigot uzun kirpikli anne ile homozigot kısa kirpikli babanın uzun kirpikli çocuklarının olma ihtimali kaçtır? (Uzun kirpik kısa kirpiğe baskın)

<u>Dersin Ortası</u>

Olasılık türlerinin neler olabileceği öğrencilere sorulur. Örnekler verilir (örneğin; havanın durumu ile ilgili). Deneysel olasılık, teorik olasılık, ve öznel olasılık türleri açıklanır. Not yazdırılır. Örnek sorular verilir.

3) Aysel ve Mehmet çiftinin 1 kız 3 erkek çocukları vardır. Buna göre bu çiftin 5. çocuklarının

a) deneysel olarak kız olma olasılığı kaçtır?

b) teorik olarak kız olma olasılığı kaçtır?

Etkinlik 1 Para atma (deneysel olasılık, teorik olasılık, ve öznel olasılık) yaptırılır.

İlgili soru çözümleri yapılır.

Örnek sorular çözülür.

4) Saç şekli bakımından homozigot kıvırcık saçlı bir anne ile heterozigot kıvırcık saçlı bir babanın düz saçlı kız çocuklarının olma olasılığı yüzde kaçtır?

5) Siyah ve beyaz renkte tavşanlar arasında yapılan çaprazlamada 60 siyah renkli ve 20 beyaz renkli tavşan oluştuğuna göre çaprazlanan tavşanların genotiplerini belirleyerek bu çaprazlamada heterozigot siyah tavşan elde etme olasılığı kaçtır? (siyah gen beyaz gene baskın)

6) Heterozigot A kan gruplu bir baba ile heterozigot B kan gruplu bir annenin çocuklarının 0 kan grubuna sahip olma olasılığı % kaçtır?

7) Aşağıda bir DNA parçası bulunmaktadır. Bu zincirin 5. basamağına SG gelme olasılığı nedir?

G S
A T
S G
A T
S G

Dersin Sonu

-Deneysel, teorik ve öznel olasılık türleri özetlenir.

Bazı fen bilgisi konularının matematik konuları ile ilişkili olabileceği vurgulanır. Başka hangi konularda bu ilişkiyi farkettikleri sorusu öğrencilere sorulur.

Entegrasyon Etkinlik Taslağı

Üniteler: Olasılık-Kalıtım

Seçtiğiniz öğretme metodu: Yaparak yaşayarak öğrenme, deney.

Seçtiğiniz konular: Olasılık-Kalıtım

Sınıf Düzeyi: 8 **Süresi:** 25 dk

Kazanımlar:
1. Deneysel, teorik ve öznel olasılığı açıklar.
3. Bir olayın olma olasılığı ile ilgili problemleri çözer ve kurar.
2.3. Mendel'in calışmalarının kalıtım açısından önemini irdeler.
2.5. Fenotip ve genotip arasındaki iliskiyi kavrar.
2.6. Tek karakterin kalıtımı ile ilgili problemler cozer.
4.2. DNA'nın yapısını sema uzerinde gostererek basit bir DNA modeli yapar.

Giriş:

Araç gereçler:
Her grup için iki adet madeni para, tahta kalemi, defter

Amaç: Bir bezelye tohumunun teorik olarak düzgün veya buruşuk olma olasılığını deneysel olarak gerçekleştirerek, teorik olarak elde edilen sonuca ulaşmaya çalşmak.

Etkinlik:
-Sınıf ikişer kişilik gruplara ayrılır ve her gruba iki madeni para verilir. En az 15 grup.
-Paraların ikisinin de bir yüzüne S diğer yüzüne s yazılır (Yani ikisi de heterozigot düzgün Ss)
-Her grup önce 1. parayı sonra 2. parayı havaya atarakүst yüze gelen işaretleri oluşturacakları tabloya not eder. Bu işlemi her grup 10 kez tekrarlar.

	Örnek	1	2	3	4	5	6	7	8	9	10
Oluşan Genotip	SS Homozigot										
Oluşan Fenotip	Düzgün										

-Sınıf genelinde alınan sonuçlar tahtaya yazılır. (toplam atış sayısı, düzgün ve buruşuk bezelye sayısı). Toplamda 150 atış olacak.
-Böylece bir bezelyenin deneysel olarak düzgün ve buruşuk olma olasılıkları ve homozigot ve heterozigot olma olasılıkları hesaplanır.
Öğrencilere fen dersinde gelen bu tip sorularda teorik olasılığı kullanmaları gerektiği hatırlatılır.

Sonlandırma ve Değerlendirme:
Deneysel olasılıkta deney sayısı arttırıldığında elde edilen sonuç, teorik olasılıkla elde edilen sonuca yaklaştığı vurgulanır. **60/150 mesela, teorikte ½ ye yaklaşacağını. 2/10den 60/150ye**

APPENDIX D

INTERVIEW PROTOCOL

1) Entegrasyon planının uygulanmasını nasıl değerlendiriyorsunuz? Beklediğiniz gibi gerçekleşti mi? Öğrenciler üzerinde nasıl bir etkisi oldu?

2) Terazi modeline göre hazırlanan ve uygulanan planı nasıl değerlendiriyorsunuz?

3) Fen dersi için amaçlanan kazanımları yerine getirebildiniz mi?

4) Matematik dersi için amaçlanan kazanımları yerine getirebildiniz mi?

5) Kazanımlarla ilgili eksik/gereksiz olduğunu düşündüğünüz noktalar var mı?

6) Uygulama gerçekleştirildiği 4 farklı sınıftada aynı şekilde mi işlediniz? Farklılıklar var mıydı? Bunlar neler?

7) Planın uygulanmasıyla ilgili sınıfta bir anlık bile olsa tereddüt ettiğiniz ya da sıkıntı yaşadığınızı hissettiğiniz bir nokta oldu mu? Olduysa bunu nasıl aştınız?

8) Böyle bir durum olduysa bu durumun öğrenciler üzerinde nasıl bir etkisi olmuş olabilir?

9) Derste kullandığınız etkinliği nasıl değerlendiriyorsunuz? Öğrenciler bu etkinlikle ne kazandılar?

10) Tekrar yapma şansınız olsa etkinlikte değişiklik yapar mısınız? Hangi noktalarda değişiklik yaparsınız? Neden?

11) Anlattığınız konu için "böyle yaptık diğer konuda şunu değiştirir/eklersek entegrasyon daha iyi şekilde yapılmış olur" diyebileceğiniz bir öneriniz var mı? Açıklayınız.

12) Tekrar hazırlama ve uygulama şansınız olsa kalıtım-olasılık entegrasyon planında neleri değiştirirdiniz?

APPENDIX E

CURICULUM VITAE

PERSONAL INFORMATION

Surname, Name: Yeniterzi, Betül
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EDUCATION

Degree	Institution	Year of Graduation
MS	Selçuk University Elementary Mathematics Education	2009
BS	Selçuk University Elementary Mathematics Education	2006
High School	Atatürk High School, Konya	2002

WORK EXPERIENCE

Year	Place	Enrollment
2010- Present	METU- Elementary Education	Research Assistant
2009-2010	Kahramanmaraş Sütçü İmam University- Elementary Mathematics Education	Research Assistant
2007-2009	Ministry of National Education	Teacher

FOREIGN LANGUAGES

Advanced English

AWARDS

TÜBİTAK Scientific Publication Award, 2011.

HOBBIES

Calligraphy, Orienteering, Fitness.

WORKSHOPS

Participant of NWU-Essen Research Group & Graduate School Teaching & Learning Science Winter School (12-14 Feb, 2013), University of Duisburg Essen,

RESEARCH PROJECTS

Investigation of Planning and Implementation Processes of Integrated Science and Mathematics Instruction, 2013-2014. Middle East Technical University, Scientific Research Project 07-03-2014-007. As a researcher, PhD Thesis Project.

PUBLICATIONS

A. Articles Published in International Scientific Journals

A1. Tekerek, M., **Yeniterzi, B.**, & Ercan, O. (2011). Math attitudes of computer education and instructional technology students, *Turkish Online Journal of Educational Technology, 10*(3), 168-174.

A2. Cebesoy, Ü. B. & **Yeniterzi, B.** (2014). Investigation of science and technology exam questions in terms of mathematical knowledge. *Procedia – Social and Behavioral Science, 116*, 2711-2716.

B. Conference Paper Presentations in International Conferences

B1. Tekerek, M., **Yeniterzi, B.**, & Ercan, O. (2011, May). *Math attitudes of CEIT students.* Paper presented at 11th International Educational Technology Conference (IETC), İstanbul, Turkey. (Awarded by11th IETC as the best article)

B2. Tekerek, M., **Yeniterzi, B.**, & Yıldırım, Z. (2012, September). *Web-based geometry teaching*. Paper presented at 1st Applied Education Congress, Ankara, Turkey.

B3. **Yeniterzi, B.** & Tekerek, M. (2012, October). *The effect of computer assisted instructional material on teaching mathematical concepts in pre-school.* Paper presented at 6th International Computer & Instructional Technology Symposium, Gaziantep, Turkey.

B4. Cebesoy, Ü. B. & **Yeniterzi, B.** (2013, February). *Investigation of science and technology exam questions in terms of mathematical knowled*ge. Paper presented at 5th World Conference on Educational Sciences (WCES), Rome, Italy.

B5. **Yeniterzi, B.**, & Cebesoy, Ü. B., & Kılıçaslan, F. (2013, September). *Middle school students' mathematical difficulties in force and motion unit.* Paper presented at European Conference on Educational Research (ECER), Bahçeşehir University, Istanbul, Turkey. Abstract retrieved from http://www.eera-ecer.de/ecer-programmes/conference/8/contribution/21566/

B6. **Yeniterzi, B.** & Ulusoy, F. (2013, September). Investigation on pre-service mathematics teachers' knowledge about eight grade students' possible errors in exponents. Paper presented at The European Conference on Educational Research

(ECER), Bahçeşehir University, İstanbul, Turkey. Abstract retrieved from http://www.eera-ecer.de/ecer-programmes/conference/8/contribution/21092/

B7. **Yeniterzi, B.** & Cebesoy, Ü. B. (2014, September). *Reflections of mathematics into science: line graphs in heat-temperature unit.* Paper presented at International Society of Educational Research (ISER) World Conference, Nevsehir, Turkey.

B8. Cebesoy, Ü. B., Mehmetlioglu, D., & **Yeniterzi, B.** (2015, September). *An example of integrating mathematics to science: Graphs and living organisms.* Paper presented at The 11th Conference of the European Science Education Research Association (ESERA), Helsinki, Finland.

B9. Cebesoy, Ü. B. & **Yeniterzi, B.** (2015, October). *Investigation of preservice science teachers' ideas towards science-mathematics integration.* Paper presented at The International Conference on Best Practices and Innovations in Education, Izmir, Turkey.

C. Articles Published in National Scientific Journals

C1. Doğan, M. & **Yeniterzi, B.** (2011). Attainment level of seventh grade students for rational numbers. *Ahmet Kelesoglu Education Faculty (AKEF) Journal, 31*(14), 217-237.

C2. **Yeniterzi, B.** & Işıksal-Bostan, M. (2015). An examination of the 7th grade mathematics teacher's guidebook in terms of the relationship between mathematics and science. *Elementary Education Online, 14*(2), 407-420. http://dx.doi.org/10.17051/io.2015.31557

D. Conference Paper Presentations in National Conferences

D1. **Yeniterzi, B.** & Işıksal, M. (2012, June). *Using science subjects in mathematics education: Example of elementary 7th grade teachers' guide book.* Paper presented at 10th National Science and Mathematics Education Conference (UFBMEK), Niğde, Turkey.

D2. Ulusoy, F. & **Yeniterzi, B**. (2013, September). *Eighth grade students' errors about operations in exponents of integers.* Paper presented at 22th National Education Sciences Congress, Eskişehir, Turkey.

D3. **Yeniterzi, B.** & Haser, Ç. (2015, May). *Factors that affects science and mathematics teachers' process of planning integrated lesson plans, encountered problems and solution ways.* Paper presented at Turkish Computer and Mathematics Education Symposium-2 (TURKBİLMAT 2). Adıyaman, Turkey.

APPENDIX F

TURKISH SUMMARY

Giriş ve Alan Yazını

Matematik ve fenin yakın bağlantılarının uzun bir geçmişi bulunmaktadır (NCTM, 2000). Bir çok araştırmacı (Lederman ve Niess, 1998; Basista ve Mathews, 2002; Wang, 2005) fen ve matematik arasındaki bu karşılıklı ilişkiyi desteklemişler ve bu ilişkinin öğrencilerin hem fen hem de matematik kavramlarını bağlantılar kurarak daha anlamlı şekilde öğrenebileceklerini ifade etmişlerdir.

Milli Eğitim Bakanlığı, matematik (MEB, 2011a; 2013a) ve fen programlarında (MEB, 2011b, 2013b) öğrencilerin başarılı olması için kazandırılması hedeflenenen ortak kazanımlardan bahsetmektedir. Bunlar eleştirel düşünme, yaratıcı düşünme, araştırma ve sorgulama, problem çözme becerileri ve bilişim teknolojilerinin kullanımı olarak sıralanabilir. Ortaokul matematik programında disiplinler arası ilişkilendirme özellikle fen konuları ile ilgili olarak vurgulanmaktadır. Benzer şekilde, ortaokul fen programı da fenin diğer disiplinlerle ilişkilendirilmesini önerirken matematik ile ilişkilendirilmesini önemsemektedir. Bu bağlamda, fen ve matematikteki belli konulardaki kavramların birbirinin ön bilgilerini oluşturduğu söylenebilir ki bu durum iki disiplin arasındaki ilişkilendirmenin önemini ortaya koymaktadır. Bu yüzden öğrencilerin fen ve matematik kavramlarını ard arda ve ilişkili olarak öğrenmeye ihtiyaç duydukları sonucuna ulaşılabilir. Bu noktada öğretmenlerin bu kavramları bir uyum içerisinde öğretmeleri gerekliliği ortaya çıkmaktadır.

Matematiğin her yaşta öğrenilmesi ve öğretilmesini geliştirmek amacıyla kurulmuş bir organizasyon olan Amerikan Ulusal Matematik Öğretmenleri Birliği-NCTM (2000) de matematiğin fen, sosyal bilgiler, geometri konularındaki sanat gibi alanlarla ilişkilendirilmesinin önemli olduğunu vurgulamaktadır. NCTM ayrıca matematiğin bir durum içerisinde kullanılmasının öğrenciler açısından önemli olduğunu ve fen ve matematik arasındaki bağın sadece içerik olarak değil aynı zamanda süreç bazında da yapılması gerektiğini de belirtmektedir. NCTM matematik öğretmenlerine; öğrencilerini matematiği günlük hayatla ilişkilendirerek ve fenle ilgili durumlarla bağlantılandırarak keşfetmeleri ve kullanmaları için cesaretlendirme ve fen öğretmenleriyle bu ilişkilendirmeleri sağlıklı şekilde yürütebilmek için işbirliği yapmaları yönünde tavsiyelerde de bulunmaktadır.

Fen ve matematiğin entegrasyonu son yıllarda daha sık gündeme gelmektedir. Ancak entegrasyonun öğrenci başarı ve tutumuna olumlu katkılar getireceğine dair öngörüler gerçek sınıf ortamında öğretmenler tarafından uygulanması ve deneyimlenmesi ile mümkün olabilir (Mason, 1996). Örneğin, Kıray (2012) fen ve matematiğin entegre edilebilmesi için terazi modelini önermiştir. İçerik bilgisi modelin merkezinde yer alırken, beceriler, öğrenme ve öğretme süreci, duyuşsal özellikler, ve ölçme ve değerlendirme modelin diğer önemli bileşenlerini oluşturmaktadır. İçerikte yedi ayrı boyut oluşturulmuştur. Bunlar, Matematik, Matematik Temelli Fen Destekli Entegrasyon, Matematik Ağırlıklı Fen Bağlantılı Entegrasyon, Tam Entegrasyon, Fen Ağırlıklı Matematik Bağlantılı Entegrasyon, Fen Temelli Matematik Destekli Entegrasyon, ve Fen dir.

Öğretmenlerin fen ve matematiğin gerçek uygulayıcıları olduğu düşünüldüğünde, onların entegrasyonun planlaması ve uygulama süreçlerinin nasıl gerçekleştirdiğini görmek entegrasyonu okul ortamında anlamak açısından katkı sağlayabilir. Bu noktada, bu çalışmanın amacı, bir matematik ve bir fen öğretmeninin matematik ve fen entegrasyonunu planlama ve uygulama süreçlerini incelemektir. Özel olarak, bu çalışma (a) bir matematik ve bir fen öğretmeninin uygulamalarının matematik ve fen entegrasyonu açısından mevcut durumuna, (b) öğretmenlerin entegre dersleri planlamalarına, (c) öğretmenlerin entegre edilmiş ders planlarını uygulamalarına ve (d) öğretmenlerin planlama ve uygulama süreçlerini nasıl değerlendirdiklerine odaklanmıştır. Bu amaçlar doğrultusunda aşağıdaki araştıma sorularına cevap aranmıştır:

1. Bir ortaokul fen ve bir ortaokul matematik öğretmeninin fen ve matematik entegrasyonu ile ilgili var olan uygulamaları nasıldır?
2. Bir ortaokul fen ve bir ortaokul matematik öğretmeni entegre edilmiş ders planlarını nasıl hazırlamaktadırlar?

2.a. Planlama esnasında öğretmenler hangi kritik noktaları göz önünde bulundurmaktadır?

2.b. Entegre edilmiş planların planlama sürecini etkileyen faktörler nelerdir?

3. Bir ortaokul fen ve bir ortaokul matematik öğretmeni entegre edilmiş ders planlarını nasıl uygulamaktadır?

   3.a. Öğretmenler entegre edilmiş planlar ne derecede uygulamaktadır?

   3.b. Öğretmenler entegre edilmiş planları uygularken hangi problemle karşılaşmaktadır?

4. Öğretmenler entegrasyon sürecini kendi öğretimleri açısından nasıl değerlendirmektedir?

Entegre edilmiş derslerin gerçek sınıf ortamında uygulanması önemli ancak net olmayan bir durumdur (Mathison ve Freeman, 1997). Entegre edilmiş programların etkililiğini net olarak görebilmek için uzun süreli öğretimler yapılması önerilmektedir (Kurt ve Pehlivan, 2013). Hurley (2001) de ileride yapılacak araştırmaların entegre edilmiş öğretim programlarının farklı şekillerinin uygulanmasına odaklanılmasını önermektedir. Diğer taraftan, entegre edilmiş öğretimlerin uygulanması sırasında ortaya çıkabilecek sıkıntıların açığa çıkarılmasına ve bu anlamda öğretmenlerin her sınıf seviyesinde yaşayacakları sıkıntılara çözüm getirilmesine odaklanılması gerektiğini literatürde vurgulamaktadır (Pang ve Good, 2000). Frykholm ve Glasson (2005) fen ve matematiğin entegre edilmesinin öğretmenler tarafından sınıf ortamında planlamasının ve uygulanmasının araştırılmasını önermektedir.

İlgili alanyazını ışığında, bir çok araştırmacının entegrasyonun planlama ve uygulama süreçlerinin zor olmasına rağmen uzun süreli olarak araştırılması gerektiğini önerdiği sonucuna ulaşılabilir. Diğer taraftan, çok az araştırmacının entegrasyonu gerçek sınıf ortamında araştırdığı söylenebilir. Ayrıca öğretmenlerin entegrasyon derslerinin öğretiminde karşılaştığı problemlerin araştırıldığı çok az sayıda çalışma bulunmaktadır. Bu yüzden öğretmenlerin fen ve matematik entegrasyonunu hazırlama ve uygulama süreçlerini anlamak, hem başarılı entegrasyon uygulamaları için gerekli hususların belirlenmesi için hem de öğretmenlerin öğretimi, muhtemel sıkıntıları ve ihtiyaçları hakkında bilgi sahibi olmak açısından önemli olabilir. Ayrıca, fen ve matematik entegrasyonu literatüründe öğretmenlerle yapılmış ve onların bu dersleri öğretirken neler yaptığını, öğretmenlerin işbirliği içerisinde bu süreci nasıl sürdürdüklerini araştıran oldukça az sayıda çalışma bulunmaktadır. Bu çalışmanın bulguları planlamadan uygulamaya kadar entegrasyon sürecindeki büyük resmi anlamayı sağlayabilir. Bu bağlamda, bu çalışma entegrasyonla ilgili olarak yapılacak uygulamalarda öğretmenleri ve araştırmacıları cesaretlendirebilir. Temel, Dündar ve Şenol (2015) ise fen ve matematik entegrasyonu ile ilgili olarak Türkiye' de çok az çalışma olduğunu ve entegrasyonun önemi ve gerekliliğine dikkat çekecek çalışmaların yapılmasını önermektedirler. Bu sebeple, bu çalışma Türkiye'deki entegrasyon literatürüne de katkı sağlayabilir.

Bu çalışmada Ankara'da bir devlet ortaokulunda çalışan bir fen ve bir matematik öğretmeni bir takım olarak işbirliği yaparak 8. sınıflar için fen ağırlıklı matematik bağlantılı entegrasyon (FAMBE) ve matematik ağırlıklı fen bağlantılı entegrasyona (MAFBE) yönelik ders planları hazırlamışlardır. Fen ve matematik arasındaki ilişkinin önemi bir çok çalışmada vurgulanmasına rağmen bu ilişkilendirmenin öğretim programlarına ve sınıflardaki öğretime yansıması açık değildir (Kurt ve Pehlivan, 2013). Entegre edilmiş fen ve matematiğin gerçek sınıf ve okul ortamında ve gerçek öğrencilerle uygulanması (Czerniak, Weber, Sandman ve Ahern, 1999) ve öğretmenlerin entgerasyonu kavramsallaştırmalarının öğretimlerine yansımasını görmek için sınıf ortamının gözlenmesi (de Araujo, Jacobson, Singletary, Wilson, Lowe ve Marshall, 2013) entegrasyon için araştırma taslağı olarak önerilmektedir.

Bu çalışmada biri fen ve diğeri matematik olmak üzere iki öğretmen bir akademik dönem boyunca yakından gözlenmiştir. Daha sonra, bu iki öğretmen beş tane entegre edilmiş ders planını işbirliği yaparak birlikte hazırlamışlardır. Bir yıl boyunca hazırlanan planları konuların sırası geldikçe sınıflarında ayrı ayrı uygulamışlardır. Hem planlama hem de uygulama süreci süreç hakkında detaylı olarak bilgi sahibi olabilmek için derinlemesine gözlenmiştir. Bu yüzden bu çalışmanın bulguları hem derinlemesine, hem de süreç boyunca yaşananları görmek adına katkı sağlayabilir.

Entegrasyonla ilgili olarak çalışan araştırmacılar (Jacobs, 1989; Meier, Nicol ve Cobbs, 1998), bu derslerin planlama ve uygulamasıyla ilgili olarak belli noktalara dikkat çekmişlerdir. Bunlar; en az iki öğretmenle işbirliği halinde çalışmak, ortak planlama, aynı öğrencilere öğretim yapma, mesleki işbirliğinde yeterli öğretmenlerle çalışma, fikir birliği sağlama ve öğretim programı geliştirme olarak sıralanabilir. Bunun yanında, araştırmacılar başarılı ve etkili entegrasyona engel teşkil edebilecek sıkıntı ve problemleri de zaman sıkıntısı, sınıf yönetimi, idari destek eksikliği, öğretmen bilgisi ve öğretmen inancı şeklinde vurgulamışlardır. Bu çalışma bu problemlerden bazılarını entegrasyon süreci başlamadan önlediği için de önemlidir. İlk olarak, okul yönetiminden okuldaki tüm olanakları kullanabilmek için izin alınmıştır. İkinci olarak, çalışmaya katılan öğretmenler tecrübeli öğretmenler oldukları için herhangi bir sınıf yönetimi problemi beklenmemiştir. Üçüncü olarak, entegre edilmiş ders planlarının hazırlanma süreci öğretmenler tarafından işbirliği halinde akademik ders yılı başlamadan önceki seminer döneminde yapılmıştır. Böylece planlama ile ilgili olarak zaman sıkıntısı yaşanmamıştır. Son olarak, öğretmenler çalışmaya gönüllü olarak katıldıkları için entegrasyonun etkililiği ile ilgili olarak olumlu düşüncelere sahiplerdir.
Literatür incelendiğinde görülmektedir ki, entegrasyona yönelik zorluklar genel olarak literatür inceleme çalışmalarında tartışılmış ve değerlendirilmiştir. Bu bağlamda, bu çalışma öğretmenlerin entegrasyonla ilgili tecrübelerini ve entegrasyonun planlama ve uygulama süreçlerindeki zorlukları ve sıkıntıları direkt olarak görmeye fırsat tanıyabilir. Bu çalışma ayrıca entegrasyonla ilgili kritik noktalar hakkında öğretmenlere farkındalık kazandırabilir. Bu çalışmanın bulguları, entegrasyon literatüründe sıkça önerilen hizmetiçi öğretmen eğitimlerinin içeriğinin hazırlanmasında öğretmenlerin entegrasyon süreçlerinin incelenmesi ve entegrasyon için ihtiyaçların belirlenmesi sayesinde Milli Eğitim Bakanlığı'na rehberlik edebilir. Bunun yanında, okul idarelerine başarılı bir entegrasyon için ortam hazırlama ve destek sağlama anlamında yardımcı olabilir. Ayrıca, bu çalışma öğretmen adaylarına entegrasyonla ilgili eğitimlerin tasarlanması için öğretmen eğitimi programlarına da yol gösterici olabilir.

Basista ve Mathews (2002)’nin bahsettiği üzere öğretmenlerin fen ve matematik entegrasyonunu nasıl değerlendirdikleri ve entegrasyonun öğrenciler ve öğretmenler üzerinde ne tür etkilerinin olduğunu görmek anlamlı olacaktır. Öğretmenlerin fen ve matematiğin gerçek uygulayıcıları olduğu göz önüne alındığında, bu iki disiplinin entegrasyonunu nasıl algıladıklarını, planladıklarını, uyguladıklarını ve entegre edilerek yapılan derslerde neler olduğunu derinlemesine incelemek entegrasyonu ve muhtemel etkilerini tam anlamıyla anlamaya katkı sağlayacaktır. Dolayısıyla bu çalışma öğretmenlerin entegrasyonu planlaması, uygulaması ve değerlendirmesine kadar gerçekleşecek olan büyük resmi görebilmek açısından önemli bulunmuştur.

Yöntem

Bu çalışmada matematik ve fen öğretmenlerinin entegrasyonu birlikte planlama ve uygulamaları sürecinin nasıl gerçekleştiğini detaylı olarak anlayabilmek için nitel araştırma yöntemi kullanılmıştır. Entegrasyon süreci hakkında derin bir anlayış elde edebilmek için çalışmanın araştırma soruları “nasıl” ve “ne” olarak belirlenmiştir. Veriler gözlem, mülakatlar ve video kayıtları yoluyla çoklu veri toplama araçları kullanılarak okuldaki sınıflarda, toplantı odasında ve arşiv odasında öğretmenlerle birlikte uzun zaman geçirilerek toplanmıştır.

Bu çalışma nitel araştırma yöntemlerinden örnek olay (durum) çalışmasına bir örnektir çünkü bu çalışmada 2013-2014 eğitim öğretim yılı boyunca bir devlet ortaokulunda çalışan bir fen ve bir matematik öğretmeninin 8. sınıf seviyesinde fen ve matematiğin entegre edilmesini planlama ve uygulama durumuna odaklanılmıştır. Özel olarak, bu çalışma Bogdan ve Biklen (1992) ve Merriam (2009)’un da belirtttiği gibi gözlemsel durum çalışması olarak isimlendirilebilir. Bogdan ve Biklen (1992)’e göre gözlemsel durum çalışmalarında ilgi okul, rehabilitasyon merkezi gibi belli bir kurum ya da bu kurumdaki sınıf, öğretmenler odası, laboratuvar gibi belli bir yerdedir. Kurumdaki belli bir grup insan ve kurumun öğretim programı geliştirme gibi belli bir etkinliği de gözlemsel durum çalışmalarının odağını oluşturabilir. Bu çalışmada, belli bir grup insanı (bir fen ve bir matematik öğretmenini), belli bir mekanı (seçilen ortaokul) ve belli bir etkinliği (öğretmenlerin fen ve matematik entegrasyonunu) planlama ve uygulamaları oluşturmaktadır.

Aynı devlet ortaokulunda birlikte çalışan ve aynı sınıflara ders veren gönüllü bir matematik ve bir fen öğretmeni amaçlı örneklem yöntemi yoluyla seçilmiştir. Çalışmaya katılan matematik öğretmeni 2007 yılında bir devlet üniversitesinin İlköğretim Matematik Öğretmenliği programından mezun olmuştur. Çalışma yapıldığı sırada matematik öğretmeni aynı program ve üniversitede yüksek lisans yapmaktaydı. Matematik öğretmeni ayrıca fen bilgisi yan alanıyla mezun olmuştur ancak entegrasyonla ilgili herhangi bir eğitim ve ders almamıştır. Altı yıllık öğretmenlik tecrübesi olan matematik öğretmeni, tüm sınıf seviyelerinde öğretmenlik yapmış ve hiç fen öğretmenliği yapmamıştır. Fen öğretmeni ise 1998 yılında bir devlet üniversitesinin Biyoloji bölümünden mezun olmuştur. Herhangi bir yan alanı yoktur. Entegrasyonla ilgili herhangi bir eğitim ya da ders almamıştır. Fen öğretmeni 15 yıldır tüm sınıf seviyelerinde fen öğretmenliği yapmıştır. Fen öğretmeni hiç matematik öğretmenliği yapmamıştır.

Veri toplama sürecinin en başında hem fen öğretmeninin hem de matematik öğretmeninin 7. ve 8. sınıflardaki dersleri öğretmenlerin fen ve matematik entegrasyonunu ne derecede ve nasıl yaptıklarını anlamak için araştırmacı tarafından gözlenmiştir. Bu gözlemler öğretmenlerin entegre edilmiş ders planlarının hazırlanmasında rehberlik etmiştir. Ek olarak öğretmenlerin entegrasyonla ilgili var olan uygulamalarını daha ayrıntılı görebilmek için 7. ve 8. sınıflardan dört öğrencinin 2012-2013 eğitim öğretim yılına ait fen ve matematik defterleri kopyalanmış ve incelenmiştir. Ayrıca matematik öğretmeni ve fen öğretmenine ilişkili olabilecek fen ve matematik kavramlarının tanımları sorulmuş ve onların entegrasyona ne kadar hazır oldukları incelenmiştir. Daha sonra, öğretmenler farklı zamanlarda fen ve matematik konularından birbiri ile bağlantılı olanları belirlemişlerdir. Sınıf seviyeleri de gözönüne alınarak her iki öğretmenin ders anlatacağı ortak sınıflar olan okuldaki tüm 8. sınıf öğrencileri için entegre edilebilecek konular belirlenmiştir. Bu konular kalıtım-olasılık (Plan1), kaldırma kuvveti-oran orantı (Plan2), ısı sıcaklık-grafikler (Plan3), olasılık-kalıtım (Plan4) ve geometrik cisimlerin hacimleri-kaldırma kuvveti (Plan5) olarak belirlenmiştir.

Araştırmacı öğretmenlerin entegrasyona hakkında fikir sahibi olabilmeleri için fen ve matematik programından örnekler sunmuş ve entegrasyon alanyazınından başarılı entegrasyon için sunulan önerileri açıklamıştır. Daha sonra fen ve matematik entegrasyonunu tanımlamaya yönelik sunulmuş Berlin-White Entegre Edilmiş Fen ve Matematik Modeli ve Türk eğitim sistemine uygun olduğu düşünülen Kıray (2012)'nin Terazi Modeli öğretmenlere anlatılmıştır. Öğretmenlerden Terazi modelinin iki basamağı olan Fen Ağırlıklı Matematik Bağlantılı Entegrasyon (FAMBE) ve Matematik Ağırlıklı Fen Bağlantılı Entegrasyon (MAFBE)'ye uygun olarak daha önce belirlenmiş konulara yönelik ders planları hazırlamaları istenmiştir. Öğretmenler fen ve matematik programlarının olanak sağlamadığı gerekçesiyle Terazi Modelinin merkezindeki Tam Entegrasyon basamağına odaklanmak istememişlerdir. Terazi modeli yapılandırmacılığı temel aldığı için öğretmenler bu planları hazırlamakta zorluk yaşamayacaklarını düşünmüşlerdir.

Ardından öğretmenler 6. sınıf seviyesinde oran-orantı ve kütle-ağırlık konuları için FAMBE ve MAFBE'ye uygun olarak iki plan hazırlamışlardır. Bu ısındırma çalışmasından sonra, araştırmacı Kıray (2010)'ın hazırlayıp uyguladığı örnek entegrasyon ders planlarını öğretmenlere göstermiştir. Öğretmenler bu planları kendi geliştirdikleri planlarla kıyaslayıp tartışmışlardır. Bu süreçten sonra öğretmenler yaz tatiline girmişler ve araştırmacı öğretmenlerle iletişimi telefon ve e-mail yoluyla devam ettirmiştir. Öğretmenlere araştırmacı tarafından konuları hatırlayıp planlarla ilgili düşünmelerini sağlamak ve eksik oldukları konularla ilgili sıkıntılarını giderebilmeleri amacıyla fen ve matematik dersleri için gerekli sınıf seviyelerinde öğretmen kılavuz kitapları gönderilmiştir.

Eğitim öğretim yılı başlamadan önceki seminer döneminde öğretmenler FAMBE ve MAFBE için belirlenen konularda ders planlarını hazırlamak amacıyla bir araya getirilmiştir. Fen öğretmeni ve matematik öğretmeni planları tartışıp taslak halinde yazmışlardır. Bu planlama sürecinin araştırmacı tarafından ses kaydı alınmıştır. Araştırmacı ses kayıtlarını dinledikten sonra planlara yazılmayan ama yapılmaya karar verilen noktalarını da planlara ekleyerek planların son halini öğretmenlere tekrar göstermiştir. Bu şekilde ufak değişikliklerle planların son hali verilmiştir.

2013-2014 eğitim öğretim yılı başladıktan sonra fen ve matematik öğretim programındaki sırayı bozmayacak şelkilde planlar sırasıyla dört 8. sınıf şubesinde uygulanmaya başlanmıştır. Matematik öğretmeni MAFBE planlarını sınıflarda uygularken, fen öğretmeni de FAMBE planlarını uygulamıştır. Planların uygulama süreçleri araştırmacı tarafından video kaydına alınmıy, ayrıca her plan tamamlandıktan sonra planı uygulayan öğretmenle yarı yapılandırılmış mülakatlar gerçekleştirilerek öğretmenlerin entegrasyon planlarını uygulamalarını değerlendirmeleri istenmiştir.

Bu çalışmada verilerin analizi için içerik analizi yöntemi kullanılmıştır. İçerik analizi, veri setlerini açıklayan kavramlar ve ilişkileri elde etmek amacıyla uygulanır (Yıldırım ve Şimşek, 2008). Krippendorf (2004) de içerik analizini kullanılan kapsamdaki metinlerden tekrarlı ve geçerli çıkarımlar yapmak amacıyla kullanılan bir araştırma tekniği olarak tanımlamaktadır. Elo ve Kyngäs (2008) da nitel ve nicel verilerin içerik analizi metodu kullanılarak tümden gelim ve tümevarım yoluyla analiz edilebileceğini belirtmektedirler.

Bu çalışmada dört ayrı sınıfta uygulanan beş tane entegrasyon planı bulunmaktadır. Entegrasyon derslerinin planlanması sürecinde fen öğretmeni ve matematik öğretmeni işbirliği yapmışlardır. Ses kaydı alınan planlama süreci araştırmacı tarafından deşifre edilmiştir. Entegrasyon planlarının uygulanması sürecinin ise video kaydı alınmıştır. Dört ayrı sınıfta gerçekleştirilen uygulamaların video kayıtlarını deşifre etmek oldukça zaman alıcı olacağı düşünülerek, araştırmacı her planın ilk uygulandığı sınıfın video kayıtlarını deşifre etmiştir. Diğer sınıfların video kayıtları da tek tek izlenmiş ve ilk sınıftan farklı olarak ortaya çıkmış durumlar, öğretmenlerin kullandığı farklı sorular ve öğrencilerden gelen sorular da deşire edilerek not alınmıştır.

Ulaşılan alanyazınında fen ve matematik entegrasyonunun planlama ve uygulanması için kullanılabilecek uygun ve kullanışlı bir kuramsal çerçeve bulunamadığı için alanyazını ve araştırma soruları ışığında bir kod listesi oluşturulmuştur. Bu kod listesi kullanılarak deşifre edilen veriler analiz edilmiştir. İlk olarak kalıtım-olasılık

FAMBE planı ve daha sonra olasılık-kalıtım FAMBE planı kodlanmıştır. Kodlanan planlar nitel analizde deneyimli bi araştırmacı ile bir araya gelinerek ilk kodlar tartışılmıştır. Nitel araştırmada veri analizi, analiz birimin belirlenmesi ile başlar (Merriam, 2009). Analiz birimi araştırma sorularının cevaplanmasına hizmet edecek ve araştırılan olguyu tanımlayacak verideki en küçük anlamlı parçadır. Bu çalışmada da öğretmenlerin entegrasyonu planlama ve uygulama kayıtları fen ve matematik entegrasyonu açısından incelenmiştir. Anlamlı bilgi içeren bir cümle, birkaç cümle, bir diyalog ya da bir paragraf belirlenmiştir. Yani anlamlı ifadeler içeren her veri yığını analiz birimi olarak belirlenmiştir.

Araştırmacının ve ikinci kodlayıcının arasındaki tutarlılığı yani kodlayıcılar arası güvenirliği sağlayabilmek için, eldeki tüm verinin %10 unun değerlendirilmesi yeterlidir (Neuendorf, 2002). İlk olarak araştırmacı kalıtım olasılık FAMBE planı ile olasılık-kalıtım MAFBE planının planlama metinlerini fen eğitimi alanında doktrasını tamamlamş ve fen ve matematik entegrasyonu çalışmış bir araştırmacıya vermiştir. Bu araştırmacı aynı zamanada kullanılan mülakat soruları için de uzman görüşü vermiştir. Kodlayıcılar arasındaki tutarlılık Miles ve Huberman (1994)'e göre hesaplanarak %94 bulunmuştur. İkinci olarak aynı planların uygulama metinleri matematik eğitimi alanında doktorasını yapmakta olan başka bir araştırmacıya verilmiş ve kodlaması istenmiştir. Bu kodlamadaki tutarlılık da %97 olarak hesaplanmıştır. Hesaplanan tüm değerler Miles ve Huberman (1994)'ın önerdiği %80'den oldukça fazla olarak bulunmuştur. Farklı şekilde kodlanan yerler kodlayıcılarla tekrar gözden geçirilmiş ve anlaşmaya varılmıştır. Tüm ikinci kodlayıcıya verilen metinler toplam verilerin % 40'ını oluşturmaktadır ve bu oran Neuendorf (2002)'un önerdiği %10'dan oldukça fazladır.

Bulgular

Entegrasyon uygulamasından önceki dönem gerçekleştirilen ön çalışma matematik öğretmeninin son üç ünitesinin ve fen öğretmeninin son iki ünitesinin gözlenmesi sonucunda, fen öğretmeninin derslerinde matematik kavramlarını, matematik öğretmeninin derslerinde fen kavramları kullanmasından daha çok kullandığı görülmüştür. Matematik programı fen ve matematik arasındaki ilişkiyi vurgulamasına rağmen matematik öğretmeni herhangi bir fen kavramını derslerinde kullanmamıştır. Fen öğretmeninin matematik kavramlarını daha çok kullanmasının sebebi fen konularının matematiğe ihtiyaç duyması durumundan kaynaklanabilir. Örneğin, ışık konusunda öğrencilerin ışık ışınının ne olduğu ve farklı durumlarda nasıl yansıdığını anlayabilmeleri için matematikteki ışın ve açı kavramlarını bilmeleri gerekmektedir. Bu yüzden fen öğretmeninin daha sık matematik kavramlarını kullanması fenin doğasından kaynaklanıyor olabilir. Gözlem bulgularına benzer şekilde, öğrencilerin defterlerini incelenmesi sonucunda da fen öğretmeninin ders notlarında daha çok matematiksel kavrama rastlanırken, matematik öğretmeninin ders notlarında çok az fen kavramına rastlanmıştır.

Matematik öğretmeninin fen kavramlarını tanımlaması ve fen öğretmeninin matematik kavramlarını tanımlamasına bakıldığı zaman, fen öğretmeninin matematik kavramları hakkındaki bilgisinin matematik öğretmeninin fen kavramları ile ilgili bilgisinden daha fazla olduğu görülmüştür. Bu durum fen öğretmeninin derslerinin gözlenmesinden ve öğrencilerin fen defterlerinde daha çok matematik içeriği görülmesinden dolayı beklenen bir sonuçtur. Fen öğretmeni birçok matematik kavramını doğru şekilde tanımlayabilmiştir ve bu durumu derslerinde sık şekilde matematiği kullanmasına bağlamaktadır. Aksine, matematik öğretmeni fen kavramlarını tanımlarken oldukça zorluk yaşamış ve bu durumu fen kavramlarını sadece üniversite eğitiminden hatırlamasına bağlamıştır. Bu bulgu öğretmenlerin sınıf gözlemleri ve öğrenci defterleri ile tutuarlılık göstermektedir. Entegrasyon ders planlarının hazırlanması uygulanması sürecinden önce yapılan ön çalışma bulguları, fen öğretmeninin matematik öğretmenine göre entegrasyona daha hazır ve tanıdık olduğunu ve fen öğretmeninin matematik bilgisinin, matematik öğretmeninin fen bilgisine göre daha çok olduğunu göstermiştir.

Entegrasyon derslerinin planlanmasında öğretmenler öncelikli olarak kullanılacak kazanımlara odaklanmışlardır. Daha sonra öğretmenler öğrencilerin fen ve matematikle ilgili gerekli önbilgilerini gözönünde bulundurmuşlardır. Ayrıca entegrasyonu nasıl ve hangi amaçla kullandıklarını da ifade etmişlerdir. Bulgular göstermiştir ki, öğretmenler entegrasyonu üç ana amaçla kullanmışlardır. Bunlar: (i) önceki/en son matematik/fen kavramını hatırlatma, (ii) yeni fen/matematik konu/kavram/işleme giriş yapma, ve (iii) konu/kavramları fen ve matematiği bağlantılandırarak açıklama olarak belirlenmiştir. Öğretmenler planlama sürecini fen ve matematik arasında zengin bağlantılar kurarak ve anlamlı içerikler oluşturmaya çalışarak tamamlamaya çalışmışlardır.

Öğretmenlerin entegrasyon dersi uygulamaları da başarılı bir entegrasyon için öğrencilerin ön bilgilerini kontrol ettiklerini göstermiştir. Fen öğretmeninin entegre edilmiş fen planlarını uygulaması incelendiğinde, fen öğretmeni Plan1 ve Plan2'de fenle ilgili ön bilgileri kontrol etmeye daha çok önem vermiş fakat matematikle ilgili ön bilgileri kontrol etmeye odaklanmamıştır. Plan1'de olasılık kavramının tanımını sadece bir sınıfta kontrol etmiştir. Fakat fen öğretmeni Plan3'ün uygulanmasında öğrencilerin grafiklerle ilgili önbilgilerini ayrıntılı şekilde kontrol etmiştir. Öğrencilerin bilgilerini kontrol ederken gelen yanlış cevapları düzeltmiştir. Entegre edilmiş matematik dersleri incelendiği zaman, matematik öğretmeninin öğrencilerin hem fen hem matematik ön bilgilerini Plan4 ve Plan5'te kontrol etmeye çalıştığı görülmüştür. Ancak, matematik öğretmeni fenle ilgili kavramları sorduğu zaman öğrenci cevaplarını dinlemiş ve hiç bir ek açıklama ve düzeltme yapmadan öğrenci cevaplarını tekrar etmiştir. Aksine, matematik kavramlarıyla ilgili olarak ayrıntılı açıklama yapmış ve örnekler vermiştir.

Fen öğretmeni Plan1'de olasılık çeşitleriyle ilgili sorular sorarak ve cevapları açıklayarak matematik kavramlarını hatırlatmaya çalışmıştır. Benzer şekilde Plan2'de de kaldırma kuvvetinin ve yoğunluğun formülünü açıklamak için doğru ve ters orantıyı ve Plan3'de sıcaklık zaman grafiğinin nasıl çizileceğini açıklamak için de çizgi grafiğini hatırlatmıştır. Fakat fen öğretmeni planlamış olmalarına rağmen hiçbir dersin sonunda kullanılan matematik kavramlarını hatırlatmamıştır. Öte yandan, matematik öğretmeni Plan4 ve Plan5'in uygulaması sırasında tüm basamakları tek tek yerine getirmeye çalışmıştır. Hatırlatılması planlanan tüm fen kavramlarını amacın dışına çıkmadan hatırlatmaya çalışmıştır. Örneğin, Plan4'te belli bir karakterin kalıtımını ve Mendel'in bezelye deneylerini sorduğu sorularla vurgulamıştır. Matematik öğretmeni kalıtım, genotip, fenotip gibi bazı tanımları sormamış ve bunu öğrencilerin bildiğini farkedip sormaya ihtiyaç duymadığı şeklinde açıklamıştır. Plan5'te ise, yoğunluk, kaldırma kuvveti, kaldırma kuvvetini etkileyen faktörleri planlandığı gibi hatırlatmaya gayret etmiştir. Ancak, bu kavramları hatırlatırken sadece kaldırma kuvvetinin formülüne odaklanarak fen kavramlarının açıklamayı ihmal etmiştir. Bu yüzden hatırlatma amacının yüzeysel olarak gerçekleştiği söylenebilir.

Fen öğretmeni fen ve matematiği yeni bir konu/kavram/işleme giriş yapma amacıyla da kullanmıştır. Örneğin, olasılık çeşitlerine giriş yapmak amacıyla olasılık çeşitlerini kalıtımla ilgili durumlara entegre etmiştir. Öznel olasılık ve teorik olasılığı kıyaslarken, entegrasyonu öğrencilere anlamlı hale getirmek için bu kavramlara giriş yapmak amacıyla kullanmıştır. Ancak fen öğretmeni Plan2'de oran-orantıyı yeni bir kavrama giriş yapma amacından öte yeni bir kısa yol göstermek amacıyla kullanmıştır. Kaldırma kuvvetini etkileyen faktörler arasındaki ilişkiden bahsederken formülü büyüklükler arasındaki doğru ve ters orantıyı kullanarak kolay bir yol ile açıklamaya çalışmıştır. Bu planlardan farklı olarak Plan3'ün uygulamasında yeni bir duruma giriş yapma amacıyla entegrasyon kullanımına rastlanmamıştır. Çizgi grafiği ve ısı-sıcaklık konularının yer aldığı ve bu konularla ilgili olarak öğrencilerin matematik bilgilerinde kazanacakları yeni bir kavram bulunmadığı Plan3'te bu amaç görülmemiştir. Matematik öğretmeninin uygulamalarına bakıldığında, Plan4'te yeni bir konuya giriş yapma amacı görülmüştür. Matematik öğretmeni entegrasyonu kalıtım örnekleri yardımıyla olasılık ve çeşitlerine giriş yapmak için kullanmıştır. Ayrıca, hem Plan4, hem de Plan5'in sonunda matematik öğretmeni kendisinin önceki dersleri ile bu dersleri arasındaki farkı vurgulayarak öğrencilerin dikkatini fen ve matematik arasındaki ilişkiye çekmeye çalışmıştır. Plan3'te olduğu gibi Plan5'te de entegrasyon yeni bir konuya giriş yapmak için kullanılmamıştır. Onun yerine geometrik şekillerin hacmi konusunda kaldırma kuvveti ile ilgili günlük hayat örneklerinden faydalanılmıştır.

Öğretmenler entegrasyonu konu ve kavramları fen ve matematik arasında ilişkilendirerek açıklamak için de kullanmıştır. Bu, bir kaç farklı şekilde ortaya çıkmıştır. Birinci ilişkilendirme şekli fen kavramıyla başlayıp matematiğe bağlanan

Fenden-Matematiğe (F-M) ilişkilendirmedir. Entegrasyon derslerinin planlanmasında bu ilişkilendirme en sık kullanılan yol olmuştur. Planların uygulanması incelendiğinde hem fen hem de matematik öğretmeninin kavramları entegre edebilmek için bu ilişkilendirmeyi sıkça kullandığı görülmüştür. Örneğin, Plan1'de fen öğretmeni genotip ve fenotip kavramlarını oran, yüzde ve olasılık kavramlarıyla ilişkilendirmiştir. Plan2'de ise kaldırma kuvvetinin formülünü oluşturmak için kaldırma kuvvetini etkileyen faktörler arasında orantı kullanarak bu ilişkilendirmeyi kullanmıştır. Plan3'te de çizgi grafiğinin çizimi ve yorumlanmasında bu ilişkilendirme kullanılmıştır. Matematik öğretmeni de planların uygulanmasında F-M ilişilendirmesini kullanmıştır. Plan4'te olasılığın kalıtımda yaygın olarak kullanılma şeklinden birisi olarak karakterlerin çaprazlanmasını olasılık hesaplamayla ilişkilendirmiştir. Plan5'te de kaldırma kuvvetini hesaplamak için önce nasıl bulunacağını açıklayarak ve formülü uygulayarak bu ilişkilendirmeyi kullanmıştır.

Diğer bir ilişkilendirme yolu olarak öğretmenler hem planlamada hem de uygulamada Matematikten Fene (M-F) ilişkilendirmesini kullanmışlardır. M-F ilişkilendirmesi önce matematiksel bir durumla başlayıp bu durumu fene bağlamayı gerektirmektedir. Planlamada öğretmenler bu ilişkilendirmeyi kalıtım ve olasılık konularını içeren Plan1 ve Plan4'te kullanmamışlardır. Fen öğretmeni bu ilişkilendirmeyi Plan2'de çizgi grafiğini yorumlayarak ve ısınma ve soğuma eğrilerini çizgi grafiği üzerinden açıklayarak kullanmıştır. Matematik öğretmeni de bu ilişkilendirmeyi Plan5'te kullanmıştır. Planların uygulanmasında ise, fen öğretmeni bu ilişkilendirmeyi planlamadığı halde Plan1'de kullanmıştır. M-F ilişkilendirmesinin Plan3'te fen öğretmeninin grafikteki çizgilerin durumunu sorguladığı noktalarda ve grafiğin ısınma ya da soğuma grafiği olarak isimlendirmesinde daha çok kullanıldığı görülmüştür. Matematik öğretmeni de M-F ilişkilendirmesini uygulama esnasında kullanmıştır. Örneğin, Plan5'te matematik öğretmeni prizmaların hacmini kullanmayı gerektiren bir durumla başlayıp bu durumu yoğunluk ve kaldırma kuvvetinin hesaplanmasına bağlamıştır.

Son olarak öğretmenlerin planlama ve uygulamada kullandığı ilişkilendirme yolu Fenden Matematiğe ve Fene (F-M-F) olarak belirlenmiştir. Öğretmenler bu ilişkilendirmede fen ile başlayıp matematikle bağlantı kurmuşlar ve daha sonra matematiği fenle tekrar ilişkilendirmişlerdir. Planlamada bu ilişkilendirme sadece kalıtım-olasılık konulu Plan1'de görülmüştür. Örneğin, çaprazlama ile başlayıp ve olasılık hesaplattırmışlar, daha sonra bireylerin genotiplerini yazdırmışlardır. Uygulamada ise sadece fen öğretmeni Plan1 ve Plan2'de bu ilişkilendirmeyi bir kaç kez kullanmıştır. Plan2'nin planlamasında kullanılmamasına rağmen uygulamasında bu ilişkilendirme görülmüştür.

Öğretmenlerin işbirliği ve iletişimi entegre edilmiş ders planlarının hazırlanma sürecini etkileyen faktörlerden biri olarak ortaya çıkmıştır. İşbirliği ve iletişim başarılı entegrasyon dersleri hazırlamada ve oluşabilcek yanlış kullanım ve kavram yanılgılarını önlemede öğretmenlerin uyumunu ve birbirinden nasıl faydalandıklarını görmek açısından önemli idi. Öğretmenler daha çok ek açıklamalar yaparak ya da durum ve kavramları netleştirerek birbirlerini desteklemiş ve onaylamışlardır. Ayrıca öğretmenler birbirlerine öneriler sunmuşlardır. Bu öneriler öğretmenlerin öğrencilerin dersi anlamalarıyla ilgili farkında olmaları, planların uygulanmasıyla ilgili hazırlanma ve öğrencilerden gelebilecek sorulara hazır olma açısından fikir sahibi olmalarını sağlamıştır. Fen öğretmeninin matematik öğretmeninden daha çok öneride bulunduğu gözlenmiştir. Öğretmenler her zaman her konuda aynı fikirde olmamışlardır. Bazen öneri ve fikirleri kabul etmemişler ya da içerikle ilgili belirsizlik yaşamışlardır. Bu durumlarda birbirlerini ikna etmeye çalışmışlardır. Fen öğretmeni genel olarak matematik öğretmeni ile anlaşmazlığa düştüğünde ikna eden taraf olmuştur. Öğretmenler aynı zamanda birbirlerini tereddüt edilen noktalarda ayrıntılı açıklamalar yaparak da ikna etmeye çalışmışlardır.

Entegrasyon derslerinin planlama ve uygulama süreçleri bazı problemlerden de etkilenmiştir. Bu problemler içerik bilgisi eksikliği ve içeriği önemsizleştirme olmak üzere iki başlıkta toplanmıştır. Entegrasyon derslerinin planlanmasında, fen öğretmeni Plan1 ve Plan2'de matematikle ilgili içerik bilgisi eksikliği problemi ile karşılaşmıştır. Plan3'ün hazırlanmasında herhangi bir problem görülmemiştir. Entegre edilmiş matematik derslerinin planlanmasında matematik öğretmeni de benzer şekilde fenle ilgili içerik bilgisi eksikliği yaşamıştır. Fakat hem fen hem matematik öğretmeni bağımlı ve bağımsız olaylar kavramlarıyla ilgili matematik içerik bilgisi eksikliği göstermişlerdir. Yani, matematik öğretmeni Plan4'te hem fen hem de matematik içerik bilgisi eksikliği olduğunu gösteren durumlar yaşamıştır. Benzer şekilde hem fen hem de matematik öğretmeni Plan5'te fen içerik bilgisi eksikliği yaşamıştır. Her iki öğretmen de kütle ve ağırlık kavramlarını ayırt edemeyerek bu kavramları birbirinin yerine kullanmıştır. Öğretmenlerin içerik bilgisi eksikliği aynı zamanda planlama sürecinde güven eksikliği sorunu yaşamalarına da sebep olmuştur.

Öğretmenler işbirliği yapmalarına ve planları birlikte tartışarak hazırlamalarına rağmen planların uygulanmasında planlamadan daha çok içerik bilgisi eksikliği problemi gözlenmiştir. Örneğin fen öğretmeni, Plan1'in uygulanması sırasında öznel olasılığı "bana göre olan olasılık" şeklinde tanımlamıştır. Benzer şekilde teorik olasılığın tanımını ve teorik ve deneysel olasılığın karşılaştırılmasını yanlış şekilde açıklamıştır. Fen öğretmeni ayrıca yüzde, oran ve olasılık kavramlarını biribirinin yerine kullanmıştır. Fen öğretmeni oranı matematik kavramı olarak kullanmış ve fendeki genotip ve fenotip oranının farklı kullanımıyla ilgili herhangi bir açıklamada bulunmamıştır. Plan2'de, fen öğretmeni bir cismin hacmini onun kapladığı alan olarak ifade etmiştir. Plan2'yi uygularken kürenin hacminin nasıl hesaplandığını hatırlayamadığını söylemiştir. Matematik öğretmeni de Plan4 ve Plan5'te içerik bilgisi eksikliği yaşamıştır. Genel olarak planları uygularken öğrencilere sorular yöneltmiş ve sadece öğrencilerin cevaplarını tekrar etmiştir. Bazı fen kavramlarını yanlış kullanmıştır. Örneğin Plan4'te "bezelyelerin şekli açısından karakterlerin çaprazlanması" demek yerine "bezelye çaprazlaması yaptık" ifadesini kullanmıştır. Plan5'te de öğrencilerin kaldırma kuvvetinin büyüklüğünü hesaplamayla ilgili sorduğu soruya cevap verememiş ve soruyu gözardı etmeyi tercih etmiştir. İçerik bilgisi eksikliği fen öğretmeninin Plan1 ve Plan3'te, matematik öğretmeninin de Plan4 ve Plan5'te güven eksikliği problemi yaşamalarına sebep olmuştur. Bu durumlarda öğretmenler, öğrenciler ya da araştırmacı tarafından onaylanma ve desteklenme istediklerini işaret eden ifadelerde bulunmuşlardır.

İçeriğin önemsizleştirilmesi problemi öğretmenlerin yaşadığı diğer bir sorun olmuştur. Örneğin, Plan2'nin hazırlanmasında her iki öğretmen de dört işlemin fen konusunun içeriğine eklenmesini ve kaldırma kuvvetinin formülünün uygulanmasını entegrasyon için yeterli bulmuşlardır. Diğer bir örnek ise Plan4'te görülmüştür. Matematik öğretmeni belirlenen kazanımlar dışında bir soruyu plana koymak istemiştir. İçeriğin önemsizleştirilmesi problemi planların uygulanmasında da gözlenmiştir. Örneğin Plan1'de fen öğretmeni o anda oluşturduğu çoktan seçmeli test sorularında konunun amacı dışında ilgisiz seçenekler belirtmiştir. Matematik öğretmeni de Plan4'te odağını kaybetmiş ve konu ile ilgisi olmayan ve öğrencilerin derste dikkatini kaybetmelerine sebep olabilecek bazı cümleler kullanmıştır.

Planlamadan farklı olarak öğretmenlerin öğretim şekliyle alakalı entegrasyon açısından başka problemler de gözlenmiştir. Örneğin, fen öğretmeni Plan1'de matematikten fene anlamlı ilişkilendirme yapmadan keskin geçişler yapmıştır. Benzer şekilde matematik öğretmeni de kaldırma kuvvetinin formülünden geometrik cisimlerle ilgili bir soruya hiç bir bağlantı kurmadan keskin geçiş yapmıştır. Ayrıca öğretmenlerin dersteki hızı, yönlendirici sorular sormaları, öğrencilerin sorularını kavramsal açıklamalar yapmadan yüzeysel olarak cevaplamaları da entegrasyon dersleri boyunca ortaya çıkan diğer problemler olarak göze çarpmıştır.

Öğretmenlerin entegrasyon derslerini değerlendirmeleri incelendiğinde her iki öğretmenin de bu derslerden olduça memnun oldukları söylenebilir. Öğretmenler planlarla ilgili çok küçük değişiklikler önermişlerdir. Bir sonraki yıl bu planları tekrar kullanmak istediklerini belirtmişlerdir. Ayrıca öğretmenler entegrasyon derslerinin öğrencilerin fen ve matematikle ilgili başarı ve tutumları üzerinde olumlu etkisi olduğunu ifade etmişlerdir.

Tartışma ve Öneriler

Fen öğretmeni fen programında yer alan matematikle ilgili bağıntıların kullanılmaması yönündeki sınırlamaları gözardı etmiş ve kullanmıştır. Bu sebepten, fen programı matematiğin fen derslerindeki kullanımı açısından yeniden düzenlenebilir. Benzer şekilde matematik öğretmenlerinin de matematik program ve kitaplarındaki fen içeriği ile ilgili farkındalıkları artırılabilir ve bu ilişki vurgulanabilir. Fen ve matematik arasındaki ilişkinin güçlü bir şekilde vurgulanması öğretmenlerin bu ilişkinin önemi ile ilgili düşüncelerini olumlu şekilde değiştirebilir.

Bu çalışma entegrasyon sürecini, öğretmenlere entegrasyonla ilgili uzun bir eğitim vermeden incelemiştir. Fen ve matematik öğretmenlerine birlikte ve ayrı ayrı öğretmen eğitimleri verilebilir ve bu eğitimlerin süresi alanyazınında önerildiği gibi uzun tutulabilir (Kurt ve Pehlivan, 2013). Bu çalışmada ayrıca öğretmenler entegrasyon ders planlarını işbirliği yaparak bir takım halinde hazırlamışlardır. Öğretmenlerin işbirliğini ve iletişimini incelemek daha iyi dersler hazırlanması ve birbirlerine destek sağlamaları için oldukça önemlidir. Takım olarak derslerin anlatılması, takım olarak planlama yapılması kadar önemli bir husustur. Bazı araştırmacılar öğretmenlerin takım olarak aynı sınıfta ders anlatmalarını tavsiye etmektedir (örneğin; Steen, 1994; Loepp, 1999; Koirala ve Bowman, 2003; Furner ve Kumar, 2007; Browning, 2011). Öğretmenlerin etkili bir entegrasyon için eğitimi, daha iyi sonuçlara ulaşmayı sağlayabilecek takım halinde planlama ve uygulamayı içermelidir. Ayrıca, gelecekte yapılacak çalışmalar öğretmenlerin takım olarak entegrasyon derslerini anlatmalarına odaklanabilir.

Entegrasyonla ilgili veriecek öğretmen eğitimlerinin içeriği bu çalışmanın bulguları ışığında tasarlanabilir. Planlama boyunca öğretmenler sadece fen ve matematik arasındaki benzerliğe odaklanmışlardır. Öğretmen eğitimcileri sadece bu benzerliklere değil aynı zamanda fen ve matematikteki farklı kullanımlara da dikkat çekerek iki disiplin arasında ortak bir dil oluşmasını sağlayabilir. Öğretmenler fen ve matematikteki problem çözme, sorgulama, yorumlama, kıyaslama-sınıflama, model oluşturma, ölçme, bilgi toplama ve veri, tahmin, çıkarımda bulunma, veri kaydetme, iletişim ve gözlem gibi ortak beceriler yerine daha çok içeriği entegre etmeye odaklanmışlardır. Halbuki, bazı araştırmacılar, (örneğin; Steen, 1994; McGinnis, McDuffie ve Graber, 2006) sadece içeriği entegre etmek uğruna fen ve matematikteki ortak beceri ve metotları gözardı etmemek gerektiğini belirtmişlerdir.

Fen öğretmeni uygulama aşamasında kendi tecrübesine ve bilgisine güvenerek süreçte daha rahat ilerlerken, matematik öğretmeni emin olamadığı noktalarda takılmış ve özellikle fenle ilgili kavramlarda ders esnasında sıkıntı yaşamıştır. Bu durum, entegrasyonla ilgili yapılan çalışmalarda belirtilen öğretmenlerin içerik bilgilerinin eksikliğinin entegre edilmiş fen ve matematik derslerinde problemlere sebep olabileceği ifadeleriyle paralellik göstermektedir (Batista ve Mathews, 2002; Frykholm ve Glasson, 2005; Lehman ve McDonald, 1988). İçerik bilgisi eksikliği entegrasyonun başarılmasında önemli bir problem olmuştur. Bu noktada öğretmenlerin içerik bilgisi eksiklikleriyle ilgili farkındalık sahibi olmaları gerekmektedir. İçerik bilgisi problemi kadar içeriğin önemsizleştirilmesi, keskin geçişler ve öğretimle ilgili sıkıntılar da öğretmen eğitimcileri ve program geliştiriciler tarafından dikkate alınmalıdır. Eğer öğretmenlerin bu sorunlarla ilgili farkındalıkları artırılabilirse, bu sorunları aşmak da kolaylaşabilir.
Her iki öğretmen de süreç içerisinde entegrasyon planlarının hazırlanmasında çaba göstermişlerdir. Ancak fen öğretmeni kendine olan güveni sebebiyle planları beklendiği gibi uygulayamamıştır. Uygulama esnasında planlamadıkları uygulamalarda bulunmuştur. Matematik öğretmeni ise planların her noktasını dikkatli şekilde uygulamaya çalışmıştır. Ancak, uygulama esnasında sınıfta çok rahat olmadığı ve bir çok sıkıntıyla karşılaştığı görülmüştür. Bu bağlamda öğretmenlerin entegrasyonu planlama ve uygulamasında rolü olabilecek özgüven ve özyeterlik gibi olguların da incelenmesi gerekebilir.

Öğretmenlerin entegre edilmiş planları kendilerinin hazırlaması onların bu planları içselleştirmelerini ve daha kolay uygulamalarını sağlayabilir. Bu yüzden öğretmenlere hazır planlar vermektense, kendilerinin hazırlaması için fırsat verilmelidir. Ayrıca Johnston, Ní Ríordáin, ve Walshe (2014)'nin de önerdiği gibi öğretmenlere entegre edilecek planların tasarlanmasında teknolojiden de faydalanma fırsatı verilebilir. Terazi modeli öğretmenlerin entegrasyonu planlamasına yardım edebilir. Fakat planlama ve uygulama için gerekli olan kriterler öğretmenleri daha iyi yönlendirebilmek için netleştirilmelidir.

Çalışmaya katılan öğretmenler planları uygularken diğer dersin konularının ne zaman öğretildiğini düşünmemişlerdir. Öğretmenlerin bu konuda bilgi sahibi olmaları önemli olabilir çünkü fen ve matematikteki konular birbirinin ön öğrenmelerini oluşturabilir. Bu yüzden, entegrasyonla ilgili yapılacak çalışmalarda öğretmenlerin diğer dersin öğretim programı ile ilgili bilgileri de dikkate alınmalıdır. Katılımcı öğretmenlerin eğitim hayatlarında entegrasyonla ilgili herhangi bir uygulamaları olmamıştır. Bu yüzden entegrasyonun başarılı uygulamaları video kaydına alınarak öğretmenlere örnek olarak gösterilebilir. Bu da okul üniversite işbirliği ile desteklenerek gerçekleştirilebilir.

Daha önce de belirtildiği gibi matematik öğretmeni fen eğitimi yan alanına sahipti. Ancak fen ve matematiğin entegrasyonu ile ilgili bir ders almamıştı. Öğretmen adayları için tasarlanacak fen ve matematik entegrasyonu ile ilgili derslerin öğretmen yetiştirme programlarına eklenmesi öğretmen adaylarının ileride entegrasyon yapmaları açısından faydalı olabilir.

Bu çalışmanın, fen ve matematiğin gerçek uygulayıcıları olan fen ve matematik öğretmenlerince entegrasyonun kendi planlama ve uygulamalarını değerlendirilmesini sağlaması açısından da yararlı olacağı düşünülmektedir. Bu bağlamda öğretmenler kendilerini hem kendi alanlarında geliştirecekler, hem de disiplinler arası ilişkilendirmenin önemini kavrayarak konuları daha anlamlı, eğlenceli ve günlük hayatla bağlantılar kurarak öğretebileceklerdir. Ayrıca, bu çalışmanın hem öğretmenleri hem de eğitim araştırmacıları ve program hazırlayan yetkililere entegrasyon ve uygulaması açısından aydınlatıcı olması beklenmektedir. Okullarda çalışan fen ve matematik öğretmenlerinin birlikte çalışabileceği fen ve matematik zümreleri oluşturulabilir.

Bu çalışmada beş tane entegrasyon ders planı hazırlanıp uygulandığı için öğretmenlerin karşılıklı olarak ilişkilendirdiği kalıtım ve olasılık konuları haricinde tüm konular için plan hazırlanamamıştır. Eğer karşılıklı konular belirlenip hem entegre edilmiş fen hem de entegre edilmiş matematik planı olarak aynı kazanımlar

üzerinden ders planları hazırlanıp uygulanabilirse, öğretmenlerin uygulamaları karşılaştırılabilir.
Bu çalışma ayrıca farklı okul kültürüne sahip olan özel okullarda da uygulanabilir. Özel okullarda entegerasyonun planlama ve uygulamasıyla ilgili olarak farklı kritik noktalar ve farklı problemler ortaya çıkabilir.

Katılımcı öğretmenler kullanılan planları bir sonraki eğitim-öğretim yılında tekrar kullanmak istediklerini belirtmişlerdir. Öğretmenlerin planları daha sonraki yıllardaki kullanımları daha uzun süreli bir çalışma tasarlanarak incelenebilir. Bu çalışma ayrıca diğer sınıf seviyeleri için de uygulanabilir.

Farklı okullardan en az iki fen ve iki matematik öğretmeninden oluşacak bir öğretmen takımı ile entegre edilecek ders planlarının hazırlanma süreci öğretmenlerin iletişimi ve işbirliği açısından daha detaylı olarak incelenebilir. Ayrıca bir fen ve bir matematik öğretmeninden oluşan bir takım aynı sınıfta aynı planı birlikte uygulayabilir ve bu süreçte yaşanan durumlar araştırılabilir.

Uzun süreli uygulanacak tasarım tabanlı araştırmalar yapılarak tekrarlar ve yeniden düzenlemelerle öğretmenlerin planlama ve uygulama süreçlerinin gözlenmesi sağlanabilir. Bu sayede öğretmenler karşılaşılan problemlere çözümler getirerek ve tekrar deneyerek daha başarılı entegrasyon dersleri hazırlayıp uygulama fırsatına sahip olabileceklerdir.

Bu çalışma bir fen ve bir matematik öğretmeni ile gerçekleştirildiği için bu açıdan bazı sınırlılıkları bulunmaktadır. Öğretmenlerin var olan öğretim yöntemleri, üç yıldır yakın arkadaş olmaları ve öğretmenlik tecrübelerindeki fark bu çalışmanın bulgularını etkileyen faktörler arasında sayılabilir. Bu çalışmada öğretmenlerin belirlediği konularla hazırlanmış beş plan bulunmaktaydı. Bu yüzden sonuçlar bu konularla sınırlıdır. Ayrıca bu çalışmanın odaklandığı sınıf seviyesi 8. sınıflardı. Öğretmenler bu seviyeye uygun planlar hazırlamış olsalar da, uygun entegre edilecek kazanımları bulamadıklarında 7. sınıf kazanımlarından da faydalanmışlardır. Diğer taraftan, 8. sınıflar için uygulanan ülke çapındaki sınavlar sebebiyle öğretmenlerin ders uygulamaları daha çok soru çözme eğilimli olmuştur. Bu durum da bu çalışma için bir sınırlılık olarak kabul edilebilir.

APPENDIX G

TEZ FOTOKOPİSİ İZİN FORMU

ENSTİTÜ

- [ ] Fen Bilimleri Enstitüsü
- [x] Sosyal Bilimler Enstitüsü
- [ ] Uygulamalı Matematik Enstitüsü
- [ ] Enformatik Enstitüsü
- [ ] Deniz Bilimleri Enstitüsü

YAZARIN

Soyadı : Yeniterzi
Adı : Betül
Bölümü : İlköğretim

TEZİN ADI (İngilizce) : The Case of Planning and Implementing Mathematics and Science Integration in the 8^{th} Grade in a Public Middle School

TEZİN TÜRÜ : Yüksek Lisans [ ] Doktora [x]

1. Tezimin tamamından kaynak gösterilmek şartıyla fotokopi alınabilir. [ ]
2. Tezimin içindekiler sayfası, özet, indeks sayfalarından ve/veya bir bölümünden kaynak gösterilmek şartıyla fotokopi alınabilir. [ ]
3. Tezimden bir bir (1) yıl süreyle fotokopi alınamaz. [x]

TEZİN KÜTÜPHANEYE TESLİM TARİHİ: