

## Integration of engineering design in early education: How to achieve it

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### Abstract

Young boys and girls make houses and beds from cloths and cartons for their dolls, erect shelters and fences for toy animals, build ramps and garages from blocks for toy cars, and lift objects using a rope and reel for having fun. Thanks to their experiences with such design-based games, children combine science with engineering and try to understand and explain the facts and happenings around them with their own information and explanations. In recent years, the literature heavily provided marked evidence that integration of engineering design into science and maths curricula from preschool up to the end of senior high school offers various learning opportunities. Despite bearing potentials for achieving objectives of preschool education, curriculum integration poses the question of ‘How to achieve the integration’ to preschool teachers. In this research, engineering design methods were introduced to a number of preschool teachers so that they could build a learning environment on engineering design in their classes and then an account of implementation of such an activity as a part of preschool education.

**Keywords:** Engineering design, pre-school period, STEM education.

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## 1. Introduction

Children have the innate capacity of conceptual learning and scientific abilities necessary for reasoning such as asking an unlimited number of questions, solving problems and proposing solutions (Gilliam et al., 2017; Hoisington & Winokur, 2015). They select materials of building used for design by taking into account their structural functions (is this fence high enough to keep the horse inside?), strength (can the wall bear the roof?) and balance features (how can I keep the castle standing?), and they make several combinations of them. Also, they observe the features of the selected building material (rigid, flexible, soft, etc.), the effect of the force applied (gravity and friction) on the material and its design, and they realise that survival, shaking or falling down of structures depends on the force affecting the features of the material and type of design (Hoisington & Winokur, 2015). Thanks to the experience and observations during this kind of design-oriented pedagogical games, children happen to combine engineering skills with science and try to make sense of and explain the physical world with the information and explanations they make up. Although these explanations are generally not scientifically correct (e.g., 'You need to use long blocks to build tall buildings'), they can improve the understanding of combining science and engineering through continuity of curiosity and experience. Such designing activities not only offer kids meaningful experience in sciences, mathematical thinking and engineering but also teach them lexicological and grammatical skills such as making hypotheses, designing, communication and reporting information (Clements & Sarama, 2016; Gilliam et al., 2017; Kanter, 2010; Zan & Geiken, 2010).

The literature suggests that children's early experience with engineering applications has implications for them to follow STEM careers in the forthcoming period (Gilliam et al., 2017; Kanter, 2010; Kier, Blanchard, Osborne & Albert, 2014). In support of this, the Next Generation Science Standards [NGSS] (2013) states that children cannot specialise in the knowledge and skills of STEM disciplines unless they participate in scientific research and engineering practices. For this reason, it is essential for preschool teachers to have knowledge about engineering practices and to teach science subjects along with technology and engineering topics with a design-based and learner-centred approach.

When the relevant literature is examined, it is seen that especially preschool teachers practise design-based activities quite rarely and only few of such practices seem to suffice for the learners to elicit engineering ideas (Akçay, 2015; Balat & Gunsen, 2017; Bers, Seddighin & Sullivan, 2013; Chesloff, 2013; Cinar, 2013; Dejonckheere, De Wit, Van de Keere & Vervaet, 2016; Farran, Plummer, Kang, Bilbrey & Shufelt, 2006). The reason could be preschool teachers' inadequate pre-service and in-service training, lack of resources, lack of parental involvement and teachers' reluctance to collaborate (Bequette & Bequette, 2012; Brenneman, Lange & Nayfeld, 2018; Capobianco, 2013; Felix, Bandstra & Strosnider, 2010; Nathan, Atwood, Prevost, Phelps & Tran, 2011). In this regard, researchers argue that the teacher could be a big obstacle before instruction based on engineering design, but teachers can overcome most obstacles as long as they possess the knowledge and skills for integrating engineering into disciplines such as science and maths by means of training and good guidance (Bagiati & Evangelou, 2015; Kolodner, 2002).

When a glance is taken at the existing scientific researches that pave the way for preschool teachers to prepare a learning environment based on engineering design in their classrooms, the number of researches in preschool context is seen to be smaller than those at other academic levels, especially K-12, despite the crucial role of the former for overall STEM education, and only a little attention is paid to researching engineering design in preschool period (Brenneman et al., 2018; Sullivan, Kazakoff & Bers, 2013; Siu & Lam, 2003). This situation regarding preschool STEM education has been regarded as a research gap and the present research has been planned in an attempt to give an account of how to create a learning setting in preschool classrooms around engineering design. The aim of the study is thus to introduce preschool teachers to engineering design methods for organising a learning setting accordingly and enlighten them about transferring design-based activities into practice in preschool classrooms.

This part of the paper is dedicated to define engineering design and explain how to integrate engineering design into the preschool curriculum.

### **1.1. Engineering design**

As one looks at games' children play at school or outside, they can easily notice that children apply steps such as planning the design process, creating and developing, which indicates their innate affinity for design applications (Fortus, Dershimer, Krajcik, Marx & Naaman, 2004). Moreover, Wendell (2008) argues that design and construction are more appropriate to the nature of children than experimenting and researching due to their innate curiosity towards design practices.

In the report titled 'Framework for K-12 Science Education' by the National Research Council [NRC] (2012), it reads as '...within the framework of learning and teaching, repeated cycle of design offers a huge potential for putting into practice scientific knowledge in the classroom and undertaking engineering practices'. In addition, a number of reports on integration of engineering into curricula (Ministry of National Education [MoNe], 2016; National Academy of Engineers [NAE], 2010) and surveys (Bagiati & Evangelou, 2015; Brenneman et al., 2018; Felix et al., 2010) place emphasis on engineering design. In particular, in the Ministry of Education's (2016) report on STEM, it is stated that the letter E in the acronym, which bridges the gap among STEM disciplines, refers to 'design and production' beyond merely 'Engineering'.

Within the scope of STEM education, engineering design is considered as a pedagogical tool that provides meaningful learning by providing a real-life context for the STEM education approach and achieves integration of other STEM disciplines to science and maths education (Billiar, Hubelbank, Oliva & Camesano, 2014; Daugherty, 2009; Felix et al., 2010). Billiar et al. (2014) point out design process is a logical way to provide content and framework for STEM course activity development due to the fact that design process embodies the nature of problem-solving and the ability to integrate disciplines. Bers and Postmore (2005) state that the engineering design process offers teachers a mechanism to develop STEM activities while helping them gain confidence and skills in the teaching of engineering in the classroom.

Specific researches incorporating science and maths disciplines with engineering show that students are able to achieve more permanent and meaningful learning of targeted scientific concepts as well as acquire engineering conceptions and skills (Felix et al., 2010; Ryan, Camp & Crismond, 2001), they understand that a problem can be represented in more than one single way, solved in more than one way and that these ways can be tested and repeated in a cycle for the most effective solution (Atman et al., 2008; Bers & Postmore, 2005; Fortus et al., 2004; Hynes et al., 2011), and students' attitudes towards and interest in science, maths and technology tend to change for the better (Daugherty, 2009; Gonzalez & Kuenzi, 2012).

The literature offers quite a few engineering design methods that help preschool children live STEM experiences. Despite the abundance of methods describing the design process, they all can be said to follow mono-type procedures. All those engineering design methods require implementation of a set of steps such as identifying the problem, exploring probable solutions, analysing solutions, retesting and evaluating the solutions, and repeating the solution if necessary, presenting ideas, and communication (Brunsell, 2012; Hynes et al., 2011; Leonard, 2005; Nathan et al., 2011). In the report titled 'The Framework for Technology and Engineering Literacy' published by the National Assessment Governing Board (NAGB) (2010a; 2010b), it is underlined that engineering design process should not be limited to one single model and that design process can be carried out in different steps depending on the particular context it will be used. The following chapter gives an overview of the engineering design methods applied in preschool classrooms.

### 1.1.1. Engineering design methods

As also mentioned earlier, in particular, international literature provides various projects and programs based on engineering design for preschool STEM education, which has carried out several studies by using the engineering design process methods. This chapter is devoted to particular methods such as Engineering for Kids (EFK), Cultivating Young Scientists (CYS) and Engineering is Elementary (EIE) along with the design steps since they are predominantly referred to in the literature.

The EFK is a project implemented in the State of Virginia. It considers children as natural engineers and aims to improve the problem-solving skills of children between the ages of 4 and 14 years and to teach engineering to children in both fun and practice. On the EFK, which aims at building a learning centre on engineering design, children learn how to solve problems in depth by using the process of 'Ask, Imagine, Plan, Create, Test, Improve' (Fig. 1). Furthermore, in lots of training occasions in fields ranging from chemistry to space, aviation to construction and electrics to environmental engineering, children are exposed to practices and experiments that improve their hand skills (URL-1, 2018).

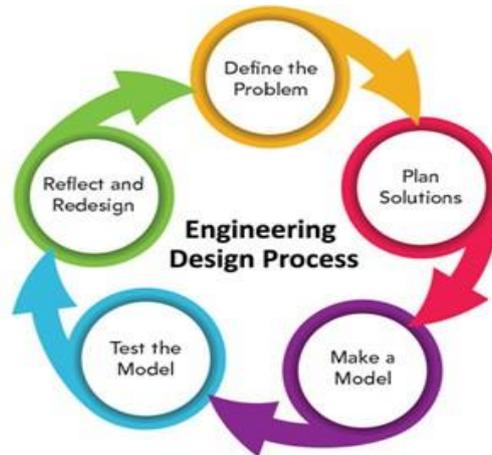


Figure 1. Preschool EFK-Engineering design process model

Another engineering design process model addressed here is the Engage-Explorer-Reflect (EER) cycle, which is implemented on the CYS program developed for preschool teachers in Connecticut-Hartford in the USA (Chalufour & Worth, 2004). On this program, preschool teachers work on the design and design-based units for more than 5 months. After the course, the teachers apply the design-based modules of learning which they developed during the course, in their own classes (classes with 3-, 4- and 5-year-old students).

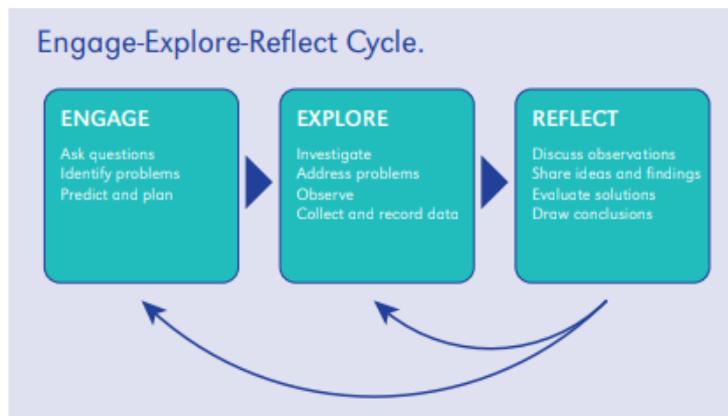


Figure 2. Preschool EERC-Engineering design process model

Another commonplace engineering design model for preschool education is the Engineering Design Process (EDP) cycle (Fig. 3). It is used on the programs called 'Engineering for Wee Kids' appealing to children aged 3–5 years and 'Engineering for Kindergarten Kids' for children aged 5 to 6 as a part of the project called EIE devised by Massachusetts Department of Education (MDOE) in 2006, which introduced school curriculum to engineering education in the USA. The Explore-EDP model used for enhancing pupils' knowledge and skills of engineering, like the others, starts with the step of exploring the problem(s) followed by 'choose applicable criteria', 'design' and 'create', finalised with 'test against the criteria' and 'improve' (URL-2, 2018).



**Figure 3. EDP model**

Furthermore, the EDP model is used by the NASA Education Center in STEM classes under the 'STEM Lesson From Space' program targeting preschool education grades within the framework of the EIE program. The program comprises classes and reference materials about working and life space, space station construction, comets, meteors and asteroids, astronauts, the world and career for use of teachers and pupils (URL-3, 2018). Furthermore, in this research, the EDP method is adopted as a design model that helps preschool teachers create a learning environment based on engineering design.

## **2. Methodology**

One of the objectives of this research is to prepare a sample activity based on engineering design. Therefore, in this chapter, in-detail information is given on a sample activity of that type to be applied in classes and the procedure followed. The activity was prepared by using the EDP method (Table 2).

Can you proceed to the engineering design process in preschool classes immediately? No, we cannot, because there are three important issues to handle before teachers teach the engineering design process in preschool classrooms;

- Writing the design problem scenario that kicks off the engineering design process,
- Presenting the design problem to illiterate pupils,
- Giving pupils an understanding of who an engineer is, what s/he does and how s/he does it.

Remembering that engineering design process is kicked off with a design problem that will meet the needs of children, the teacher should first create a problem scenario in a way that allows pupils to engage in engineering and apply their emotional, physical, cognitive and linguistic skills. Regardless of the foregoing, it would not be difficult to write the scenario when preschool learners' motor,

cognitive, linguistic, social and emotional developmental skills are addressed with an approach in harmony with their surrounding physical environment.

Writing the design problem scenario: To start with, the teacher should select a topic or learning outcome that sits in the heart of the problem scenario. The topic should not be too wide or too narrow. For example, our research is planned around the learning outcome of ‘observes living things’ among scientific learning outcomes in preschool. Next, sub-outcomes and learning areas are listed that are relevant to the central learning area. The learning outcomes and indicators that are thought to be related to the learning area of science in the curriculum are given in Table 1.

**Table 1. Gains and indicators associated with science acquisition**

		Learning outcome 19. Produces solutions to problem situations. Indicators: Tells the problem. Proposes various solutions to the problem. Selects a solution. Tells the reason for the solution s/he chose. Tries the solution chosen. Selects a new solution in case of failure. Suggests creative solutions to the problem.
Cognitive Zone	Development	Learning outcome 9. Sorts objects or things according to their properties. Indicators: Sorts objects/things by length, size, quantity, weight and colour shade.
Motor Development Zone		Learning outcome 4. Makes movements that require the use of small muscles. Indicators: Inserts or removes objects or puts them on a string. Binds objects with different materials. Brings objects together to form new shapes.
Social-Emotional Development Zone		Learning outcome 3. Express oneself in creative ways. Indicators: Expresses emotions, thoughts and dreams in authentic ways. Uses objects extraordinarily. Creates unique products.
Linguistic Zone	Development	Learning outcome 8. Paraphrases what s/he listens/watches in various ways. Indicators: Asks questions about what s/he listens to/watches. Answers the related questions. Tells others what s/he listens to/watches. Exhibits what s/he listens to/watches in various ways such as painting, music, drama, poetry and story.

Afterwards, the common aspects of the learning outcomes are determined and they are turned into a problem. The problem constitutes the content and organisation of the design process which will be taught developed to teach the scientific topic of ‘observes living things’ in the first place. The main theme of the design problem scenario is ‘How can we help a sick meadow spider that cannot build a network for nutrition and shelter?’ (Appendix-1).

Another point is, ‘So, how will you present the problem scenario to the pupils?’ The scenario can be presented with illustrated story cards or puppet playback since the pupils cannot read or write at that stage. In this way, you will also help them better understand and internalise the problem status. In the *Meadow Spider* activity, illustrated story cards were preferred for the presentation of the problem status to the young pupils. However, in the case of the Wee Engineer program, a puppet named by the pupils was used for the activity ‘Noisemaker’.

Another crucial step for a successful design process is to give pupils an understanding of who an engineer is, what s/he does and how s/he does their job. For this purpose, a preparatory phase was planned as shown in Table 2. After the preparatory phase, learners get into the engineering design process with the question: ‘How can we help a sick meadow spider that cannot build a network for nutrition and shelter?’ During the design phase, the pupils create the model following the steps of solving a problem by an engineer, which are *explore*, *create* and *improve*. Finally, they review and assess their design.

The procedure of the preschool activity ‘Let’s Help the meadow spider!’ is described in detail in Appendix-1.

**Table 2. Stages and content of the design activity**

Activity	Content	Method-Duration
Activity-1 Preparation	Students recognise who an engineer is and what s/he does.	All-class: 15 minutes
	Students realise that engineers use design steps to solve problems, learn the Engineering Song, discuss the steps of the EDP and resing the song to remember the steps engineers use to solve problems.	All-class: 20 minutes
Activity-2 Explore	Students are introduced to an engineering problem: The sick garden spider needs a strong spider web.	All-class: 5 minutes
	Students understand the content of the garden spider problem.	Group Work: 10 minutes
	Students investigate the available materials to make a strong spider web.	Group Work: 10 minutes
	Students decide which material can better serve to solve the problem.	Group Work: 10 minutes
Activity-3 Create	Students draw and discuss the spider web design.	Group Work: 10 minutes per group
	Students review the spider web problem.	Group Work: 5 minutes
	Students classify the materials in the spider web design according to their functions.	Group Work: 15 minutes
	Students create the first web designs with adult guidance.	Group Work: 15 minutes
Activity-4 Improve	Students test and assess the web designs.	Group Work: 15 minutes
	Students improve the web designs reflecting on the assessment.	Group Work: 10 minutes
Activity-5 Reflect	Students present their designs.	Group Work: 5 minutes per for each group
	Students exhibit their designs in the classroom.	
	Students resing the Engineering song.	All-class: 15 minutes
	Students notice how to use each step of the Engineering design.	
	The teacher praises the students’ engineering work.	

### 3. Discussion and recommendations

The current preschool curriculum in Turkey is a teaching program that focuses on pedagogical approaches and integrated curriculum (MoNE, 2013). The curriculum includes learning areas and activities about science and maths disciplines, while there are no learning areas related to technology and engineering. Nevertheless, the teachers have the flexibility to integrate science and maths with other disciplines using a variety of materials. As mentioned earlier, instruction materials hinging on engineering design can be taken as a logical pedagogical instrument for integrating STEM disciplines in the preschool period due to their problem-solving nature and being an umbrella for bringing divergent disciplines together (Billiar et al., 2014). Apart from this, there are many characteristic engineering

design process models and steps to be used in the integration of engineering design to preschool education. Because of this, preschool teachers and trainers might perceive the engineering design process as 'complex'. In a research by Guerra-Lopez and Toker (2012), it has been found out that not all of the design processes covered in engineering curricula for K-12 follow a cyclical design process since 8 out of 11 engineering design processes at K-12 level can be repeated in a cycle while the rest follow a linear path. Still, according to the researchers, all these EDP models are bound to similar steps and processes. Moreover, in the face of a problem, engineers select the best solution rather than sticking to a predefined procedure (ITEA, 2007; NAGB, 2010a; 2010b). Teachers can adapt this way of thinking to their classes by applying the steps of engineering design flexibly. In this way, pupils can understand that a problem status may be represented and solved in more than one specific way, the ways are testable and the overall process can be repeated as a loop for the best solution (Atman et al., 2008; Bers & Postmore, 2005; Stohlmann, Moore & Roehrig, 2012).

On the other hand, there is an ongoing debate among researchers about teachers' knowledge and skills for integrating two or more disciplines in one of the STEM fields. The relevant literature reveals that teachers, especially in preschool period, offer only an unsatisfactory environment where children cannot discover engineering ideas and use technology unconsciously for the purpose of passing time (Akçay, 2015; Balat & Gunsen, 2017; Banilower et al., 2013; Brenneman et al., 2018; Capobianco, 2013; Cinar, 2013; Farran et al., 2006; Felix et al., 2010; Nathan et al., 2011; Prevost, Nathan, Stein, Tran & Phelps, 2009). Bequette and Bequette (2012) think that preschool teachers avoid doing design activities in their classrooms due to the lack of pedagogical content knowledge about engineering practices. Researchers suggest that the engineering design process is promising in terms of providing a mechanism for teachers to develop STEM activities and infusing them confidence and skills in teaching engineering design. Also, according to Capobianco (2013), when teachers and prospective teachers participate in design activities, they become more competent in understanding the engineering design process and applying them in their classes. Hence, it can be argued that such an opportunity can be available to teachers and prospective teachers if they are exposed to a curriculum covering activities relying on engineering design process (Brenneman et al., 2018; Capobianco, 2011; Cinar, Pirasa, Uzun & Erenler, 2016; Felix et al., 2010; Nathan et al., 2011). Furthermore, the present research is regarded as significant for broadening horizons for similar researches by describing engineering design and methods and a concrete instruction activity. In particular, the international literature addresses curricula maintaining engineering design activities for teachers. For instance, in the state of Florida, courses titled 'Teaching Science and Technology to Young Children' are taught for preschool teachers at the University of Central Florida as a part of the EIE. Within the scope of that program, teachers of preschool, kindergarten and primary school perform applied activities by using the EDP method. In addition, the teachers are taught the knowledge and skills about how to develop and implement EDP activities in their classrooms. As for Turkey, initiatives are lately taken by Re-De departments under universities, private institutions and Ministry of National Education in order to improve preschool teachers' attitudes towards STEM education and give them the necessary knowledge and skills. However, the early STEM education activities for teachers have a drawback. They target teaching the teachers the STEM field knowledge but ignore pedagogical content knowledge for developing and applying activities based on the engineering design process needed for incorporating engineering design into classes. Therefore, it is considered crucial for early STEM education in Turkey to develop and execute preschool teacher training programs with the theme of engineering design.

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## Appendix-1

### Activity-1. Let’s Help the Garden Spider

Preparation: The purpose of this stage is to raise awareness about engineers and engineering among students. The other purpose is to present and teach the Engineering Design Process to students.

Objective	Content	Method and Duration
Preparation Stage I	Introduction to engineering;	<i>All-class: 15 minutes</i>
	Who is an engineer?	
	What do engineers do?	
	It is taught that engineers are persons who design how to do things.	
	What's noticeable about your shoes?	
	What if there were no engineers designing your shoes?	
	Who do you think imagined how to make this crayon?	
	What are crayons helping us to do?	
	What would happen if engineers hadn't designed crayons?	
	Do you remember what engineers do?	
Engineers use steps to design how to do things. I know a song to remember these steps. It is called the ‘Engineering Song’.		
Do you like singing?		
‘I’m an engineer’		
‘I’m an engineer’		

'I solve problems'

'I'm an engineer'

The Engineering Design Process poster is posted at a spot where everyone can see.

The Explore card (magnifying glass image) is shown to students.

What attracts your attention in this picture?

Engineers make many discoveries when they explore. Remember when you discovered some materials before you made your own tower in previous activities.

You studied them to make the tower long and balanced. Actually, you were making a discovery when you were doing this.

The Create card (hand image) is shown.

- What attracts your attention in this picture?
- When engineers create something, they try to concretise a thought by doing it with their hands.
- Do you remember making your own tower by stacking wooden blocks?
- The Improve card (star image) is displayed.
- What attracts your attention in this picture?
- When engineers improve something they create, they optimise it. If you built a tower using uneven wooden blocks, would it be tall and strong?
- How did you improve your tower to make it better?
- In order to familiarise children with the steps of the engineering design process which are *create*, *explore* and *improve*; the whole engineering song is repeated for a few more times including verse two (a melody known to the children can match this song).

*All-class:  
20 minutes*

Preparation Stage II

"I am an engineer"

"I am an engineer"

"I solve problems"

"I am an engineer"

"I explore first"

"Then I create"

"I improve it for getting better"

"Engineers are brilliant"

"Engineers are brilliant, Hey Hey"

## APPENDIX

### Problem Scenario:

#### THE CURIOUS GARDEN SPIDER

Haylaz, Bıcırık and Zıpzip are three spiders living in the same forest. These spiders are cheerful, love to play games and are very good friends. Haylaz is very curious, Zıpzip loves sleep, and Bıcırık is a lazy spider.



One day; Haylaz, Bıcırık and Zıpzip were playing in the forest. While playing, attention of Haylaz was attracted to a glowing light ahead. Haylaz wondered a lot what the light was. In the meantime, Zıpzip called Haylaz to play. But Haylaz could not forget the glowing light.



After the end of the game; Bıcırık, Zıpzip and Haylaz left to return to their nests. Meanwhile, the shining light was on Haylaz's mind. In order to satisfy his curiosity, Haylaz decided to go where the light was shining.

After the end of the game; Bıcırık, Zıpzip and Haylaz left to return to their nests. Meanwhile, the shining light was on Haylaz's mind. In order to satisfy his curiosity, Haylaz decided to go where the light was shining.



After a little rest, Haylaz understood that it cannot return. It knitted a web to spend the night in the jungle. At that moment, a strong wind came out and heavy rain began.

Due to the severe wind and heavy rain, the web that was woven by Haylaz was damaged. Because it was tired and hungry, Haylaz were not able to repair or renew the web. So how can we help Haylaz?

**Engineering Step: Students make designs towards solving a problem by using EDP stages at this step.**

	<p>The problem status is announced to the whole class.          Come on, young engineers, let's help this garden spider;</p> <ul style="list-style-type: none"> <li>• What is the problem of this spider?</li> <li>• Have you seen a spider which knits a web?</li> <li>• How does it make the web?</li> <li>• What does a spider's web look like?</li> </ul>	
	<p>The Engineering Design Process-EDP Poster is put on the board or on the wall.          The EDP poster is indicated and each step is shown again and the content is taught.          Today, we will investigate materials to learn more about the materials to be used in the construction of spider webs.          Can you help me explore the materials today?          Then we will create a web according to the drawing you have drawn in the construction of the web.          Then we will develop your web. We will make it even better.          The Explore (magnifying glass image) card is shown.          What was the meaning of this card?          What should we do when we see this card?          Students are directed to the material desk.          The students go to the material desk and touch and examine the materials for making spider webs.          Then the group goes back to their desk.          Students are given pieces of paper for drawing and told to draw the spider web they will construct.          Then each group introduces their drawing in front of the class - <u>5 minutes for each group</u>.          Can you tell me about the spider web you drew?          What materials will you use in the construction of this spider web? Why?          Do you think this spider web is good for the garden spider's life? Why?          The Create card (hand image) is shown. Children are informed that it is time to create.          Groups of students are directed to the material desk in turns to pick up the materials they will use for construction. Groups that get their materials are told to start making their models.          Once all groups have taken their materials, children are encouraged to create their first spider webs and test the strength.          Children are assisted in assessing the success of their design by asking questions as follows.</p> <ul style="list-style-type: none"> <li>• Is your spider web strong or weak?</li> <li>• What materials did you use to make the web? Why did you choose them?</li> </ul>	<p><i>All-class:</i>  <b>10 minutes</b></p> <p><i>Group Work:</i> <b>35 minutes</b></p> <p><i>Group Work:</i> <b>35 minutes</b></p>
Explore	<p>Children are advised to try to improve their web to further strengthen it even if it is durable.          The Improve card (star image) is shown. Children are informed that it is time to improve their spider webs.          After all groups have finished their studies, students are asked to present their models in groups - <u>5 minutes for each group</u>.          After each group presents their work, students are asked what they have liked and disliked with the models.          New materials are added to the material desk.          Student groups are encouraged to develop their models and they are given the opportunity to enhance the models.</p>	<p><i>Group Work:</i> <b>35 minutes</b></p>
Create		
Improve		

When children are busy, check their thoughts by asking the following questions:

What have you modified?

Is your spider web more durable than before? Why?

The spider webs are displayed at the teacher's desk or on a table that everyone can see.

The Engineering Song is sung again by the teacher.

Children are reminded of how they use each step of the Engineering Design.

We searched first. We have found more about what materials can be used for making spider webs.

Then we created it. We made a spider web and we tried it.

We have improved the spider web to make it stronger.

We are engineers! We have found the way to make a strong web for the garden spider.

Children are celebrated for the engineering work.

Children are celebrated for their engineering work by saying the following:

You all have put forward a lot of different, creative ideas on how to solve the problem of the garden spider. You guys are great!

- Would you like to be an engineer again?
- In this lesson you have learned how to make a spider web. What kind of stuff would you like to explore next lesson? Why?

Reflect

Tell the children that they can become engineers whenever and wherever they want!

The lesson ends by singing the 'Engineering Song' whole class.

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*All-class:  
15 minutes*