REPUBLIC OF TURKEY
YILDIZ TECHNICAL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

THE EFFECT OF SCIENCE INSTRUCTION INTEGRATED WITH UNPLUGGED COMPUTATIONAL THINKING ACTIVITIES ON STUDENTS' ACADEMIC ACHIEVEMENT AND COMPUTATIONAL THINKING SKILLS

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A thesis submitted by İlayda KILIÇ in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE is approved by the committee on 30.06.2021 in Department of Mathematics and Science Education, Science Education Program.

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İlayda KILIÇ

Signature

Dedicated to the loving memory of my older brother Ş. Şenol Kılıç whom I miss from the bottom of my heart…

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İlayda KILIÇ

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LIST OF SYMBOLS

X_{std} standard score

LIST OF ABBREVIATIONS

CSTA	Computer Science Teachers Association
CT	Computational Thinking
CTLS	Computational Thinking Levels Scale
ICT	Information, Communication and Technology
ISTE	International Society for Technology in Education
MoNE	Ministry of National Education
NGSS	Next Generation Science Standards
NRC	National Research Council
NSF	National Science Foundation
OECD	Organization for Economic Co-operation and Development
STEM	Science, Technology, Engineering, Mathematics
TIMMS	Trends in International Mathematics and Science
PISA	Programme for International Student Assessment Study
P21	Partnership for 21st century skills
TUSIAD	Turkish Industry and Business Association
SPMUAT	Structure and Properties of Matter Unit Achievement Test
SPSS	Statistical Package for the Social Sciences

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ABSTRACT

The Effect of Science Instruction Integrated with Unplugged Computational Thinking Activities on Students' Academic Achievement and Computational Thinking Skills

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Master of Science Thesis

Advisor: Prof. Dr. Mustafa Sami TOPÇU

Computational thinking (CT) is a significant competency of 21st-century skills. The acquisition of computational thinking skills has become an important debate in science, technology, engineering and mathematics disciplines. This study enlightens the potentiality of computational thinking integrated instruction in K-12 science classrooms. The purpose of this study is to find out the impact of unplugged CT activities during the subject of pure matter and mixtures on seventh-grade students' academic achievement and CT skills. The study has a quasi-experimental design with a non-randomized control group to which a pre-test and a post-test were administered in two regular science classrooms in a public middle school located in Uskudar/Istanbul. The experimental group was subjected to a treatment of unplugged CT based constructivist science instruction, while the students in the control group were treated based on the constructivist approach. Consequently, there were statistically significant differences between before and after treatment in the experimental group regarding the achievement in the subject of pure matter and mixtures and CT skills, with a large size effect (d= 1.56) on achievement in the subject of pure matter and mixtures, and a large size effect on CT skills (d= 0.95). CT skills of the control group did not show a statistical distinction between pre-test and post-test, and academic achievement in the control group elicited a statistically significant difference between pre-test and post-test indicating a large size effect (d= 1.49) in favour of the post-test. It was also found out that there was a meaningful difference between the post-test scores of CT skills of the experimental and the control group. However, there was no significant difference in the post-test scores of subject-specific success between the experimental group and the control group. Finally, interpretation and discussion were provided in line with research findings.

Keywords: Computational thinking, science education, academic achievement

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ÖZET

Bilgi İşlemsel Düşünme Etkinlikleriyle Bütünleştirilmiş Fen Öğretiminin Öğrencilerin Akademik Başarısına ve Bilgi İşlemsel Düşünme Becerilerine Etkisi

İlayda KILIÇ

Matematik ve Fen Bilimleri Eğitimi Anabilim Dalı

Yüksek Lisans Tezi

Danışman: Prof. Dr. Mustafa Sami TOPÇU

Bilgi işlemsel düşünme 21. yüzyılın önemli becerileri arasında yer alır. Bilgi işlemsel düşünme becerisinin itibaren kazanımı fen, teknoloji, mühendislik ve matematik disiplinlerinde önemli bir tartışma konusu olmuştur. Bu araştırma, bilgi işlemsel düşünme ile bütünleştirilmiş öğretimin K-12 düzeyindeki fen bilimleri derslerine sunduğu imkânlara ışık tutmaktadır. Bu çalışmanın amacı digital araç kullanımını içermeyen bilgi işlemsel düşünme etkinliklerinin yedinci sınıf öğrencilerinin saf madde ve karışımlar konusundaki akademik başarılarına ve bilgi işlemsel düşünme becerilerine olan etkisini incelemektir. Ön-test ve son-test kontrol gruplu yarı deneysel desen İstanbul ili Üsküdar ilçesindeki bir devlet ortaokulundaki iki sınıfta uygulanmıştır. Deney grubunda digital araç kullanımını gerektirmeyen bilgi işlemsel düşünmeyle bütünleştirilmiş yapılandırmacı fen öğretimi uygulanırken; kontrol grubunda yapılandırmacı yaklaşım kullanılmıştır. Sonuç olarak, deney grubunda uygulama öncesi ve sonrası arasında saf madde ve karışımlar konusundaki başarıda ve bilgi işlemsel düşünme becerisinde istatistiksel olarak anlamlı fark bulunmuştur. Bu farkın akademik başarıya büyük bir etkisi olduğu (d= 1.56) ve bilgi işlemsel düşünme becerilerine büyük bir etkisi olduğu (d= 0.95) bulunmuştur. Kontrol grubu bilgi işlemsel düşünme becerileri ön-test ve son-test puanları istatistiksel olarak anlamlı bir farklılık göstermemiştir. Kontrol grubunun akademik başarısında ön-test ve son-test puanları arasında son-test lehine istatistiksel olarak anlamlı bir fark çıkmıştır ve bu farkın büyük bir etkiye sahip olduğu bulunmuştur (d= 1.49). Ayrıca deney ve kontrol grubunun bilgi işlemsel düşünme becerilerine ilişkin son test puanları arasında anlamlı bir farklılık olduğu bulunmuştur. Fakat uygulama sonucunda gruplar arasında saf madde ve karışımlar konusundaki başarıda istatistiksel olarak anlamlı bir fark yoktur. Son olarak ise araştırma sonuçlarına uygun olarak yorum ve tartışma yapılmıştır.

Anahtar kelimeler: Bilgi işlemsel düşünme, fen eğitimi, akademik başarı

1
INTRODUCTION

This study has five chapters starting with Introduction. The next chapters are respectively the conceptual framework, methodology, findings, results and discussion. Introduction has the following order: literature review, purpose of thesis, original contribution, research question, hypothesis, assumption and limitation.

1.1 Literature Review

Literature review of this study mentions the scholarly resources relevant to the research context. This section mainly focuses on the definition and aspects of academic achievement in science and computational thinking.

1.1.1 Academic Achievement in Science

Academic achievement refers to a measurement of students' understanding, which is the percentage of children at a school whose learning presently matches or surpasses grade-level norms (Minnesota Department of Education, 2017). Academic achievement in science education could be measured by in-class assessments and international examinations. Even though there are several reasons to measure academic achievement in classrooms, the classroom level assessments would be particularly informative regarding at which points students make mistakes and to what extent students are able to understand learning goals.

The assessment of a particular subject or unit in class may also help to detect the misconceptions that students hold and let the teachers fix them with the help of scientifically accurate explanations by using some specific techniques. Assessment of learning outcomes after a particular treatment may be used to address the impact of treatment in a relevant subject.

By doing so, the change in student success in the given topic can be interpreted based on the treatment, and measurement of these aspects can give meaningful information for future implications.

International examinations such as Trends in International Mathematics and Science Study (TIMMS) and Programme for International Student Assessment (PISA) reveal the academic performance in global scales, and the result of these international tests report the participant countries' educational facilities in many ways. Academic achievement is a significant topic that researchers, policymakers, and practitioners scrutinize since it is seen as an accurate indicator of academic performances while enabling data to evaluate the educational rankings of participant countries on global scales. It was stated that, despite the decrease in Science, Engineering, Technology, and Mathematics (STEM) enrollment in the United Kingdom (National Audit Office, 2018), student performance in PISA 2018 was high above the average score of the Organisation for Economic Co-operation and Development (OECD) countries. The scores of the United States have similar characteristics with the United Kingdom except for mathematics success. The mathematics success of the United States in PISA 2018 was lower than the average OECD score (OECD, 2019a). According to the results of the PISA 2018 test, the scores of Turkey were below the general score of OECD countries on account of mathematics and science success (OECD, 2019a). Although the comparison of Turkish national scores in PISA 2015 and PISA 2018 has become better in favor of the recent examination, the current place of Turkey in international rankings is falling behind the top-performing OECD countries (Ministry of National Education [MoNE], 2019).

International assessments show the global evaluation of educational quality among participant countries. Their results necessitate changing educational regulations, enacting new procedures, following trends for educating young people since they evaluate educational policies of participant countries from many perspectives. Fostering the implementation of recent educational movements in classrooms is a way to meet desired levels at international rankings. Using novel educational trends in classrooms may change the classroom culture.

Therefore, researchers and policymakers should jointly regulate promising approaches in order to reach demands. One of the recent movements is called the STEM Movement, which is described below.

1.1.2 STEM Movement

The acronym “STEM” stands for Science, Technology, Engineering, and Mathematics disciplines. White (2014) claimed that the STEM movement was firstly encountered in the Sputnik era, and STEM was practiced without a certain recognition at that time. According to other studies in literature, STEM was firstly used by the National Science Foundation (NSF) of the United States in the 1990s (Bybee, 2010; White, 2014). It was emphasized that STEM did not originate in educational sciences, but it was the financial and industrial fluctuation in the world that caused the appearance of STEM. The decrease in employment and university enrollment in engineering and science disciplines impelled policymakers to start initiatives and stakeholders to call for research, promotion, and implementation in STEM disciplines (Williams, 2011).

The emergence of STEM in education has become a debate for many years, and researchers could not give a solid definition. Bybee (2010) who points this issue implies that STEM is a trend of science and mathematics disciplines in the last decades, of which reflects global problems to be solved with techniques that technology and engineering serve. According to another study, STEM consists of any activity in which science, technology, mathematics, and engineering disciplines are taught together regardless of the type of degree (Gonzales and Kuenzi, 2012).

Fluctuation in enrollment to natural sciences in universities and the loss of STEM workforce still maintain. Although there are enactments in line with recent trends, the result of regulations has had little progression towards desired levels. National Audit Office (2018) emphasizes that the decrease in enrollment in engineering and computer science in the United Kingdom is remarkable. This decrease still goes up in spite of the large-scale investments in the United Kingdom. Only 24% of STEM graduates hold a job in their disciplines, which means STEM graduates do not prefer to work in their work fields. Akgündüz (2016) reported that the number of students who enrolled in STEM disciplines declined dramatically among the ones who ranked at the top thousand list in National University Examination in Turkey between 2000 and 2014. It means that students who get the top degrees in the national university enrollment exam in Turkey do not prefer to register in STEM fields. It was stated in a report of PricewaterhouseCoopers Turkey and Turkish Industry and Business Association (TUSIAD) that the rate of STEM graduates between 2013 and 2016 in Turkey was no more than 18% of total university graduates of the country (PricewaterhouseCoopers Turkey and TUSIAD, 2017).

Whereas there is a decrease in STEM enrollment in universities, the students in K-12 grades should be orientated to STEM disciplines not only to prevent the loss but also to start valuable experiences in STEM learning. Teaching in STEM disciplines should be considered as a goal to promote 21st-century skills since interdisciplinary learning environments enable enriched contexts for students to become scientifically literate by experiencing real-world problems.

STEM competencies provide promising ways to acquire fundamental qualifications and increase learning performances. Thus, STEM has been promoted with financial investments and educational policies. Countries shape their routes in education based on skills that universally accepted. Many international organizations emphasize the importance of 21st-century skills in terms of the demands of current qualifications. To elaborate, a number of frameworks for current qualifications are discussed below.

1.1.3 Frameworks for current skills in demand

While there is a broad spectrum of competency in STEM disciplines, educating young people to master the basic and complex skills may be carried out by following trends in society. Most scholarly and government reports show the indicators of capabilities for current and future skills; thus, some of them are explained herein.

1.1.3.1 Partnership for 21st-Century Skills Framework

21st-century skills are qualifications that people should acquire so as to expertise in their disciplines and regulate their daily routines successfully (Ananiadou and Claro, 2009; Partnership for 21st century skills [P21], 2009). The implication of these skills in pedagogical practices will enhance students' engagement in science and society since 21st-century skills are ubiquitous in daily life (E. Silva, 2009). P21 Framework includes a set of categories in which a teaching subject may be integrated with competencies. A network of Battelle for Kids called P21 focuses on the development of 21st-century skills. These skills have been recently documented as in the following (Battelle for Kids, 2019):

- ✓ Key Subjects and 21st Century Themes
- ✓ Learning and Innovation Skills
- ✓ Information, Communication and Technology Skills (ICTs)
- ✓ Life and Career Skills

21st-century skills proposed by P21 present practice-oriented approach to integrate these capabilities with an academic subject. (P21, 2019). In a similar vein, OECD suggests the interdisciplinary learning environments to transfer knowledge across the disciplines. It supports the mutual interaction of disciplines and promotes interdisciplinary approaches to reach through 2030 (OECD, 2019b). In a disciplinary perspective, training scientifically literate students is a goal in science and mathematics classrooms. The disciplinary connection with some of 21st-century skills, such as collaboration, critical thinking, problem solving, creativity, and ICT literacy which are categorized in sub-themes, may be drawn upon in science and mathematics education substantially.

1.1.3.2 ISTE Standards

International Society for Technology in Education (ISTE) is a community that promotes the integration of technology in education. The community guides scientists, educators, teachers, and it plays a critical role for forming global educational standards called ISTE Standards (ISTE, n.d). According to ISTE standards, students who are educated in line with ISTE Standards will succesfully manage self-regulation in learning with the use of technological products. They will consider the effectiveness of different tools whether these tools are useful for them in learning process or not. ISTE Standards emphasize how technology-driven instruction can contribute learning process effectively. Thus, the student competencies in ISTE Standards have been substantially integrated with computer science (ISTE, 2016).

Among the standards, ISTE acknowledges computational thinking (CT) as an important competency. ISTE encourages to generate learning environments in which students experience the inter-connection of disciplinary practices with a strong technology-driven influence on learning process. The term CT is mentioned as an important skill that students hold. Cultivating students to be computational thinkers carries significant missions to enhance student development recently (ISTE, 2016).

1.1.3.3 National Research Council K-12 Science Framework

National Research Council of the United States (NRC) published a framework of major capabilities for science classrooms. The council reports that students in the United States should be educated in light of recent and fundamental developments in society and engineering. Qualifications in this framework shape the future labor and cooperate with skills in demand (NRC, 2012). It lists the fundamental skills that students ought to acquire, three of which are the inquiry of problems in science and engineering, working on these problems with data modeling and analysis with engineering and scientific perspective, and the usage of computational and mathematical thinking (NRC, 2012).

1.1.3.4 Next Generation Science Standards

Next Generation Science Standards (NGSS) is a resource, namely curriculum for science learning and performance expectations in the United States. NGSS covers three major dimensions in science teaching, which are disciplinary science and engineering practices, core ideas and croscutting concepts (NGSS Lead States, 2013). Among the science and engineering practices, CT is introducted with mathematical thinking to understand how science and natural processes work.

The two major reports of the United States in education, Framework of NRC (NRC, 2012) and NGSS (NGSS Lead States, 2013), suggest to use CT in K-science classrooms for educating students.

Since many international organizations and policymakers suggest to educate the youth align with significant capabilities, learning the current skills and forming learning environments in line with them are important factors for educating students. Thus, CT as a critical thinking skill is introduced below, and its importance in education is described thereafter.

1.1.4 Computational Thinking

CT is acknowledged as a 21st-century skill (Haseski et al., 2018; Tabesh, 2017; Yadav et al., 2016); however, both the origin and definition of the term are major debates among scholars. Researchers pointed out that CT was initially mentioned by Seymour Papert, yet definition extended by Jeannette Wing was popularly accepted by the scientific community (Rijke et al., 2018; Shodiev, 2015; Shute et al., 2017). Wing defined CT by raising the significance of the term for all disciplines as "Computational thinking is a fundamental skill for everyone, not just for computer scientists." (Wing, 2006, p. 33). The call of Wing (2006) has gradually increased, and the term has been promoted across the disciplines. Wing (2011) states that CT is problem-solving methodology in which artificial agents take a role in the process to function at the problems and carry out precise operations to corresponding tasks. A report of OECD indicates that CT integrates natural and applied sciences that utilize ICT to practice inter-related skills (Paniagua and Istance, 2018).

Scholars have noticed that there is no consensus for the definition of CT (Beecher, 2017; García-Peñalvo and Mendes, 2018). After reviewing several studies, Shute et al. (2017) referred to CT as an umbrella term to which a problem is solved with different approaches and can be processed in several media. Despite the efforts in literature, some of interpretations caused misconceptions. One of those common misconceptions is that CT is computer programming. Instead, computer programming is a wheel to solve a problem computationally.

Grover and Pea (2013) state that CT may cover the tasks which necessitate a complicated syntax if a problem requires such to be solved. CT could be stated as an approach which computer scientists prefer since it is appropriate and handy in their disciplines (Grover and Pea, 2018). ISTE and the Computer Science Teachers Association (CSTA) surveyed how people see CT, and they concluded that CT is seen as a problem-solving process which covers many elements for a solution (ISTE and CSTA, 2011). The scope of CT and its components are thus stated in the following.

1.1.4.1 Computational Thinking Components

CT which is a problem solving method emerged from computer science has conjunctive parts to handle the problems succesfully. CT uses computer-science driven methodologies and perspectives to answers the problems. It is affirmed that CT consists of several components that are practiced in this process (Fernández et al., 2018). These are stated below:

- **Abstraction**

Abstraction is described as the most critical CT feature which pays attention to the core aspects of the problem. Its purpose is to detect anything out of the target and then to remove it with the most effective way. Abstraction is ubiquitous. One example of this is that computers can function at hard tasks simultaneously so that users operate many commands at the same time (Wing, 2011). In daily life, people may focus on a specific dimension of anything so that they spend less time on unnecessary details. Abstraction could be identified as a way to reach the most advantageous and simplified solution for the problem.

- **Decomposition**

Decomposition is a process of dividing the problem into smaller parts that are easy to deal with. Firstly, the problem is viewed from a holistic perspective, then it is broken down into smaller parts. It is explained in three steps: recognizing the association of items, selecting a method to partially down the phenomenon, and investigating the effectiveness of the method in other problems (Rich et al., 2019).

- **Algorithmic Thinking**

Denning and Tedre (2019) clarify algorithms as particular statements that computers can function once they receive the command. Beecher (2017) notes that algorithms consist of sequences that fulfill a flow of tasks, and they are anticipated to work according to the procedures they are formed. Curzon and McOwan (2017) place algorithmic thinking at the center of CT and state that CT is a perspective to seek the truth similar to scientific thinking. In another study, algorithmic thinking is explained as a way of using algorithms in a stepwise process (Futschek, 2006). Given these points, algorithmic thinking should comprise the procedures which provide consistency and accuracy to flows to work in order.

- **Logical Thinking**

Beecher (2017) states that logic is the determination process of ensuring the acceptability of statements. Computers require to receive clearly expressed commands to interpret them accurately; thus, they need to be issued what to do in case of an opposite situation occurs in the command sequences. In brief, logical thinking is to tell the system "to do this; otherwise, to do that".

- **Debugging**

Debugging is stated as the elimination of bugs and coding errors in computer programs. It has several methods to revise and arrange algorithmic sequences (McCauley et al., 2008).

- **Pattern Recognition**

Pattern recognition is to show specific themes in the underlying phenomenon and to see the images, schemas, and loops which are iterative in it. It is a method to find out hidden properties of data. Dasgupta and Purzer (2016) report that pattern recognition has been slightly studied as a CT aspect even though it reflects several CT dimensions. Grover and Pea (2018) expound that pattern recognition streamlines the problem-solving process so that it takes less time to evaluate the several aspects of the phenomenon.

- **Computational Modeling and Simulation Practices**

In computational science and most of the STEM fields, computational modeling is used to visualize data and digital artifacts for research and development in STEM. Clark and Ernst (2008) endorse the integration of data practices in engineering and science education to develop systems and STEM scientist thinking for learners.

Weintrop et al. (2016) established a taxonomy of CT practices for mathematics and science classrooms in their seminal paper. In the computational modeling and simulation practices category, Weintrop et al. (2016) listed a number of tasks to practice this competency such as understanding, testing, assessing, and designing computational modeling and simulations. In another study, it was claimed that computational modeling and simulations are the outputs of CT practices as a result of the problem-solving process (Selby and Woollard, 2013).

- **Data Practices**

Weintrop et al. (2016) define the data practices in their CT taxonomy. Data practices encapsulate steps such as generation, manipulation and evaluation of data. Data practices reflect major CT aspects. The key abstraction here is to demonstrate data simply and properly (Weintrop et al., 2016). Most K-12 science and STEM classrooms implement core practices to collect data, demonstrate data appropriately and evaluate data with a scientific perspective. Data practices are shown and estimated with approaches that are driven by computer science in this context.

- **Iteration**

Iteration defines the continual repetition of whole or partial algorithmic sequences.

- **Loop**

It is a repetitive action, of which a process taking a start several times in order to carry out a number of actions.

- **Evaluation**

Evaluation is generally to critique several aspects of any assignment. Particularly, evaluation in CT is to determine which parts of computational products, e.g codes, computational models, are worth being acceptable in theory and practice. It is emphasized that evaluation in CT is to assess the exactitude of representational artifacts within their context or technical standards. Evaluation can also be considered to decide the effectiveness of the solution (Grover and Pea, 2018).

1.1.4.2 Importance of Computational Thinking

Technology tools became indispensable products in life as a result of the developments in ICT. Individuals correspond to their basic needs with few clicks such as ordering food from a website and communicating with other people online. Computers have a great capability to do tasks in seconds, and they are configured to work effectively. The impact of computer systems will thrive in the long run. Rotman (2013) doubts that artificial systems have a chance to replace human power in near future. A majority of people may face losing their job or else they need to acquire ICT skills. Pew Research Center (2014) stimulates practitioners and policymakers to inform and cultivate people in line with 21st century skills before this situation poses a threat to employment. On the contrary, there is also a possibility that improvements in technology offer novel fields in recruitment likewise in the previous years.

Vallance and Towndrow (2016) emphasize the importance of using technology as a part of classroom practice instead of using its tools individually to achieve learning goals. Integrating ICT into other disciplines is an essential step to cultivate the young generation. In this regard, CT should be promoted in K-12 levels since it can develop several competencies.

CT comprises fundamental skills such as problem solving, logical thinking, and 21st-century competencies. Román-González et al. (2017) have analyzed the cognitive skills which underlie CT and documented that CT was related to reasoning and spatial skills. Another study on cognitive skills associated with CT skills found that spatial skills, academic achievement, and intelligence were the indicators of CT skills (Ambrosio et al., 2014). As CT is the key feature in STEM disciplines, the development of CT should be considered across the grades and disciplines. Also, informing students about the potential threats of employment in near future and cultivating them concerning these qualifications should become a mission. Jeannette Wing also suggested the promotion of CT as problem-solving and articulated that "it [CT] represents a universally applicable attitude and skill set everyone, not just computer scientists, would be eager to learn and use" (Wing, 2006, p. 33).

While there is a significant influence of CT on STEM disciplines, students suffer from the lack of capability to use CT in their disciplines. Qin (2009) states that students who major in life sciences know little about computer science in spite of the fact that there are implication fields of computing in life science disciplines such as bioinformatics, biotechnology, and bioengineering. This may now seem to be a disadvantage to drawing the attention of STEM undergraduates and graduates; yet, recent research reported otherwise. Stefan et al. (2015) introduced CT practices to biology students and concluded that students found it beneficial to use CT in their disciplines. Researchers advised that incorporation with CT aids students' understanding of biology and guide them on how to take advantage of computer science in their disciplines (Helikar et al., 2015; Rubinstein and Chor, 2014). Instead of exposing students in natural sciences to standalone programming instruction, researchers suggest applying an integrated instruction approach that connects programming with students' professions (Rubinstein and Chor, 2014; Stefan et al., 2015). By means of integral practice, students will understand the affordances of CT in their disciplines, develop interest and expertise in their area of research (Stefan et al., 2015).

Wong and Jiang (2018) studied with elementary students to raise their CT skills and concluded that CT could be practiced from childhood education up to undergraduate degrees. The introduction of CT in elementary education is a critical step for engaging students in STEM disciplines either it is directly implemented in introductory computer programming or it is integrated with other disciplines. According to Tran (2018), introductory computer science education is a keystone for students' early engagement so as to reach a broader population in STEM disciplines as well as computer science. Barr and Stephenson (2011) exhort practitioners from different disciplines to implement CT in learning environments. In addition to core CT practices in computer science education, CT can be used in mathematics, science, social science, language education and more. In this study, CT in science education is investigated and used in a K-12 science classroom.

1.1.5 Computational Thinking Practices in Science Education

CT practices in science education may have twofold aspects to advance in student profiles: improvement of CT skills and learning in science education. CT skills can be developed by integrating them with science subjects in line with curricular expectations, national standards and learning goals. Learning science subjects and practicing CT should be mutually adjusted in line with the accurate connection of pedagogical practices. There are a considerable number of studies in STEM education that offer interdisciplinary learning environments to teach CT practices. These studies are integrated with programming approaches including maker movement or robotics (Alden and Tramonti, 2020; Juškevičienė et al., 2020a, Leonard et al., 2016; Yang et al., 2021), design thinking and engineering design process (Love and Griess, 2020) and augmented reality (Jesionkowska et al., 2020).

Teaching computer programming as well as CT practices requires the classification of teaching approaches in science education. Previous research has been limited to discipline-specific teaching methods of programming in computer science education. There are two studies in the current literature that articulate teaching methods of programming and CT (Waite, 2017; Weinberg, 2013). Teaching CT practices in science classrooms and computer science classrooms share core pedagogical similarities. However, current research needs a categorization of CT teaching methods in science education. It would be better to provide information about CT practices in science and engineering curricula with a wide range of CT teaching approaches.

Students experiment in science subjects by practicing CT competencies in science classrooms with different levels of programming involvement. CT practices are generally performed in digital environments since the interaction with artificial systems is considered a substantial engagement in computer science. Nevertheless, computer-free environments could be representative to take an initiative for introductory CT activities. This present study groups CT teaching methods in science education whether there is an existence of a digital teaching tool, digital (plugged-in), and computer-free (unplugged) approach. Since CT makes use of any programming language as a way of practice, it may eliminate the main focus on teaching a particular programming syntax but rather may emphasize programming principles and perspective. Thus, the present research classifies CT teaching approaches as plugged and unplugged methods in line with the scope of the study. These approaches are discussed herein.

1.1.5.1 Plugged Approach

Plugged approach encapsulates computer-based interventions for students to acquire CT skills. Several tools derived from different programming languages are used with respect to learning goals and user profiles. The common programming languages used for practicing CT skills in computer science education as well as in STEM education are block-based programming, text-based programming, agent-based programming, hybrid programming, and physical programming.

Different subjects in science are used as teaching contexts to practice CT skills in classrooms. In chemistry subjects, students may design computational models of chemical substances and chemical bonds since there are abstract concepts and relationships in this topic to understand the subject. Students may create simulations that depict chemical bonds between specific atoms and compounds. A recent study used simulations, depicting chemical reactions of some well-known compounds, to integrate CT practices with curricular goals (Bortz et al., 2020). This particular teaching subject namely chemistry may remain uncertain in CT-based science instruction whereas other science subjects are widely taught within CT practices.

Biology subjects are commonly practiced in classrooms by computational tools. It is suggested to embody CT in K-12 biology classrooms since there is a thorough connection between the logic of CT and biology (Peel and Friedrichsen, 2018). An example of this instance is the illustration of viruses, bacterias and other microscopic organisms in computational modeling tools. This practice is a common approach to examine the biological processes in science education across the grades. Digital visualization of organisms and the search of patterns on genetic codes enable learners to understand abstract concepts and help to connect interrelations among these subjects.

Many researchers chose environmental science subjects such as ecosystems, population dynamics, evolution and ecology since these subjects have several complex relationships that cause significant impact on the mechanism (Arastoopour-Irgens et al., 2020; Basu et al., 2017; Peel et al., 2019; Pierson et al. 2020; Sengupta et al., 2013; A. Silva et al., 2020; Wagh et al., 2017; Wagh and Wilensky, 2018; Waterman et al., 2020; Wilkerson-Jerde et al., 2015). Swanson et al. (2019) incorporated CT practices that were associated with model-building activities in science subjects and instructed dynamics of populations in different contexts. In their study, students analyzed the mechanism of the natural phenomenon that was represented in a digital system and carried out data practices to observe feedbacks of the system based on changes in parameters and variables. Thus, they gained an understanding of how similar that natural mechanism works (Swanson et al., 2019).

As it is frequently seen in most engineering design tasks and robotics activities, the physics subjects and concepts are leveraged by computing. Kinematics, electricity, and mechanics are some of the common topics in which most researchers implement physical programming. The enriched learning environments like STEM classrooms thrive on programming knowledge and CT skills altogether. Several studies (Litts et al., 2017; Yin et al., 2020) performed physical computing activities which were integrated with electrical circuits, and a few studies used kinematics to build either modeling or robotics artifacts (Akşit and Wiebe, 2020; Hutchins et al., 2020; Merkouris and Chorianopoulos; 2018).

Design-based learning involved in artifact building with a programming tool frequently necessitates former experience and programming knowledge since each of these requires knowing how to operate a programming tool. Students need to possess both the knowledge of scientific phenomena and programming language so as to transfer scientific knowledge into a visual environment. Research on how students use disciplinary knowledge over another discipline concludes that students have a difficulty in describing precise steps they should go through (Taub et al., 2013). In the study of Taub et al. (2013), students were expected to create a simulation that describes circular motion, and they struggled to interpret theoretical physics knowledge in the way a computer could analyze. The study of Akşit and Wiebe (2020) reported that students had challenges in constructing and revising algorithms even though they were scaffolded both at the beginning and during the classes. This evidence indicates that transferring disciplinary knowledge into another discipline is a barrier for students to reach the solution even though they are scaffolded during the lesson.

Although the digital approach is a common choice among scholars, it requires critical inquiry of practice before implementation. Management of digital tools influences the classroom. The heterogeneous structure of the classroom in terms of students' computer skills and profiles could become an issue that influences engagement with digital tools. In spite of the fact that user-friendly digital tools are mentioned as appropriate for students in K-12 grades, they raise debates about the effectiveness of classroom implications. Students may have difficulty understanding the functionality of the tool. Researchers categorized three major aspects that students had challenges in CT practices, two of which emanate from programming; agent-based thinking challenges, and modeling and simulation challenges (Basu et al., 2016). The fact that involvement of programming tools can increase competencies in programming skills, yet can also bring about challenges for novices either. Nevertheless, the use of such tools to practice CT is not compulsory.

Researchers move through the implementations where students do not necessarily practice CT in computer based techniques. Instead they experience CT by playing games out of classrooms or doing regular practices based on paper materials. Unplugged CT instruction is a way to conduct non-computer-based practices in classrooms, and it is described below.

1.1.6.2 Unplugged Approach

The Unplugged approach was firstly initiated in the Computer Science Unplugged project by a group of researchers at Canterbury University to teach how to solve daily life problems by using fundamentals of computer science (Bell et al., 2009). It is a method to teach programming concepts without the continuous use of computers, and it encapsulates problem scenarios to raise awareness of the computer science discipline (Aranda and Ferguson, 2018). The Unplugged approach is feasible in a wide range of grade levels including pre-school education. This instructional approach is an initiative to teach what programming is and to shed light on how computer scientists construct logical statements in programming.

There are several motives to promote an unplugged CT approach in compulsory education. Taub et al. (2012) explored students' intentions to participate in computer science and views about computer science after a particular unplugged computing educational program. It was concluded in their study, unplugged coding reminded students that, it was possible to carry out computer functions without computers (Taub et al., 2012). Besides, unplugged programming is implemented in after-school and summer camp projects. One summer camp project was reported to be successful in terms of teaching central computer science vocabularies and increasing conceptual understanding in the middle school and high school levels (Alamer et al. 2015). By and large, CT unplugged is used in lower grades including pre-school education and it provides early engagement to computer science since it is feasible in pre-school and K-12 grades. Serious games, outdoor and in-class games at which students spend kinesthetic efforts to solve the problem scenarios, paper, and pencil assignments, or embodied activities are among the unplugged activities (Nishida et al., 2009). There is no need to teach a specific programming language in unplugged approach. Besides, it creates an opportunity to teach computer science concepts without computers and other technological tools when there is restricted or no access to them. The benefit of the unplugged method is to understand tacit knowledge related to cognitive processes in CT (Venkatesh et al., 2021).

Research proves that unplugged CT activities enhance CT skills (Brackmann, 2017; Looi et al., 2018). Brackmann et al. (2017) found out that the unplugged CT method increased the CT skills of students aged between 10-12. Besides, there are various alternative techniques of unplugged implications. Gardeli and Vosinakis (2017) have created an ideal unplugged approach that presents a transition phase through digital CT implications in a classroom environment.

The use of the unplugged CT approach is also performed in science classes. Since unplugged CT-based practices in science education hold key goals through development in science classrooms, they should be promoted in a sophisticated manner. When CT is performed in the classrooms as a problem-solving method in line with the literature (Bell et al., 2009; NRC, 2010; Wing, 2008), students have a chance to practice not only authentic learning experiences but also problem-solving strategies. Unplugged CT practices ease both development of students' thinking skills and the classroom management of teachers. Whereas it is simple to learn programming in an unplugged approach, digital approaches require knowing or learning a programming language. It was reported that students found tiring to detect and re-write accurate codes in a specific programming language (Weintrop and Wilensky, 2015). The problems raised by technical errors and lack of student capabilities in the classroom can be overcome by the application of the unplugged method.

1.2 Objective of the Thesis

The aim of this study is to reveal the effect of constructivist science instruction integrated with unplugged computational thinking activities on seventh-grade students' academic achievement in "pure matter and mixtures" subject and computational thinking skills.

1.3 Hypothesis

1.3.1 Alternative Hypothesis (H_A)

H_{A1}: There is a significant effect of constructivist science instruction integrated with unplugged computational thinking activities on seventh-grade students' academic achievement in "pure matter and mixtures" subject.

H_{A2}: There is a significant effect of constructivist science instruction integrated with unplugged computational thinking activities on seventh-grade students' computational thinking skills.

1.3.2 Null Hypothesis (H_0)

H_{01}: There is not any significant effect of constructivist science instruction integrated with unplugged computational thinking activities on seventh grade students' academic achievement in "pure matter and mixtures" subject.

H_{02}: There is not any significant effect of constructivist science instruction integrated with unplugged computational thinking activities on seventh grade students' computational thinking skills.

1.4 Research Question

What is the effect of constructivist science instruction integrated with unplugged computational thinking activities on seventh-grade students' academic achievement in "pure matter and mixtures" subject and computational thinking skills?

1.4.1 Sub-Questions

- What is the effect of constructivist science instruction integrated with unplugged computational thinking activities on seventh-grade students' academic achievement in "pure matter and mixtures" subject?
- What is the effect of constructivist science instruction integrated with unplugged computational thinking activities on seventh-grade students' computational thinking skills?

1.5 Original Contribution

CT has been taught in computer science and STEM classrooms on many levels. Despite the interest, many attempts fall behind because of curricular expectations and time constraints. Earlier research on this topic initiated on how to perceive CT in science education so as to establish a disciplinary background in STEM education (Juškevičienė et al., 2020b; Sneider et al., 2014). Recent efforts have been gradually expanding for the past decade. Since CT skills in K-12 science classrooms have started to being implemented recently, a need for regular classroom activities and materials has arisen. It may seem indispensable to teach computer-science related skills without computers. However, unplugged CT teaching provides feasible opportunities and practical affordances to foster CT skills. The use of computers and other technology products so as to teach CT are the common practices in learning environments; yet, there is not any method that prevents barriers to programming languages and technical problems. Given these points, this study proposes that unplugged CT practices can be effective in science instruction. CT use in K-12 science classrooms can be increased with feasible activities. Hence, the classroom activities in this study were organized with unplugged CT practices in a chemistry subject. This study has been organized in order to foster CT skills with the integration of feasible science assignments in a regular seventh-grade science classroom. This present study contributes to the current literature with an unplugged approach to practice CT and teach a chemistry subject in a seventh-grade science classroom.

Previous work has primarily focused on teaching science and practicing CT skills with programming tools, yet it has a limited understanding of how unplugged CT practices provide meaningful learning outcomes in science and engineering education. This study is a prior example of unplugged CT-integrated science instruction in a chemistry subject with proposing and forming classroom activities in the current limited literature. This study will contribute to the literature with unplugged CT-based science instruction activities formed by the researcher. A common way to implement CT in science classrooms is to focus on the manipulation of scientific variables in science subjects with the use of digital platforms. There is little known how different CT practices could be performed in other ways. The researcher has formed a number of science teaching activities in which chemistry concepts are taught with CT components unlike current relevant literature.

Pure matter and mixtures is a core chemistry subject taught in Turkish K-12 grades. Previous research investigated conceptual understanding of pure matter subject using educational technology tools (Ural and Ercan, 2015) and traditional instructional methods (Cojorn et al., 2012; Çavdar and Doymuş, 2018; Koç and Şimşek, 2016; Zorlu and Sezek, 2019); however, this study presents how this subject can be taught in an interdisciplinary context with CT practices.

Earlier research aggregated on implementing CT practices in evolutionary biology and ecology. Estapa et al. (2018) state that CT practices in science subjects mainly use natural life cycles. This may strengthen the idea that chemistry subjects are unpopularly taught with CT practices. Only a few studies could have been reached to address this issue in this recent literature. Arastoopour-Irgens et al. (2019) visualized chemical gases in a high school STEM unit to identify abstract processes. Instruction of chemistry subjects practiced by CT skills is rare and the research gap still enlarges. These unplugged CT-based chemistry activities will decrease the gap in literature since it is an example of CT-based chemistry activities for middle school students.

All things considered, the researcher decided to investigate academic achievement in a middle school chemistry subject. There is no convincing result in the current literature, which specifically examines the impact of unplugged CT-based science education on seventh grade students' academic achievement likewise the content of this study. While there is little known about unplugged CT-based implications in the science classrooms, it will be beneficial to understand to what extend student academic performances in science education could be enhanced by unplugged CT-based science instruction. The impact of unplugged CT practices on science achievement in a chemistry subject is poorly investigated and understood. Examining the influence of CT on academic achievement in a K-12 chemistry subject will reveal the benefits of CT usage and pursue researchers why CT should be promoted in K-12 science classrooms.

Another dimension of this study is to reveal how unplugged CT-based science instruction affects seventh grade students' CT skills and to enhance the CT skills of seventh-grade students in science classrooms. The computer science community has raised an interest to thrive CT skills in K-12 education. The development of core CT aspects in education is a widespread interest aimed by researchers in computer science. Many researchers successfully reached meaningful experiences with unplugged coding activities in K-12 computer science classrooms (Delal and Öner, 2020; Thies and Vahrenhold, 2013; Tonbuloğlu and Tonbuloğlu, 2019). Since CT is a significant competency for the future workforce, it should be promoted and practiced in other disciplines. A little has been studied on how unplugged CT skills can be enhanced in science classrooms. CT competencies were embedded into science curricular activities in this present study so that this integrated instruction became a construct to actualize the promotion of CT skills. Accordingly, the enhancement of CT skills should be one of the central research fields among science educators. Science educators who are willing to practice CT in the classrooms will have a chance to examine how CT-based science instruction affects students' CT skills.

1.6 Assumption

The responses given to data collection tools by participants were assumed to be honest and candid.

1.7 Limitation

This study has been limited with the participants who were seventh-grade students in a public middle school in Istanbul and with the instruction performed in classrooms and laboratory in five weeks, of which 16 hour of class periods in total.

2
CONCEPTUAL FRAMEWORK

This chapter explains the conceptual frameworks that guide the design of teaching activities. There are two guidelines to prepare instructional activities in total. First, a framework for computational thinking implementation in the experimental group is explained; subsequently, the constructivist approach is presented for science-related instructional activities in the experimental and control groups; this step is followed by science learning standards for the experimental group and control group. Finally, a comparison of classroom activities in both groups is summarized.

2.1 Framework for Computational Thinking Implementation in the Experimental Group

The design of CT-based science learning activities is twofold as it is a concurrent approach to teaching science with a CT perspective. Articulation of science learning standards and identification of CT practices may limit the teaching context. Since it is critical to specify learning standards and performance expectations before class time, practitioners should follow a framework that addresses these questions. Thus, there was a need to review examples in the literature before the design of activities.

Considering that little is known about how CT components may be used with scientific phenomena, conceptual frameworks which show a thorough guideline in the design process were significant. The researcher, as a science educator, needed to arrange the harmony between the science subject and CT components. The researcher critically examined computer science educators' recommendations about implementation strategies of CT in K-12 classrooms in order to offer CT practices in curricular activities. After the review of the literature, the researcher decided to perform CT in a way that enables one to understand scientific phenomena and to practice tacit knowledge instead of a stand-alone CT training. The researcher decided to embed CT skills into a regular middle science classroom in which CT is introduced as a problem-solving method to most computer scientists' practice. Thus, CT components were implemented and integrated into the seventh-grade science classroom.

There are a number of frameworks for CT implementation in K-12 classrooms in the current literature (Brennan and Resnick, 2017; Kalelioğlu et al. 2016; Kotsopoulos et al., 2017), which particularly focus on the development of CT skills in computer science education. Weintrop et al. (2016) proposed a framework for the implementation of CT skills in mathematics and science education which particularly focused on data practices and systems thinking, nearly associated with digital approaches. Curzon et al. (2014) developed a framework about how to accommodate CT practices into classroom activities in several disciplines. Curzon et al. (2014) guided this study to apply CT components in the classroom activities of the experimental group and provided guidelines for the development of lesson plans in this group.

The steps of framework development and design of lesson plans were intertwined, that is, Curzon et al. (2014) suggested preparing lesson plans through 4 stages which have 3 driving questions: "why, what, and how?". These three questions were answered in line with the content of this present study in the following.

1st driving question: Why do people need to solve problems with a computational perspective? (Curzon et al., 2014)

It is important to serve authentic and real-world problem scenarios that require computational solutions so that students will be aware of which scenarios can be associated with CT practices (Curzon et al., 2014). Therefore, science learning activities in this study were associated with CT components to raise and support students' engagement in CT. Students were asked to respond to thematic questions related to scientific phenomena to address the reasons for using CT in scientific problems.

2nd driving question: How to place CT components in the lesson plans? (Curzon et al., 2014)

Since this present study has twofold learning and practice foci, there are two main principles to correspond to this question. In essence, there are two determiners in the lesson activities for the experimental group, which are CT components and science subjects. To select and apply CT practices in science subjects, CT pathways stated in the study of Dorling and Walker (2014) were followed. The CT components in this pathway are abstraction, decomposition, algorithmic thinking, evaluation, and generalization, which are associated with a number of topics in computer science (Dorling and Walker, 2014).

In addition to these CT components, pattern recognition is additionally integrated with the predetermined science teaching subjects. Dorling and Walker (2014) suggested teaching these CT components to align with major computer science knowledge such as indicating data with different representations using symbols and building logical and algorithmic sequences. On balance, these principals in computer education are connected with science phenomena to teach science subjects by means of CT practices in this study.

Besides, there is a need to arrange science learning standards as this study integrates CT components with a science subject at a K-12 level. Learning standards in Turkish science classrooms are present in the Turkish Science Curriculum (MoNE, 2018). Thus, the researcher had to choose one of the teaching subjects in the Turkish Science Curriculum which was published in 2018. There were seven units in seventh-grade level (MoNE, 2018), and the teaching subject of this study had to be one among them. Since previous examples of CT-based science instruction included subjects from physics and biology, the researcher decided to choose chemistry subject to enable an example of another discipline. The only chemistry unit in seventh grade in the Turkish Science Curriculum (MoNE, 2018) was Pure Matter and Mixtures; thus, it was decided to implement CT practices into this subject. The Pure Matter and Mixtures unit has main 4 teaching topics.

Considering that it is critical to provide harmony between CT components and science subjects, out of four topics of the unit, three of them were mainly included in the current study. Nevertheless, the researcher acknowledged the concepts of the first topic to maintain consistency of this unit by recapping the learning objectives to activate background knowledge. The three teaching topics and CT components were expressed in the following sub-section and in the Lesson Plans (Part A)

3rd driving question: What are learning performances students will gain? (Curzon et al., 2014)

During the design of classroom activities, the researcher has taken the classroom routines into account. The rapid change in classroom culture and lesson objectives might damage the implication process; thus, the CT practices have been gradually implemented to the activities. It was considered that students should learn scientific phenomena while experiencing CT as a problem-solving method in line with the scope of the study. Thus, these CT components were implemented from simple to complex throughout the learning activities.

After the verdict of the science subject, CT components were associated with the subjects. The classroom activities in the experimental group are called Computational Thinking Activities where this study takes its title from. Students who are taught with these activities have had the opportunity to practice CT in science classes. Finally, evaluation of classroom activities in this group were carried out by integrated questions about CT skills and science subjects or standalone disciplinary questions.

Figure 2.1 below demonstrates lesson plan and classroom activities development align with driving questions.

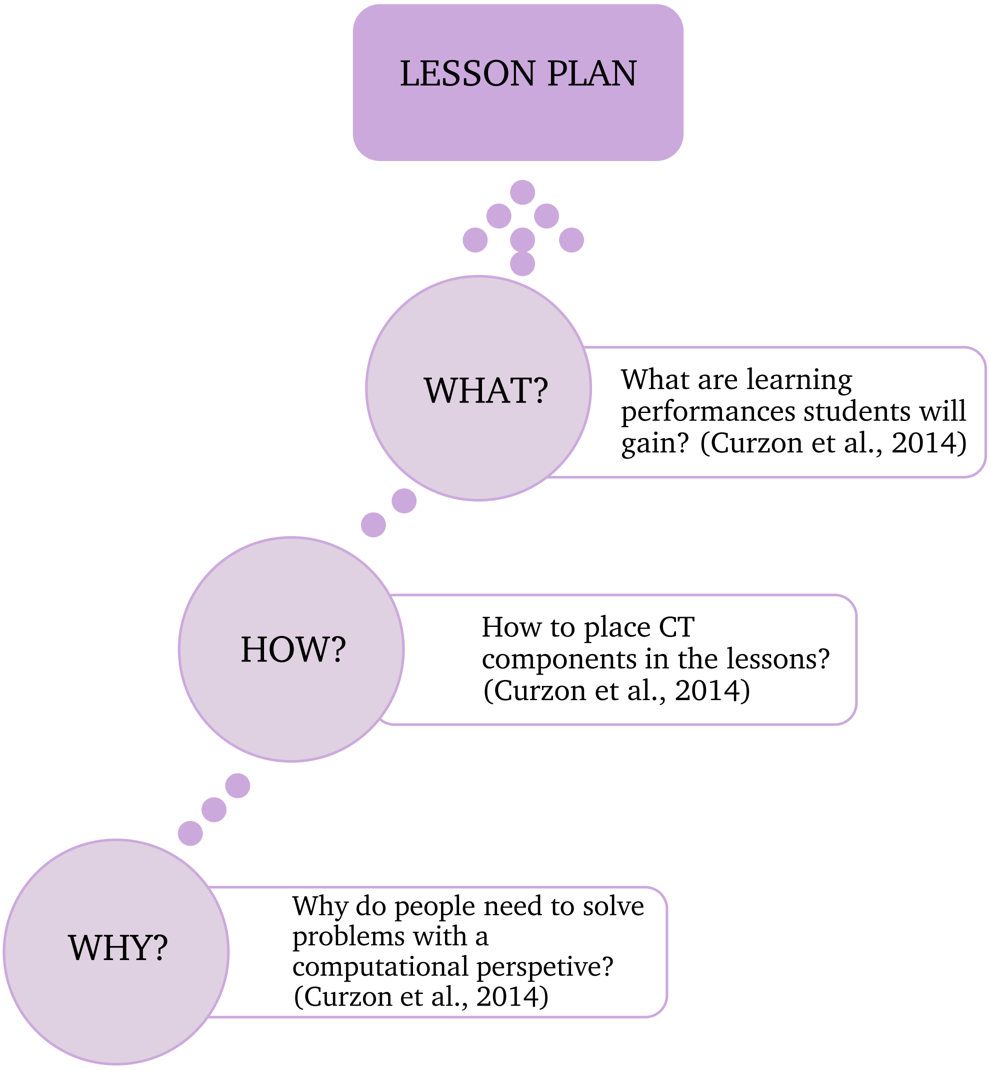

Figure 2.1 Phases and driving questions of lesson plan development

2.2 Framework for Constructivist Science Instructional Activities in the Experimental and Control Group

The regularly practiced teaching approach in Turkish science classrooms is constructivist teaching. Students treated in this group were taught based on the constructivist approach as they normally do in Turkish science classrooms. Constructivism is a broad term that has been explained in various ways because of the core idea and perspective. For instance, constructivism is admitted as a psychological theory of learning (Fosnot and Perry, 1996), pluralist theory of science education (Bächtold, 2013), learning theory (Bada, 2015), an educational theory (Taber, 2011) while Colburn (2000) accepted constructivism both as a philosophy and learning theory. Although each definition of constructivism might seem similar, each stands on a different theoretical framework.

In the constructivist perspective, social interaction is encouraged in order to create a place where students discuss with peers or do group-working. Saunders (1992) expresses four strands in constructivist science classrooms, which are the organization of inquiry in the laboratory, mental readiness, peer collaboration, and frequent assessments. The main perspective of recommendations in the study of Saunders (1992) is to create real-world experiences and examine them by eloquent thinking approaches.

With its consistent characteristics, the practice of constructivism entailed how to implement it in classrooms across the disciplines. Therefore, it was needed to create regular structures which could be standardized as instructional principals, and the priority was given to these principals in order to design qualified learning environments. There are various models and techniques constructed to help learners to form, adapt and re-design content knowledge. 5E instructional model was created in the 1980s as an adaptation of the science curriculum (Bybee et al., 2006). It is a model consisting of learning steps, which is popularly used in science classrooms.

Bybee et al. (2006) described the 5E model in five steps as engagement, exploration, explanation, elaboration, and evaluation. Engagement is introducing the topic, motivating students towards the topic, and giving daily life examples and scenarios associated with the topic. Exploration is a phase at which students actively engage in an activity that lets them explore the science behind the problem and scenarios. The explanation is a phase at which the scientific knowledge is correctly explained. Any related concept and process that students previously experienced should be clarified in this step. Elaboration is a further transfer of the topic in novel contexts. The advantage of this step is that it may enable students to create authentic experiences through previous learnings. Evaluation composes the wrap-up questions and assessment of the topic during and after the learning activities (Bybee, 2006).

2.3 Science Learning Standards

Learning standards stated in the Turkish Science Curriculum (MoNE, 2018) were presented in Turkish and translated to English below in order to present the learning goals in the experimental and the control group.

Pure Matters

"*7.4.2.1. Saf maddeleri, element ve bileşik olarak sınıflandırarak örnekler verir.*" [(Students) assort pure substances as elements and compounds by giving examples] (MoNE, 2018, p.42)

"7.4.2.2. Periyodik sistemdeki ilk 18 elementin ve yaygın elementlerin (altın, gümüş, bakır, çinko, kurşun, civa, platin, demir ve iyot) isimlerini, sembollerini ve bazı kullanım alanlarını ifade eder." [(Students) express the names, symbols and few of usages of the first 18 elements and common ones (gold, silver, copper, lead, mercury, platinium, iron and iodine)] (MoNE, 2018, p.42).

"7.4.2.3. Yaygın bileşiklerin formüllerini, isimlerini ve bazı kullanım alanlarını ifade eder." [(Students) express the formulas, names and few of usages of common compounds] (MoNE, 2018, p.42).

Mixtures

"*7.4.3.1. Karışımları, homojen ve heterojen olarak sınıflandırarak örnekler verir.*" [(Students) assort mixtures into homogeneous and heterogeneous mixtures by giving examples] (MoNE, 2018, p.43).

"7.4.3.2. Günlük yaşamda karşılaştığı çözücü ve çözünenleri kullanarak çözelti hazırlar." [(Students) prepare solutions by using solute and solvents that encountered in daily life] (MoNE, 2018, p.43).

"7.4.3.3. Çözünme hızına etki eden faktörleri deney yaparak belirler." [(Students) experimentally test the factors which affect the rate of dissolving] (MoNE, 2018, p.43).

Separation of Mixtures

“7.4.4.1. Karışımların ayrılması için kullanılabilecek yöntemlerden uygun olanı seçerek uygular” [(Students) select any appropriate method that can be used for separation of mixtures and [students] apply that] (MoNE, 2018, p.43).

2.4 Comparison of Classroom Activities in Both Groups

In experimental group, the science instruction was integrated with unplugged computational thinking activities. The classroom activities and lesson plans in the experimental group were examined by a science education expert who holds a doctoral degree in science education and a computer science educator who holds a master’s degree in science education. They were invited to examine the consistency of activities, compatibility of CT practices, and coherence among them after the creation of the first draft of classroom activities. The classroom activities revised and completed in line with their feedback during the design process. Figure 2.2 indicates the design strategy of unplugged CT activities in science instruction.

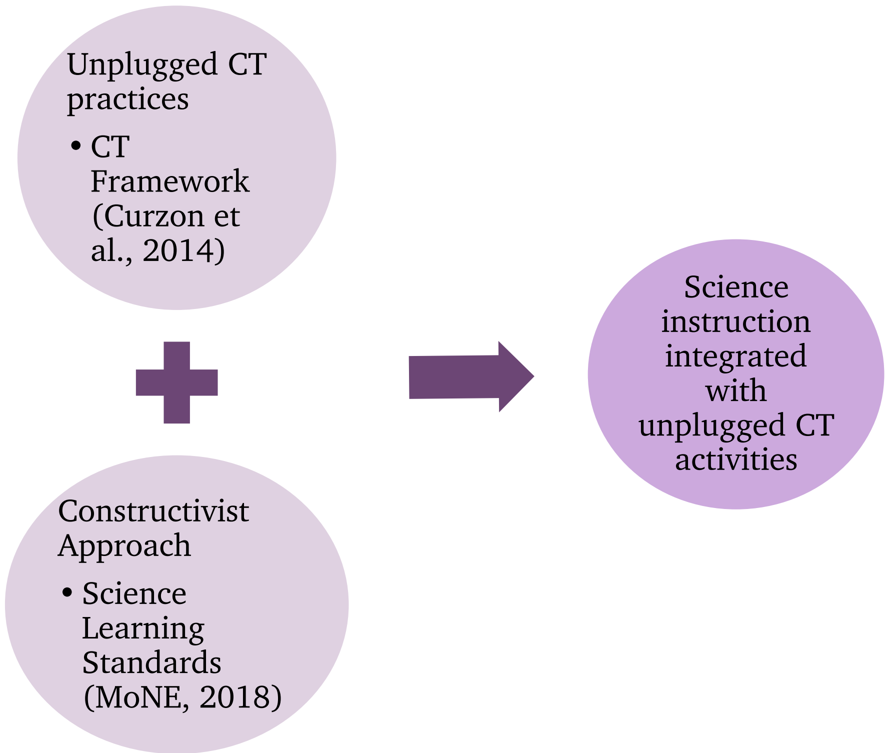

Figure 2.2 Design strategy of unplugged CT activities

In the control group, lesson plans were prepared based on the 5E instructional model. The science learning objectives in this group were the same as the ones in the experimental group, which were presented in the previous subheading. The classroom activities in the control group consisted of generally hands-on teaching activities, peer-group activities, and individual assignments. The activities in this group were checked by a science education expert who holds a doctoral degree in the discipline and a science teacher who holds a master's degree in science education, and the activities were revised based on the feedback. Figure 2.3 depicts the design schema of classroom activities in the control group.

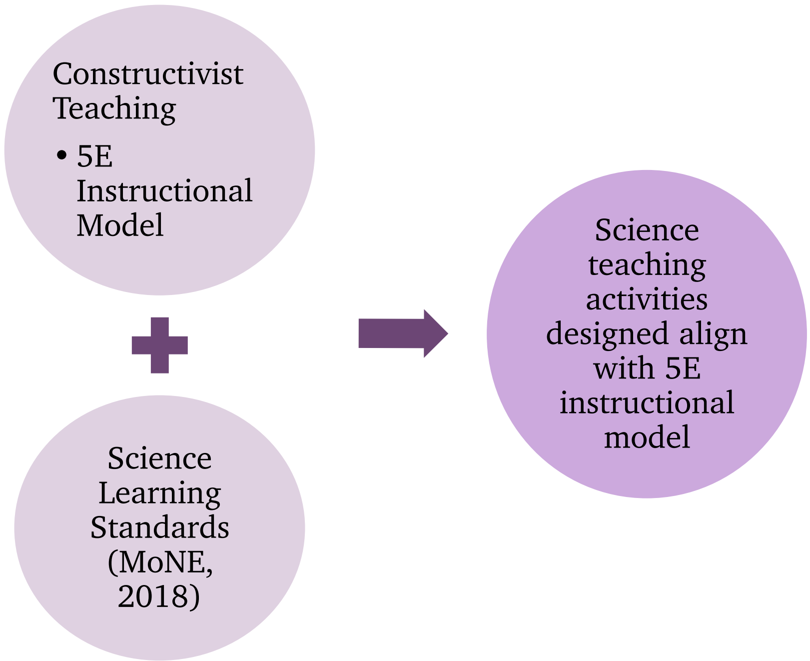

Figure 2.3 Design of 5E activities in the control group

As shown in Figure 2.2 and Figure 2.3, students in the experimental group and students in the control group were treated with constructivist science teaching while the experimental group received unplugged CT training which was integrated with the science subject. While the science curricular goals were the same for both groups, instructional contexts differed. There were four lesson hours each week for both groups; thus, the activities were explained in two-hour long sessions in order to summarize the context. Since more details about each lesson and implementation process will be articulated in the following chapter, brief explanations are presented in this section.

3
METHODOLOGY

The third section is structured as follows: the method of the study, participants, data collection tools, implementation process, internal validity, and data analysis.

3.1 Research Design

The present study investigates the impact of unplugged CT-based instruction on seventh-grade students' academic achievement in the "pure matters and mixtures" subject and CT skills. An experimental research design was utilized to carry out the study. According to Frankel et al. (2012), the advantage of experimental design is to be able to manipulate the variables directly when the research question addresses a cause and effect relationship. This present study is a quasi-experimental design with a pretest-posttest non-randomized control-group design. Leedy and Ormrod (2015) describe that pretest-posttest control-group design ensures the preliminary evaluation of differences between groups before any intervention and estimates any statistical change based on dependent variables after a particular treatment. Martin and Bridgmon (2012) explain that quasi-experimental studies have no random participant assignment in contrast to true experimental designs, and they aim to search causal inquiry of the research phenomenon.

Guthrie (2010) explains that experiments in social sciences hold two main variables called the independent variable and dependent variable. Experimental designs directly attempt to investigate the impact of variables on research findings (Frankel et al., 2012), the research design should be presented in a coherence to the readers so as to provide a clear schema of research, starting with the identification of variables (Guthrie, 2010; Martin and Bridgmon, 2012). Dependent variables in this study subsequently are academic achievement in "pure matters and mixtures" subject and CT skills. The Independent variable in this study is the instruction method.

The students in the experimental group received unplugged CT-integrated science instruction, and the students in the control group received treatment with constructivist science learning. Figure 3.1 depicts the treatment schema in both groups.

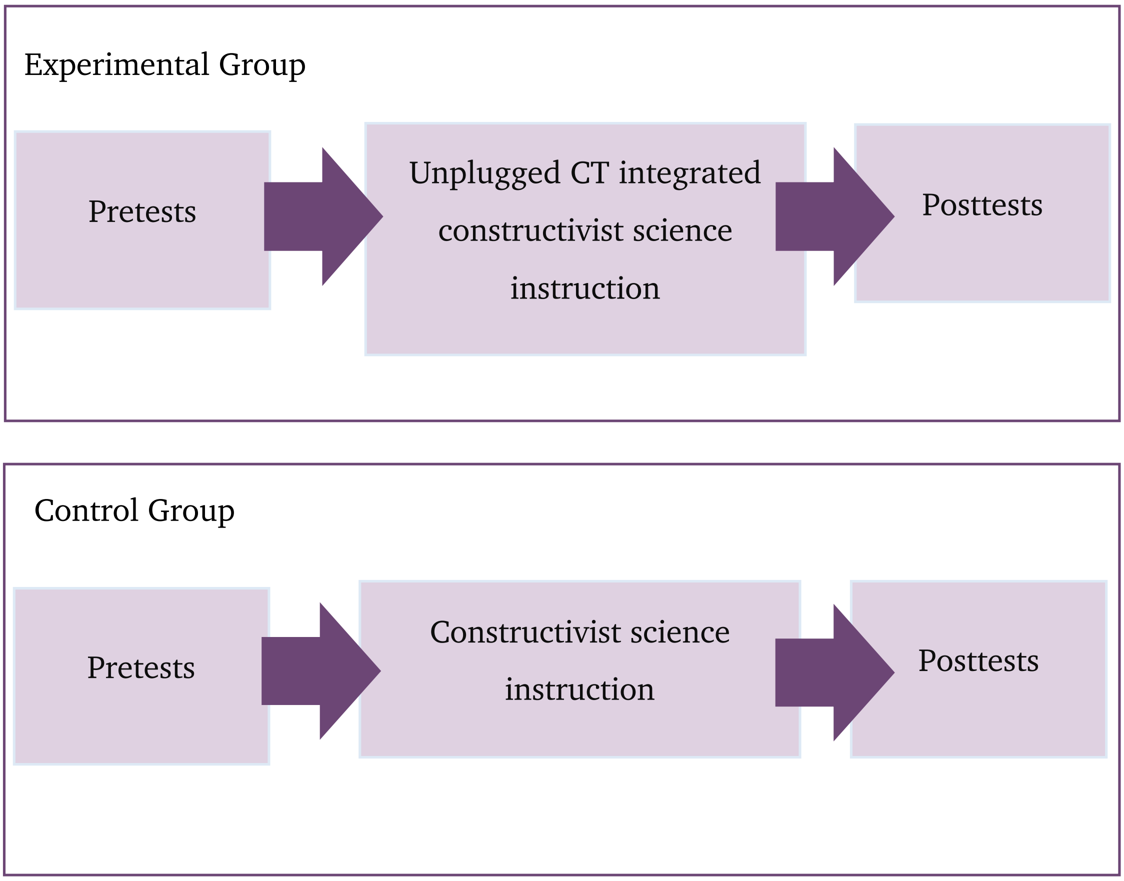

Figure 3.1 Treatment schema in both groups

3.2 Participants

Participants of this study were seventh-grade students. The first factor to choose seventh-grade students as participants was that they did not specifically study to national examinations for high school enrollment. The last grade of Turkish middle schools is 8th grade, and students in this grade generally focus on high school enrollment tests. Therefore, factors such as stress and class attendance could particularly affect their participation and motivation through the classroom implementations. Secondly, fifth-grade and sixth-grade students are subjected to learning principal concepts in contrast to upper-grade levels in science courses. The science subjects taught in these two grades are limited to the primary investigation of scientific phenomena. There was less opportunity to create and manage classroom interventions in these grades since CT would elicit cognitive load in addition to science learning. Also, learning and performance expectations for these grades in the Turkish Science Curriculum (MoNE, 2018) are limited for practicing CT-based science instruction satisfactorily. In conclusion, seventh-grade students were decided to be the participant group for this study. The 65 participants who replied to both of the pretests and posttests were included in the analysis. The number of students in each group and their genders were provided in Table 3.1 below.

Table 3.1 Participants information

Groups	**Gender**		**Total**
	Female	**Male**	
Experimental Group	15	17	32
Control Group	16	17	33

Students in this middle school were placed in their classroom based on classroom capacity and school facilities by the school administration. The science teacher was teaching three different classrooms in the 2019-2020 academic year. Out of three classroom sections, two of them were included in this study based on students' classroom attendance and general attitudes to science courses with the aid of the consultation of the teacher.

3.2.1 Role of the Science Teacher

Reaching to students who have never learned what CT is and to the teacher who ought to be successfully handling the classroom organization are important factors so as to select participants. Also, the teacher who will manage all classroom activities has a critical role along the process because the change of teacher and adapting new classroom culture might have a negative impact on students. Managing classrooms for a period of time by the researcher may include researcher positionality, and this may occur as an extraneous or confounding variable in the study. The researcher chose one of the most appropriate schools regarding the organization of the study and the location for the researcher. The accessed population of the study is a public middle school located in Üsküdar district of Istanbul.

The school is located at the center of the province, students came from socio-economically diverse backgrounds and there were five different sections in each grade. Before the implementation process, verbal confirmation for research settings was obtained from the science teacher and the school principal in September 2019. Subsequently, the official permission for implementation was approved by MoNE in December 2019. One of the science teachers in the school voluntarily implemented the teaching activities of the study. The teacher has Bachelor’s degree in elementary science teacher education and has been working in this middle school since 2017.

A professional development course was provided to the science teacher before the implementation process began. This course included what computational thinking is, how CT practices will be implemented in the classroom, what kind of pedagogical strategies will be used in the present research, and the purpose and design of the present study. The researcher prepared guidelines for the teacher in order to conduct a successful implementation and gave them to the teacher a week before the following lesson.

The teacher who applied these classroom interventions was scaffolded weekly during the application process. Then, the researcher enabled lesson plans and data collection tools to the teacher, and they reached a consensus on applicability to the regular classroom routines after discussions. The researcher organized worksheets, the PowerPoint presentations, supplied materials for classroom activities.

3.3 Data Collection Tools

The two instruments used in this study, "Computational Thinking Levels Scale (CTLS)" and "Structure and Properties of Matter Unit Academic Achievement Test (SPMUAT)", were explained below.

3.3.1 Computational Thinking Levels Scale

This instrument is an adapted version of the Computational Thinking Skills Scale (Korkmaz et al., 2017) both of which were prepared by the same authors (Korkmaz et al., 2015). Computational Thinking Levels Scale (CTLS) measures the level of CT skills of middle school students, and it is a five-point Likert-type scale that has 22 items in total. The instrument has five factors, which are creativity, algorithmic thinking, cooperativity, critical thinking, and problem-solving. Cronbach alpha reliability coefficient of the instrument is 0,809. Students could obtain a minimum of 20 points and a maximum of 110 points from the scale (Korkmaz et al., 2015).

3.3.2 Structure and Properties of Matter Unit Achievement Test

This instrument (SPMUAT) was developed by Kızkapan and Bektaş (2018) in order to assess the science achievement of seventh-grade students in the structure of matter and its characteristics subject. It has 21 items in total. Students can receive a maximum of 21 points and a minimum of 0 points in this instrument. The Cronbach alpha reliability coefficient is 0,874. This instrument was prepared in line with the learning standards of the Turkish Science Curriculum published in 2018 (Kızkapan and Bektaş, 2018).

3.4 Research Process

There were a number of procedures to organize and handle the study design and implementation. These steps are described in Figure 3.2 in order to give precise information about the flow of steps taken in this study.

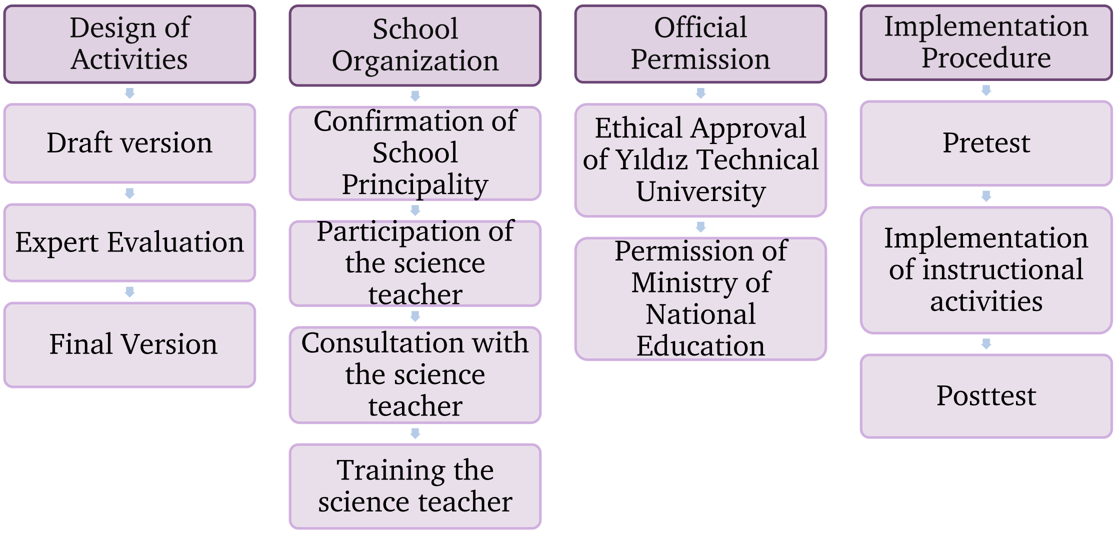

Figure 3.2 Flowchart of the study design

3.4.1 Implementation Process

Since the teaching subject and duration of implementation in both classrooms were the same, all classes completed the implementation simultaneously throughout the weeks. Besides, descriptions of each lesson hour are expressed below.

3.3.1.1 Lesson Descriptions of the Experimental Group

Students in the experimental group were treated based on unplugged CT-integrated science instruction. Table 3.2 represents the description of lesson hours in this group. The lesson plans can be found in Part A and worksheets used in this group can be found in Part C.

Table 3.2 Implementation procedure in the experimental group

Duration	Topic	Classroom Activities
2 lesson hours (40+40 minutes)	Pure Matters	Students learned elements and compounds. They were introduced to QR codes and given worksheets to fulfill and draw QR codes related to elements and compounds. Techniques/strategies: Word association test, Analogy Corresponding Lesson Plan: Lesson Plan #E1
2 lesson hours (40+40 minutes)		Students carried out an unplugged CT activity in which they bond QR codes of elements to a periodic table. Students learned the usages of elements and compounds. Technique/strategy: conceptmaps Corresponding Lesson Plan: Lesson Plan #E2
2 lesson hours (40+40 minutes)		Students solved a number of questions to review what they learned in previous lessons. Students practiced unplugged CT activities in the pure matters subject. Corresponding Lesson Plan: Lesson Plan #E3
2 lesson hours (40+40 minutes)	Mixtures	Students learned what mixture is, then gave several examples of mixtures that they have used, eaten, seen so far. They learned the properties and types of mixtures. Subsequently, they were introducted to algorithms as a stepwise process of cooking pasta, and they were given assignments to write algorithmic sequences of mixtures. Technique/strategy: Semantic feature analysis Corresponding Lesson Plan: Lesson Plan #E4

Table 3.2 Implementation procedure in the experimental group (continued)

2 lesson hours (40+40 minutes)	Mixtures	Students solved problem scenarios, such as creating mixtures by passwords and symbols that represent its components, which reflect CT skills. These enabled students to perform abstraction and introduced them preliminary coding. Technique/strategy: problem-based learning Corresponding Lesson Plan: Lesson Plan #E5
2 lesson (40+40 minutes)		The purpose of these two hours was to teach scientific process skills by experimentation. Students designed and performed experiments related to the factors which affect the process of dissolving. Technique/strategy: hands-on experimentation Corresponding Lesson Plan: Lesson Plan #E6
2 lesson hours (40+40 minutes)	Separation of Mixtures	Students learned how to separate mixtures. Then, they did role-playing activity adapting the collaboration of a computer engineer and chemist. Students were awaited to collaborate with their peers to respond the questions in their assignments. Techniques/strategies: problem-based learning, peer-work, role playing Corresponding Lesson Plan: Lesson Plan #E7
2 lesson hours (40+40 minutes)		In this lesson, students studied how to prepare and re-separate their favorite drink using algorithms. In this activity, they had to consider writing, debugging, reversing and evaluating their algorithms in the appropriate ways. Technique/strategy: problem-based learning Corresponding Lesson Plan: Lesson Plan #E8

3.3.1.2 Lesson Descriptions of the Control Group

Students in the control group were treated based on constructivist science instruction. Table 3.3 represents the description of lesson hours in this group. The lesson plans written in each column can be found in Part B, and worksheets used in this group can be found in Part C.

Table 3.3 Implementation procedure in the control group

Duration	Topic	Classroom Activities
2 lesson hours (40 +40 minutes)	Pure Matters	Students learned elements and compounds. They used play-doughs and felt-balls in order to create models of elements and compounds. Technique/strategy: Model-based learning Corresponding Lesson Plan: Lesson Plan #C1
2 lesson hours (40+40 minutes)		Students completed assignments to practice and repeat what they learned in previous 2-hour lesson. They prepared artifacts and presented them to the class. Technique/strategy: Model-based learning Corresponding Lesson Plan: Lesson Plan #C2
2 lesson hours (40+40 minutes)		Students learned the scientific demonstration of elements and compounds, and matched them with their models from the previous lesson. Corresponding Lesson Plan: Lesson Plan #C3
2 lesson hours (40+40 minutes)	Mixtures	Students prepared different types of mixtures before the instruction. Subsequently, they learned its characteristics and homogenization process in order to connect scientific knowledge with daily life experiences. Corresponding Lesson Plan: Lesson Plan #C4

Table 3.3 Implementation procedure in the control group (continued)

2 lesson hours (40+40 minutes)	Mixtures	Students prepared different mixtures to find out their components and learned the properties of different types of mixtures. Technique/strategy: hands-on experimentation Corresponding Lesson Plan: Lesson Plan #C5
2 lesson hours (40+40 minutes)		Students experimented factors that impact the rate of dissolution and examined the variables in the lesson. They organized another experimental setup to test their problem scenarios. Technique/strategy: hands-on experimentation Corresponding Lesson Plan: Lesson Plan #C6
2 lesson hours (40+40 minutes)	Separation of Mixtures	In order to engage students in this subject, students read a text to find out scientifically inaccurate explanations, then carried out experimental methods of separation of mixtures. Techniques/strategies: conceptual change text, hands-on experimentation Corresponding Lesson Plan: Lesson Plan #C7
2 lesson hours (40+40 minutes)		Students learned other methods to separate mixtures and experimented them. Finally, they learned distillation of crude oil, and they modeled a production plant. Techniques/strategies: experimentation, model building Corresponding Lesson Plan: Lesson Plan #C8

3.5 Internal Validity

There are several factors to maximize internal validity in experimental research. Frankel et al. (2012) listed 10 factors to consider as threats to internal validity. Regarding the current research, these factors and how these factors could pose a threat to internal validity are presented below.

Attitude of subjects:

Since it was important to enable similar learning facilities in both classrooms, the researcher tried to create similar learning facilities with different approaches. Therefore, participants were treated as usual by their teacher in a regular classroom environment. A science teacher was the instructor of all classroom activities in order to minimize the researcher's positionality and bias to research design.

Subject Characteristics:

The participants of this study were seventh-grade students of ages 12-13. Students in both groups have never learned CT before treatment, and they showed similar test scores on academic success and scores on CT skills before the implementation, which were ensured by the pretests.

Implementation:

The science teacher who regularly instructed in both groups conducted learning activities in order to minimize the threats to the implementation process such as adaptation to a new class teacher, researcher positionality, and an unusual classroom environment.

Mortality:

There were students in both groups who were absent on the days when data were collected, and they could not be reached later due to time constraints and the COVID-19 pandemic which resulted in lockdown in schools for nearly two semesters. Frankel et al. (2012) stated that participant loss in two different groups could be neglected when each group had a similar number of participants. The participants who responded to pretests and posttests were similar in two groups.

History:

There was no specific or unrelated event to the implementation process reported to the researcher. Also, the researcher prepared a tentative schedule in case of any cancellation during the implementation process. There were two additional weeks added to the implementation process in case of any cancellation. The classroom implementations were conducted as planned.

Maturation:

Frankel et al. (2012) stated that maturation could be best ensured by the selection of group equally such as age, gender and other variables which may affect the study outcomes. Before the implementation of activities, pretests data were compared to ensure students' disposition before the implementation in both groups. The gender distribution and age intervals of students were similar in both of the groups.

Instrumentation:

The authors of data collection instruments used in this study (Kızkapan and Bektaş, 2018; Korkmaz et al., 2015) individually ensured the validity of instruments. The science teacher who conducted the implementation was the data collector of this present study in order to minimize the impact of data collector bias and data collector characteristics. The researcher graded students' scores individually, and intra-rater reliability was handled by grading student scores twice in two different time intervals. Finally, there was no case for inter-rater reliability issues in this present study.

Location:

Both groups were instructed in their local classrooms and laboratories. There was no location change during the implementation. Also, students in both of the groups had equal chances to access classroom facilities such as textbooks, materials, and classroom equipment.

Testing:

There was nearly more than 30 days difference between pretests and posttests in order to prevent the possibility of a situation where students can remember the questions and items in the data collection tools and their previous responses.

Regression:

Pretest scores, revealed in the next chapter of this study, presented that students had similar performances in the instruments. There was no ceiling effect reported, accordingly.

3.6 Data Analysis

The present study collected quantitative data in order to answer the impact of unplugged CT-based instruction on seventh-grade students' academic achievement in a chemistry subject and CT skills. Students in the experimental and the control group answered Structure and Properties of Matter Unit Achievement Test (Kızkapan and Bektaş, 2018), which abbreviated as SPMUAT hereafter and Computational Thinking Levels Scale (Korkmaz et al., 2015), which abbreviated as CTLS hereafter, as pretest and posttest. Data were analyzed in IBM Statistical Package for the Social Sciences (SPSS) program (Version 23).

Korkmaz et al. (2015) stated that scores received from the CTLS scale should be transformed to standard scores since the instrument has a different number of items among its factors. X_{std} score equation stated in their study was used for transforming students' raw scores in both CTLS pretest and posttest (Korkmaz et al., 2015).

Descriptive analysis was the first set of analyses. After the descriptive analysis, the assumptions of normality were ensured. Büyüköztürk et al. (2020) stated that there are three assumptions for independent sample t-test. These are the normal distribution of data, independence of data gathered by two different groups, and whether the level of measurement should be interval or ratio. These assumptions were checked and the normality of distribution was presented in the next chapter. According to Büyüköztürk et al. (2020), there are two assumptions that should be ensured to perform a paired sample t-test. These are the normal distribution of data and ratio level of measurement. These assumptions were also checked and the normality distributions were addressed in the next chapter. When the assumptions of normality were met, the parametric statistics tests were carried out. For this purpose, two different Independent Sample t-tests were operated between the groups in order to compare the pretest and posttest findings for each variable. Lastly, two individual paired sample t-tests were performed to compare the findings of the SPMUAT pretest and SPMUAT posttest in each group. The same procedure was done between CTLS pretest and CTLS posttest in each group to find out whether there is any increase after the implications in the classrooms. The findings of these analyses are shown in the following chapter.

4
FINDINGS

This chapter reports findings of the study. It is outlined as follows: descriptive statistics, test of normality findings of pretests and posttests, the comparison of pretests between groups, the comparison of posttests between groups and comparison of pretest and posttests in two separate groups.

4.1 Descriptive Statistics

This title reveals the descriptive statistics of CTLS and SPMUAT on the pretests and posttests.

4.1.1 Descriptives of Structure and Properties of Matter Unit Achievement Test Pretest and Posttest Scores

Table 4.1 illustrates the descriptive statistics of SPMUAT pretest and posttest in both groups.

Table 4.1 Descriptive statistics of SPMUAT on the pretest and posttest

Groups		N	M	Mdn	Min	Max	SD
Experimental Group	SPMUAT Pretest	32	4.00	4.00	0	8	2.52
	SPMUAT Posttest	32	10.6	10.5	2	17	3.78
Control Group	SPMUAT Pretest	33	3.57	2.00	0	11	3.56
	SPMUAT Posttest	33	9.54	10	1	15	3.83

As shown in Table 4.1, the mean for experimental group was 4.00 (*SD*= 2.52) and the mean for control group was 3.57 (*SD*= 3.56) before the treatment. Students in the experimental group obtained scores between a minimum of 0 points and a maximum of 8 points before the treatment, and students in the control group received a minimum of 0 points and a maximum of 11 points before the treatment.

After the treament, the mean for experimental group was 10.6 (*SD*= 3.78) and the mean for control group was 9.54 (*SD*= 3.83). Students in the experimental group obtained scores between a minimum of 2 points and a maximum of 17 points after the treatment, and students in the control group received a minimum of 1 points and a maximum of 15 points after the treatment.

4.1.2 Descriptives of Computational Thinking Levels Scale Pretest and Posttest Scores

Table 4.2 provides the descriptive statistics of CTLS pretest and posttest in both groups.

Table 4.2 Descriptive statistics of CTLS on the pretest and posttest

Groups		N	M	Mdn	Min	Max	SD
Experimental Group	CTLS Pretest	32	53.6	54.5	28.2	68.1	8.91
	CTLS Posttest	32	67.80	68.18	52.11	80.82	7.66
Control Group	CTLS Pretest	33	54.6	56	34.5	77.2	9.20
	CTLS Posttest	33	56.07	58.18	39.67	77.55	8.56

According to Table 4.2, the mean of CTLS pretest in the experimental group was 53.6 with a standard deviation of 8.91, (*M*= 53.6, *SD*= 8.91) before the treatment. The mean of CTLS pretest in the control group was 54.6 with a standard deviation of 9.20 (*M*= 54.6, *SD*= 9.20) before the treatment.

Students in the experimental group received scores between a minimum of 52.11 and a maximum of 80.82 with (*M*= 67.80, *SD*= 7.66) and students in the control group received scores between a minimum of 39.67 and a maximum of 77.55 with (M= 56.07, SD= 8.56) after the treatment.

4.2 Test of Normality Findings of Pretests and Posttests

This title reveals the normality results of SPMUAT and CTLS scores on the pretest and posttest.

4.2.1 Test of Normality of Structure and Properties of Matter Unit Achievement Test on Pretest and Posttest

Table 4.3 illustrates the skewness and kurtosis values, which present the normality distribution of SPMUAT pretest and posttest results in the groups.

Table 4.3 Test of normality of SPMUAT on the pretest and posttest

Groups		Skewness	Kurtosis
Experimental Group	SPMUAT Pretest	- .294	- 1.154
	SPMUAT Posttest	- .144	- .474
Control Group	SPMUAT Pretest	+.783	-.732
	SPMUAT Posttest	- .564	-.142

The skewness and kurtosis values were within the normal distribution values suggested by Tabachnick and Fidell (2013). The SPMUAT pretest in the experimental group was normally distributed, with a skewness of -.294 and a kurtosis of -1.154. The SPMUAT posttest in the experimental group was normally distributed, with skewness of -.144 and kurtosis of -.474.

The SPMUAT pretest scores in the control group was normally distributed, with a skewness of .783 and a kurtosis of -.732. The SPMUAT posttest scores in the control group was normally distributed, with a skewness of - .564 and a kurtosis of - .142.

4.2.2 Test of Normality of Computational Thinking Levels Scale on the Pretest and Posttest

Table 4.4 shows the normality distribution of CTLS pretest and CTLS posttest findings according to skewness and kurtosis values.

Table 4.4 Test of normality on CTLS pretest and CTLS posttest

Groups		Skewness	Kurtosis
Experimental Group	CTLS Pretest	-.580	1.002
	CTLS Posttest	-.111	.340
Control Group	CTLS Pretest	-.340	-.568
	CTLS Posttest	-.101	-.253

The skewness and kurtosis values were within the normal distribution values suggested by Tabachnick and Fidell (2013). The CTLS pretest in the experimental group was normally distributed, with a skewness of - .580 and a kurtosis of 1.002. The CTLS posttest in experimental group was normally distributed, with a skewness of - .111 and a kurtosis of .340.

The CTLS pretest in the control group was normally distributed, with a skewness of -.340 and a kurtosis of - .568. The CTLS posttest in the control group was normally distributed, with a skewness of -.101 and a kurtosis of -.253.

4.3 Comparison of Pretest Scores between Groups

The SPMUAT pretest and CTLS pretest findings were compared to find out if there was any statistically difference between experimental and control before the implementation.

4.3.1 Comparison of Structure and Properties of Matter Unit Achievement Test on Pretest Scores between Groups

An Independent Sample t-test was operated in order to find out whether there was a statistically significant difference between groups or not in terms of SPMUAT pretest findings. Table 4.5 shows the findings of Independent Sample t-test on SPMUAT pretest.

Table 4.5 Comparison of SPMUAT pretest between groups

Groups	N	M	SD	t	p
Experimental Group	32	4	2.52	.552	.583
Control Group	33	3.57	3.56		

Accordingly, an Independent Sample t-test found that there was not a statistically significant difference in the scores of SPMUAT pretest between the experimental group (*M*= 4, *SD*= 2.52) and the control group (*M*= 3.57, *SD*= 3.56) conditions; $t(63)= .552$, $p= .583$. The magnitude of the differences in the means (mean difference= 0.424, 95% CI: -1.11 to 1.95) was very small effect size ($d= 0.13$) according to Cohen (1988).

4.3.2 Comparison of Computational Thinking Levels Scale on the Pretest Scores between Groups

Since the student scores of CTLS pretest were normally distributed, an Independent Sample t-test was carried out so as to find out if there was a statistically significant difference between groups before the instruction. Table 4.6 provides the results of Independent Sample t-test applied on CTLS pretest findings.

Table 4.6 Comparison of CTLS pretest between groups

Groups	N	M	SD	t	p
Experimental Group	32	53.63	8.91	-.441	.661
Control Group	33	54.62	9.20		

Accordingly, an Independent Sample t-test found that there was not a statistically significant difference in the scores of CTLS pretest between the experimental group (*M*= 53.63, *SD*= 8.91) and the control group (*M*= 54.62, *SD*= 9.20) conditions; $t(65) = -.441$, $p = .661$. The magnitude of the differences in the means (mean difference = .99, 95% CI: –5.48 to 3.50) was very small effect size ($d = 0.10$) according to Cohen (1988).

4.4 Comparison of Posttest Scores between Groups

This section demonstrates the comparison of SPMUAT posttest and CTLS posttest findings between the experimental group and the control group. These comparisons will help to draw conclusion on the impact of the particular treatments in the groups.

4.4.1 Comparison of Structure and Properties of Matter Unit Achievement Test on Posttest Scores between Groups

Since the SPMUAT posttest scores for both groups followed a normal distribution, an Independent test was operated between SPMUAT posttest scores of the experimental group and SPMUAT posttest scores of the control group. Table 4.7 presents the comparison of SPMUAT posttest findings between the groups in order to report any statistically difference occurred between groups after the treatment.

Table 4.7 Comparison of SPMUAT posttests

Groups	N	M	SD	t	p
Experimental Group	32	10.6	3.78	1.109	.271
Control Group	33	9.54	3.83		

Accordingly, an Independent Sample t-test found that there was not a statistically significant difference in the scores of SPMUAT posttest between the experimental group ($M = 4$, $SD = 2.52$) and the control group ($M = 10.6$, SD= 3.78) conditions; $t(63) = 1.109$, $p = .271$. The magnitude of the differences in the means (mean difference = 1.06, 95% CI: -8.4 to 2.93) was small effect size ($d = 0.27$) according to Cohen (1988).

4.4.2 Comparison of Computational Thinking Levels Scale on Posttest Scores between Groups

As the CTLS posttest scores in the experimental and the control group followed a normal distribution, an Independent Sample t-test was carried out to compare the CTLS posttest scores between the groups. Table 4.8 presents the comparison of CTLS posttest scores between groups.

Table 4.8 Comparison of CTLS posttests

Groups	N	M	SD	t	p
Experimental Group	32	67.80	7.66	5.81	.000***
Control Group	33	56.07	8.56		

Note: ***p < .001

An Independent Sample t-test was opeated to compare CTLS posttest findings between the experimental group (M=67.80, SD= 7.66) and the control group (M= 56.07, SD= 8.56). This test was found to be statistically significant, $t(63)$= 5.81, p< .001 with a Cohen's effect size (Cohen, 1988) value (d= 1.44). It indicated the large effect size on CTLS posttest between groups.

4.5 Comparison of Pretest and Posttest Scores in Two Separate Groups

This section explains the pretest and posttest comparison performed within the group so as to show if there is any statistical difference occurred after the instruction in each group.

4.5.1 Pretest and Posttest Scores Comparison of Structure and Properties of Matter Unit Achievement Test

A Paired Sample t-test test was performed in each group. The pretest and posttest comparison in each group shows the impact of the instruction on students' scores of science success. Table 4.9 presents the comparison of pre and post treatment findings of science success in the groups.

Table 4.9 Comparison of pretest and posttest of SPMUAT

Groups		N	M	SD	t	p
Experimental Group	SPMUAT Pretest	32	4	2.52	8.84	.000***
	SPMUAT Posttest	32	10.6	3.78		
Control Group	SPMUAT Pretest	33	3.57	3.83	8.58	.000***
	SPMUAT Posttest	33	9.54	3.56		

Note: ***p < .001

The student scores were compared before and after treatment in the experimental group. On average, students in the experimental group performed worse before (M= 4, SD= 2.52) than after the treatment (M= 10.6, SD= 3.78). A Paired Sample t-test revealed a statistically significant increase in academic success of statistics following unplugged CT integrated science instruction, $t(31) = 8.842$, $p < .001$ with a Cohen's effect size (Cohen, 1988) value ($d = 1.56$). This increase shows a large size effect.

The student scores were compared before and after treatment in the control group. On average, students in the control group performed worse before (M= 3.57, SD= 3.83) than after the treatment (M= 9.54, SD= 3.56). A Paired Sample t-test indicated that this difference was statistically significant, $t(32) = 8.582$, $p < .001$ with a Cohen's effect size (Cohen, 1988) value ($d = 1.49$). This increase shows a large size effect.

4.5.2 Pretest and Posttest Scores Comparison of Computational Thinking Levels Scale

Since the CTLS scores followed the normal distribution in each group, Paired Sample t-test was carried out to compare the CTLS pretest and CTLS posttest scores in the experimental and the control group.

Table 4.10 documents the comparison of CTLS pretest and CTLS posttest findings in each group.

Table 4.10 Comparison of pretest and posttest of CTLS

Groups		N	M	SD	t	p
Experimental Group	CTLS Pretest	32	53.6	8.91	- 5.37	.000***
	CTLS Posttest	32	67.8	7.66		
Control Group	CTLS Pretest	33	54.6	9.20	- .748	.460
	CTLS Posttest	33	56	8.56		

Note: ***p< .001

The CTLS scores in the experimental group were compared before and after the unplugged CT based science instruction. On average, students performed worse before (*M*= 53.6, *SD*= 8.91) than after the unplugged CT-based science instruction (*M*= 67.8, *SD*= 7.66). This increase, 14.2, 95%CI, was statistically significant, $t(31)= -5.37$, $p< .001$. Cohen's d statistics (Cohen, 1988) indicated a large size effect ($d= 0.95$)

The CTLS scores in the control group were compared before and after the constructivist science instruction. A Paired Sample t-test was found to be statistically non-significant, $t(32)= -.748$, $p= .460$, with a small size effect ($d=$ 0.13).

5
RESULTS AND DISCUSSION

The final chapter of this study consists of the results and discussion. Throughout this chapter, readers will find out the final representation of research findings, discussion of findings, and recommendations to the scholarly community for future research in unplugged CT-integrated science instruction.

5.1 Results

This study aimed to measure the impact of science instruction integrated with unplugged CT activities on seventh-grade students' academic achievement on the pure matter and mixtures subject and CT skills. It was found that students' CTLS and SPMUAT scores in the experimental group increased after the treatment. The impact of unplugged CT integrated science instruction on science achievement in this subject was measured in the experimental group with an effect size of Cohen (1988) (d= 1.56), which indicated a large effect size. Students in the control group received constructivist science instruction, and they gained higher SPMUAT test scores after the treatment, with a large effect size (d= 1.49). The statistically significant difference of SPMUAT scores on posttest between groups was not found between groups. Despite the statistically no significance, the students in the experimental group enhanced their performance on SPMUAT concerning their posttest scores better than students in the control group, which resulted in higher science achievement performance scores and higher effect size.

On account of CT skills, after the unplugged CT integrate science instruction, students' CT skills performances in the experimental group increased in favor of posttest with an effect size of d= 0.95. This indicated the large size impact of unplugged CT-based instruction on seventh-grade students' CT skills. A statistical difference was found, revealing that students in the experimental group performed better CT skills than students in the control group after treatment.

CTLS scores of students in the control group, who did not receive unplugged CT-integrated science instruction, did not show a statistically significant difference before and after treatment. Consequently, the alternative hypothesizes (H_{A1} and H_{A2}) in this study are accepted in line with research findings, indicating that there is a statistically significant impact of unplugged CT-integrated science instruction on success in the pure matter and mixtures subject and CT skills of seventh-grade students.

5.2 Discussion

Research results were discussed in line with the sub-research questions below.

5.2.1 Interpretation of Findings related to Academic Achievement in Science

This present research found out that students in the experimental group increased their success in pure matter and mixtures subject and CT skills in favor of posttests. Students in the experimental group showed better performance on the SPMUAT posttest than the SPMUAT pretest. It is possible to state that unplugged CT-based instruction leverage learning in pure matter and mixtures subject.

Literature on CT-based science instruction offers similarities with this present study. A growing body of literature has examined science learning performance in CT integrated science instruction. That is to say, science instruction integrated with CT practices increases learning scores in science learning tests. Akşit and Wiebe (2020) and Sengupta et al. (2013), whose studies taught kinematics concepts and principles of Newton's laws to K-12 students with modeling and simulation practices, concluded that student scores on science learning test increased after the instruction. Other studies in the literature which incorporate with CT practices to teach science subjects, with different level of complexity of CT practices and teaching approaches, share similar affordances and draw parallel conclusions on the enhancement of learning performance in science with this present study. There are similar interpretations between the present study and those revealed by Swanson et al. (2017) and their follow-up paper (Swanson et al., 2019). Students in these studies examined the reflections of a computational system that depicts the process of cloud-climate feedback and the impact of gas concentration on the climate. This natural mechanism and underlying variables of this phenomenon are addressed through CT practices. It was concluded in their study that students enhanced their performances in science learning with an approach that embodied computational modeling and simulation practices in the context of greenhouse aspects (Swanson et al., 2017; 2019). It can be commented that computational modeling and simulation practices can deepen understanding in science.

The abstract and complex scientific phenomena such as ecology subjects can be modeled through CT practices. Studies that applied modeling, simulation, and automation components in CT practices in the ecology topic supported the view that students' knowledge in this subject increased after the instruction. Instruction of ecology unit through investigating the complex and abstract relationships in an ecosystem provided an effective approach to clarify both behaviors of the computational system and natural processes in an ecosystem (Arastoopour Irgens et al., 2020; Basu et al., 2017, Pierson et al., 2020; Zhang et al., 2020).

The study of Waterman et al. (2020), where CT practices were integrated with curricular goals and fifth students played outdoor games to make models of evolutionary mechanism, examined the unplugged CT-based science instruction on science learning. According to Waterman et al. (2020), students demonstrated meaningful learning experiences in science with the discussion of natural phenomena through modeling and role-playing. As seen in previous papers, this present study leads similar conclusion which is CT-based science instruction enhances learning performances in science in K-12 classrooms.

The creation of good teaching practices can support valuable learning experiences and contribute to learning through different learning dimensions such as psychomotor, logical-mathematical, and visual learning. In addition to general teaching strategies, elements and compounds have been taught within QR codes in this present study. Indeed, QR codes can identify specific item and property of a product and has a number of cells indicating data patterns. This unique identification of QR codes can deepen the idea that elements have specific ID numbers (atomic numbers) which are coded with symbols, and the chemical compounds have specific formulas which can be detected by the structure of chemical bonds and models. It can be interpreted that the bridge between QR codes and the matter concept in chemistry provided meaningful learning experiences to students.

In spite of the fact that there was statistically no difference in SPMUAT posttests between groups after the treatment, students in the experimental group increased academic achievement in the SPMUAT posttest. This raise in the experimental group showed a higher increase of SPMUAT posttest scores than the control group, indicating a higher effect size. Accordingly, the increase between SPMUAT pretest and posttest scores of the control group was less in the control group. Students in the experimental group learned the science subject through CT practices and completed all assignments even though they were not given additional classroom hours. It can be stated that unplugged CT integrated science instruction may provide similar opportunities in comparison to constructivist teaching. Provided that CT practices enhanced learning performances in science subjects under time restrictions, exposure to CT practices may have had an influence on carrying out CT tasks with science subjects contemporaneously. Students in the experimental group needed to understand the logic of writing algorithms; express scientific knowledge computationally; design computer science-based artifacts associated with science subjects. In either case, this present research reached a shred of significant evidence for feasible implementation of CT practices in science curricular activities.

5.2.2 Interpretation of Findings related to Computational Thinking Skills

Students' CT skills were assessed by CTLS, and it was found that there was no statistically significant difference between the experimental and the control group before the implementation of classroom activities in the present study. After the classroom interventions in both groups, on which unplugged CT practices were implemented in the experimental group while students in the control group were exposed to no training, it was detected by a statistical test that students in the experimental group developed their CT skills after treatment. On contrary, CT skills of students in the control group who did not receive unplugged CT-based instruction remained at similar levels before and after treatment.

In the present study, students in the experimental group engaged in problem scenarios in which they used computationally-oriented problem-solving approaches to solve questions related to science fields. Students' understanding of the science phenomenon was supported through CT practices. For example, students solved a number of problems using analytic thinking, logical thinking, and algorithmic thinking. There were worksheets in the experimental group that included algorithmic thinking and abstraction. Students needed to not only articulate concepts in the subject scientifically accurate way but also explain them through CT practices. For example, students explained pure matters through QR codes, and they learned how they can differently represent variables of a hypothesis through different data patterns. They tried to represent them with different representational graphics in addition to symbols and formulas. In another subject, students used algorithmic sequences to describe the process of mixture composition and separation. They built an experimental setup to test the hypothesis based on these practices. These activities let them demonstrate a number of CT competencies, which helped to improve CT skills.

This study estimated the impact of unplugged CT-enriched science teaching on CT skills. The increase in the scores of CTLS in favor of the posttest in the experimental group indicated the statistically significant impact of CT-based science instruction in the seventh-grade science classroom. Students in the experimental group developed their CT skills with ($d = 0.95$) a large size effect. In light of this finding, it can be inferred that unplugged CT-based science teaching enhances the CT skills of seventh-grade students. This concurs well with earlier findings in K-12 literature. Peel et al. (2018; 2019; 2021) and Waterman et al. (2020) found similar advantages of unplugged CT-based science teaching on K-12 students' CT skills. Peel et al. (2021) prove that incorporation of CT skills with science subjects elaborate understanding in science and CT skills, and argue that these affordances can be advanced without the use of computers. A similar conclusion was reached by Waterman et al. (2020). Accordingly, unplugged CT practices embedded into the subject of natural mechanisms contributed to students' CT understanding and competencies.

Extensive results show that plugged CT integrated science instruction improves CT skills in line with the findings of this study. Zhang et al. (2020) designed engineering design and computational modeling tasks, implemented them in a science classroom, and concluded that sixth-grade students' CT skills showed an incremental difference between the score of pretest and posttest with a large size effect. Garneli and Chorianopoulos (2018; 2019) reported that middle school students showed significant CT competencies to describe and analyze electric circuits in Scratch.

As stated in Shodiev (2015), digital tools undoubtedly contribute to the development of CT competencies in schools. CT practices are performed in programming tools which are namely digitally-represented platforms in science classrooms. Given these good results, it can be concluded that this present study shares and point out a robust understanding of how well CT practices leverage CT skills in K-12 science classrooms.

5.3 Recommendation and Implication

Although CT usage can build crossroads in K-12 classrooms, the current CT literature shares common pedagogical practices. In order to shed precise light on future research in CT-integrated science education, the researcher shares some recommendations in light of the research lens in the following order: science instruction with computational thinking practices in K-12 levels and development of CT skills in K-12 science classrooms.

5.3.1 Science Instruction with Computational Thinking Practices in K-12 levels

This present work has shown that the unplugged CT-based science teaching approach has the potential to improve science understanding and increasing achievement in science subjects. The results of this present work validate the possibilities of how unplugged CT integrated science teaching can be brought into

K-12 science classrooms. The unplugged CT-based science instruction, where CT was presented as a problem-solving method to understand science subjects in this study, served as a teaching approach to enhance learning performances in science and widened the current understanding of science instruction. The recommendations are shared with the scholarly community in light of the results and the researcher's self-experience in designing the unplugged CT-based science teaching activities.

The effectiveness of unplugged CT-based science instruction on science achievement in the subject of pure matter and mixtures were assessed after the particular treatment in the experimental group, and the impact of these curricular materials on seventh-grade students' academic performance in science elevated statistically. In light of this finding, it can be recommended to practitioners and teachers to implement CT practices in science curricular activities with a holistic instructional pedagogy. As mentioned by Lu and Fletcher (2009), there are specific challenges to design and identify CT practices in curricular activities. Instructional techniques and approaches have been questioned so long to address this problem; however, Lu and Fletcher (2009) argued that CT aspects had better be infused into spoken language and characterized in well-structured settings. This finding is deemed as a CT language that included an empirical and active use of computer science vocabularies. In a similar vein, CT competencies and vocabularies can be implemented in science curricular activities. In this discussion from the perspective of a science educator, the problem-solving aspect of CT may be the central idea to elicit a meaningful experience in science classrooms.

Proficiency in CT practices would bring a richer understanding of the scientific phenomena. Student success in science learning can be connected with CT practices, and this can stand for scientifically supportive engagement in science and engineering fields. Park and Green (2019) suggest that CT should be understood from a disciplinary perspective. Given this background, they explain CT in the frame of scientific literacy which is a mainstream purpose of science education. Conjecturing CT into different disciplinary aspects can help the resurgence of the term in the subject field. Narrowing down the definition of the term limits the applicability of the practices in different contexts, and this may cause a monolithic perspective of understanding the term. Thus, researchers can articulate CT components in a sophisticated disciplinary perspective, which may not be associated with conceptualization in computer science education in future research. For instance, abstraction is delineated as removing minutiae of logical and algorithmic statements in computer science. In the present study, abstraction has been taught and practiced as separating mixtures through algorithmic sequences and deciding the concentration of mixture components in a problem scenario. Likewise, abstraction can be taught and exemplified within science subjects. In this way, students do not particularly learn the conceptual definition of CT components in computer science since they deduce disciplinary meaning from CT-based science practices. In this way, the interpretation of CT components in science subjects could reduce the cognitive load of students, which may help to associate theoretical stances of CT components with conceptualization in computer science.

Interdisciplinary educational experiences provide rigorous and effective outcomes in learning. Moreover, recent endeavors of research in science education encourage the versatile development of student competencies in formal and informal settings. In school environments, unplugged CT integrated practices can be taught through different science subjects. Since CT can enhance academic success and students' understanding of scientific phenomena, CT should be promoted across the grades in science classrooms. There is a need to show rigorous examples for other science subjects taught within CT practices in future research. Researchers can organize and exemplify how CT can be taught in science subjects in written documents to guide teachers and practitioners. In future research, scholars may design problem scenarios related to science subjects and let students explore the connections between the nature of science and CT practices in order to impel students to realize how CT practices are connected to nature. For instance, students can join some outdoor activities such as orienteering and outdoor walking to solve scientific problems with CT practices. Through these practices, students can gain an analytic perspective, and they will be able to use CT competencies strategically and effectively.

5.3.2 Development of Computational Thinking Skills in K-12 Science Classrooms

This present work has concluded that unplugged CT-based science instruction helped seventh-grade students to enhance their CT skills. Students in the experimental group improved their CT skills ($d = 0.95$), which is a large size effect. This result affirms a strong impact of unplugged CT integrated science instruction on the development of CT skills. It is estimated in this study that transmitting unplugged CT practices can be enough in terms of attaining thorough proficiency in CT skills.

While many see unplugged CT instruction as disadvantageous to have less emphasis on computer science, this may be influential to construct an engagement in science subjects. A group of researchers recounted how to identify and evaluate unplugged CT practices in student artifacts (Looi et al., 2018). Provided that unplugged CT instruction is the technically valuable experience in order to yield easy engagement to novice programmers, the introduction of technical aspects with feasible projects in science classrooms should be taken into consideration. Reducing cognitive load with easier CT tasks can provide higher academic performances in science. Thus, unplugged CT can bring advantages for instructors who may plan to introduce CT as a problem-solving approach in science problems. Implementation of CT practices through different assignments in science classrooms supports the development of CT skills instead of using the assignments in programming tools. At this point, unplugged CT practices can provide a clear understanding as similar as to the ones digital CT approaches present.

Those who have technically enriched facilities in schools can also use unplugged CT integrated science instruction. CT competencies have been long taught in computer science education. As there are schools in low-income countries which suffer from restricted access to digital and technological facilities and where technological devices are not ubiquitous, it is much more important to provide technical and technological aspects to student learning there. Education is a major and critical human right and every child should be educated aligning with the competencies and skills the current standards require. With this aim, students can be taught computer science and also science subjects, which require experimentation in science and solid technical support, through an unplugged CT integrated science instruction approach. Practitioners can provide interdisciplinary learning experiences to students with CT competencies in science education.

In addition to unplugged CT instruction, a hybrid approach which includes both unplugged and digital CT practices can be implemented in K-12 classroom to foster CT skills and have a further engagement in CT practices. This can help to warrant attention among students while orientating them from simple to complex processes, starting with unplugged interventions. A study indicated that students were able to transfer written algorithmic sequences to visual programming language, which made it easier for them to deal with the codes and gave hints to remember the algorithmic operations (Gardeli and Vosinakis, 2017). As a result, CT in the science classrooms can serve an integrated instructional method and it could boost student engagement in science classrooms in collaboration with computer science and engineering education.

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A
LESSON PLANS OF THE EXPERIMENTAL GROUP

LESSON PLAN #E1

Subject: Pure Substances

Duration: 2 lesson hours (40+40 minutes)

Objectives of lesson:

<u>Science Learning:</u> Students assort pure substances as elements and compounds by giving examples (MoNE, 2018).

<u>CT practices:</u> Students find out to different data types, and their representation in various ways that a program run through (Dorling and Walker, 2014).

Resources: play dough, felt balls, marbles, chopsticks, adhesive, and student textbook, Worksheet #1, Worksheet #2 and Worksheet #3.

Instructional Sequences:

Duration	Dimension of Science Learning	Dimension of CT *(practices, components)*
25 minutes	Impel students to think about what kind of matters are called pure substances. (Worksheet #1) Have students read a text about the atoms and collect their responses. Explain the meaning of elements and compounds. (Worksheet #2)	Introduce the QR codes (unique materials that hold specific information) and draw an analogy between the QR codes and models of elements & compounds. Ask whether it is possible to present models of pure substances within the QR Codes or not. (CT Components: Abstraction, Pattern recognition and Generalization)
25 minutes	Explain students the differences between the elements and compounds through showing the scientific models. Create the models of elements and compounds.	Remind students that both of the QR codes and models of elements & compounds have unique scientific representations (e.g chemical bonds or binary numbers). (CT Component: Abstraction) (Worksheet #3)
20 minutes	Draw an analogy to differentiate the atomic elements and molecular elements. (Worksheet #2)	Let students create the QR codes of elements and compounds. (CT Components: Pattern Recognition, Decomposition)
10 minutes	**Evaluation:** Evaluate the answers given to Worksheet #2 and Worksheet #3 for science understanding and CT skills.	

LESSON PLAN #E2

Subject: Pure Substances

Duration: 2 lesson hours (40+40 minutes)

Objectives of lesson:

Science Learning: Students express the names, symbols and some usages of first 18 elements and the common ones (gold, silver, copper, lead, mercury, platinium, iron and iodine). Students express the formulas, names and some usages of common compounds (MoNE, 2018).

CT skills: Students understand the logic of indicating digital content in different types such as symbols, formulas, visuals. (Dorling and Walker, 2014).

Resources: Sticky notes, adhesive, student textbook.

Instructional Sequences:

Duration	**Dimension of Science Learning**	**Dimension of CT *(practices, components)***
10 minutes	Start with the warm up questions about previous lesson. Lead students to discuss the need of categories to identify elements.	
30 minutes	Explain few of usages of aforementioned elements and compounds.	Have students accommodate previous QR codes representing elements in the periodic table. (CT Components: Abstraction and Generalization)
30 minutes		Show several QR codes related to elements and compounds and ask the names, structures, usages of pure substances.
10 minutes	**Evaluation:** Assess science learning with the concept map and examine the representational accuracy of QR codes for the acquisition of CT skills.	

LESSON PLAN #E3

Subject: Pure Substances

Duration: 2 lesson hours (40+40 minutes)

Objectives of lesson:

Science Learning: Students express the names, symbols and some usages of first 18 elements and common ones (gold, silver, copper, lead, mercury, platinium, iron and iodine). Students express the formulas, names and some usages of common compounds (MoNE, 2018).

CT skills: Students find out to different data types, and their representation in various ways that a program run through. Students understand the logic of indicating digital content in different types such as symbols, formulas, visuals (Dorling and Walker, 2014).

Resources: Worksheet #4 and student textbook.

Instructional Sequences:

<table>
<tr><th>Duration</th><th>Dimension of Science Learning</th><th>Dimension of CT (practices, components)</th></tr>
<tr><td rowspan="2">80 minutes</td><td colspan="2">Distribute Worksheet #4 to practice and review the previous lessons. Worksheet #4 includes questions about pure substances subject which also have computational problem solving processes.

(CT components: Problem solving, abstraction, decomposition, generalization)</td></tr>
<tr><td colspan="2">Evaluation: Worksheet #4 is used as evaluation of the subject and the additional exercises in student textbook are carried out to assess the learning acquisitions.</td></tr>
</table>

LESSON PLAN #E4

Subject: Mixtures

Duration: 2 lesson hour (40+40 minutes)

Objectives of lesson:

Science Learning**:** Students assort mixtures into homogeneous and heterogeneous mixtures by giving examples (MoNE, 2018).

CT skills: Students understand algorithms and write simple steps in a given context to articulate sequences using conditionals and loops (Dorling and Walker, 2014).

Resources: Worksheet #5 and student textbook

Instructional Sequences:

Duration	**Dimension of Science Learning**	**Dimension of CT *(practices, components)***
25 minutes	Give examples of well-known mixtures in daily life. Use a semantic feature analysis to describe the components of them. (Worksheet #5)	Let students to find out the hidden concepts about mixtures in a reading text to engage them at a simple level of abstraction process. (Worksheet #5)
40 minutes	Define the properties of mixtures as the homogeneous mixtures (solutions) and heterogeneous mixtures.	Have students write a stepwise process of their favorite food, which is a type of mixture. CT Components: Algorithms, Algorithmic thinking)
15 minutes	**Evaluation:** Complete the questions in the student textbook for assesing conceptual learning in science, and evaluate the accuracy of students' algorithms for CT skills.	

LESSON PLAN #E5

Subject: Mixtures

Duration: 2 lesson hour (80 minutes)

Objectives of lesson:

Science Learning: Students assort mixtures into homogeneous and heterogeneous mixtures by giving examples (MoNE, 2018). Students prepare solutions by using solute and solvents that can be used in daily life (MoNE, 2018).

CT skills: Students use the logical statements and debugging to calculate probabilities in algorithmic statements (Dorling and Walker, 2014).

Resources: Worksheet #6, student textbook, water, salt, sugar, and other accessible or edible materials.

Instructional Sequences:

<table>
<tr><th>Duration</th><th>Dimension of Science Learning</th><th>Dimension of CT (practices, components)</th></tr>
<tr><td rowspan="2">80 minutes</td><td colspan="2">Let students prepare the solutions using daily life materials. Distribute the worksheet to practice the previous lesson (Worksheet #6). This resource includes the questions about writing algorithms, abstraction, data types, and decomposition in the mixtures subject.

(CT Components: Algorithms, data & data representation, pattern recognition, decomposition.)</td></tr>
<tr><td colspan="2">Evaluation: Worksheet #6 is used and additional exercises in the student textbook are carried out to assess the acquisitions of science learning.</td></tr>
</table>

LESSON PLAN #E6

Subject: Mixtures

Duration: 2 lesson hours (40+40 minutes)

Objectives of lesson:

Science Learning: Students experimentally test the factors which affect the rate of dissolving (MoNE, 2018).

CT skills: Students make sense of human and computer collaboration and exemplify impact of ICT on social and classroom life (Dorling and Walker, 2014).

Resources: Student textbook, EBA.

Instructional Sequences:

Duration	**Dimension of Science Learning**	**Dimension of CT *(practices, components)***
40 minutes	Have students to prepare different kind of mixtures to test factors affecting the rate of dissolving process.	
30 minutes	Use graphs to visualize the data received from experiments. Symbolize data with variables.	Show a video of graph to stimulate different sort of data representation. Address and discuss the need of virtual representations to deal with complex data. (CT Components: Data representation and abstraction)
10 minutes	**Evaluation:** Let students to complete the questions in their textbook.	

LESSON PLAN #E7

Subject: Separation of Mixtures

Duration: 2 lesson hours (40+40 minutes)

Objectives of lesson:

Science Learning: Students select any appropriate method that can be used for separation of mixtures and students apply that (MoNE, 2018).

CT skills: Students make sense of human and computer collaboration (…) Students understand algorithms and write simple steps in a given context to articulate sequences using conditionals and loops (Dorling and Walker, 2014).

Resources: Worksheet #7, Worksheet #8

Instructional Sequences:

Duration	Dimension of Science Learning	Dimension of CT *(practices, components)*
20 minutes	Get students to read a conceptual change text to find out misconceptions about melting and dissolving. (Worksheet #7)	Students will learn how the STEM scientists collaborately work to carry out a project.
20 + 30 minutes	Let students to form basic mixtures and then separate with physical methods.	Let students do a role playing in which a chemist and computer engineer collaborate to produce shampoo. (CT Components: Algorihms, debugging, abstraction, decomposition) (Worksheet #8)
10 minutes	**Evaluation:** Evaluate students' projects in terms of the scientific and representational accuracy.	

LESSON PLAN #E8

Subject: Separation of Mixtures

Duration: 2 lesson hours (40+40 minutes)

Objectives of lesson:

Science Learning: Students select any appropriate method that can be used for separation of mixtures and students apply that (MoNE, 2018).

CT skills: Students create algorithms so as to solve a problem using if-else statements (Dorling and Walker, 2014).

Resources: Worksheet #9

Instructional Sequences:

Duration	**Dimension of Science Learning**	**Dimension of CT** ***(practices, components)***
80 minutes	In this lesson, students are given Worksheet #9 to follow instructions to build up various algorithms which specify the formation of different sorts of mixtures, e.g their favourite drinks.	
	Evaluation: Worksheet #9 is used as assesment of learning performances.	

B

LESSON PLANS OF THE CONTROL GROUP

Lesson Plan #C1

Subject: Pure Substances

Duration: 2 lesson hours (40+40 minutes)

Objective of lesson: Students assort pure substances as elements and compounds by giving examples (MoNE, 2018).

Resources: Play doughs, chopsticks, pipettes, marbles, felt wool balls, adhesive, Worksheet #10

Lesson Description:

Duration	Instructional Sequences
10 minutes	**Engagement:** Have students in an activity whose aim is to find students' cognitive schemas about elements and compounds. Use a word association test to address questions. (Worksheet #1)
20 minutes	**Exploration:** Guide students to classify the elements and compounds based on their properties.
15 minutes	**Explanation:** Explain the characteristics of pure matters, also consider common misconceptions to clarify students' understanding.
20 minutes	**Elaboration:** Help students to create the models of elements and compounds in order to grasp the differences between them.
15 minutes	**Evaluation:** Use Worksheet#10 to assess students' learning.

Lesson Plan #C2

Subject: Pure Substances

Duration: 2 lesson hours (40+40 minutes)

Objective of lesson: Students assorts pure substances as elements and compounds by giving examples (MoNE, 2018).

Resources: Play doughs, chopsticks, pipettes, marbles, felt wool balls, adhesive, Student textbook, Worksheet #2

Lesson Description:

Duration	Instructional Sequences
10 minutes	**Engagement:** Remind and ask wrap-up questions about previous lesson.
20 minutes	**Exploration:** Re-use the scientific models of pure matters from previous lesson to guide and discuss their matter properties. Let them prepare poster presentation.
15 minutes	**Explanation:** Enlighten the basic characteristics of elements and compounds.
20 minutes	**Elaboration:** Distinguish the differences between atoms, elements and compounds. Remind the chemical bonding.
15 minutes	**Evaluation:** Distribute Worksheet #2 to students to assess their learning.

Lesson Plan #C3

Subject: Pure Substances

Duration: 2 lesson hours (40+40 minutes)

Objectives of lesson: Students express the names, symbols and some usages of first 18 elements and common ones (gold, silver, copper, lead, mercury, platinium, iron and iodine). Students express the formulas, names and some usages of common compounds (MoNE, 2018)

Resources: Adhesive, sticky note papers, student textbook, workheet #11

Lesson Description:

Duration	Instructional Sequences
10 minutes	**Engagement:** Ask a question if there is any relationship between daily products and compounds. Start a discussion aligning with students' responses.
20 minutes	**Exploration:** Give students the adhesives to stick their element models on periodic table so as to identify their places. This will enable students to associate symbols, formulas with representational models. Highlight the difference between elements and compounds.
15 minutes	**Explanation:** Give explanations of aforementioned 18 elements and few of compounds.
20 minutes	**Elaboration:** Show and present a simulation to extend their learning.
15 minutes	**Evaluation:** Ask and review the questions from student textbook.

Lesson Plan #C4

Subject: Mixtures

Duration: 2 lesson hours (40+40 minutes)

Objective of lesson: Students assort mixtures into homogeneus and heterogeneus mixtures by giving examples (MoNE, 2018).

Resources: Water, sugar, salt, oil, sand, soil, chalk, and other safe and daily used materials, Worksheet #11, Worksheet #12,

Lesson Description:

Duration	Instructional Sequences
10 minutes	**Engagement:** Ask driving questions to address the today's discussion. Ask about any resemblance of matters they have confronted so far (such as greensalad, nailpolish, sand, gasoline etc.) to inquiry their components.
20 minutes	**Exploration:** Invite students to prepare mixtures without a certain recognition of the scientific categorization of mixtures. Let them guess about their physical properties such as color, texture, apparence.
15 minutes	**Explanation:** Inform students about the concept of mixture. Give explanation about homogeneity and heterogeneity.
20 minutes	**Elaboration:** Extend the topic by discussing the production process of milk. Inform students about the homogenization process. (Worksheet 11)
15 minutes	**Evaluation:** Ask wrap-up questions with true-false statements. (Worksheet #12)

Lesson Plan #C5

Subject: Mixtures

Duration: 2 lesson hours (40+40 minutes)

Objective of lesson: Students prepare solutions by using solute and solvents that can be used in daily life (MoNE, 2018).

Resources: Worksheet #13, student textbook, water, salt, sugar, and other accessible or edible materials.

Lesson Description:

Duration	Instructional Sequences
10 minutes	**Engagement:** Ask driving questions about solutions and their properties.
20 minutes	**Exploration:** Let students prepare several solutions using materials used in daily life.
15 minutes	**Explanation:** Describe the concept of mixture including solutions and heterogeneous mixtures and their characteristics.
20 minutes	**Elaboration:** Support the learning acquisitions with a structured grid activity. (Worksheet #13)
15 minutes	**Evaluation:** Review the questions from student textbook.

Lesson Plan #C6

Subject: Mixtures

Duration: 2 lesson hours (40+40 minutes)

Objective of lesson: Students experimentally test the factors which affect the rate of dissolving (MoNE, 2018).

Resources: Worksheet #14, water, salt, sugar.

Lesson Description:

Duration	Instructional Sequences
10 minutes	**Engagement:** Review the concepts of previous lesson and motivate students that they will make experimentation at today's class.
20 minutes	**Exploration:** Carry out experiments with students.
15 minutes	**Explanation:** Discuss the findings from students' experiments and give scientifically accurate explanations.
20 minutes	**Elaboration:** Impel students to complete an assignment which designs an experiment. (Worksheet #14)
15 minutes	**Evaluation:** Evaluate students' responses in their tasks.

Lesson Plan #C7

Subject: Separation of Mixtures

Duration: 2 lesson hours (40+40 minutes)

Objective of lesson: Students select any appropriate method that can be used for separation of mixtures and students apply that (MoNE, 2018).

Resources: Worksheet #7, water, oil, salt, sugar, soap, etc.

Lesson Description:

Duration	Instructional Sequences
10 minutes	**Engagement:** Have students to read a conceptual change text that consists of the misconception about dissolving and melting. (Worksheet #7)
20 minutes	**Exploration:** Let students prepare mixtures based on their choices. Then, request them to separate their mixtures if it is possible do it with physically.
15 minutes	**Explanation:** After the investigation of previous activity, teach students the categorization of separation methods.
20 minutes	**Elaboration:** Differentiate the variations in atomic dimension and physical dimension of mixtures.
15 minutes	**Evaluation:** Ask wrap-up questions about whole subjects.

Lesson Plan #C8

Subject: Separation of Mixtures

Duration: 2 lesson hours (40+40 minutes)

Objective of lesson: Students select any appropriate method that can be used for separation of mixtures and students apply that (MoNE, 2018).

Resources: water, oil, salt, sugar, soap, etc.

Lesson Description:

Duration	Instructional Sequences
10 minutes	**Engagement:** Remind students the change in different dimensions, and ask them what to do if there is not any other method to separate mixtures physically.
20 minutes	**Exploration:** Carry out experiments about evaporation, distillation, and density separation. Then, show simulations if possible.
15 minutes	**Explanation:** Explain the stepwise process of mixture elimination and clarify the differences between different mixture separation methods.
20 minutes	**Elaboration:** Have students watch a video about oilgase production.
15 minutes	**Evaluation:** Let students to design a production site for oilgase.

C

WORKSHEETS

WORKSHEET #1

Aşağıda yer alan anahtar kavramları verilen cümlelerle tamamlayalım.

Atom | Molekül | İyon | Moleküler yapı

Element | Bileşik | Atomik yapı | Bağ

Formül | Sembol

- ❖ Saf maddeler . . . .
- ❖ Saf maddeler . . . .
- ❖ Saf maddeler . . . .
- ❖ Saf maddeler . . . .
- ❖ Saf maddeler . . . .
- ❖ Saf maddeler . . . .

WORKSHEET #2

Aşağıda yer alan metni okuyunuz ve sınıfta tartışınız. Ardından kutucuklarda istenen yapıları çiziniz.

OKSIJEN ILE ALUMİNYUMUN HIKAYESI: “SEN TEK BIZ İKİMİZ”

Oksijen ve Hidrojen elementi ve bazı diğer elementler doğada moleküler halde bulunmaktadırlar. Örneğin oksijen elementinin oluşturan moleküllerin her birinde 2 tane oksijen atomu yanyana bulunur. Tıpkı yapışık ikiz kardeşler gibi.

Sodyum, Klor, Berilyum gibi elementler ise doğada atomik yapıda bulunurlar. Örneğin Sodyum elementini oluşturan binlerce atom, tek başlarına birarada durabilirler. Aslında her biri tek yumurta ikizleri gibidirler.

Oksijen atomunun elektron katman dizilimi	Oksijen İyonu	Oksijen Molekülü	Oksijen Elementi
Aluminyum atomunun elektron katman dizilimi	Aluminyum İyonu	Aluminyum Molekülü	Aluminyum Elementi

WORKSHEET #3

Karekod nedir?

Karekodun içinde ne saklı olabilir?

Sizce elementlerin ve bileşiklerin karekodu olabilir mi?

Karekodlar aslında içeriğindeki bilgiye kısa sürede ulaşmamızı sağlayan 2 boyutlu araçlardır. Karekodun sahip olduğu bilgi, karekod okuyucular tarafından işlenince bize sahip olduğu içeriği görmemizi sağlar. Örneğin marketten aldığımız herhangi bir ürünü kasadan geçirirken ürünün karekodu okutulur ve fiyatı açığa çıkar.

Elementlerin sembolleri ve bileşiklerin formülleri de bize onların isimlerini verir. Elementlerin ve bileşiklerin modellerini çizmek ise bize onların hangi birimlerden oluştuklarını ve kimyasal bağ türleri gibi birçok özellikleri hakkında bilgi sahibi olmamızı sağlar.

Şimdi hep birlikte, öğretmeninizin söylediği element ve bileşiklerin modellerini çizelim ve arkadaşınınkiyle karşılaştıralım! Çizdiğiniz her bir yapı, sizin oluşturduğunuz özel karekodlar olsun!

Karekodlarını aşağıdaki boşluğa çizebilirsin!

Çizdiğiniz modellerden yola çıkarak aşağıdaki boşlukları doldturalım.

❖ Elementler ile ilgili benzerlikler şunlardır

. . . .

❖ Bileşikler ile ilgili benzerlikler şunlardır

. . . .

❖ Elementler ile ilgili farklılıklar şunlardır

. . . .

❖ Bileşikler ile ilgili benzerlikler şunlardır

. . . .

❖ Moleküler haldeki elementlerin gösterimi şu şekillerde olabilir:

. . . .

❖ Bundan hareketle elementler ile ilgili vardığım sonuç şudur:

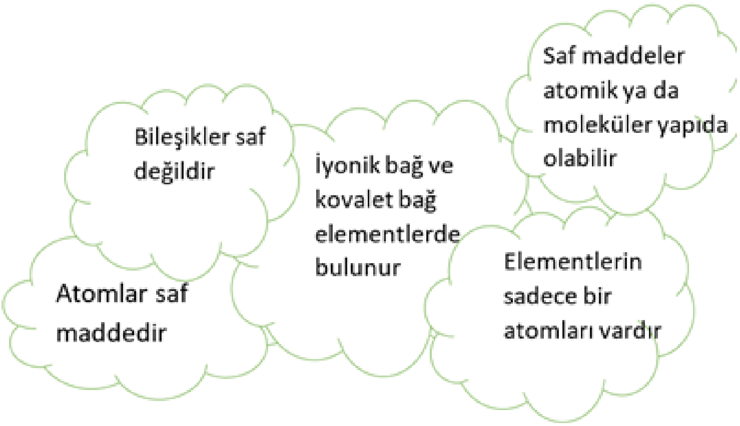
. . . .

❖ Bundan hareketle bileşikler ile ilgili vardığım sonuç şudur:

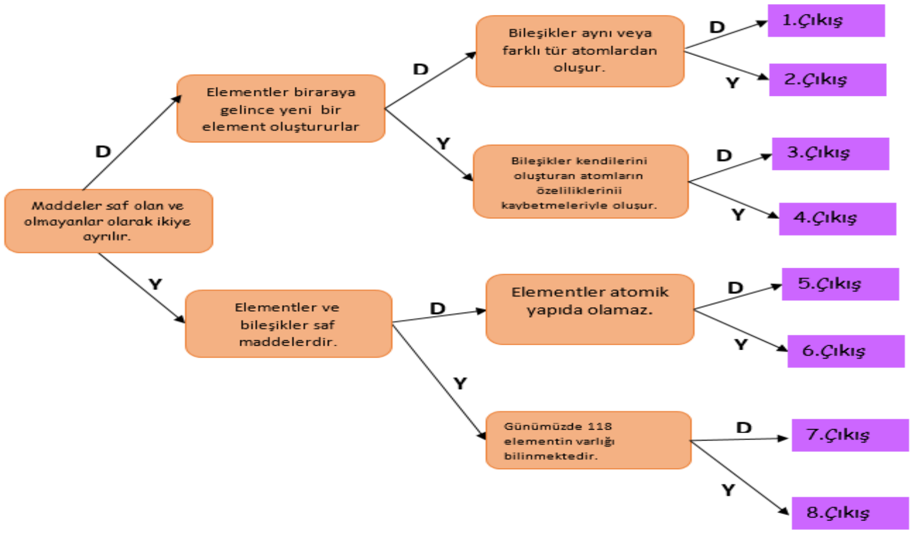
. . . .

WORKSHEET #4

1. Elif'in biraz kafası karışmış. Ona yardım eder misin? Hatalı olduğunu düşündüğünüz fikri siyaha boyayınız. Doğru olanı kırmızıya boyayınız. Yanlış olanların ifadelerin doğru şeklini Elif'e nasıl anlatırdınız?



2. Aşağıda yer alan önermeleri dikkatlice okuyalım ve doğru olan çıkışa doğru ilerleyelim.

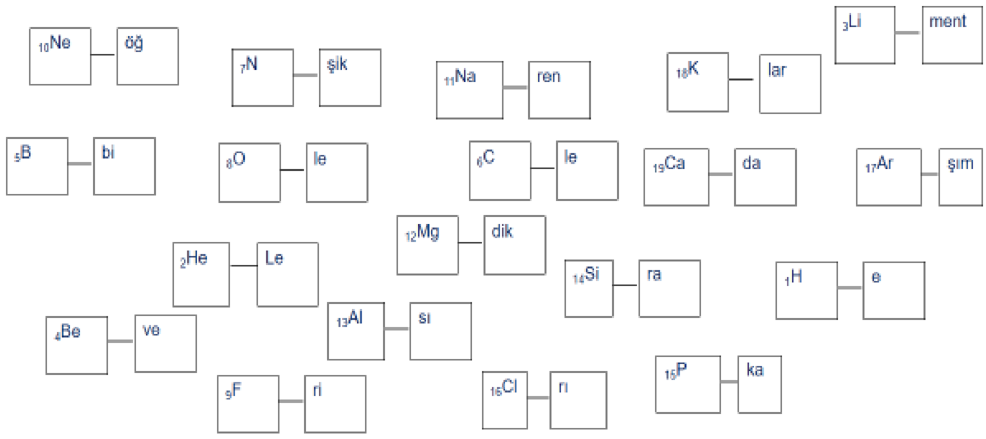


3. Aşağıda yer alan modellemelerin türlerini tespit ederek altındaki yazınız ve genel özelliklerini belirtiniz.

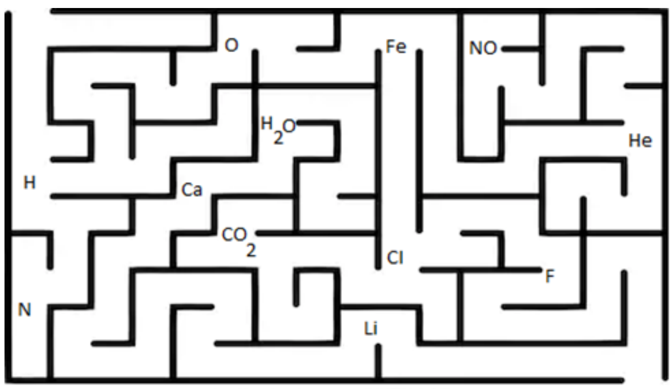
Derste yaptığınız karekod etkinliğini hatırlayın. Karekodları nelere benzetebiliriz?

4. Aşağıda yer alan modellemelerin türlerini tespit ederek altındaki yazınız ve genel özelliklerini belirtiniz.

5. Aşağıda yer alan elementlerin her biri bir heceyle eşleştirilmiştir. Elementleri atom numaralarına göre sıralarsanız kurallı ve anlamlı bir cümle bulacaksınız.



6. Aşağıda yer alan labirentte çıkışa ulaşınız. Çıkışa giderken üzerinden geçtiğiniz saf maddeleri yapılarına göre sınıflandırınız.



Element kutusu

Bileşik Kutusu

WORKSHEET #5

Aşağıda yer alan metni okuyalım ve Aslan Dede'nin bulmacasını çözelim.

Sevgili çocuklar,

Ben Aslan Dede. Sizlere bir hikâye anlatacağım. Bu hikâyede geçen kavramlardan bazıları derste işlediğiniz kavramlarla örtüşüyor ama bazılarının alakası yok. Sizden istediğim bu hikâyedeki gizli kavramları ve olayları bulmanızdır.

Günlerden bir gün torunum Elmas ile vakit geçirirken o kadar yorulmuştuk ki koşturmaktan, susamış hissettik ve soğuk bir şeyler içme ihtiyacı duyduk. Elmas ile birlikte mutfağa gidip soğuk bir şeyler içmeye karar verdik. Buzdolabında donmuş 5 tane limon, soğuk su ve yoğurt vardı. Kendim için ayran yapmaya, Elmas için limonata yapmaya karar verdik. 5 tane limonun önce çözünmesini bekledik, 10 dakika geçti baktık olmuyor, kaynamış bir sürahi suyun içine atıp daha hızlı çözünmesini sağladık. Daha sonra limonların suyunu sıktık, üzerine biraz şeker ve su ekleyince yeni bir karışım elde ettik. İsmi tabii ki limonata! Kendim için de ayran yapmaya başladım. 2 kaşık yoğurda 100 ml su ilave ederek karıştırdım. Soğuması için dolapta bekletmeye başladım. 10 dakika geçti ve yoğurt bardağın tabanında su ise bardağın üstünde birikmeye başlamıştı. Sanki tekrar yoğurt olmuştu. Tekrar yoğurt ve suyu bir kaşık yardımıyla karıştırdım ve tekrar bir bütün görüntü elde ettik. Daha sonra Elmas ile birlikte içeceklerimizi içtik ve serinledik.

❖ Hikayede yer alan öğrendiğimiz kavramlar:

. . . .

. . . .

. . . .

❖ Aslan Dede’nin hikayesinde geçen karışımların isimleri ve türleri:

Karışımın İsmi	**Çözünen**	**Çözücü**	**Çözelti**	**Çözünme nasıl gerçekleşir?**

❖ Aslan dedenin yaptığı ayranın bir süre geçtikten sonra sanki yoğurt gibi olmasının nedeni ne olabilir?

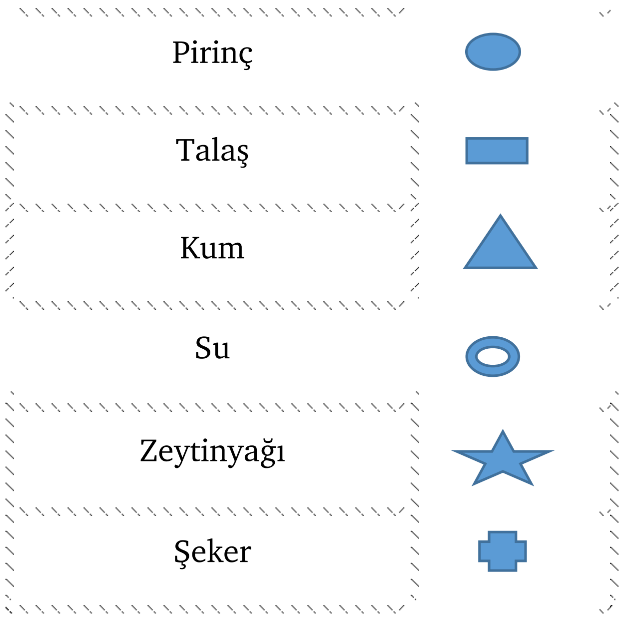
. . . .

WORKSHEET #6

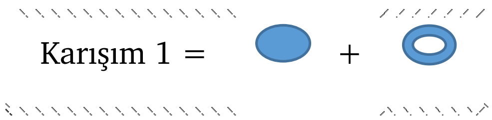
Algoritmalar her yerde **HER YERDE!**

Kukla Kermit aşağıda yer alan malzemelerden homojen ve heterojen karışımlar oluşturmak istiyor ama bunu şifrelerle yapmak istiyor. O yüzden farklı gözükmeli!

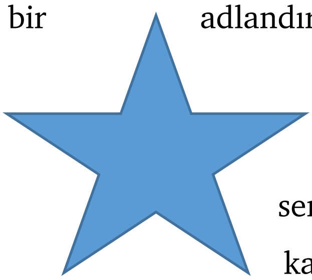
Aşağıda gördüğünüz tabloda bazı maddeler ve yanlarında onları temsil eden şekiller bulunmaktadır.



Örneğin pirinç ve sudan oluşan bir karışım oluşturmak istiyorsanız şu şekilde ifade edebilirsiniz:



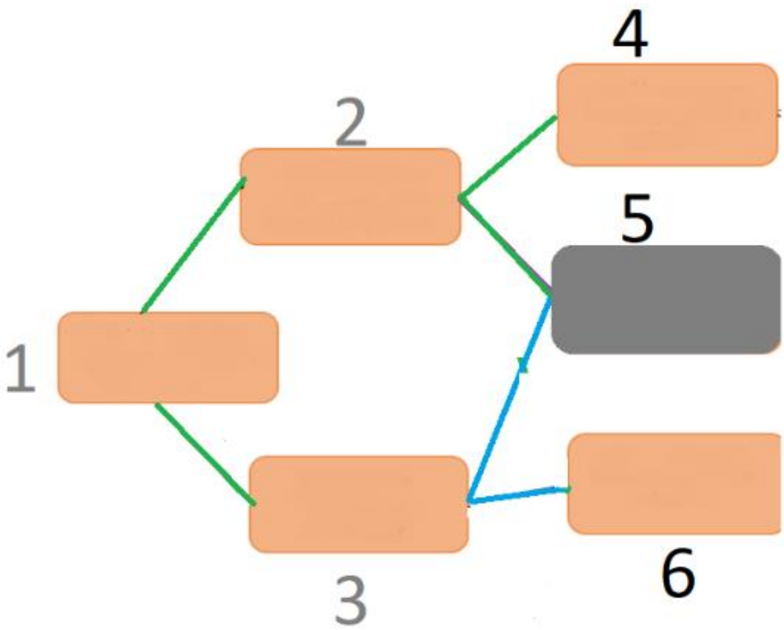
Yukarıda yer alan malzemelerden karışım oluşturmanız isteniyor. Bu karışımı oluşturan çözücü, çözünen ve karışım türünü de belirtmeliniz. Bunun için yanlarında bulunan sembollerle kodlar oluşturun ve modeller üretin. Sizin ürettiğiniz bu kodlar tıpkı fen bilimlerinde element ve bileşiklerde olduğu gibi özel bir adlandırma sistemi olacak.



Oluşturduğunuz karışımları ve karışımınızı simgeleyen kodlarınızı sınıfta arkadaşlarınıza gösteriniz. Sizce semboller kullanarak ifade etmek fen ve teknolojide bize ne katkı sağlayabilir? Örnekler veriniz.

Aşağıda karışımları basamaklar halinde oluşturamanız için gereken adımlar yer alıyor.

2 katı ve 1 sıvı maddeden oluşan bir karışım oluşturmak için gereken malzemeleri kutulara yazınız. Ancak unutmayın ki ilk önce başla komutuna ihtiyacınız var.



WORKSHEET #7

Aşağıdaki metinde Esra ile Tuncay'ın arasında geçen konuşmaları okuyalım.

Esra ve Tuncay sıra arkadaşlarıdır. Esra o gün hasta olduğu için okula gelememişti ve ertesi gün sınıfa geldiğinde Tuncay'a dün fen bilimleri dersinde hangi konuyu öğrendiklerini sordu. Tuncay'ın cevabı "karışımlardı". Tuncay, Esra'ya karışımların ne demek olduğunu şöyle açıkladı:

…………………………………………………………………………………………

………………………………………………………………………………………….

Bunun üzerine Esra şöyle dedi:

- Yani bir bardak çaya şeker atınca şeker içinde eriyor muymuş?

Tuncay:

- Hayır, ona bilimsel olarak eriyor demiyoruz. Evet, evde, sokaktaki herkes şeker eridi diyebiliyor ama öyle değilmiş. Şeker, çayın içinde çözünüyormuş. Aslında sadece bizim gözümüzden kayboluyor, çayın yapısına katılıyor. Buna da çözünme deniyormuş. Biliyor musun? Bazı yöntemlerle, istersek, şekeri eski görünen haline getirebilirmişiz. Onu da bir sonraki derste öğrenecekmişiz.

Soru 1: Tuncay'ın cevabında yer alan "bilimsel açıdan" ifadesiyle neler anlıyorsunuz?

Soru 2: Günlük hayatta kullandığımız ifadeler bilimsel gerçeklerle uyuşmuyorsa ne yapabiliriz?

Soru 3: Karışımlar konusunu öğrendikten sonra, günlük hayatta sık sık karşılaştığımız ancak yanlış olarak ifade ettiğimiz başka olay veya durumlar olabilir mi? Düşünelim.

Soru 4: Karışımlar bileşenlerinin eski haline geri döndürülebilirle r mi? Tuncay'a katılıyor musunuz?

WORKSHEET #8

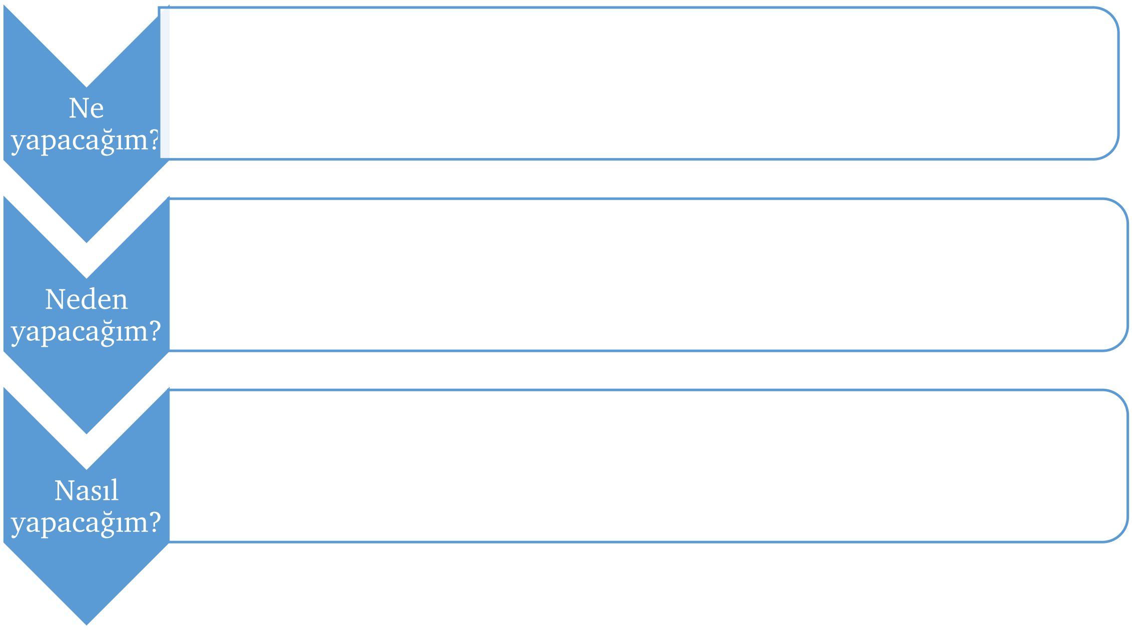
Bir şampuan firmasında, araştırma ve geliştirme bölümünde çalışan bilgisayar mühendisi olduğunuzu düşünün. Çalışma arkadaşlarınızdan kimyager Deniz Hanım, şampuanı oluşturacak A B C D E maddelerinden oluşan bir karışım hazırlamıştır, yapılan ön denemelerde insan sağlığına zararlı herhangi bir etkisi bulunmadığı anlaşılmıştır. Bunun üzerine firma yönetimi şampuanın seri üretime geçmesine izin vermişlerdir. Siz de bu şirketin bilgisayar mühendisi olarak, bu şampuanın seri üretime geçmesi için fabrikadaki bilgisayar sistemine uygun algoritmayı yazmanız isteniyor.

(İlk önce şunu düşünelim: Bazı şeyler ilk kez okuduğumuzda karmakarışık gözükse de dikkatli davranır ve adım adım ilerlersek sonuca daha kolay ve hızlı bir şekilde ulaşabiliriz. Mesela yukarıdaki sorunu çözmek için)

İşe koyulmadan önce hemen plan yapalım! Bu sayede hata yapma olasılığımız azalır.Şöyle yapmayı planlıyorum:

………………………………………………………………………………………

………………………………………………………………………………………



Aşağıda yer alan Deniz Hanım'ın size göndermiş olduğu bilgileri dikkate alarak işlem basamaklarını yazalım.

- A maddesi: 1 cm^3 hacme sahip katı taneciklerden oluşan maddedir ve B maddesi ile karıştırıldığında homojen olarak dağılmaktadır.
- C maddesi: Akdeniz Bölgesinden topraktan çıkarılmaktadır. Kullanılmadan önce uygun yöntemlerle ayrıştırılması gerekmektedir. Küçük numunelerde elle ayıklanabilir ancak büyük numunelerde başka yöntemler kullanılmalıdır.
- B maddesi: Sıvı halde bir maddedir.
- D maddesi: Bir alkol çeşidir ve çözücü olarak kullanılmaktadır.
- E maddesi: Gaz haldedir ve parfüme güzel koku vermesi için kullanılmaktadır.

Programı çalıştırmaya başladıktan sonra her turda 50 ml şampuan üretilmektedir. Şirketin seri üretim yapması için 5000 ml şampuana ihtiyacı vardır.

1.adım: C maddesini katı-katı karışımların ayrılma yöntemleriyle ayrıştırın.

2. adım: A ile B maddesi ile homojen çözelti oluşturun.

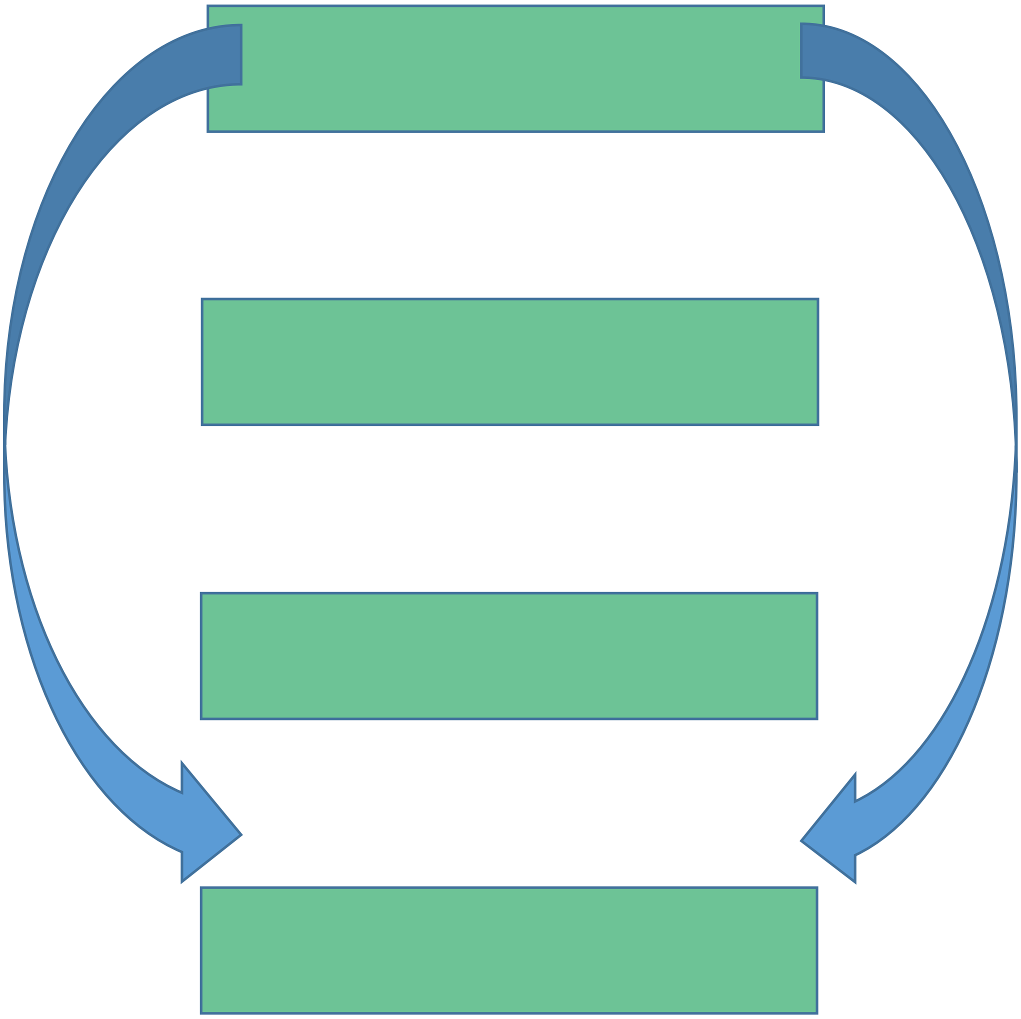
3.Adım: A ve B maddesinden oluşan çözeltiye C maddesini ekleyin.

4 adım: D maddesini en son elde ettiğiniz karışımda çözücü olarak kullanın.

5.adım: E maddesini en son adımda ekleyin.

Aşağıda yapman gereken adımları adım adım gösteren bir algoritma var. Sırayla ne yapman gerektiğini yaz. Daha sonra algoritmanda istediğin ve uygun olan değişikleri yap!

Başla



İşlemin tümünü ………. kere tekrar et

Bitir

WORKSHEET #9

Bugün sınıfımızda etkinlik günü! Sen ve 2 arkadaşınla birlikte nefis bir içecek yapalım mı?

Smoothie yapalım!!

Fakat önce ne yapmak istediğine karar ver.

Seçebileceğim malzemeler:

. . . .

(Yaptığım işlemin adı: ....’dır)

Mesela lezzetli bir yemek mi yapmak istiyorsun yoksa sıcak/soğuk bir içecek mi yapmak istiyorsun? Ama şunu unutma, şuan yaptığın o ilginç karışımı daha sonra bileşenlerine ayırmaya çalışacaksın…

Yukarıda seçmiş olduğun malzemeleri değiştirmek istersen buraya son halini yaz.

. . . .

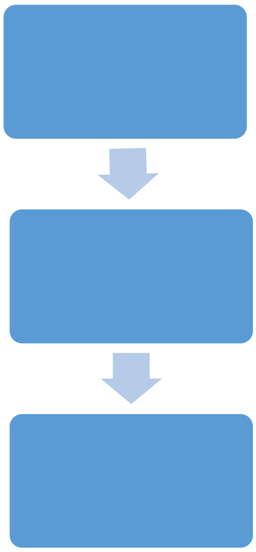
(Yaptığım işlemin adı.............................’dır)

Şimdi geldik ayrıştırmaya. Karışımları nasıl ayrıştırdığımızı hatırlıyor musun? Hazırladığın karışımda asıl olarak elde etmek istediğin malzemeyi seç ve onu diğer maddelerden ayırmaya çalış.

. . . .

(Yaptığım işlemin adı, bilgi-işlemsel düşünme basamaklarından...........’dır.)

Seçtiğin malzemeler ve kullacağın tekniklerden eminsen, haydi bunların hepsini basamaklar halinde kodlayalım.

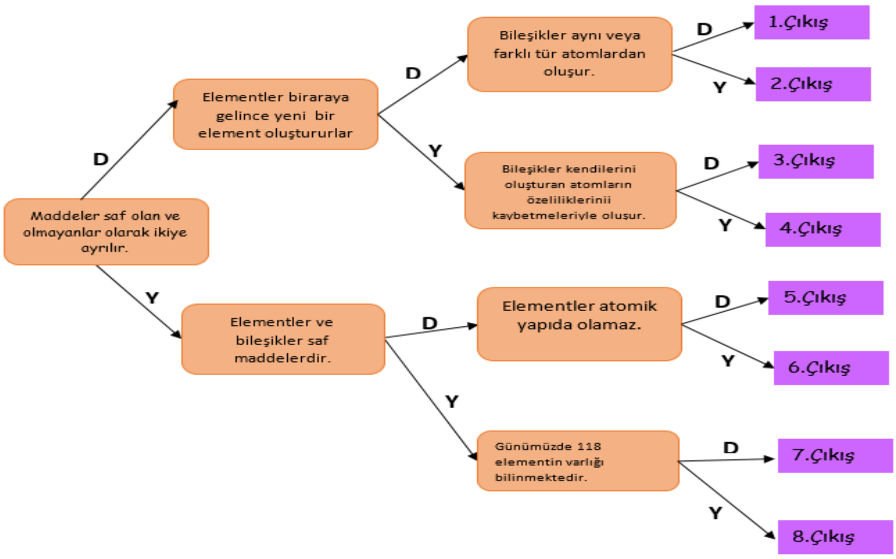


WORKSHEET #10

1. Aşağıdaki soruları yanıtlayınız.

- Maddeler ……………………..’dan meydana gelir.
- ………………………….. maddeleri ………………………. ve …………………. olarak 2’ye ayırabiliriz.
- Maddeler eğer aynı taneciklerden oluşuyorsa ………………. farklı taneciklerden oluşuyorsa …………….. diye adlandırılırlar.

2. Kutulardaki ifadeleri okuyun ve hangi çıkıştan çıktığınızı söyleyin.



3. Aşağıda verilen ifadeyle katılıyorsanız EVET katılmıyorsanız HAYIR deyip, nedeninizi açıklayınız.

•Bileşiklerin en küçük yapı taşı elementlerdir.

Evet. Çünkü…………………………………………………………………………..

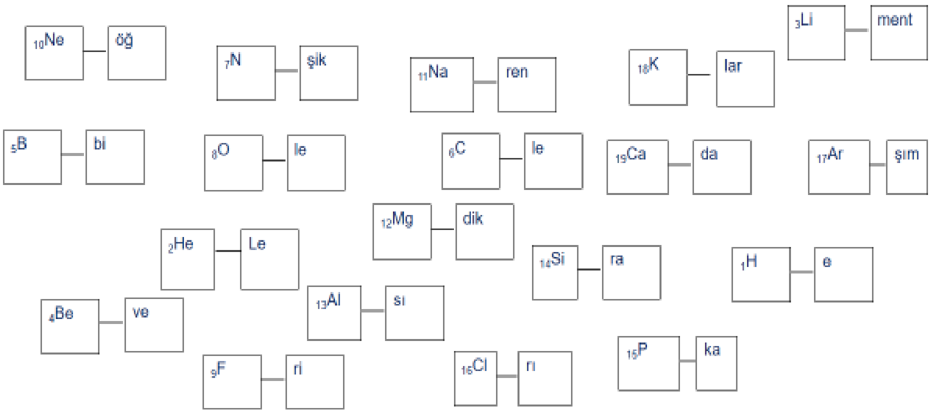
Hayır. Çünkü…………………………………………………………………………

•Elementler ve bileşikler çeşitli amaçlarla amaçlarla kullanıldığı gibi, yiyeceklerde de bulunurlar ve vücudumuzun yapısına katılırlar.

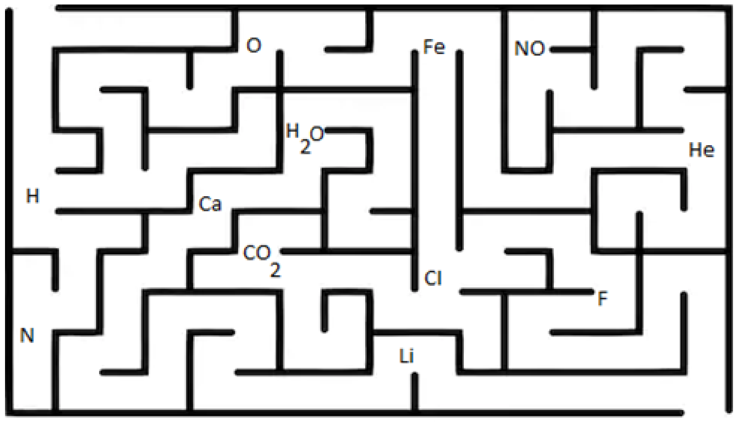
A)Katılıyorum.
Çünkü...

B)Katılmıyorum.
Çünkü...

4. Aşağıda yer alan elementlerin her biri bir heceyle eşleştirilmiştir. Elementleri atom numaralarına göre sıralarsanız kurallı ve anlamlı bir cümle bulacaksınız.



5. Aşağıda yer alan labirentte çıkışa ulaşınız. Çıkışa giderken üzerinden geçtiğiniz saf maddeleri yapılarına göre sınıflandırınız.



Element kutusu

Bileşik Kutusu

WORKSHEET #11

Günlük olarak tüketmemiz gereken proteinlerden sütü düşünelim. Her sabah kalktığımızda kahvaltıda, yiyeceklerimizin içinde ya da akşam yatmadan önce tükettiğimiz süt acaba homojen midir, heterojen midir? Cevabınızı nedenini belirterek yazınız

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

Daha önce hiç işlem görmemiş, doğal sütü gördünüz mü?

………………………………………………………………………………………………

Marketlerden aldığımız "uzun ömürlü süt" olarak geçen süt ile çiftliklerde, köylerde sağılan ve hemen tüketilen süt arasında ne gibi farklar olabilir?

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

Genel olarak sütte protein, yağ şeker gibi temel kimyasal bileşenler büyük miktarda yer alır. Köylerde ve çiftliklerde ineklerden sağılan süte baktığınızda veya bir süre dinlendirip beklettiğinizde sütün üzerinde yağ damlalarını görürsünüz. Bu yağ damlalarına "süt yağı" denir. Hiçbir işlem yapılmamış süte baktığımızda onun heterojen bir karışım olduğunu anlayabiliriz. Ancak marketlerde satılan sütlere baktığımızda bunu anlayamayız. Çünkü marketlerde satılan bu "uzun ömürlü" ya da "pastorize edilmiş" sütler birtakım işlemlerden geçmiştir ve sütün içerisinde yer alan o yağ damlacıkları homojenize edilerek gözle göremeyeceğimiz hale getirilmiştir.

Sütün ilk hali ile marketlerden aldığımız son hali arasındaki farkın sebebi ne olabilir?

………………………………………………………………………………………………

WORKSHEET #12

1. Aşağıda verilen ifadeleri okuyalım. Yanına doğru ise D, yanlış ise Y yazalım.

(……..) Birden fazla maddenin bir araya gelmesiyle oluşan yapılara karışım denir.

(……..) Çözeltilere heterojen karışımlar da denir.

(……..) Bir karışımın homojen olup olmadığını anlamak için rengine bakmak yeterlidir.

(……..) Çaya şeker attığımızda şeker içinde erir.

(……..) Bir karışımın içinde çözünen madde yok olur.

(……..) Bir çözeltiyi karıştırırsak içindeki çözücü madde daha hızlı çözünür.

(……..) Çözelti, çözünen ve çözücüden oluşur.

(……..) Sıcaklık artarsa çözünme hızı azalır.

WORKSHEET #13

1. **Aşağıda yer alan yapılandırılmış gridde, karışımlarla ilgili bazı kavramlar, durumlar ve en altta ise bazı sorular yer almaktadır. Soruları gridde yer alan kavram ve durumların numaralarını kullanarak cevaplayınız.**

1. Homojen Karışım	2. Heterojen Karışım	3. Çözücü	4. Element
5. Çözelti	6. Derişik	7. Saf madde	8. Çözünme Hızı
9. Seyreltik	10. Çözünme	11. Çözünen	12. Bileşik
13. Temas yüzeyini değiştirmek	14. Karıştırmak	15. Erime	16. Sıcaklığı değiştirmek

1. Hangisi ya da hangilerinde saf maddelere ait kavramlar yer alır?

2. Hangisi ya da hangilerinde bir homojen karışımı oluşturan bileşenler yer alır?

3. Hangisi ya da hangilerini yaparsak çözünme hızına etki etmiş oluruz?

4. Hangisi ya da hangilerinde çözeltideki madde miktarıyla ilgilidir?

5. Hangisi ya da hangilerinde karışımın fiziksel özelliği ile ilgilidir?

6. Hangisi ya da hangileri bileşenlerine ayrılamaz?

WORKSHEET #14

Cemre'nin fen bilimleri dersinde karışımlar konusunu öğrendikten sonra öğretmeni Cemre'den bir deney tasarlamasını istemiştir. Aşağıdaki yönergeleri okuyup Cemre'ye yardım edelim.

Cemre, ilk önce bir karışım oluşturmak istemektedir.

- Bu karışım şu maddelerden oluşabilir:

- Oluşturduğu karışımda sıcaklığın çözünme hızına etkisini test etmek istemektedir. Yapacağı deneyde göz önüne alması gereken değişkenler şunlardır:

Bağımlı değişkeni: Bağımsız değişkeni:

- Cemre'nin kurması gereken deney düzeneğini çiziniz.

- Deneyin nasıl yapılabileceğini yazınız.

- Tasarladığın deney düzeneğinde eksiklik var mı, tekrar kontrol et. Arkadaşlarının yaptıklarıyla karşılaştır.

- Elde ettiğiniz sonuçları grafik üzerinde gösteriniz.

PUBLICATIONS FROM THE THESIS

Conference Paper

1. Kılıç, İ. & Topçu, M.S. (2021). Establishing Computational Thinking Practices in Turkish Science Curriculum. In *VIII. International Congress on Curriculum and Instruction (ICCI-EPOK 2021),* (pp. 56-57).