

LEGO® MINDSTORMS® Education EV3

Maker Activities – Secondary School



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mINDSTORMS
education

EV3

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1. Introduction to the Maker Lessons



The LEGO® MINDSTORMS® Education EV3 Maker Lessons have been developed to engage and motivate secondary school pupils, piquing their interest in learning about design, engineering and coding using motorised models and simple programming.

Each lesson provides an initial brief as a starting point. The open-ended prompts allow for unlimited answers and enable the pupils to express a wide range of creative solutions as they sketch, build and test prototypes of the designs that they create.

The teacher's role in these lessons is to provide the pupils with the tools and necessary freedom to connect with and define a problem, make a solution and share what they have made.

Use your creativity to adapt these activities to suit the needs of your pupils.

"The role of the teacher is to create the conditions for invention rather than provide ready-made knowledge."

– Seymour Papert

Classroom Management Tips

Required Materials

- LEGO® MINDSTORMS® Education EV3 Core Set
- Lesson plan
- Student Worksheet for each activity
- Inspirational images for each activity
- Modelling materials already available in your classroom

How much time do you need?

Each lesson is designed to take 90 minutes. If you work in shorter class periods you can break this down into two 45 minute sessions.

Preparation

It is important to establish work groups for the pupils. Groups of two work well. Ensure that each of the pupils has a copy of the Student Worksheet for recording their design process. Alternatively, they can use their own preferred method for recording their design journey. They will also need the LEGO MINDSTORMS Education EV3 Core Set (one set for every two pupils is recommended).

The LEGO® Education Maker (Design) Process



Defining the Problem

It is important for the pupils to define a real problem to solve or to find a new design opportunity from the start. The “Connect” images are provided to help the pupils to think about the design of their solutions. At this stage of the process it is important that you do not show examples of a final or sample solution.



Brainstorm

Brainstorming is an active part of making. Some pupils will find it easier to explore their thoughts through tinkering (i.e. hands-on experimentation) with the LEGO® bricks and others will prefer to record sketches and notes. Group work is essential, but it is important to allow time for the pupils to work alone before sharing their ideas with their groups.



Define the Design Criteria

Discussing and reaching an agreement about the best solution to build can involve a lot of negotiation and may require different techniques that are dependent on the pupils' skills. For example:

- Some pupils draw well.
- Others may build part of a model and then describe what they mean.
- Other pupils may be good at describing a strategy.



Encourage an ethos where pupils can share anything, no matter how abstract it might sound. Be active during this phase and ensure that the ideas that the pupils choose are achievable.

It is important for the pupils to set clear design criteria. Once the solution to the problem has been made, the pupils will return to these criteria, which will then form the basis for testing how well their solution works.



Go Make

The pupils must make one of their ideas using the LEGO® set, they can also use other materials if this is necessary. If they are finding it difficult to build their idea, encourage them to break problems down into smaller parts. Explain that they do not have to come up with the whole solution from the start. Remind the pupils that this process is iterative and they must test, analyse and revise their idea as they go.

Using this Maker process does not mean that you are following an inflexible set of steps. Instead, think of it as a set of practices.

For example, brainstorming may be prominent at the beginning of the process. However, the pupils may also need to brainstorm ideas when they are trying to figure out ways to improve their idea or when they have a bad test result and must change a feature of their design.



Review and Revise Your Solution

In order to help the pupils to develop their critical thinking and communication skills, you may wish to have the pupils from one group observe and critique another group's solution. Peer review and formative feedback helps both the pupils giving, and the pupils receiving the feedback to improve their work.



Communicate Your Solution

The Student Worksheet is helpful for basic documentation of the activity. The pupils can also refer to it when presenting their work in front of the class. You may also wish to use the Student Worksheet as a portfolio for performance evaluations or for the pupils' self-evaluation.



Design criteria example:

The design must...
The design should...
The design could...



The LEGO® Education Maker (Design) Process



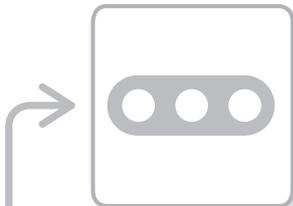
Define the Problem



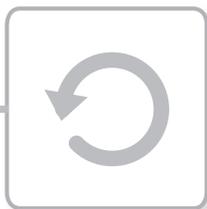
Brainstorming



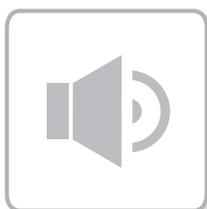
Define the Design Criteria



Go Make



Review and Revise Your Solution



Communicate Your Solution

Assessment

Where can I find the assessment materials?

Assessment materials are provided on the following page for the first three projects.

What learning goals are assessed?

The pupils use the Student Worksheet assessment rubric to evaluate their design work according to the learning goals. Each rubric includes four levels: Bronze, Silver, Gold and Platinum. The intention of the rubric is to help the pupils to reflect on what they have done well in relation to the learning goals and what they could have done better. Each rubric can be linked to engineering-related learning goals.

Share It

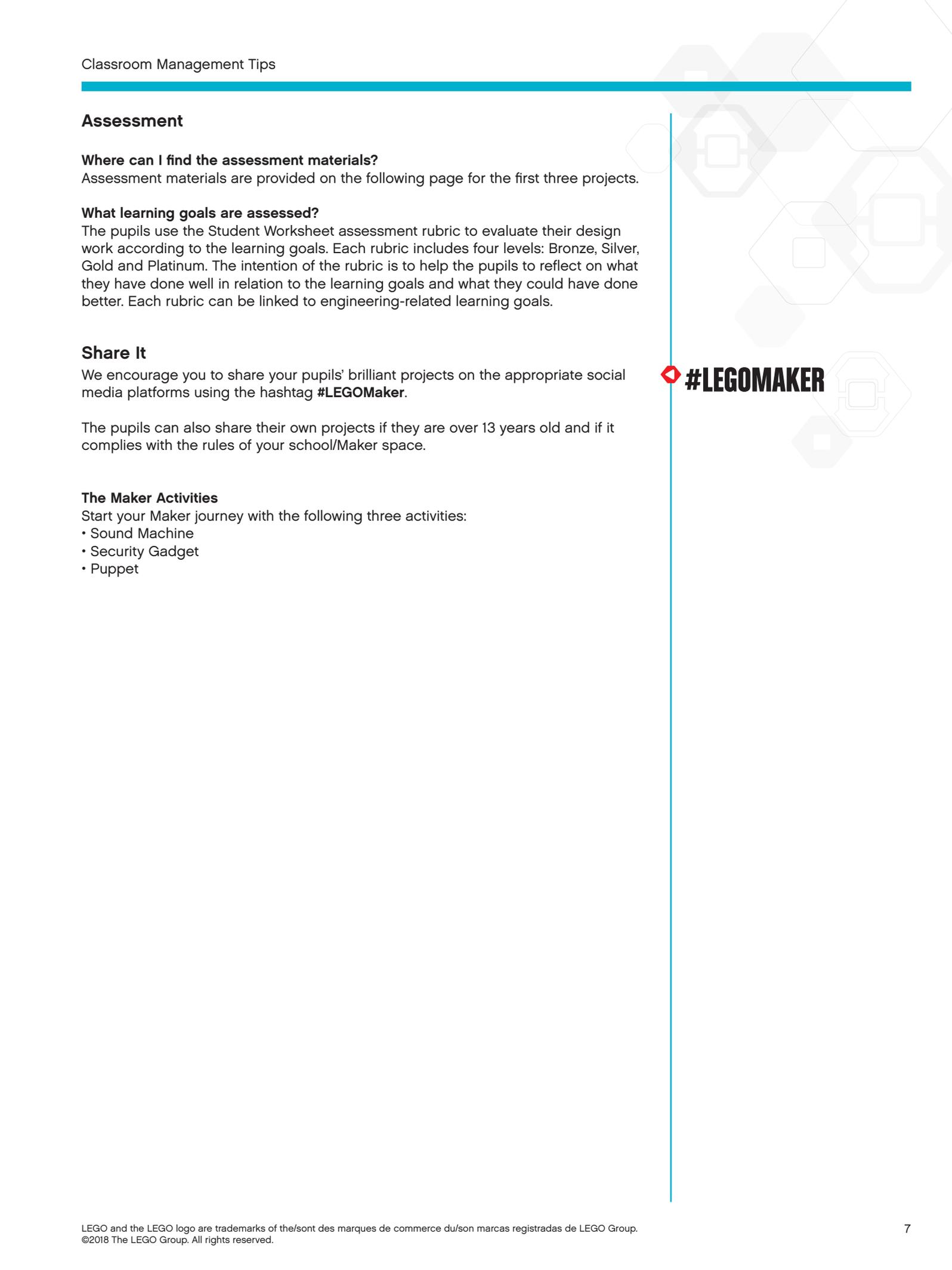
We encourage you to share your pupils' brilliant projects on the appropriate social media platforms using the hashtag **#LEGOMaker**.

The pupils can also share their own projects if they are over 13 years old and if it complies with the rules of your school/Maker space.

The Maker Activities

Start your Maker journey with the following three activities:

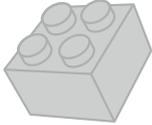
- Sound Machine
- Security Gadget
- Puppet



 **#LEGOMAKER**

Self-Assessment

Name(s): _____ Date: _____

GOALS	 BRONZE	 SILVER	 GOLD	 PLATINUM
Maker task: Sound Machine Designing Solutions	<ul style="list-style-type: none"> We have successfully built and tested one design based upon a single design criterion and design idea. <input type="checkbox"/>	<ul style="list-style-type: none"> We have successfully used two design criteria and ideas to build a solution to a defined problem. <input type="checkbox"/>	<ul style="list-style-type: none"> We have achieved Silver and refined our idea, improving it further through testing, revising and retesting. <input type="checkbox"/>	<ul style="list-style-type: none"> We have achieved Gold and successfully met all three design criteria. <input type="checkbox"/>
Maker task: Security Gadget Defining Problems	<ul style="list-style-type: none"> We have understood the design problem. <input type="checkbox"/>	<ul style="list-style-type: none"> We have defined a design problem and used one design criterion and idea to build our solution. <input type="checkbox"/>	<ul style="list-style-type: none"> We have achieved Silver and used two design criteria and ideas to build our solution. <input type="checkbox"/>	<ul style="list-style-type: none"> We have achieved Gold and used three design criteria and ideas to build an effective solution. <input type="checkbox"/>
Maker task: Puppet Obtaining, Evaluating and Communicating Information	<ul style="list-style-type: none"> We have drawn and labelled the different parts of our design. <input type="checkbox"/>	<ul style="list-style-type: none"> We have achieved Bronze and identified the location of the key component parts that are responsible for making our design work. <input type="checkbox"/>	<ul style="list-style-type: none"> We have achieved Silver and included a diagram showing how our design works. <input type="checkbox"/>	<ul style="list-style-type: none"> We have achieved Gold and used words and a diagram to explain how our new design works. <input type="checkbox"/>

Notes:

Well done! What will you make next?

2. Lesson Plan: Sound Machine

Use this lesson plan to help structure the flow of each lesson.

Learning Goals

After completing this lesson, the pupils will have:

- Used and understood the design process
- Defined a clear design need
- Developed their ability to iterate and improve design solutions
- Developed their problem-solving and communication skills

Duration

2 x 45 mins (90 mins)

Preparation

Ensure that each of the pupils has a copy of the Student Worksheet for recording their design process. They will also need the LEGO® MINDSTORMS® Education EV3 Core Set (one set for every two pupils is recommended).

Other Materials Required (Optional)

Use craft materials that you already have in your classroom to add another dimension to this activity. Some materials could be:

- Rubber bands
- Pipe cleaners
- Thin cardboard
- Construction paper
- Thin wire
- Thin plastic sheets
- Recycled materials
- Foam

Procedure

1. Introduction/Discussion

Hand out the Student Worksheets and allow the pupils to interpret the activity for themselves, or read the Maker 'Connect' text aloud to set the scene.

2. Defining the Problem

As the pupils look at the 'Connect' images and questions, facilitate a discussion to steer them towards a problem or a new design opportunity. Once they have decided upon a problem to solve, ensure that they record this in some way. They can use the worksheet to help structure their project documentation or use their own preferred method to record their design journey.

3. Brainstorm

The pupils should initially work independently, spending three minutes to generate as many ideas as they can to solve the problem. They can use the bricks from the LEGO® set during the brainstorming process or sketch out their ideas in the space provided on the worksheet.



The pupils must define a problem before they can start brainstorming ideas.



It is important for the pupils to spend time tinkering with the LEGO® bricks in order to generate ideas. The goal of tinkering is to explore as many solutions as possible. You can use the tinkering examples that are provided at the end of this material for inspiration or as a means for getting started.

The pupils can now take turns sharing their ideas within their groups. Once all of the ideas have been shared, each group should select the best idea(s) to make. Be prepared to help facilitate this process, ensuring that the pupils choose an idea that is possible to make. Encourage diversity, not all groups have to make the same thing.

4. Define the Design Criteria

The pupils should record up to three design criteria on their worksheets. They will refer to this again as they review and revise their solutions.

5. Go Make

Now the pupils will make one of their group's ideas using the LEGO® MINDSTORMS® Education EV3 Core Set and other materials as needed.

Reinforce the idea that the pupils do not have to come up with the whole solution from the start.

During the making process, remind the pupils to test and analyse their ideas as they go, making improvements where necessary. If you would like the pupils to submit their documentation at the end of the lesson, ensure that they use sketches and photos of their models to record their design journey during the making stage of the lesson.

6. Review and Revise Your Solution

The pupils will test and evaluate their designs against the design criteria that they recorded before they started making their solutions. They can record notes on their Student Worksheets.

7. Communicate Your Solution

Allow time for each pupil or group of pupils to present their solution to the class. A good way to do this is to set out a table that is large enough to display all of the models. If you are short of time, pair off the groups and have them present to each other.

8. Assessment

The pupils will use the Student Worksheet assessment rubric to evaluate their design work according to the learning goals. Each rubric includes four levels: Bronze, Silver, Gold and Platinum. The intention of the rubric is to help the pupils to reflect on what they have done well in relation to the learning goals and what they could have done better. Each rubric can be linked to engineering-related learning goals.

9. Tidy Up

Ensure that you leave approximately 10-15 minutes at the end of the lesson to break down the models and sort them back into the LEGO® boxes.

Take turns to sharing your ideas.



Design criteria example:
The design must...
The design could...
The design should...



How well does it work?
What if...?



Additional Teacher's Notes

Optional Materials

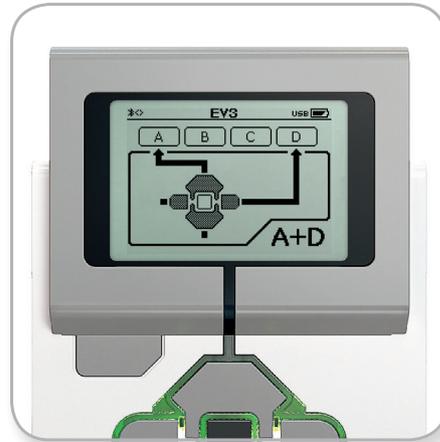
- Plastic or paper cups
- Small musical instruments, such as chimes, bells and small drums

Prior Learning

Before beginning this Maker activity, it is recommended that the pupils know how to use the on-brick motor control function and also how to program a motor to move.



Brick app screen



Motor control

Tinkering Examples

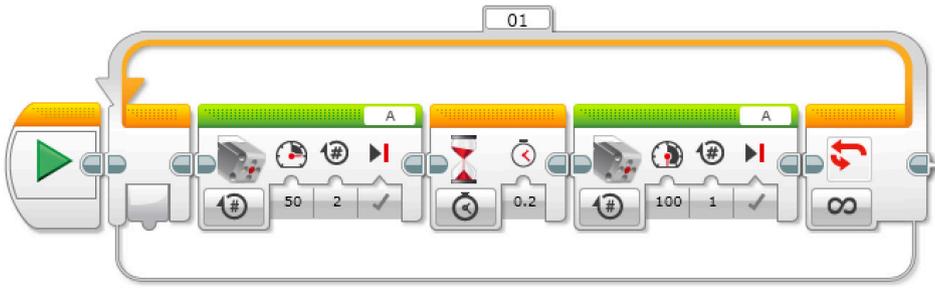
Some pupils may need a little inspiration and scaffolding to help them to get started. The pupils can remix an existing model or invent a new design.

Note: You are advised not to share these images with your pupils.



Sound Machine

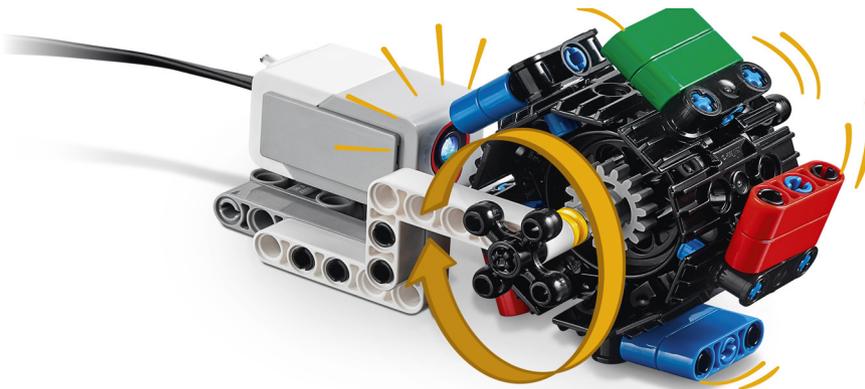
This example program combined with the small model will make a beat and rhythm on any surface when the program is run.



Tinkering Examples

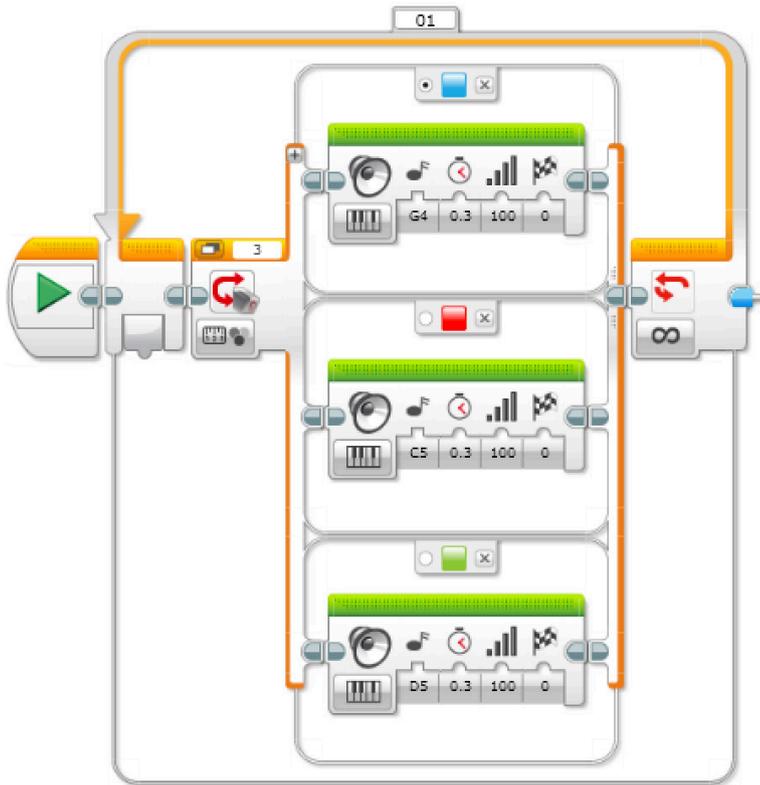
Note: You are advised not to share these images with your pupils.

You can also tinker with the use of sensors.



Sound Machine

This program will play different sounds when the wheel is rotated. The sound is determined by which colour is placed in front of the Colour Sensor.





Sound Machine

Maker Connect

Music is made up of a combination of sounds, notes and rhythm. A rhythm is a regular movement or a repeated pattern of movements that can be used in many different ways. In mechanical machines, a rhythm can help keep a machine running smoothly. It can also be used to generate different sounds in music.

Look at the photos below and answer the questions.

- What do you see?
- Can you see any new design opportunities?
- What problems can you see?
- How could you make use of the LEGO[®] bricks, EV3 Brick, motors and sensors?



Student Worksheet - Sound Machine

Name(s): _____ Date: _____

Defining the Problem

What problems can you see in the pictures? Pick one problem and explain it below.

Brainstorm

Individual work: Now that you have defined a problem, take three minutes to generate ideas for solving it. Be prepared to share your ideas with your group.

Group work: Share and discuss your ideas for solving the problem.

Define the Design Criteria

You should have generated a number of ideas. Now select the best one to make.

Based upon your brainstorming discussion, write out two or three specific design criteria that your design must meet:

1. _____
2. _____
3. _____



Documenting your work is very important in the design process. Record as much as you can using sketches, photos and notes.



Use LEGO® bricks and sketches to explore your ideas.



Sometimes simple ideas are the best ideas.



Design criteria example:
The design must...
The design should...
The design could...



Go Make

It is time to start making. Use the components from the LEGO® set to make your chosen solution. Test and analyse your design as you go and record any improvements that you make.

Review and Revise Your Solution

Have you managed to solve the problem that you defined at the beginning of the lesson? Look back at your three design criteria.

How well does your solution work? Use the space below to suggest three improvements to your design.

- 1. _____
- 2. _____
- 3. _____

Communicate Your Solution

Now that you have finished, make a sketch or take a photo of your model, label the three most important parts and explain how they work. You are now ready to present your solution to the class.



You can use other materials from around the classroom.



Print off your photos, and attach all of your work to a piece of paper or card.



3. Lesson Plan: Security Gadget

Use this lesson plan to help structure the flow of each lesson.

Learning Goals

After completing this lesson, the pupils will have:

- Used and understood the design process
- Defined a clear design need
- Developed their ability to iterate and improve design solutions
- Developed their problem-solving and communication skills

Duration

2 x 45 mins (90 mins)

Preparation

Ensure that each of the pupils has a copy of the Student Worksheet for recording their design process. They will also need the LEGO® MINDSTORMS® Education EV3 Core Set (one set for every two pupils is recommended).

Other Materials Required (Optional)

Use craft materials that you already have in your classroom to add another dimension to this activity. Some materials could be:

- Rubber bands
- Pipe cleaners
- Thin cardboard
- Construction paper
- Thin wire
- Thin plastic sheets
- Recycled materials
- Foam

Procedure

1. Introduction/Discussion

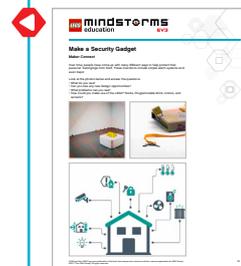
Hand out the Student Worksheets and allow the pupils to interpret the activity for themselves, or read the Maker 'Connect' text aloud to set the scene.

2. Defining the Problem

As the pupils look at the 'Connect' images and questions, facilitate a discussion to steer them towards a problem or a new design opportunity. Once they have decided upon a problem to solve, ensure that they record this in some way. They can use the worksheet to help structure their project documentation or use their own preferred method to record their design journey.

3. Brainstorm

The pupils should initially work independently, spending three minutes to generate as many ideas as they can to solve the problem. They can use the bricks from the LEGO® set during the brainstorming process or sketch out their ideas in the space provided on the worksheet.



The pupils must define a problem before they can start brainstorming ideas.



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The pupils can now take turns sharing their ideas within their groups. Once all of the ideas have been shared, each group should select the best idea(s) to make. Be prepared to help facilitate this process, ensuring that the pupils choose an idea that is possible to make. Encourage diversity, not all groups have to make the same thing.

4. Define the Design Criteria

The pupils should record up to three design criteria on their worksheets. They will refer to this again as they review and revise their solutions.

5. Go Make

Now the pupils will make one of their group's ideas using the LEGO® MINDSTORMS® Education EV3 Core Set and other materials as needed.

Reinforce the idea that the pupils do not have to come up with the whole solution from the start.

During the making process, remind the pupils to test and analyse their ideas as they go, making improvements where necessary. If you would like the pupils to submit their documentation at the end of the lesson, ensure that they use sketches and photos of their models to record their design journey during the making stage of the lesson.

6. Review and Revise Your Solution

The pupils will test and evaluate their designs against the design criteria that they recorded before they started making their solutions. They can record notes on their Student Worksheets.

7. Communicate Your Solution

Allow time for each pupil or group of pupils to present their solution to the class. A good way to do this is to set out a table that is large enough to display all of the models. If you are short of time, pair off the groups and have them present to each other.

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Take turns to sharing your ideas.



Design criteria example:
The design must...
The design could...
The design should...



How well does it work?
What if...?



Additional Teacher's Notes

Optional Materials

- Card or paper
- String

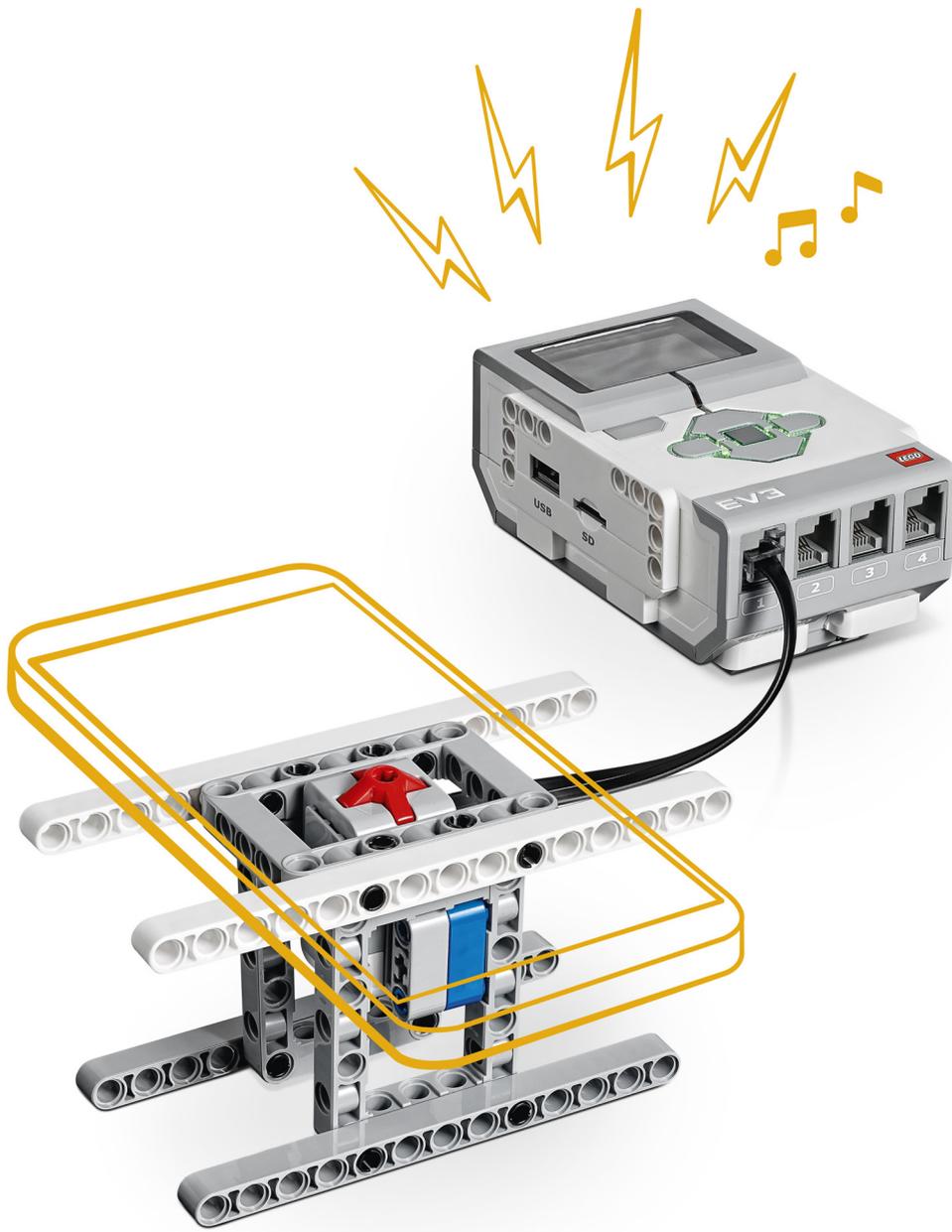
Prior Learning

Before beginning this Maker activity, it is recommended that the pupils know how to use the input sensors.

Tinkering Examples

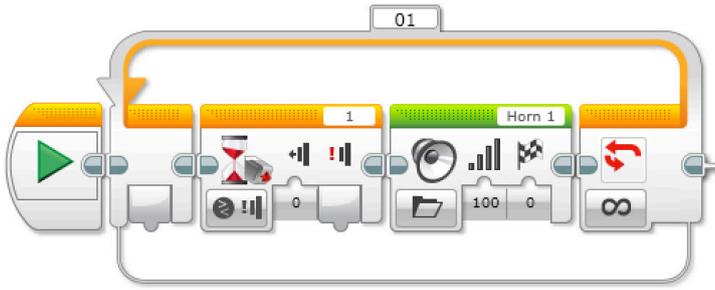
Some pupils may need a little inspiration and scaffolding to help them to get started. The pupils can remix an existing model or invent a new design.

Note: You are advised not to share these images with your pupils.



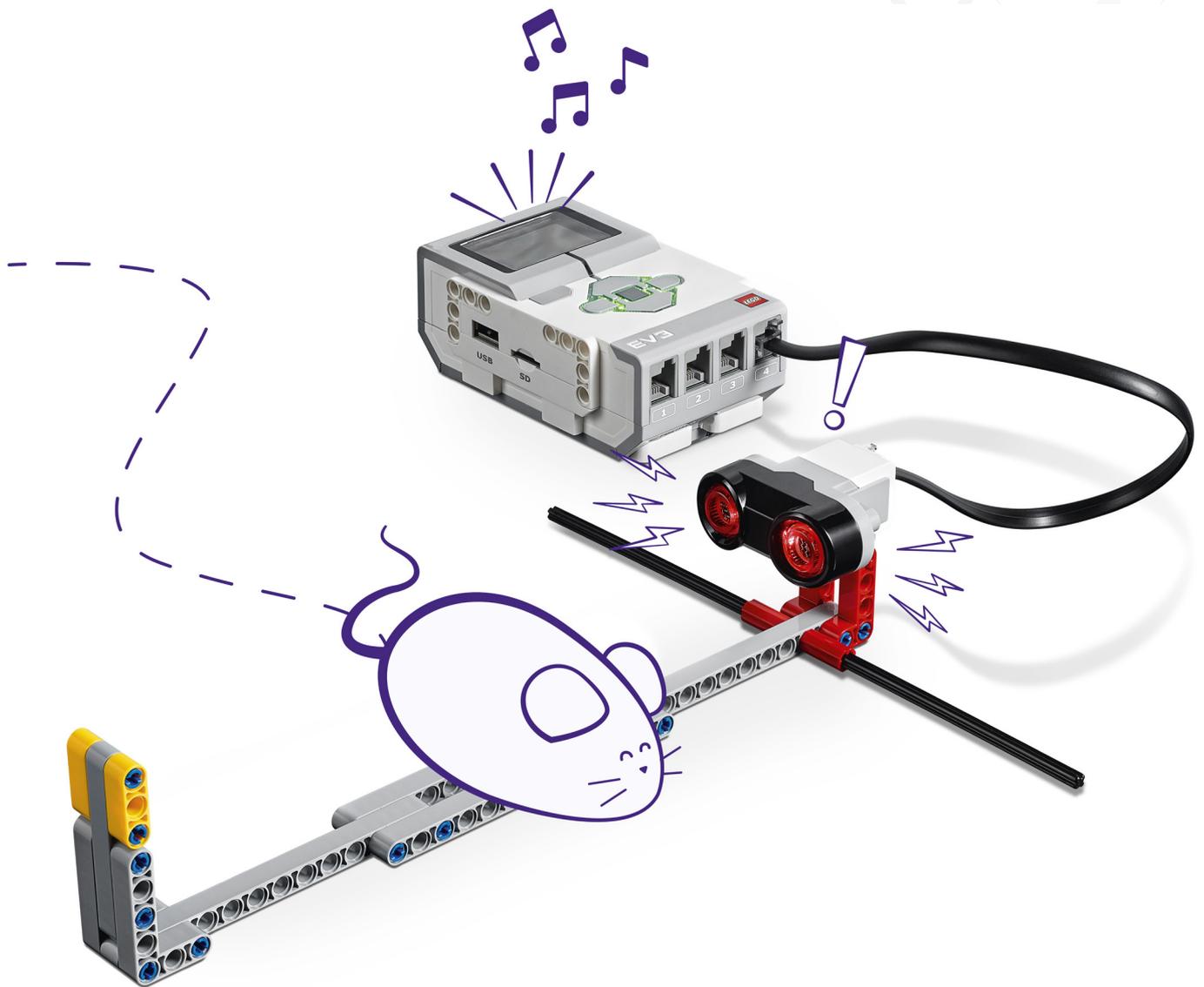
Security Gadget

This program will activate an alarm when an object is lifted from the Touch Sensor.

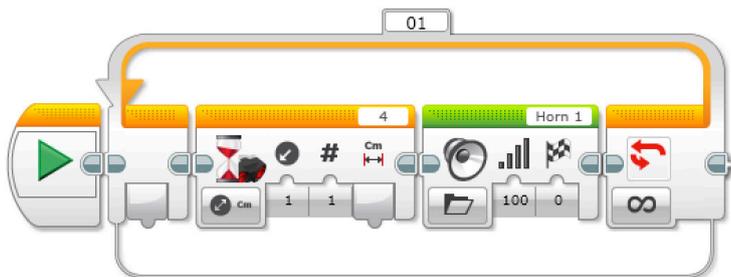


Tinkering Examples

Note: You are advised not to share these images with your pupils.



This program will activate an alarm when an object moves in front of the Ultrasonic Sensor.



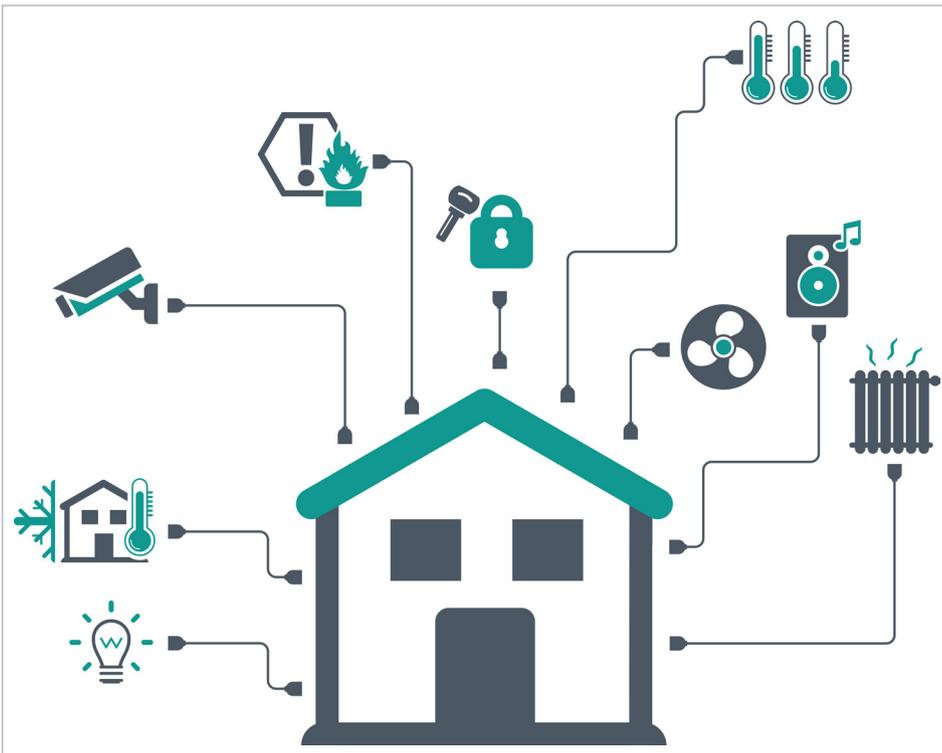
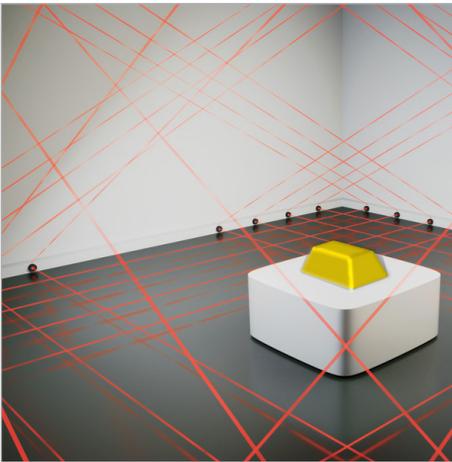
Security Gadget

Maker Connect

Over time, people have come up with many different ways to help protect their personal belongings from theft. These inventions include simple alarm systems and even traps!

Look at the photos below and answer the questions.

- What do you see?
- Can you see any new design opportunities?
- What problems can you see?
- How could you make use of the LEGO® bricks, EV3 Brick, motors and sensors?



Student Worksheet - Security Gadget

Name(s): _____ Date: _____

Defining the Problem

What problems can you see in the pictures? Pick one problem and explain it below.

Brainstorm

Individual work: Now that you have defined a problem, take three minutes to generate ideas for solving it. Be prepared to share your ideas with your group.

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Use LEGO® bricks and sketches to explore your ideas.



Sometimes simple ideas are the best ideas.



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The design should...
The design could...



Go Make

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Review and Revise Your Solution

Have you managed to solve the problem that you defined at the beginning of the lesson? Look back at your three design criteria.

How well does your solution work? Use the space below to suggest three improvements to your design.

- 1. _____
- 2. _____
- 3. _____

Communicate Your Solution

Now that you have finished, make a sketch or take a photo of your model, label the three most important part, and explain how they work. You are now ready to present your solution to the class.



You can use other materials from around the classroom.



Print off your photos, and attach all of your work to a piece of paper or card.



4. Lesson Plan: Puppet

Use this lesson plan to help structure the flow of each lesson.

Learning Goals

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- Defined a clear design need
- Developed their ability to iterate and improve design solutions
- Developed their problem-solving and communication skills

Duration

2 x 45 mins (90 mins)

Preparation

Ensure that each of the pupils has a copy of the Student Worksheet for recording their design process. They will also need the LEGO® MINDSTORMS® Education EV3 Core Set (one set for every two pupils is recommended).

Other Materials Required (Optional)

Use craft materials that you already have in your classroom to add another dimension to this activity. Some materials could be:

- Rubber bands
- Pipe cleaners
- Thin cardboard
- Construction paper
- Thin wire
- Thin plastic sheets
- Recycled materials
- Foam

Procedure

1. Introduction/Discussion

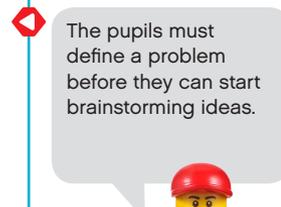
Hand out the Student Worksheets and allow the pupils to interpret the activity for themselves or read the Maker 'Connect' text aloud to set the scene.

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3. Brainstorm

The pupils should initially work independently, spending three minutes to generate as many ideas as they can to solve the problem. They can use the bricks from the LEGO® set during the brainstorming process or sketch out their ideas in the space provided on the worksheet.



It is important for the pupils to spend time tinkering with the LEGO® bricks in order to generate ideas. The goal of tinkering is to explore as many solutions as possible. You can use the tinkering examples that are provided at the end of this material for inspiration or as a means for getting started.

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5. Go Make

Now the pupils will make one of their group's ideas using the LEGO® MINDSTORMS® Education EV3 Core Set, and other materials as needed.

Reinforce the idea that the pupils do not have to come up with the whole solution from the start.

During the making process, remind the pupils to test and analyse their ideas as they go, making improvements where necessary. If you would like the pupils to submit their documentation at the end of the lesson, ensure that they use sketches and photos of their models to record their design journey during the making stage of the lesson.

6. Review and Revise Your Solution

The pupils will test and evaluate their designs against the design criteria that they recorded before they started making their solutions. They can record notes on their Student Worksheets.

7. Communicate Your Solution

Allow time for each pupil or group of pupils to present what they have made to the class. A good way to do this is to set out a table that is large enough to display all of the models. If you are short of time, pair off the groups and have them present to each other.

8. Assessment

The pupils will use the Student Worksheet assessment rubric to evaluate their design work according to the learning goals. Each rubric includes four levels: Bronze, Silver, Gold and Platinum. The intention of the rubric is to help the pupils to reflect on what they have done well in relation to the learning goals and what they could have done better. Each rubric can be linked to engineering-related learning goals.

9. Tidy Up

Ensure that you leave approximately 10-15 minutes at the end of the lesson to break down the models and sort them back into the LEGO® boxes.

Take turns to sharing your ideas.



Design criteria example:
The design must...
The design could...
The design should...



How well does it work?
What if...?



Additional Teacher's Notes

Optional Materials

- Card or paper
- Fabric scraps for decoration
- Coloured felt pens or pencils

Prior Learning

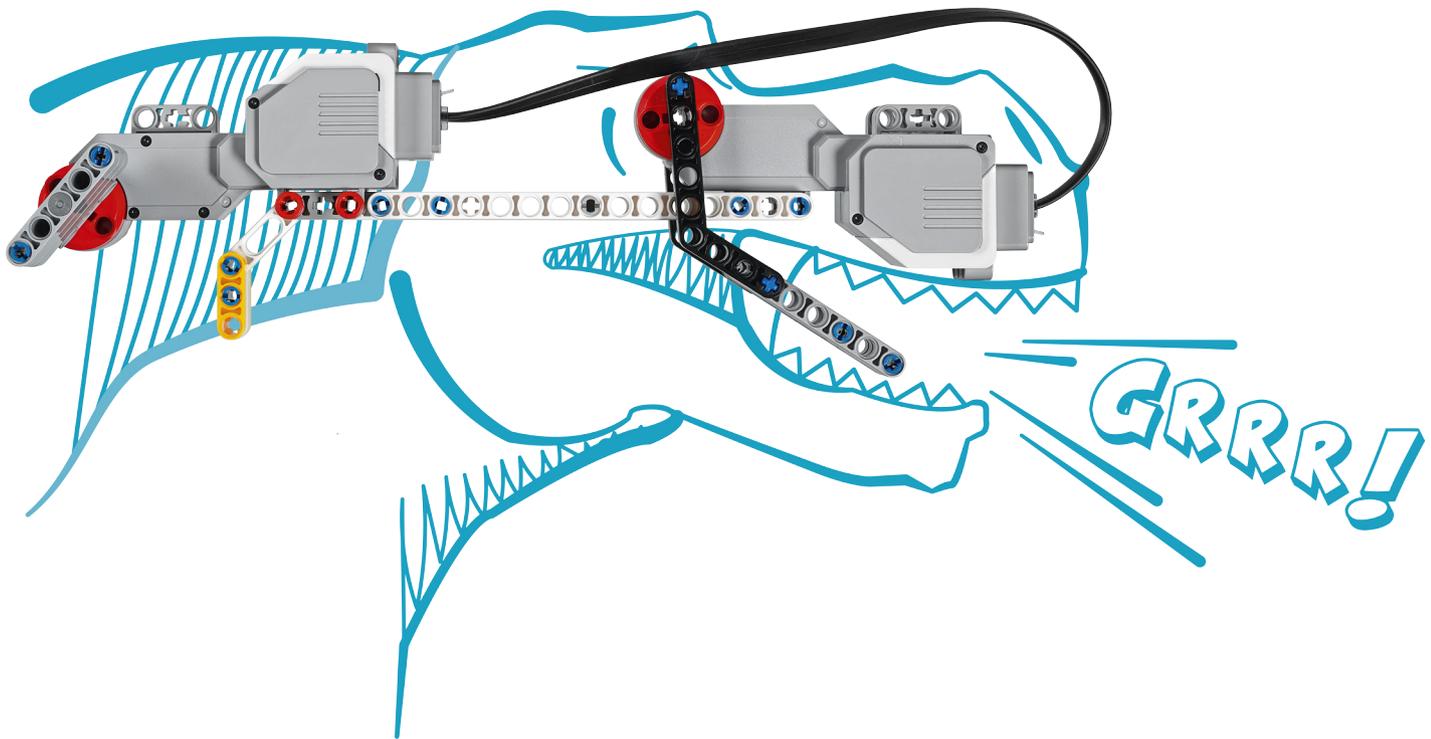
Before beginning this Maker activity, it is recommended that the pupils know how to use the on-brick motor control function and know how to program a motor to move.

The pupils can also try connecting two motors together as this which is a great way to explore movement.

Tinkering Examples

Some pupils may need a little inspiration and scaffolding to help them to get started. The pupils can remix an existing model or invent a new design.

Note: You are advised not to share these images with your pupils.



Puppet

Use this program with the 'Connect' and Large Motor.



Puppet

Maker Connect

Puppets have been used for generations to tell stories and create characters for TV and film. They can be as simple as a thumb puppet or as complex as a moving animatronic dinosaur that is used in a movie.

Look at the photos below and answer the questions.

- What do you see?
- Can you see any new design opportunities?
- What problems can you see?
- How could you make use of the LEGO® bricks and the EV3 Brick?



Student Worksheet - Puppet

Name(s): _____ Date: _____

Defining the Problem

What problems can you see in the pictures? Pick one problem and explain it below.

Brainstorm

Individual work: Now that you have defined a problem, take three minutes to generate ideas for solving it. Be prepared to share your ideas with your group.

Group work: Share and discuss your ideas for solving the problem.

Define the Design Criteria

You should have generated a number of ideas. Now select the best one to make.

Based upon your brainstorming discussion, write out two or three specific design criteria that your design must meet:

1. _____
2. _____
3. _____



Documenting your work is very important in the design process. Record as much as you can using sketches, photos and notes.



Use LEGO® bricks and sketches to explore your ideas.



Sometimes simple ideas are the best ideas.



Design criteria example:
The design must...
The design should...
The design could...



Go Make

It is time to start making. Use the components from the LEGO® set to make your chosen solution. Test and analyse your design as you go and record any improvements that you make.

Review and Revise Your Solution

Have you managed to solve the problem that you defined at the beginning of the lesson? Look back at your three design criteria.

How well does your solution work? Use the space below to suggest three improvements to your design.

- 1. _____
- 2. _____
- 3. _____

Communicate Your Solution

Now that you have finished, make a sketch or take a photo of your model, label the three most important parts and explain how they work. You are now ready to present your solution to the class.



You can use other materials from around the classroom.



Print off your photos, and attach all of your work to a piece of paper or card.



5. Additional Maker Briefs

Once you have completed the first three activities, use the same Maker design process to try out one or more of the activities that are listed below.

1. Table Top Game

Games can help people to make new friends, communicate and share new ideas, and just have fun together. Some examples of this include mini sports games, problem-solving puzzles and games that can help you to remember the things that you have learned in class today.

2. Drawing Machine

We are surrounded by mechanisms and machines that can draw diagrams or print pictures. These devices are often used for drawing repeated patterns and creating abstract art.

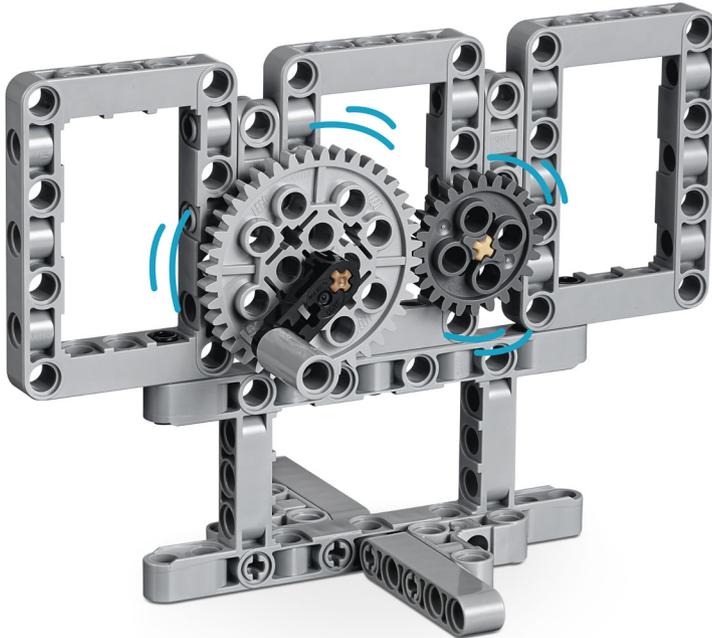
3. Wearables

'Wearables' or 'wearable technology', is being used more and more in everyday life. We see wearable technology in the form of health monitors, mind-controlled and gesture-controlled devices, invisibles, VR headsets and smart watches that can pay for your shopping or even reveal your flight boarding pass! These are just a few of the many products that already exist.

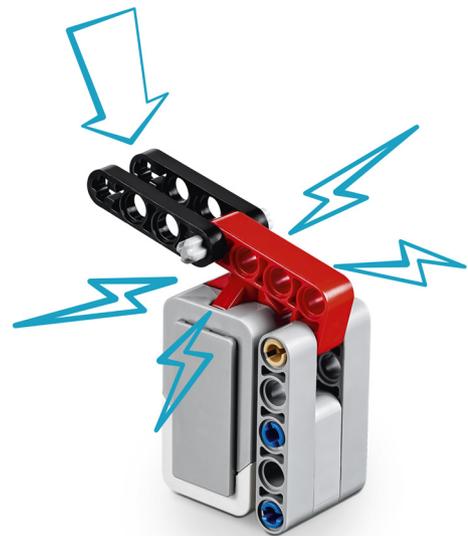


6. Tinkering Ideas

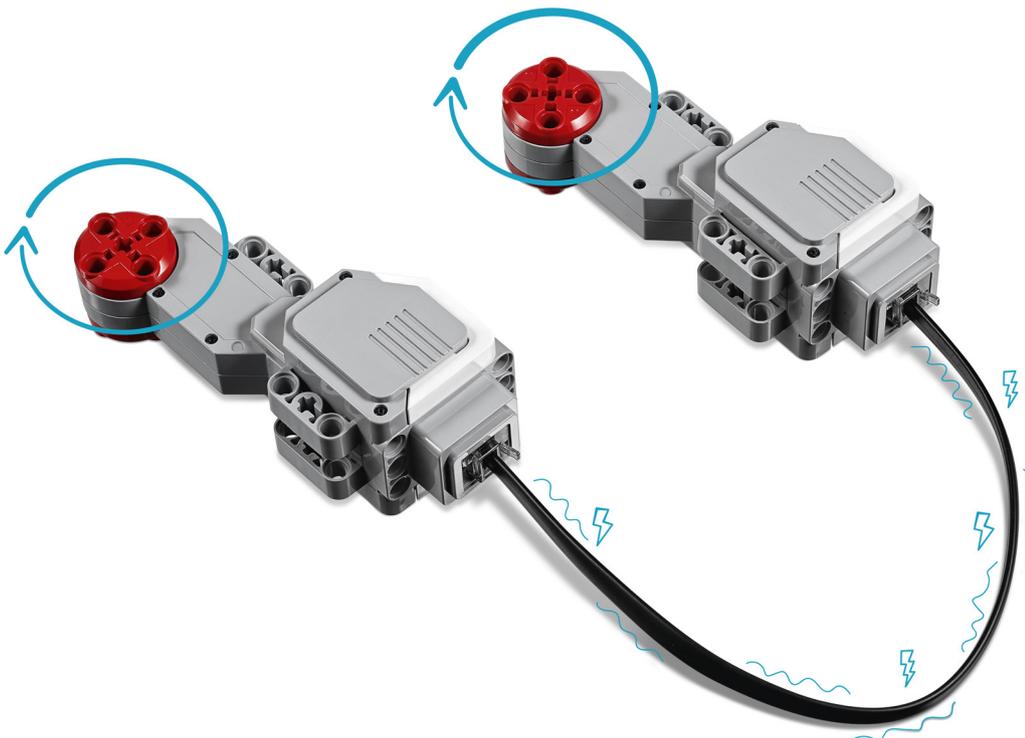
Maker Spaces are often set up with a tinkering wall where pupils can get hands-on inspiration using examples of principle mechanisms. We have provided the following three ideas to help you to get started. See what else you and your pupils can come up with, and please share your models on social media using the hashtag **#LEGOMaker**.



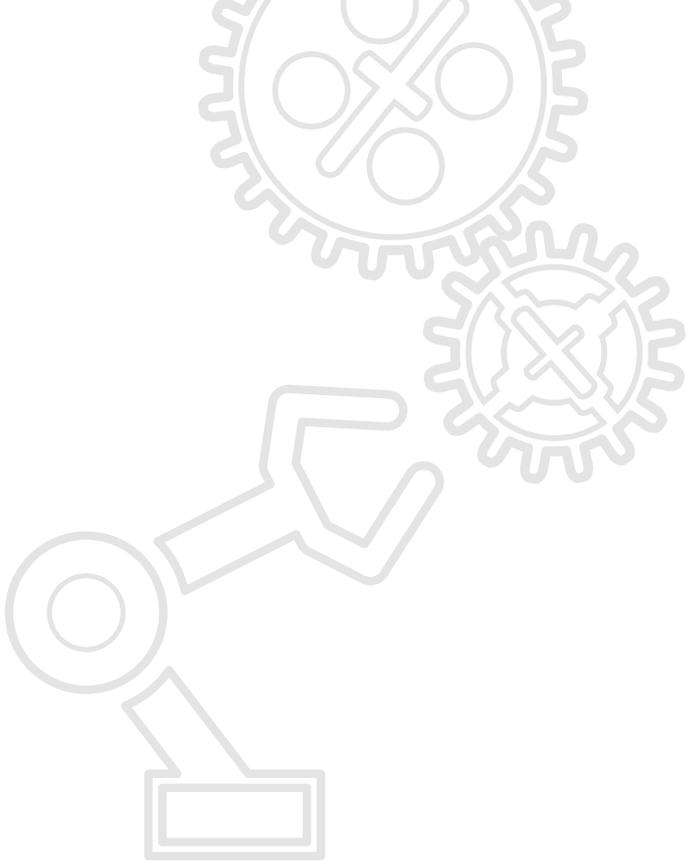
Tinker stand



Switch



Large Motor – to – Large Motor movement



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