Introduction

The LEGO® Education team is pleased to present the LEGO MINDSTORMS® Education EV3 Science Activity Pack for use in Secondary education (Years 7 - 13). These innovative teaching and learning materials will help you to carry out science projects with your students as mapped out in the curriculum.

Target Group

These science experiments will help teachers inspire students to think about the key phenomena, principles, and concepts involved in physics and physical science. Students will also gain and acquire the knowledge called for in the curriculum as part of a creative process. Teachers will also be able to draw upon the digital Content Editor integrated into the EV3 Software.

The science experiments will help simplify lesson planning and aid the actual teaching process by providing practical applications for typical science class course content and practicals aimed at students from Years 7 - 13. Teacher support is provided in the form of notes to aid lesson preparation, learning objective descriptions, pedagogical notes, Building Instructions, predefined programs, and learning success review questionnaires. You do NOT need to possess extensive experience with LEGO MINDSTORMS EV3 to be able to use this material in your class. Teachers who are unfamiliar with LEGO MINDSTORMS can easily acquaint themselves with its features using the Robot Educator tutorials.

Objective

The students should behave like physicists while working on the science experiments. Every student is assigned to a small team that is given an experiment to conduct. Initially, the whole class goes over preliminary considerations together; students are encouraged to make qualified conjectures about the sequence and results of the experiment. After that, the students will conduct the experiment following the instructions. 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 an ability on the part of each student to express themselves; it aids in the acquisition and application of engineering procedures while imparting knowledge of the physical sciences.

Content of the Pack

Science projects

The 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. Prior preparations (e.g., preparation of additional material such as lamps, fans, or ice) are identified explicitly in the teacher notes. The experiment to be carried out is at the core of each individual project. The accompanying materials include step-by-step Building Instructions, notes, and background materials about the topic or the category to which the science project belongs and with questionnaires (including 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 integrated into the EV3 Software, whose features enable multimedia presentation, interaction, and documentation. It includes the following features, among others:

- Images of the structure of the experiment, both in the form of general overviews and at the detailed level
- 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 project for students contains the following pages related to the experimentation process:

- Introduction
- Preliminary Considerations
- Building Instructions
- Download Program
- Notes on Using the Model
- Experiment – Measure
- Analyse
- What Did We Measure and What Did We Find Out?
- This Is What We Learned
- On to New Discoveries

The Learning Success Review can be performed using questionnaires handed out by the teacher.

While working on the science projects, pages with teacher notes will be displayed in Teacher Mode. These will include:

- Information About the Project
- Learning Objectives
- Teacher Notes
- Lesson Preparation
- Notes on Preliminary Considerations
- Experiment – Measure
- Analyse
- Review
- Report
- Learning Success Review

In addition, the teacher notes include comments, warnings, suggestions for further experiments, and other helpful material.
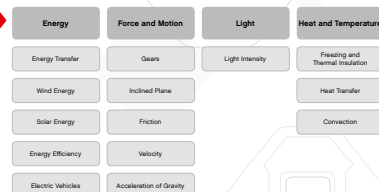
Click the button to toggle between the student pages and the teachers' notes.

Lesson Sequence

Select the Science option in the EV3 Software menu.

1. Choose between the categories Energy, Force and Motion, Light, or Heat and Temperature and select one of the projects offered.

2. Read the page with Information About the Project to learn what 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 having the class conduct the experiment.

3. The next page provides Building Instructions for the model required in the experiment you selected. The next step is to build the model or to have the students build it. Most experiments will now require you to download the program as well.

4. Next, carry out the experiment according to the instructions. The instructions may vary from experiment to experiment. 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. Observations made while conducting the experiment should then be analyzed; encourage the students 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.

Lesson Organization Tips

Time required

The time required by 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 Years 7 - 13. 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 Instruction 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.

There is additional teaching material available in accompanying PDF files for the topics explored through the fourteen science projects. This material consists of background knowledge, definitions, relevant equations, historical facts, ties to modern developments, and inspiration for student research topics. Also included in this material are 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 projects are distributed over the four categories as follows:

Energy
• Energy Transfer
• Wind Energy
• Solar Energy
• Energy Efficiency
• Electric Vehicles

Force and Motion
• Gears
• Inclined Plane
• Friction
• Velocity
• Acceleration of Gravity

Light
• Light Intensity

Heat and Temperature
• Freezing and Thermal Insulation
• Heat Transfer
• Convection

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 on their projects in the next lesson. Students are encouraged to present their work to classmates by having to document the work process and their results. For example, you can ask each team of students to present its own project or discuss the projects in a larger group or as an entire class. This will allow students to compare their experiences and discuss the reasons behind differing results. One of the main lessons the students will learn in the physics projects is that no solution is perfect. Every experiment is subject to disruptive factors or unplanned side effects that may skew the results.

Tying the Tutorials Provided in the Robot Educator into 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 while 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, so that they will know how to locate information there.

If you prefer to begin by having the students work through the Robot Educator tutorials before starting the physics projects, you can find more detailed information in the PDF document Robot Educator – Introduction that is located under the Teacher's Guide section of Robot Educator.

Content Editor

Customized instructions

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's particular needs. Here are some of the things that you can do:
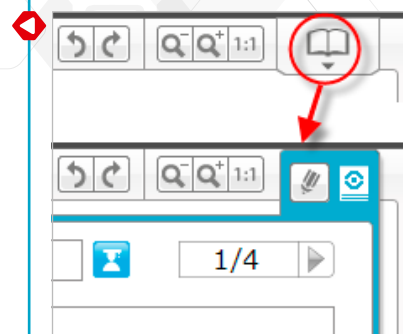

- Adapt the text to better match your students' reading comprehension skills

- 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

- Add your own evaluation categories or evaluation tools

To ensure that you do not overwrite the files included in the science projects, any changes made are saved as a new project. All of the files included in the original project will also be transferred into the new project file so that you can then make them 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 the respective project. It 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 on the experiment and recordings related to their discussions and experimental methods;

- 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)

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