

Introduction

The LEGO® Education team is pleased to present the LEGO MINDSTORMS® Education EV3 Science Activity Pack for use in grades six through twelve. These innovative teaching and learning materials will help you to carry out science projects with your students as mapped out in the curriculum.

Who Is It For?

These science experiments will help teachers inspire students to think about the phenomena, principles, and concepts involved in physics and physical science. Students will use a creative process to acquire the knowledge called for in the curriculum. The digital Content Editor, which is integrated into the EV3 Software can further assist teachers in inspiring students to expand their knowledge.

The science experiments help simplify lesson planning and the actual teaching process by providing practical applications for typical science class course content in grades six through twelve. Notes on lesson preparation, learning objective descriptions, pedagogical notes, Building Instructions, predefined programs, and learning success review questionnaires are all provided to help you in the classroom. Extensive experience with LEGO MINDSTORMS EV3 is not a prerequisite for being able to use this material. The forty-eight Robot Educator tutorials will acquaint you with all of its features.

What Is It For?

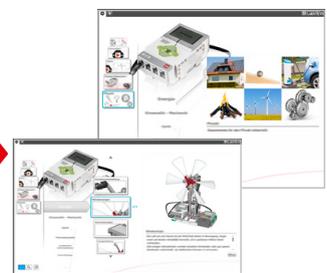
Working in small teams, the students should approach the experiments like physicists. Initially, the class should go over preliminary considerations together, with encouragement to make qualified conjectures about the sequence and results of the experiment. After that, the students conduct the experiment. If several teams are working in parallel, they can explain their methods to each other and compare results. This type of experimental learning requires teamwork, communication skills, and each student to express themselves; it aids in the acquisition and application of engineering procedures, while imparting knowledge of the physical sciences.

What Is in the Pack?

The LEGO MINDSTORMS Education EV3 Science Activity Pack includes fourteen Science Projects in the following Categories:

- Energy
- Force and Motion
- Light
- Heat and Temperature

The multimedia environment contains material for teachers and students. The experiment is at the core of each individual Project, and any necessary preparations (e.g., additional materials such as lamps, fans, or ice) are identified explicitly in the Teacher Notes. The accompanying materials include step-by-step Building Instructions, notes, and background information about the topic or the Category to which the Science Project belongs, along with questionnaires, which include sample solutions. In addition to the LEGO MINDSTORMS Education EV3 Core Set, some Projects require the LEGO MINDSTORMS Temperature Sensor (9749) or the LEGO Education Renewable Energy Add-on Set (9688).



Science Projects

Each Project revolves around an experiment-based assignment. The assignment is organized through the Content Editor, which is integrated into the EV3 Software, which enables multimedia presentation, interaction, and documentation. Its features include:

- Images giving general and detailed overviews of the structure of each experiment
- Notes on how to build or use the models
- Tables to facilitate the structuring and organization of test data and observations
- Data logging tools for sensor data analysis (measured values)
- Software buttons that make it easy to add video clips, photos, and other images as well as text, audio recordings, and webcam recordings

Every student Project contains the following experiment-related pages:

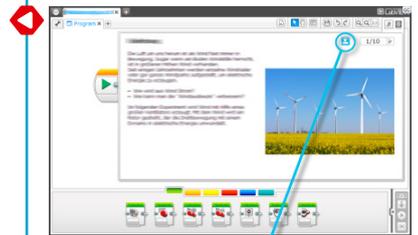
- Introduction
- Preliminary Considerations
- What You Will Do in This Activity
- Building Instructions
- Download Program
- Notes on Using the Model
- Experiment – Measure
- Analyze
- What Did We Measure and What Did We Find Out?
- This Is What We Learned

Each Project also includes two pages to support assessment. These pages include rubrics for evaluating NGSS Practices of Scientists and Engineers and NGSS Cross Cutting Concepts. See the Assessment section for details.

Teacher Mode displays the following pages for each Science Project:

- Information About the Project
- Learning Objectives
- Teacher Notes
- Lesson Preparation
- Notes on Preliminary Considerations
- Notes for Activity Overview
- Construction Notes
- Program Description
- Notes on Using the Model
- Experiment - Measure
- Analyze
- Review
- Report
- Notes on Using the Rubrics
- Learning Success Review

In addition, the Teacher Notes include comments, warnings, suggestions for further experiments, and other helpful information.



Click the button to toggle between the student pages and the Teacher Notes.

Assessment

Where Can I Find the Assessment Materials?

Assessment materials are provided for all fourteen experiments.

You can find the materials in two places:

- As PDF documents in the Lobby menu for each experiment. Find a link to open the document in the Lobby menu explanation for the experiment. You may have to scroll down to see it. Each PDF includes assessment pages for all of the projects in that category. Using the PDF form, assessment pages can be easily opened and printed as handouts for students or for yourself.
- As pages within each of the fourteen Science Experiments (see the description below). This way, assessment is directly integrated into the student's electronic documentation. The EV3 Projects are fully editable, so you can modify the learning goals or formatting.

What Learning Goals Are Assessed?

Learning goals compatible with the Next Generation Science Standards (NGSS) were chosen for each of the fourteen Science Experiments. There is a specific focus on learning goals from the NGSS Practices of Scientists and Engineers, and the NGSS Cross Cutting Concepts.

Each experiment includes two assessment pages:

1. **Practices of Scientists and Engineers:** A rubric page on which students can evaluate their project work according to learning goals based on two practices. A model rubric is provided.
2. **Cross Cutting Concepts:** A second rubric page on which students can evaluate their project work according to learning goals based on one theme. A model rubric is provided.

Each rubric includes four levels: Bronze, Silver, Gold and Platinum. The intention is to help students reflect on what they have done well in relation to the learning goals and what they might do better.

Students can type an X or type in a date to mark the appropriate rubric level.

You can use the rubrics to do your own evaluation of the students' work, adding your own X to the appropriate column. You can also type comments in the Notes column.

You may modify or add to the provided rubrics to satisfy additional assessment goals.

The screenshot shows the EV3 software interface with a focus on the 'Energy Transfer' experiment. It displays a 'Teacher's Guide' with various energy-related icons and a 'Energy Transfer Rubrics' section. Below the rubrics, there are two tables for evaluation: 'Evaluate NGSS Goals: Practices of Scientists and Engineers' and 'Evaluate NGSS Goals: Cross Cutting Concepts'. Both tables have columns for Bronze, Silver, Gold, and Platinum, and a Notes column. A blue arrow points to an 'X' mark in the 'Practices of Scientists and Engineers' table under the 'Bronze' column for the 'Analyze and Interpret Data' goal.

Goal	Bronze	Silver	Gold	Platinum	Notes
Ask for help and feedback	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Plan and Carry out an Investigation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Analyze and Interpret Data	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

Goals	Bronze	Silver	Gold	Platinum	Notes
Patterns	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Cause and Effect	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Scale, Proportion, and Quantity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

How Do I Get Started?

Select the Science option in the EV3 Software menu.

1. Choose between the Categories **Energy**, **Force and Motion**, **Light**, or **Heat and Temperature**, then select a Project.
2. Read the Information About the Project page to learn which grade level(s) the Project is suitable for, how much time to allow for the experiment, and what technical prerequisites are required. The next two pages contain information about the learning objectives and pedagogical methods. The Lesson Preparation page has additional information that you should consider before the class conducts the experiment.
3. The next page provides Building Instructions for the model that will be used in the experiment. Build the model or to have the students build it. Most experiments will also require you to download a program to the EV3 Brick. Before conducting the experiment, students will benefit from scanning ahead to look at the procedure, analysis, reflection questions, and assessment rubrics.
4. Next, carry out the experiment according to the instructions. Some experiments involve producing measurement series whose values are shown on the EV3 Brick display, and some of the values measured will need to be entered in data tables.
5. After the experiment is completed, the students analyze their observations, encourage them to enter comments in the field provided for this purpose.
6. Now the students document the experiment by summarizing their results, entering information in the appropriate field.
7. The students describe what they have learned (physical phenomena), entering their information in the appropriate field.



Classroom Management Tips

How Much Time Do I Need?

The time required for the individual Projects depends on a range of factors, including the students' age, their prior experience with LEGO® MINDSTORMS®, the complexity of the experiment, and the scope of the topic addressed by the Project in question.

There are four Categories containing different numbers of Projects. These Categories correspond to the curriculum established for science in grades six through twelve. Every experiment includes possible variations and options for further investigation. There are no standard solutions that would suggest an exact time allowance. The forty-five-minute time allotment is an approximate indication of how much time an average student will need to build the model according to the Building Instructions and then carry out the experiment. The time allotment does not include the time required for documentation or the Learning Success Review, since these may vary considerably depending on the students' capabilities and the demands placed on them by the teacher.

Additional teaching material for the topics explored in the fourteen Science Projects is available in accompanying PDF files. This material includes background knowledge, definitions, relevant equations, historical facts, ties to modern developments, and inspiration for student research topics. It also includes questions you can use as pre- or post-assessments for the broad range of topics linked with the fourteen Science Projects. Explore this material before using it with your students to ensure it meets your teaching objectives.

The "Science Projects Overview" at the end of this guide shows how the Projects are distributed over the four Categories of study: **Energy, Force and Motion, Light, and Heat and Temperature.**

If you do not have a double period available for the Project, the digital tools will help students save the current status of their work so that they can resume work in the next lesson. Encourage the students to document the process and their results, and to present their work to their classmates. For example, you can ask each team of students to present their own project and discuss the projects in a larger group or as an entire class. This will allow the students to compare their experiences and discuss the reasons behind differing results. One of the main lessons the students will learn in the Science Projects is that no solution is perfect. Every experiment is subject to disruptive factors or unplanned side effects that may skew the results.



Science Projects Overview

Please see page 8.

Energy	Force and Motion	Light	Heat and Temperature
Energy Transfer	Gears	Light Intensity	Friction and Thermal Insulation
Wind Energy	Inclined Plane		Heat Transfer
Solar Energy	Friction		Convection
Energy Efficiency	Velocity		
Electric Vehicles	Acceleration of Gravity		

Classroom Management Tips

How Do I Use the Robot Educator Tutorials with the Science Projects?

The EV3 Software Lobby contains a Robot Educator with a total of forty-eight tutorials. If the students have no prior experience with the EV3 Software, we recommend working through at least a few relevant learning units in the Robot Educator before moving on to the physics experiments. The Data Logging involved in numerous experiments is particularly important.

Some teachers ask their students to work through a few of the tutorials before they are allowed to start building the models. Other teachers inform the class about what hardware and software is available, as the students are building their models. Both methods will lead to the desired outcome.

It is a good idea to go over the menus in the Robot Educator in detail so that the students are familiar with the overall structure and content of the tutorials.

If you prefer to begin by having the students work through the Robot Educator tutorials before starting the Science Projects, you can find more detailed information in the PDF document LEGO® MINDSTORMS® Education EV3 Introduction that is located in the **Teacher's Support** section of the Lobby.

Classroom Management Tips

Use the Content Editor to Create Customized Tutorials

The Content Editor gives you the power to customize the project files included in the Science Projects, allowing you to create lessons tailored to your class' particular needs.

Here are some of the things that you can do:

- Adapt the text to better match your students' reading comprehension skills
- Add pictures that are more relevant to your students
- Modify the assignments to make them easier or more difficult
- Change the Project objectives to either expand or narrow the range of potential experiments
- Formulate your own Project objectives or assignments
- Modify the provided evaluation tools
- Add your own evaluation categories or evaluation tools

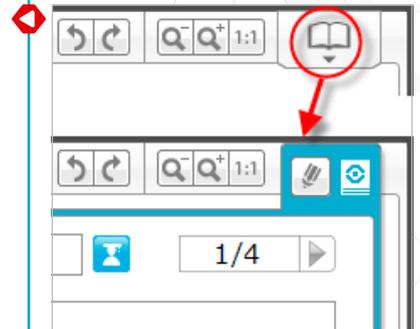
To ensure that you do not overwrite the files included in the Science Projects, any changes are saved as a new project. All of the files included in the original project will also be transferred into the new project file that you can then make available to the students (e.g., on a shared network drive).

The Content Editor can be used to document progress, findings, and results while working through a Project.

The Content Editor allows students to:

- Compose descriptions of their group discussions, methods employed, observations, results, and reflections
- Enter their data in tables
- Post audio recordings of their ongoing work, and recordings related to their discussions and experimental methods
- Import images of pen and paper based charts, graphs, and drawings that support their work on the experiment
- Add their own pages
- Add images and videos showing their own models in action
- Publish their unique projects and share them with fellow students

More information about the Content Editor is available in the Quick Start Videos (open the video called "Content Editor") and in the User Guide located under Quick Start in the EV3 Software Lobby.



Science Projects Overview

