Argumentation Integrated STEM Activity

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Introduction

Science has a wide range of subjects. Due to the fact that these subjects are spread over a wide area and there are difficulties in learning, different alternatives are sought. Approaches such as Toulmin's argumentation model and STEM education can be used in learning sciences. Constructing knowledge using discussion and principles within STEM disciplines suggests that learning will be effective. Therefore, various integrations have been foreseen in order to increase learning in science subjects to a higher level. The integration of the Toulmin argumentation model and the STEM education approach is one of them. Below, first the Toulmin argumentation model, then STEM education, and then the theoretical infrastructure for integrating the two are discussed. Finally, it is aimed to facilitate the understanding of the subject with examples and sample activities.

Argument and Argumentation

Before the concept of argumentation, the concept of argument needs to be defined. Argument is the product of an individual in defending his claims and opinions with evidence. Argumentation, on the other hand, is defined as the process of creating an argument. Although argumentation is seen as a high-level thinking ability of the mind (Scheuer, Loll, Pinkwart, & Mclaren, 2010) for ancient philosophers, it has been explained as a claim and accompanying justification for Toulmin (1958). Argumentation in general; defines a scientific phenomenon as a process that includes both cognitive and social dynamics, involving scientific discussions, in which individuals evaluate, criticize, analyze and provide evidence for explanations verbally or in writing (Aydın & Kaptan, 2014; Simon, Erduran & Osborne , 2006).

Toulmin is determined to be one of the pioneers of informal logic and rhetorical theory today who born in London-England in 1922. He stated that his book "The Uses of Argument", published in 1958, is a model of argument for the analysis of rhetorical arguments. Creating a model consisting of six items, Toulmin also showed that there is a relationship between the items (Aldağ, 2006). According to Toulmin, logical ordinary arguments against a "narrow" approach can be a serious reaction. He noted that the application of these arguments is present in daily life conversations among the public rather than advocates in the legal field. According to Toulmin, each element in the argumentation process will be used in the logical interpretation and judgment of the data. In addition, it is stated that these elements can be used in both experimental and non-

experimental creative and logical calculations, targeting a broad approach. Toulmin's research on light, based on his logical examples, and as a result of this research, comments were made about the argument that emerged with logical knowledge (Zarębski, 2009). In addition, as Toulmin pointed out, he stated that creating an argument is effective even in choosing one of two different objects in daily life, as well as discussions. It is explained that the arguments for beliefs and options should be formed and the principles of decision making and the right options should be determined. In addition, it was stated that the arguments created should have clear goals, as they may be exposed to external threats (Amgoud & Prade, 2009).

Toulmin Argumentation Model

Toulmin focused on discussion and philosophy in his studies in order to form the logic of argument and argumentation. Toulmin defines discussion as an interactive and dynamic process that takes place in such a way that the testing of ideas, the assertions and the evidence, create a social meaning. In the model created by Toulmin (Figure 1); mentions three basic elements (claim, data and warrant). Three more auxiliary elements (backing, qualifier and rejecter (rebuttal)) are used to reinforce these elements. In addition, Toulmin states, changes can be made in the model by adding auxiliary elements when necessary during the process of structuring the knowledge (Akkus, Gunel, & Hand, 2007).

In this model, the claim is the opinion or explanation put forward for the solution of the existing problem. The data includes the facts or observations used to support the claim. The warrant is the reasons for supporting the claim. Backing is examples given to strengthen the warrant. The qualifier indicates the positive aspects of the claim, and the rejecter (rebuttal) indicates the negative aspects of the claim (Simon, Erduran, & Osborne, 2006; Tümay & Köseoğlu, 2011).

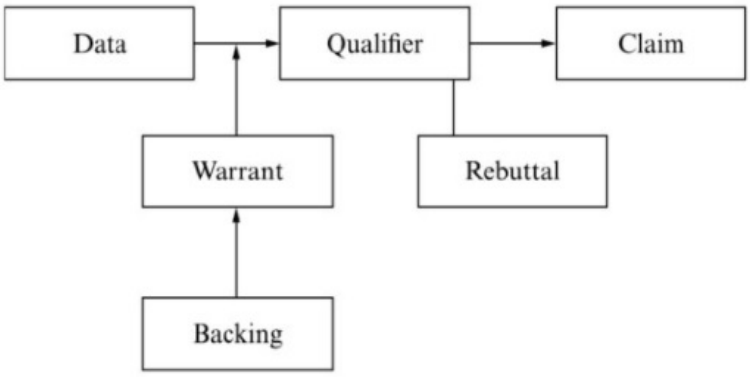

Figure 1. Toulmin's Argumentation Model

The following example can be used to better understand the concepts in the model. If we examine the Ali version of the "Harry" example that Toulmin gives in his studies:

Data: Ali was born in Ankara.

Claim: Ali is Turk.

Warrant: Those born in Ankara become Turkish.

Support (backing): Ankara is Turkey's land.

Qualifier: Those born in this city are Turkish.

Rejecter: If his parent is foreign, he is not Turkish.

When the example of Ali is examined, it is understood that in Toulmin's argumentation logic, the claim is formed based on data and warrant, and this claim is emphasized with supporting, qualifying and rejecting elements. Similarly, when the cigarette example is examined:

Data: Smoking causes serious inconveniences to human health.

Claim: Smoking is harmful.

Warrant: Smoking damages the lungs.

Support: If you smoke, you cough because your lungs are damaged.

Qualifier: My father coughs constantly

Rejecter: Cigarette smoke can kill some harmful bacteria in the body.

Toulmin argumentation model stages are seen in the example of cigarettes, as in the example of Ali. The biggest factor between these two examples is the origin of the claim. As a matter of fact, while the claim is "positive" in the case of Ali, it is seen that the claim is "negative" in the example of cigarettes. These are extremely common. However, it should be noted that when the claim is positive, the qualifier is also positive, but the rejecter is negative. On the contrary, when the claim is negative, the qualifier is also negative, but the rejecter is positive (Amgoud & Kaci, 2006; Scheuer et al., 2010). Now, when we consider both cases with a different example, the following table data can emerge.

Table 1. Example of Toulmin Argumentation Model

Data	Within the scope of the science course, Ceylin and Erva take the task of constructing a simple electrical circuit with the electrical circuit elements given to them. Ceylin uses a battery, a switch and two light bulbs in a simple electrical circuit. Ceylin, who created the electrical circuit with the help of conductors, observed that the bulbs gave light when the switch was closed. Meanwhile, Erva, using the conductor in her hand, added a connection that will divide the circuit into two with the light bulbs on one side and the switch on one side and the battery on the other. It was observed that the bulbs did not light even though the switch was closed at this time.	
Claim	Ceylin knows how to set up an electrical circuit.	Erva does not know how to set up an electrical circuit
Warant	The bulb gave light because it connected the conductor and circuit elements correctly.	If she knew how to connect conductors and circuit elements, the bulb would light like Ceylin's circuit.
Support	In the electrical circuit, the power source and the light bulb must be connected to the same conductor. A "short circuit" happens when another conductor is added in between.	If the conductor is connected with the bulbs on one side and the battery on the other, the circuit is "short-circuited".
Qualifier	Ceylin gets high grades.	Erva gets low grades.
Rejecter	Ceylin's success may be accidental.	By making mistakes, she can reach the right result by trial and error.

When Table 1 is examined, examples of positive and negative claims that can be obtained from the data are presented. Accordingly, only two of the claims that may occur in the Ceylin-Erva event are included. In fact, in this example, it is emphasized that the variety of claims may increase. Therefore, it should be known that the arguments created using claims and elements should be based on scientific data. In addition, the arguments used in proving the claim are important here. Evidence needs to be supported by scientific data (Gülen, 2020; Tsai, 2018). Toulmin's argumentation approach is an application approach that aims to prove his claims made in the light of data (Gülen, 2018). Although there are slight differences between applications, similar steps are generally used (Hall & Sampson, 2009; Sampson & Gleim, 2009). The purpose of this approach is to create the claim from the data, present the claim together with the evidence and support it in the relevant discussions during the argument creation process.

STEM Education

Director of the US National Science Foundation, Dr. Judith Ramaley pioneered the name of the Foundation's integration of Science-Technology-Engineering and Mathematics as STEM for the first time in 2001 (Gülen, 2016; Zouda, 2018). STEM, which emerged as a result of scientific studies and social needs, is an educational approach that is accepted as the new trend of education in the international arena. This approach arose from the competition in international scientific mobility (Ayaz, Gülen, & Gök, 2020; Honey, Pearson, & Schweingruber, 2014).

Increasing economic and scientific developments have caused many countries to compete in the international arena. Countries have turned to education policies in order to be successful in this competition. After Japan's success in every field since the eighties, a similar success came from China, especially the USA aimed to renew its education system in order to achieve the same success. The USA has started to reform education in order to have qualified engineers and workers (Aydeniz et al., 2015). The STEM approach, which has come to the fore as a state policy in the United States since the 2010s, has made a rapid exit with the budget allocated to it. First of all, it was ensured that the growth of STEM business areas was determined and the business world focused on this area with the agreements made with the private sector. The newly opened schools stand out as schools where innovative pedagogies such as project-based learning and engineering design process are applied (Dönmez, 2020; U.S. Department of Education, 2015). With this mobility, it is aimed to obtain employees who have developed metacognitive thinking skills and trained in different disciplines in the business world. Currently, courses such as neurobiology, robotics, microelectronics, bionanotechnology, DNA science, advanced astronomy data and physics laboratory are taught in these schools (Drew, 2011; Pierson, Brady, & Clark, 2020). The situation in the USA is also seen in European countries. Rocard et al. (2007) stated the importance of STEM education in European Union countries in the report titled "Science education now: A new pedagogy for the future of Europe". In the report, the importance of education of science subjects, especially teachers, for the future of countries, was discussed with a social support. Another noteworthy factor here is the perspective of STEM disciplines and the provision of gender balance in vocational acquisition. For this purpose, with the realization of the 7th Framework between 2007-2013 and the HORIZON 2020 programs between 2014-2020, actions for STEM education emerged (Honey, Pearson, & Schweingruber, 2014; MoNE, 2018; Tzu-Ling, 2019).

Studies on STEM education in Turkey were first carried out at Istanbul Aydın University and Hacettepe University. Especially the STEM education laboratory established in Hacettepe University in 2014 has started to make an important contribution to the studies in this field (Aydeniz et al., 2015). In addition, since similar years, the Ministry

of National Education has pioneered the official dissemination of STEM education in the national education community by organizing STEM education seminars and activities to introduce STEM materials to the teachers of pilot schools (Gülen, 2016). Particularly, the recent workshops and symposiums on STEM education by various universities in Turkey affect the promotion of this field. In addition, there are studies to increase incentives for STEM fields in accordance with the vision 2023 policy of both the Ministry of National Education and the Higher Education Institution (Dönmez, 2020). Basically, the targets related to STEM disciplines and their uses in our country's vision 2023 policy are given below.

1. To increase interest in STEM disciplines from an early age,
2. To guide young people to choose STEM disciplines as a career through vocational guidance and counseling activities,
3. To ensure gender balance among students in STEM fields,
4. To train enough and qualified teachers in STEM courses,
5. To increase the intake of scientific and technical courses in secondary education programs,
6. Schools directing students to choose STEM courses and increasing their status in teaching these courses,
7. To provide the infrastructure of STEM disciplines in higher education, to establish education and research laboratories in all disciplines,
8. To make productions in all STEM areas of the country and to ensure that products are an important export item until 2023,
9. To ensure that every individual in the country receives STEM education and to become technical personnel who can work at home, at work and in the industry as qualified individuals in the society.

The said vision 2023 policy will be evaluated with the increase in the number of indicators and targets resulting from STEM education (Dönmez & Gülen, 2021; Gülen, 2020).

STEM Education Aims

STEM education; It aims for every member of the society to do practical training with their family or friends anytime and anywhere as a hobby or professional (National Recearch Council (NRC), 2015). One of the primary aims of STEM education is to ensure that individuals who make up the society have 21st century skills. These skills are;

Learning Skills (such as creative thinking, critical thinking, reflective thinking, making arguments and problem solving), Information and Technology Skills (information literacy, communication technology literacy, media literacy) and Life Skills (flexibility and adaptability, self-management, social skills, productivity and leadership) (Han, Kelley, & Knowles, 2021).

21st century skills and the qualities that an individual should have in solving daily life problems are listed. It is thought that STEM disciplines will be effective in gaining these skills throughout the world, including Turkey (Gülen, 2020). In addition to these disciplines, the individual can reach creative solutions in cooperation by using communication and information technologies and making use of all the opportunities at his disposal (Şahin, Ayar & Adıgüzel, 2014). They can easily create arguments and offer solutions on issues such as elections, environmental pollution, global warming, protection of natural resources, and renewable energy sources that concern all humanity (Marker, 2019; Honey, Pearson, & Schweingruber, 2014). It also emphasizes the importance of these skills due to reasons such as a qualified workforce and gender imbalance that prefer STEM disciplines. Another aims of STEM education is to increase the interest in these fields by enabling students to choose a profession from STEM disciplines in the future (Carnevale, Smith, & Melton, 2011). According to a study conducted by Istanbul Aydın University in 2014; While the occupancy rate of the quotas among the choices made in the fields of science-technology-engineering and mathematics in the 2000s was around 90%, this rate has decreased continuously over the years and has decreased to 38% in 2014. In fact, this rate decreased to 28% in 2010. In addition, while 72% of the preferences in these areas belong to boys, 28% of them belong to female students (Aydeniz et al., 2015). When similar studies and community needs are examined, three important target points for STEM education are determined: These points, which can be determined as economy, quality and choice or preference, have a significant impact on the development of the society and the individual (Aguilera, Lupiáñez, Vílchez-González, & Perales-Palacios, 2021; Gülen & Yaman, 2019).

Since the individual's STEM education from an early age may increase their preferences for STEM professions, the products, inventions or practical solutions made using STEM disciplines will benefit the economic development of the country. The professions preferred by the individual within the framework of STEM disciplines and the 21st century skills gained as a result of STEM education will affect both the elimination of the qualified job or worker shortage of the countries and the development. In addition, individuals who become literate with STEM education will significantly increase their follow-up or future studies for their own professions or business areas. It will be able to produce sustainable solutions from global problems to individual problems with decisions and choices for itself and the world (Gülen, 2016; Zouda, 2018).

STEM Integration

Today, the above-mentioned objectives of STEM education are tried to be implemented at the kindergarten, primary-middle-high school and university levels. Scientific studies are intensifying, especially for the solution of the problems experienced in the integration of STEM education into lower-level classrooms (Dönmez, 2020; Gülen & Yaman, 2019). In this integration, science-technology-engineering and mathematics disciplines should establish a harmonious and complementary context. It was emphasized that the realization of STEM education in schools depends on the integration of the model. Accordingly, integrations such as design-based STEM, Engineering-based STEM, 5E or 7E integrated STEM have been made. In addition to these, it is possible to come across STEM applications with argumentation integrated. In particular, STEM education applications with Toulmin argumentation model integrated are encountered (Ayaz, Gülen, & Gök, 2020; Gülen; 2016; Honey, Pearson, & Schweingruber, 2014;

Toulmin argumentation model integrated STEM education is based on the principle that STEM disciplines and Toulmin argumentation model support each other. The following model was developed based on Toulmin's (1958) model and STEM approach. In this model, students can collect data in a case they come across, create their claims based on these data, and design by determining the tools and materials for this claim. They can perform mental or physical operations on this design. In addition, it can determine the reasons, positive and negative aspects of its claims. At the last stage, they can transform their designs into products by using their tools (Gülen, 2016).

In figure 2 model;

Claim: Opinions or explanations for the solution of the problem.

Data: Events or observations used to support the claim.

Reason (Warrant): These are the reasons why the data support the claim.

Support: Examples are given daily.

Qualifier: Conditions that the claim is valid.

Rejective: Conditions that the claim is invalid.

Technology: It is the equipment used in the product to be built.

Engineering: Design of the product to be built and planning with existing technology.

Mathematics: Processes to solve the problem through the product.

Product: It is the concrete model that students use engineering and mathematics with

technology.

Science: Container concept covering every step described above (Gülen & Yaman, 2019).

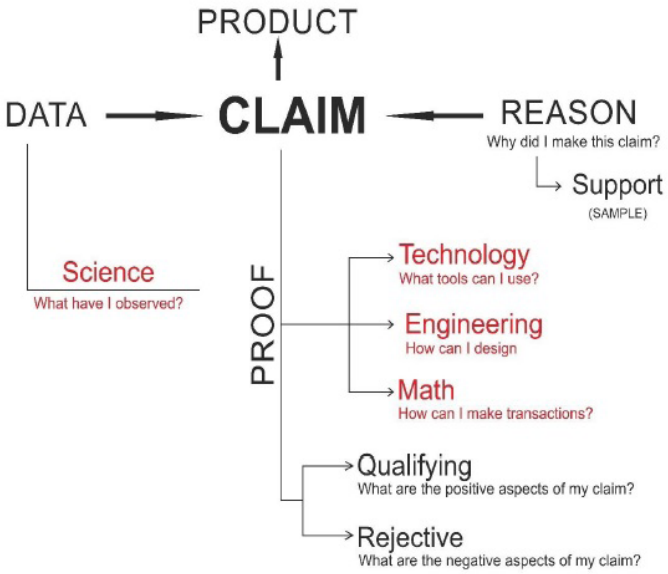

Figure 2. Toulmin Argumantation Integrated STEM Model

The model in the figure shows the use of the Toulmin argumentation model in the integration of the STEM education approach into the science course. In the activities carried out based on this model, the following student studies were obtained.

Example Activity 1

Teacher Salih teaches the planets on the subject of Solar System in Child Science and Technology course (participants are students studying Child Development associate degree program. Students are in the 19-20 age groups). Short documentary films prepared beforehand on the subject were watched. The preparation, editing and montage of these documentary films in accordance with the concepts were made by him. Students watched the movies in the links below.

http://www.biyolojiegitim.yyu.edu.tr/kf/sggezegennk/sggezegennk.mp4

http://www.biyolojiegitim.yyu.edu.tr/kf/sggezegennte/sggezegennte.mp4

After watching the documentary films, the students were given a data collection tool (Appendix 1). Accordingly, the students filled out the data collection tool. Data collection tool; It consists of My Data, My Claim and sections (Only one participant's data is presented below).

My Data

Question1: What did I observe in the video about planets? (Science)

K1. Planets are made up of dust and particles formed around them while Stars are forming.

My Claim

Claim: (I can form the claim based on the data above.)...

K1. The wobble of sunlight allows us to discover Planets orbiting them that are even smaller than Earth.

Question 2. What tools do I use for my claim? (Technology)

K1. Video but I can do it using a telescope

Question 3. How do I design for my claim? (Engineering)

K1. I make a telescope, a telescope capable of deep examination, and I observe the sun for a long time.

Question 4. What action do I take for my claim? (Math)

K1. When I observe the Sun, I think it's a planet blocking its light when a wobble occurs in the Sun's light. I can also calculate the distance of this planet from us by the wobble time of the light.

Warrant: (Why did I make this claim)…

K1: As the planet revolves around the Star, due to gravity, it attracts the star and causes the Star to wobble back and forth. This shows us the Planet.

Support: (I can give an example)…

K1. How long a star is extinguished and how much light is blocked tells scientists the size of the Planet and its distance from the Sun.

Qualifier: (What are the positive aspects of my claim?)…

K1. Thanks to these claims and methods, they think that they will be able to find a habitable Planet in the coming years.

Rejecter: (What are the negative aspects of my claim?)…

K1. Because scientists look through a telescope, they cannot detect Planets. They have to follow the stars to find out if a Planet exists.

As it is understood from the event, after viewing the participant videos and data; it is understood that s/he got information about the formation of planets and got an idea about planet detection. Based on these data, the participant claims that s/he can "discover planets as a result of the wobble of the Sun-Star light". The participant stated that by using a telescope (Technology) or by designing (Design-Engineering) if there is no telescope, they can operate based on the wobbling time of the starlight (Mathematics) so that they can discover planets. As the reason for this claim, the participant stated that there may be wobbles in the light due to the gravitational attraction between the star and the planet. The participant gave an example of calculating the yaw time in the light to support his reasoning. S/He also stated that s/he could obtain information about the size and distance of the planet based on this period. The participant stated that a habitable planet could be discovered in the future as the positive aspect of his/her claim, and that, as the negative aspect, the stars should be constantly followed-observed for planet detection.

Example Activity 2:

Teacher Salih studies NASA data on the ozone layer with his doctoral student. It supports this data with relevant videos on NASA's official website and channels such as YouTube. Below are the links used by the doctoral student to obtain data.

https://ozonewatch.gsfc.nasa.gov/monthly/monthly_2021-04_SH.html

https://www.youtube.com/watch?v=aU6pxSNDPhs

https://youtu.be/BL1ZsAlJKXU

After obtaining the relevant data, a data collection tool was given to the doctoral student. Accordingly, the students filled out the data collection tool.

My Data

Question1: What did I observe in NASA data and Ozone video? (Science)

It is seen that thinning increases in the South Pole between August and November. This causes the ozone density to drop below 220 Dobson and is called a hole. Also, very low temperatures in this region cause -70-80°C ice clouds. Cold is not the only reason for this reason. Population and solar flares also play a role.

My Claim

Claim: (I can form the claim based on the data above.).

Ozone depletion occurs due to the formation of ice clouds.

Question 2. What tools do I use for my claim? (Technology)

Computer, NASA data, polar observable if needed, thermometer, barometer

Question 3. How do I design for my claim? (Engineering)

If I measure the thermometer for air temperature, a barometer for air pressure and the density of icy gas, I can trade.

Question 4. What action do I take for my claim? (Math)

When the temperature values increase, I also examine the cloud density, these increases will show ozone depletion.

Warrant: (Why did I make this claim)…

Although the lowest temperatures start in August, this rate increases especially as September and October.

Support: (I can give an example)…

NASA data showed that thinning increased between August and November.

Qualifier: (What are the positive aspects of my claim?)…

When the average ozone density in the atmosphere is around 200 Dobson, ozone depletion occurs.

Rejecter: (What are the negative aspects of my claim?)…

Ozone depletion is not only affected by cold weather conditions, but also by increasing population and solar flares.

As understood from the event, the doctoral student learned about ozone depletion from NASA data and related videos. Based on these data, the participant claims that "Ozone depletion occurs due to the formation of ice clouds". The participant stated that by using a thermometer, a barometer (Technology), placing it in appropriate places on the pole (Design-Engineering), and using the relationships between the data obtained from these tools (Mathematics), s/he could determine the ozone depletion situation. As the reason for this claim, the participant cited the weather in the South Pole, which started especially in August and became quite cold like September. To support the participant's reasoning, s/he gave the example of the greatest thinning in NASA data between August and November. As the positive aspect of the participant's claim, s/he stated that ozone depletion occurs when the average ozone density in the atmosphere is around 200 Dobson. As the negative aspect of the claim, s/he stated that not only the cold weather conditions but also the increasing population and solar flares had an effect on ozone depletion.

As it is understood from the activities, the participants used the Toulmin Argumentation model and the integration of STEM disciplines (Before the activities, the participants were informed about the Toulmin argumentation model, STEM education and the integration of these two). Thanks to this, claims and all aspects of subjects such as the discovery of planets or ozone depletion have been determined.

Conclusion and Recommendations

Although the Toulmin argumentation model is for the philosophy of argument, it is understood that it can also be used in educational and scientific studies. Toulmin developed a model based on daily life conversations. In fact, today's educational goals are about solving daily life problems. Therefore, the philosophy of the Toulmin model and the educational goals overlap. As it can be used in all areas of society, it is also used in science courses. The basis of this model is to present all aspects of the claim about the subject or problem. This situation seems to be very useful in the science course. As a matter of fact, there are many different subject areas such as abstract, inaccessible (space concepts), dangerous (chemicals) in science courses. In order to understand these issues by students or society, in-depth knowledge is required.

Although STEM education has made a very rapid debut, in fact, the right goals are being imposed at the social level. The use of STEM disciplines is seen as the proportion of STEM occupations, the satisfaction of needs in terms of social welfare and economic power. Almost every subject of science course is related to STEM disciplines. Physics, chemistry, technology, mathematics and even biology are almost all related to STEM disciplines. It would be appropriate to use the principles of STEM education approach in teaching these subjects. Accordingly, many instructors have been using STEM activities in science classes in recent years.

The student is expected to be successful in solving daily life problems, which is one of the main objectives of the science course. One of the aims of STEM education is to enable the individual to use STEM disciplines in solving daily life problems. Similarly, casual conversations are one of the reasons for the development of the Toulmin model. These common goals can be combined into one integration point. Therefore, the Toulmin argumentation model with integrated STEM disciplines can be used to teach science course subjects. The model can be used as in the planets and ozone events given above.

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Appendix 1. Data Collection Tool

My Data

Question1: What did I observe in ……..? (Science)

……..

My Claim

Claim: (I can form the claim based on the data above.).

……..

Question 2. What tools do I use for my claim? (Technology)

……..

Question 3. How do I design for my claim? (Engineering)

……..

Question 4. What action do I take for my claim? (Math)

……..

Warrant: (Why did I make this claim)…

……..

Support: (I can give an example)…

……..

Qualifier: (What are the positive aspects of my claim?)…

……..

Rejecter: (What are the negative aspects of my claim?)…

……..

Product; (Optional)

……..

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