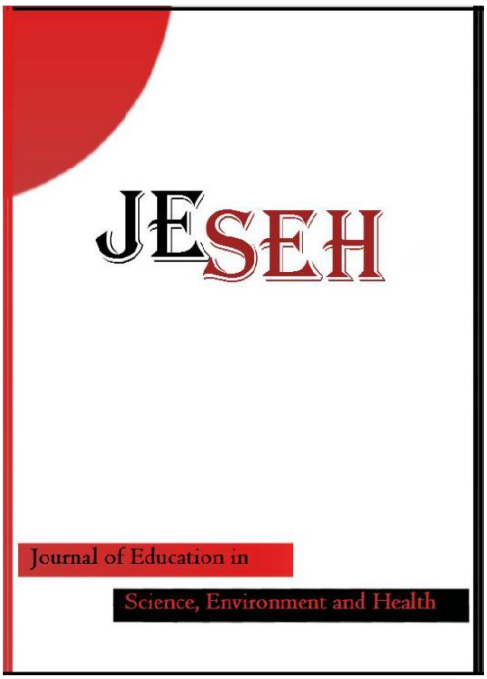


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# A Metaphor Analysis Study Related to STEM Subjects Based on Middle School Students' Perceptions

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# A Metaphor Analysis Study Related to STEM Subjects Based on Middle School Students' Perceptions

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## Abstract

The aim of this study is to determine what metaphors seventh and eighth grade students have when they identify STEM subjects. For this purpose, a form was developed to provide students to write their own metaphors related to STEM subjects. Qualitative research method was used and this research was conducted as a phenomenological study. 94 seventh and eighth grade students participated in this study from two different middle schools, which are located in the center of Ankara, Turkey. Students were encouraged to write their metaphors to identify STEM subjects. It has been seen that both seventh and eighth grade students had complexity while they were identifying science and technology subjects. Students used technology metaphor eleven times while they identified science, and they used science metaphor five times while they identified technology. It has also been learnt from students' metaphors that students have not had enough information on math and engineering since the metaphors could not explain these subjects. It is recommended that some courses might be given to students within STEM subjects to provide them to learn those subjects.

## Introduction

The scientific and technological developments have been changing many applications in our daily lives. We see these changes also in education systems. The number of planets, the number of elements and exploration a new element can be given as some changes that are carried out in both science and technology. Those mentioned changes cause some changes in engineering, as well. Within this context, it can be seen that changes affect many different disciplines especially science, technology, engineering and math. Because these four disciplines cannot be separated from each other. At this point, we have an approach which is called STEM Approach. National Research Council (1996) defines that STEM is an educational and teaching approach which integrates both the content and skills of science, technology, engineering and math. İdin (2017), states that STEM is an integration of science, technology, engineering and math which includes process between pre-school and higher education and it donates learners with 21st century skills. The content of STEM and the relationships of STEM's subjects are shown in a model that is given below. As it can be seen in the STEM Model that STEM subjects must foster

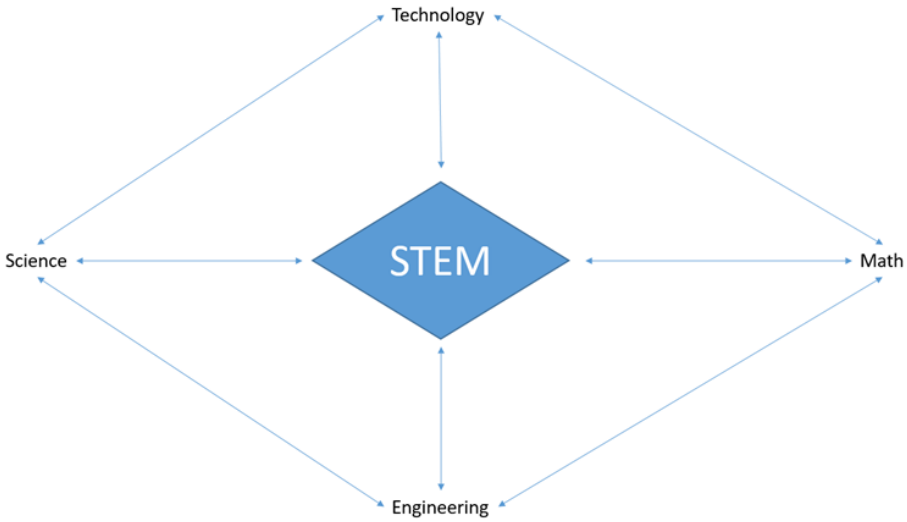


Figure 1. STEM model

to each other individually during whole educational process. For instance, science is relevant with technology and engineering and when this relevance combines with math STEM Approach is created. This means if a successful STEM Education is asked to create more attention should be paid to integration of all STEM's disciplines.

Another important point within STEM Education is why education system needs STEM Approach. We understand this from international studies such as, reports, articles, dissertations and others. According to World Economic Forum (2016), it is stated that technological drivers of change, "Mobile internet and cloud technology (34%), Advances in computing power and Big Data (26%), New energy supplies and Technologies (22%), The Internet of Things (14%), Advanced robotics and autonomous transport (9%), Artificial intelligence and machine learning (7%), Advanced manufacturing and 3D printing (6%), Advanced materials, biotechnology and genomics (6%). Another report created by TUSIAD (2016) points out that we are in Industry 4.0 so we will have new applications within Industry 4.0. Those mentioned Technologies of Industry 4.0 are given below.

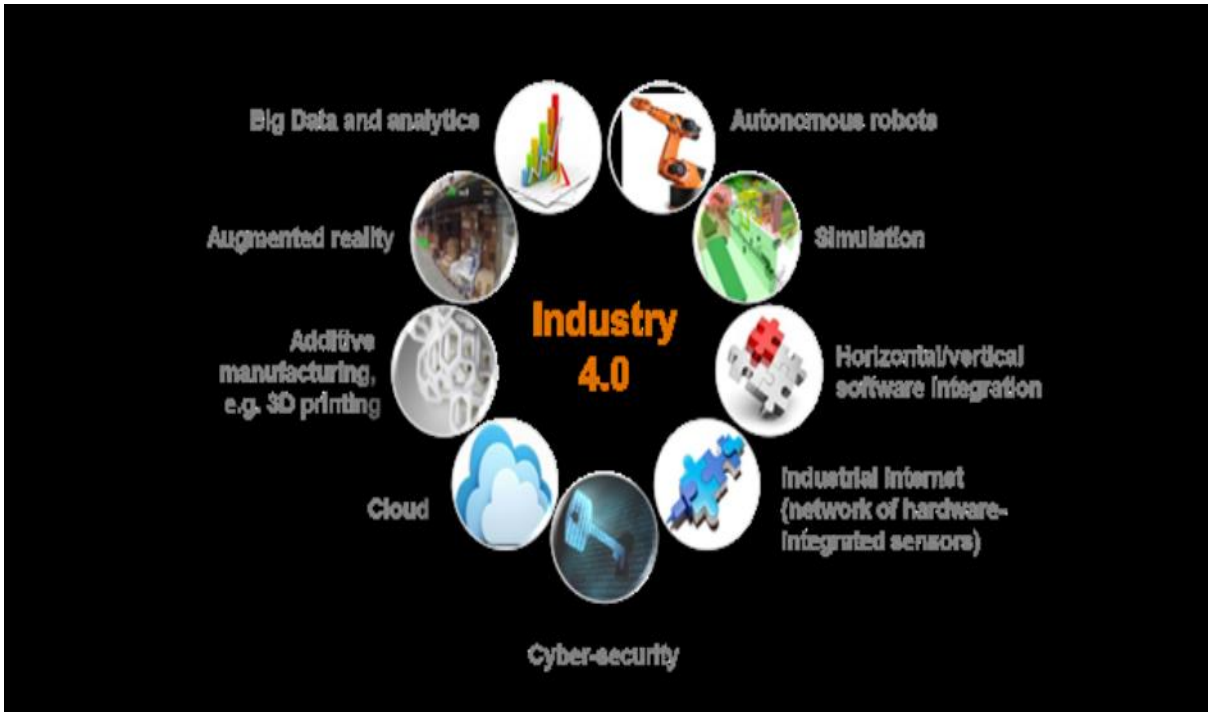


Figure 2. Technologies of industry 4.0

As it can be seen from the figure2 that the elements of Industry 4.0 are the cloud, additive manufacturing, augmented reality, big data and analytics, autonomous robots, simulation, horizontal vertical system integration, the industrial internet of things and cyber-security. Industry 4.0 has nine advanced technological products and already some of them have been used in manufacturing. It is seen that within Industry 4.0 new technological developments will be used in our daily lives.

We know that 21st century skills are paid attention to donate today's students for the future workforce. Beyond this, students should be done STEM literate people. A common definition of STEM literacy is to define, implement and integrate science, technology, engineering and mathematical concepts to solve complex problems and to renew them (Balka, 2011). To reach this aim, they should be educated under STEM Approach. To do this, 21st century skills can be given during whole the process. 21st century skills are collaborating, communication, critical thinking and creativity (The Partnership for 21st Century Skills, 2011). Besides, employability, innovation and team working can also be given as 21st century's skills (İdin, 2017). Those mentioned skills are significant because if a today's learner faces with a problem she/he can solve it and have some more option/options for solving the problem. To zoom in some of 21st century skills such as, creativity and innovation can be taken to have much more information why they are significant for the future people. Because it is expected there will be seen many new applications, which we will use, so we need to have some skills to control them all. STEM Education offers to have 21st century skills and before starting STEM Education we have to know our students' current information level of each STEM's disciplines. We will also be able to understand that these students' approximately knowledge level of 21st skills within STEM disciplines. When asked them on STEM's disciplines what they can say to tell them by using some metaphors. Because it

cannot be so easy to tell STEM disciplines by using words directly. Metaphor is employed when one wants to explore and understand something esoteric, abstract, novel, or highly speculative. As a general rule, the more abstract or speculative it is, the greater the variety of metaphors needed to grapple with it (Yob, 2003). Metaphors are thought that they are easy to be determined students' knowledge of STEM disciplines.

At this point, it is important that to determine what studies have been carried out by using metaphors in STEM Education. It is also known that there are too many studies in STEM Education but there have been been found limited direct studies related to both metaphors and STEM Education. Because of this reason, researches thought to find some studies which are related to science, technology, math and engineering separately and education, as well. It has been found some studies within those mentioned fields of education. In his study Ogborn (1997), tried to learn what is valuable in constructivism for a pupil own thinking, and on the high priority needed for ideas taught to make sense to pupils, together with the reminder that science is a human product. Lın, Shein & Yang (2012), investigated how pre-service teachers view English as a Foreign Language (EFL) courses at the beginning of their teacher education programs by using metaphorical analysis. Erdogan, Yazlik, Erdik (2014), investigated mathematics teacher candidates' perceptions about the concept of "mathematics" through the use of metaphors. They found that 77% of mathematics teacher candidates perceived mathematics as "Limitless", "Interconnected", "Basically needed", "Fun", "Cumulative", "Indispensable" figure and as a figure which laid the "foundation for other sciences". Taylor and Haydon (2016), in their study, described the process of developing, testing, and refining an explanatory metaphor to communicate the science of resilience to the public and policymakers. Yee (2017), identified how students and teachers contextualize mathematical problem solving through their choice of metaphors.

However, there can be seen some studies related to both metaphors and STEM Education, as mentioned above. Roehrig, Wang, Moore & Park (2006), investigated the need for research to explore the translation of broad, national-level policy statements regarding STEM education and integration to state-level policies and implementation in K-12 classrooms. Pillat, Negendran & Lindgren (2012), described the development of Magnetic Resonance (MR) environment which could be used in teaching STEM subjects. They basically seeked to create a space for facilitating whole-body metaphors where learners use the physical movement and positioning of their entire bodies to enact their understanding of complex concepts. Cannady, Greenwald & Harris (2014), interrogated the appropriateness of the STEM pipeline as the dominant frame for understanding and making policies related to STEM career trajectories. Rappaport, Richter and Kennedy (2016), created a model for teaching STEM which enhanced students' choice to progress their career in STEM fields. Their model created anologies and metaphors for various STEM for career enhancement and these analogies and metaphors for some STEM topics used contents of popular music videos. Çalışıcı and Sümen (2018), investigated classroom teachers' perceptions of prospective classroom teachers on STEM Education by using metaphors. They conducted the study with 138 teachers and the teachers were firstly educated in STEM fields. Then a form was given them, the statement was constructed as "STEM Education is like ...because ... ", and they were asked to write their metaphor on STEM. Henriksen and Mishra (2018), think that educators have unclear information on STEAM so the unclear can be caused from "Art". To be able to solve the problem they focused in their study and also offer figurative language for framing STEM teaching and learning, illustrated in samples of metaphor.

**Significance of the Study**

It is understood that importance of STEM subjects has been increasing so that students could have 21st skills. STEM is an interdisciplinary approach to learning in which science, technology, engineering and mathematics that makes integration between school, community, work and global enterprise and the ability to compete in the new economy (Tsupros, Kohler, & Hallinen, 2009). In the Programme for International Student Assessment (PISA) 2015, asked questions are taken from daily life within STEM subjects. Within the scope of STEM Education, if a student faces any problem in his/her daily life he/she can solve the problem. PISA already asks this kind of questions to students and it is paid attention to learn students' answers on daily life problems. As we know that PISA focuses on daily life real complex problem. In PISA, it is expected that students can use their knowledge to solve PISA questions, which they learn in schools. To be able to solve a problem asked in PISA, students should donate themselves with critical thinking skills, team working, efficient communication, innovation, creativity. If not students are not able to respond some difficult questions, which are asked in PISA, we already know this from Turkish students' PISA scores which have been carried out till now. To illustrate this statement PISA 2015 scores can be given as an example. PISA 2015 science scores of Turkish students are under OECD science test average and Turkish students are not able to solve scientific and daily life problems (OECD, 2016). Turkish 4th grade students' science score (483) is under Trends in International Mathematics

and Science Study (TIMSS) average (500), and 8th grade students' science score is 493 is under TIMSS science score (500). These indicators show us Turkish students have difficulty in STEM fields. Therefore, we decided to determine Turkish students' metaphors on STEM subjects. By this means, overarching qualitative data will be more easy to understand what can be done to enhance students' both achievement and understanding of STEM. The literature which is interested in both STEM Education and Metaphors has been studied but there have not been found any enough studies within those mentioned subjects. To be able to understand what kind of metaphors our students have in their minds the study was conducted. Because, both STEM's aims and metaphors can some deep information of the students' current situations of those disciplines. This gives us some chance to understand our students' level within their science, mathematics, engineering, and technology concepts. The study is thought that as a significant study so it is one of the study which based both STEM Education and metaphors.

### Aim of the Study

The aim of this study is to determine what metaphors seventh and eighth grade students have when they identify STEM subjects.

## Method

This section is seen accompanying some sub-chapters, research method of the study, participants of the study, data collection tool, data analyses and ethics of study.

### Research Method

In this study, qualitative research method was used, and within this context this research was conducted as phenomenography study. To determine and understand the meaning of students' metaphors with regard to STEM subjects were used. Phenomenographic qualitative research method as describes by Marton (1981). The purpose of Phenomenography is to describe some variations of conception that students have some specific phenomenon. Patton (2002), metaphors can help researchers to make some connections between things they may know and things less familiar.

### Participants of the Study

The study was conducted in two different public middle schools, which are located in Ankara, during 2016-2017education year spring term. The schools are in Keçiören and Altındağ district. It can be said that these two schools located in the similar areas within socio-economic, socio-cultural issues. Besides, it is also known that students' science, math and reading achievements are at the similar rate that we know this by looking national exams' results such as TEOG and SBS. The results of the exams' were reached by schools' administrations. 50 seventh grade and 44 eight grade students participated to the study. 45 of them were boys and 49 of them were girls. The real name of students is not given in the article. So their names are given under codes as student 1, student 2 and etc.

### Data Collection Tool

A form was created which has four boxes related to science, technology, mathematics and engineering to be able to written on, those boxes. The data was collected through the participants' completion of the prompt "Science/Tech/Engineering/Math is like . . . because. " 94 seventh and eighth grade students were asked to write their metaphors on STEM subjects. Data collection tool was prepared within document analyze technique. It is known and used one of qualitative research method. 50 seventh grade and 44 eighth grade students, wrote their metaphors in STEM subjects on the forms. Students were asked to write their metaphors on each space. After that, it was asked to complete the statement, from students to write their metaphor After all, students were asked to complete the statement. Some of their answers are given directly as the same they wrote in the results to be understood resources of the answers.

### Data Analysis

The data were obtained from students' metaphors and they were sent to two measurement and evaluation specialists to provide them to be investigated of the data. The data sent to two field specialists for providing validity and reliability. They are specialists in the study fields and specialists in qualitative studies. Specialists took all metaphors and then they determined and classified metaphors under STEM disciplines such as science, technology engineering and math. They put all given metaphors by STEM disciplines. The data was analyzed by using document analyze technique. Specialists did their analyses, independently, and to determine reliability of the data based on Miles and Huberman (1994) compatibility percentage formula was used. It was found 92.48. It can be said if a compatibility percentage is at 70 and above .70, it might be used (Yıldırım ve Şimşek, 2011) and that value should be above 80 % (Miles and Huberman, 1994; Patton 2002). As it can be seen that 92.48 is much higher than .80 so it can be said that this value is enough for the reliability of the data.

### Ethics

After necessary permission was taken from the schools' administrations, school students were informed about the study such as its content, the reason, period of study and which applications would be done during the study. Students were also provided to participate in the study voluntarily. Within this context they were given "Volunteer Participation Form".

## Results

In this section, both the data of the study and included these middle school students' metaphors are given, which were developed STEM subjects, the evaluation and explanations of these metaphors are also given under the relevant categories. To tell all data of the study, there have been created four tables of each disciplines of STEM. In the table1, it is given all metaphors that are created by students on science. In the table 1, it is given all metaphors that are created by students on science.

Table 1. Metaphors of science

| **Metaphor** | **f** | **%** | **Metaphor** | **f** | **%** |
|---|---|---|---|---|---|
| Technology | 11 | 11,95 | Test tube | 1 | 1,08 |
| Art | 7 | 7,60 | People | 1 | 1,08 |
| Life | 6 | 6,52 | Bright spark | 1 | 1,08 |
| Invention | 6 | 6,52 | Biology | 1 | 1,08 |
| Creativity | 5 | 5,43 | Einstein | 1 | 1,08 |
| Research | 5 | 5,43 | Chemistry | 1 | 1,08 |
| Information | 4 | 4,34 | Computer | 1 | 1,08 |
| Experiment | 4 | 4,34 | An amazing place | 1 | 1,08 |
| Finding | 4 | 4,34 | Inventor | 1 | 1,08 |
| Intelligence | 3 | 3,26 | Productiveness | 1 | 1,08 |
| Space | 2 | 2,17 | Cook | 1 | 1,08 |
| Nature | 2 | 2,17 | Learning new things | 1 | 1,08 |
| Design | 2 | 2,17 | Product | 1 | 1,08 |
| House | 2 | 2,17 | Living | 1 | 1,08 |
| Human | 2 | 2,17 | Konowledge | 1 | 1,08 |
| Garden | 1 | 1,08 | Researcher | 1 | 1,08 |
| Laboratory | 1 | 1,08 | Puzzle | 1 | 1,08 |
| Trying | 1 | 1,08 | Deadlock | 1 | 1,08 |
| Cloud | 1 | 1,08 | Pencil | 1 | 1,08 |
| Science | 1 | 1,08 | School | 1 | 1,08 |
| Sun | 1 | 1,08 | Earth | 1 | 1,08 |
| | | | Total | 92 | 100 |

It was determined that the participants constituted 42 different metaphors of "science" subject. It is seen that students mostly used technology (f =11) metaphor when they identified science via that metaphor. Besides, it has been determined that, art (f = 7), life (f=6), invention (f=6), creativity (f=5), research (f=5), information (f=4), experiment (f = 4), finding (f = 4), intelligence (f = 3), research (f = 5) and invention (f = 4). Participants have formed 46 different metaphors about "science" subject. It is also seen that some used metaphors are not

directly related to science such as garden (f=1), cloud (f=1), an amazing place(f=1) , deadlock(f=1) , pencil (f=1). All given concepts have also been classified under some larger concepts which they involve them. These mentioned concepts are "Objectivity, Scientist or some features of scientists, the equipment of laboratories, Productivity, Observation, Relation with other areas, Scientific Research Method, Science, Technological Dimension, Other". So, main concepts and sub-concepts have been created as "Aliveness (life and human), Objectivity (space, Earth, nature, Sun, cloud and garden), Scientist or some features of scientists (intelligence, Einstein, inventor, intelligence human, productiveness, researcher), the Equipment of laboratories (experiment, experiment tube, laboratory) Productivity (invention, creativity, discovery, design, learning new things, house and school), Observation (research), Relation with other areas (technology and art), Scientific Research Method (knowledge), Science (Biology and chemistry), Technological dimension (computer and pencil) and Other (deadlock, puzzle and an amusing place). The reason of some students' answers were asked and their thoughts are directly given below.

> Science is like technology because it creates new machines and equipment. (Student 1, School A)
>
> Science is like laboratory because it applies to many experiments. (Student 3, School A)
>
> Science is like experiment because it investigates everything within scientific issues. (Student 1, School B)
>
> Science is like a research because it wonders Earth. (Student 5, School B)

Four different answers related to science concept are given above. We see some concepts as "technology, laboratory, experiment and research". We can explain first example, Student 1 thinks that science is as technology so it creates new machines and equipment. It can be said this student thinks new machines and equipment cause technology and they feed each other. In the table 2, it is given all metaphors that are created by students on technology.

Table 2. Metaphors of technology

| **Metaphor** | **f** | **%** | **Metaphor** | **f** | **%** |
|---|---|---|---|---|---|
| Invention | 8 | 10,12 | Skill | 1 | 1,26 |
| Reproductivity | 6 | 7,59 | Progress | 1 | 1,26 |
| Design | 5 | 6,32 | Electric | 1 | 1,26 |
| Science | 5 | 6,32 | Oxygen | 1 | 1,26 |
| Life | 4 | 5,06 | Colour | 1 | 1,26 |
| Phone | 4 | 5,06 | Equipment | 1 | 1,26 |
| Development | 4 | 5,06 | Creativity | 1 | 1,26 |
| Internet | 3 | 3,79 | Aim | 1 | 1,26 |
| Wisdom | 2 | 2,53 | Tool | 1 | 1,26 |
| Digital | 2 | 2,53 | Ambulance | 1 | 1,26 |
| Deliberation | 2 | 2,53 | Research | 1 | 1,26 |
| Art | 2 | 2,53 | Communication | 1 | 1,26 |
| Inventor | 2 | 2,53 | Mathematic | 1 | 1,26 |
| Life | 2 | 2,53 | Knowledge | 1 | 1,26 |
| Future | 2 | 2,53 | Calculator | 1 | 1,26 |
| Clock | 2 | 2,53 | Cycle | 1 | 1,26 |
| Newspaper | 1 | 1,26 | Imagination | 1 | 1,26 |
| Eternity | 1 | 1,26 | Formation | 1 | 1,26 |
| Chemistry | 1 | 1,26 | Project | 1 | 1,26 |
| Water | 1 | 1,26 | Cell Phone | 1 | 1,26 |
| | | | Total | 79 | 100 |

It was determined that the participants constituted 40 different metaphors of "technology" subject. It is seen that students mostly used invention (f =18) metaphor while they identified technology via that metaphor. Besides, it has been determined that, reproductivity (f = 6), design (f=5), science (f=5), life (f=4), phone (f=4), development (f=4), internet (f = 3), digital (f = 2), inventor (f = 2), life (f = 2) and invention (f = 2). Participants have formed 79 different metaphors about "technology" subject. It is also seen that some used metaphors are not directly related to technology such as water (f=1), formation (f=1), newspaper (f=1), art (f=1), aim (f=1) and so on. All given concepts have also been classified under some larger concepts which they involve them. These mentioned concepts are "Product, Idiosyncrasy, Relation with other areas, Innovation, Relation with science and

Other." So those mentioned main concepts categorized as Product (invention, phone, internet, watch, discovery, equipment, calculator, tool, newspaper and ambulance), Idiosyncrasy (mind, reproductivity, inventor, information, imagination), Relation with other areas (art), Innovation (design, improvement, creativity, research, formation, progress and processing), Relation with science (science, Oxygen, electric, chemistry and mathematics) and Other (colour, aim, communication, hind-and seek, cycle project and fast food). The reason of some students' answers were asked and their thoughts are directly given below.

> Technology is like invention because it products new things which are very useful for people. (Student 7, School A)
>
> Technology is like design because it creates many different products. (Student 11, School A)
>
> Technology is like tool because it makes tools. (Student 6, School B)
>
> Technology is like life because we use it everywhere for our lives... (Student 20, School B)

Four different answers related to technology concept are given above. We see some concepts as "invention, design, tool and life". We can explain fourth example, Student 20 thinks that technology is like life so we see it and its products in our lives everywhere. In the table 3, it is given all metaphors that are created by students on engineering.

Table 3. Metaphors of engineering

| **Metaphor** | **f** | **%** | **Metaphor** | **f** | **%** |
|---|---|---|---|---|---|
| Design | 9 | 11,84 | Earn | 1 | 1,31 |
| Tree | 6 | 7,89 | Wisdom | 1 | 1,31 |
| Drawing | 4 | 5,26 | Inventor | 1 | 1,31 |
| Figure | 3 | 3,94 | Line | 1 | 1,31 |
| Building | 3 | 3,94 | Invent | 1 | 1,31 |
| Structure | 3 | 3,94 | Occupation | 1 | 1,31 |
| Course | 3 | 3,94 | Sedulity | 1 | 1,31 |
| Mathematics | 2 | 2,63 | Work | 1 | 1,31 |
| Worker | 2 | 2,63 | Ruler | 1 | 1,31 |
| Tool | 2 | 2,63 | Environment | 1 | 1,31 |
| Jigsaw | 2 | 2,63 | Labour | 1 | 1,31 |
| Science | 2 | 2,63 | Technology | 1 | 1,31 |
| Robot | 2 | 2,63 | Humankind | 1 | 1,31 |
| Art | 2 | 2,63 | Repair the building | 1 | 1,31 |
| Balance | 2 | 2,63 | Application | 1 | 1,31 |
| Imagination | 2 | 2,63 | Improvization | 1 | 1,31 |
| Painter | 2 | 2,63 | House | 1 | 1,31 |
| Architect | 2 | 2,63 | Model | 1 | 1,31 |
| Decoration | 1 | 1,31 | Preoccupy | 1 | 1,31 |
| Fundamental Structure | 1 | 1,31 | Block | 1 | 1,31 |
| | | | Total | 76 | 100 |

It was determined that the participants constituted 40 different metaphors of "engineering" subject. It is seen that students mostly used design (f =9) metaphor while they identified engineering via that metaphor. Besides, it has been determined that tree (6), drawing (f=4), figure (f=3), building (f=3), structure (f=3), course (f=3), math (f=2), jigsaw (f=2), science (f=2). Participants have formed 76 different metaphors about "engineering" subject. It is also seen that some used metaphors are not directly related to engineering such as course (f=3), ruler (f=1), humankind (f=1), earn (f=1) , balance (f=1) and so on. All given concepts have also been classified under some larger concepts which they involve them. These mentioned concepts are "Professional, Structure, Plan, Nature, Relation with other areas, Technological, Creavity, Human characteristics and Other." So those mentioned main concepts categorized as Professional (worker, artist, architect, president, tutorage, work, writer, head of schools and job), Structure (construction, mould, repair the building, model and block), Plan (design, drawing, mold and application), Nature (tree and environment), Relation with other areas (mathematics, science, watch and technology), Technological (tool, jigsaw, robot, ruler, arrow and house), Creavity (imagination, invention), Human characteristics to be successful, earn, occupation, labour, mind, inventor, sedulity, mankind,

improvisation and preoccupy) and Other (lesson, balance, game, decoration, warm and potty putty). The reason of some students' answers were asked and their thoughts are directly given below.

> Engineering is like design because it designs and prepares. (Student 11, School A)
>
> Engineering is like building because it builds schools and factories. (Student 30, School A)
>
> Engineering is like imagination because it presents us many things which we use them. (Student 25, School B)
>
> Engineering is like a robot because it creates robots for our works. (Student 17, School B)

Four different answers related to engineering concept are given above. We see some concepts as "design, building, imagination and robot". We can explain second example. Student 30 thinks engineering is building so it builds new structures. In the Table 4, it is given all metaphors that are created by students on math.

Table 4. Metaphors of math

| **Metaphor** | **f** | **%** | **Metaphor** | **f** | **%** |
|---|---|---|---|---|---|
| Operation | 15 | 21,12 | Wisdom | 1 | 1,40 |
| Life | 14 | 19,71 | Transition from primary to secondary education | 1 | 1,40 |
| Count | 12 | 16,90 | Human | 1 | 1,40 |
| Question | 3 | 4,22 | Brain | 1 | 1,40 |
| Science | 3 | 4,22 | Architect | 1 | 1,40 |
| Puzzle | 2 | 2,81 | Noun | 1 | 1,40 |
| Teacher | 2 | 2,81 | Geometry | 1 | 1,40 |
| Future | 2 | 2,81 | Course | 1 | 1,40 |
| Node | 2 | 2,81 | Light | 1 | 1,40 |
| Sleep | 1 | 1,40 | Nature | 1 | 1,40 |
| Guide | 1 | 1,40 | Clock | 1 | 1,40 |
| Flag | 1 | 4,40 | Tree | 1 | 1,40 |
| | | | Total | 71 | 100 |

It was determined that the participants constituted 71 different metaphors of "math" subject. It is seen that students mostly used operation (f =15) metaphor while they identified math via that metaphor. Besides, it has been determined that life (f=6), count (f=4), question (f=3), science (f=3), puzzle (f=2), teacher (f=2), node (f=2). It is also seen that some used metaphors are not directly related to math such as tree (f=1), clock (f=1), noun (f=1) and so on. All given concepts have also been classified under some larger concepts which they involve them. These mentioned concepts are "Qualitative tools, Relation with other sciences, Idiosyncrasy, Professional dimension, Concrete features and Other". So those mentioned main concepts categorized as qualitative tools (operation, count, question, geometry, course), relation with other sciences (science), real life (life) idiosyncrasy (human, sedulity and wisdom), professional dimension (teacher and architect), concrete features (tree, nature, watch, rose, storm and flag) and other (puzzle, name, node, food, brain, TEOG, light, future, guide and to sleep). The reason of some students' answers were asked and their thoughts are directly given below.

> Math is like operation because ıt focuses on numbers. (Student 37, School A)
>
> Math is like life because we see it everywhere in our lives. (Student 22, School A)
>
> Math is like count because it is a kind of art. (Student 38, School B)
>
> Math is like a puzzle because ıt solves our problems which we face in our daily lives. (Student 19, School B)

Four different answers related to math concept are given above. We see some concepts as "operation, life, count and puzzle". We can explain third example. Student 38 thinks math is like count so it has some aesthetic within art. We can also look at a general view to metaphors within all disciplines that are included in STEM. It is seen all those mentioned metaphors in figure 3, and their relation to each other within STEM.

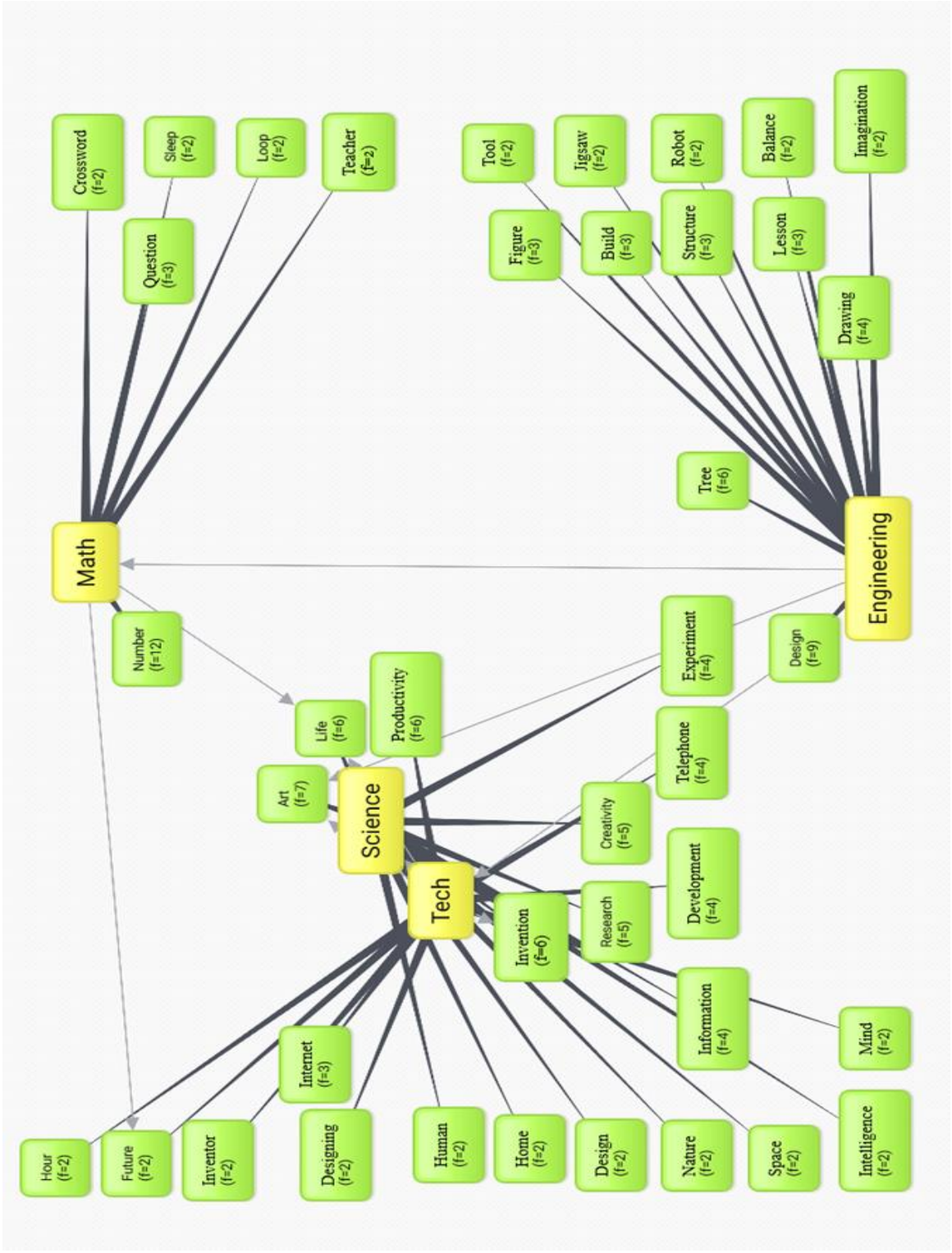


Figure 3. The metaphors developed by middle school students toward science, technology, math and engineering subjects

In figure 3, STEM subjects are given with their metaphors together. Each metaphor is given under the STEM subject which they are related to. The relation of STEM subjects can be seen via figure 3. It is seen some metaphors have been used to each other to identify different STEM concepts. There can be seen some interesting results within the study of students' data of STEM subjects. It is determined that students have complexity when they identify science and technology. It is understood that students have not enough information about the meaning of science and technology subjects. Because students substitute some both science and technology. To exemplify this, we see that creativity, invention (f=6) information (f=4), mind (f=2)

are used for both science and technology. Students have complexity while they identify science so most of them (11,95 %) stated this. Another interesting result is art (7,60 %) respondents were given by students within their metaphors. However, there are some metaphors, which are clearly right to identify science concept, such as invention (6,52 %), research (5,43 %) and laboratory (1,08 %). Another interesting result is some metaphors are not directly related to science concept such as pencil (1,08 %), house (1,08%) and garden (1,08 %). When we focus on technology concept it can be seen most of metaphors are right to identify technology such as invention (10,12 %), reproductivity (7,59 %) and design (6,32 %). However, it is again seen that science was used as a metaphor to identify technology concept. We know both science and technology used to each other within metaphors. We have also found that some metaphors are not related to technology concept such as water (1,26 %), color (1,26 %) and Oxygen (1,26 %).

"Future" metaphor is seen that it has been used to identify both math and science. Another example can be given for math and science. It can be claimed that those students would want to show the relation between math and science. So, some metaphors are not related to math such as tree (1,40 %), noun (1,40 %) and flag (4,40 %). Some metaphors such as life (f=6) and figure (f=2) are used for both science and mathematics. Students created some right metaphors to identify engineering such as design (11,84 %), figure (3,94 %), structure (3,94 %). However, it is also seen that students use math (2,63 %) and science (2,63 %) to identify engineering concept. Besides, some students have complexity while they identify engineering concept via metaphors such as, block (1,31%), humankind (1,31 %) and ruler (1,31 %). Students used some metaphors which are directly related to math concept such as operation (21,12 %), count (16,90 %) and geometry (1,40 %). It has been found that students used science (4,22 %) metaphor to identify math. Besides these, it is also known students have complication on technology and engineering. Because it seen that they used some metaphors to each other as metaphors such as design (f=9), telephone (f=4). All these metaphors show us that students do not know the meaning of STEM subjects enough.

## Discussion and Conclusion

It has been understood from the results that students have complexity when they use their metaphors to identify science, technology, engineering and math. It is also seen from students' statements about their metaphors. All given results let us know that participant students have limited knowledge on STEM subjects. This means they do not know those disciplines' real meaning. It can also be seen from their metaphors. They were asked to identify science, technology, engineering and math. There are some points which strength this statement since some irrelevant metaphors were given under STEM subjects. It can be illustrated for all STEM disciplines within the study framework based results. Science has (pencil and school), technology (ambulance and colour), engineering (ruler and block) and math (noun and light). However, it has not been found many studies on metaphors related to STEM, in literature, there are some studies on metaphors within education. Martinez, Sauleda and Huberb (2001), found in a study which they conducted with teachers that metaphors were achieved by collaboration and majority of those teachers shares traditional metaphors depicting teaching learning as transmission of knowledge. In our study, we also found that the students were not able to write their metaphors easily on STEM subjects. It can be thought that students cannot use their creativity while they have been writing metaphors. It is suggested that some small group activities might be done via using brainstorming, constructivist approach and Inquiry Based Learning approach. It is also seen by looking results of the study that at least confusion has been seen between science and mathematics. There just two metaphors with limited numbers of frequency. Niebert, Marsch, Treagust (2012), claim that it is not possible to think about and understand science without metaphors and analogies. This statement provides us to think that metaphors can be used as important tools to teach STEM subjects. We can strengthen this with a study conducted by Pellas, Kazanidis, Konstantinou & Georgiou (2017) and they state that pupils may co-construct, co-manipulate and examine in collaborative settings in world metaphorical representations, artifacts or primitives to design an innovative knowledge domain using (socio-) cognitive theoretical underpinnings.

### Recommendations

In this study, it was seen that most of students were not able to create true metaphors on STEM subjects when they were asked to write them to identify. As a solution, it can be recommended that students can be supported within STEM applications within selective courses. In this way, they do not do any mistake while they identify STEM metaphors. Besides, teachers can also be supported within STEM Education to get their students to the right way on STEM subjects.

## Note

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