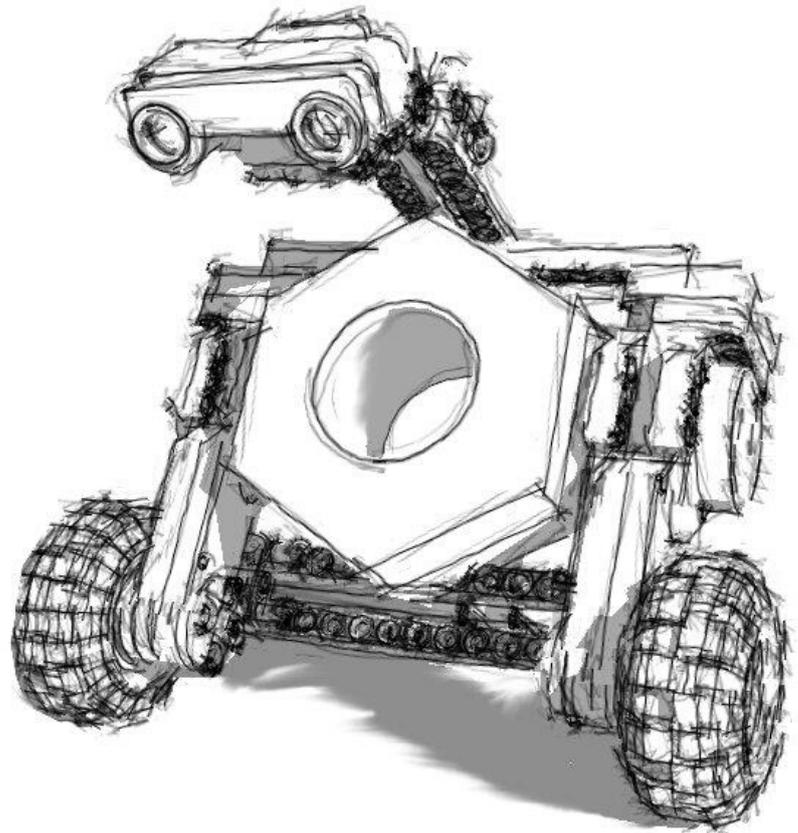
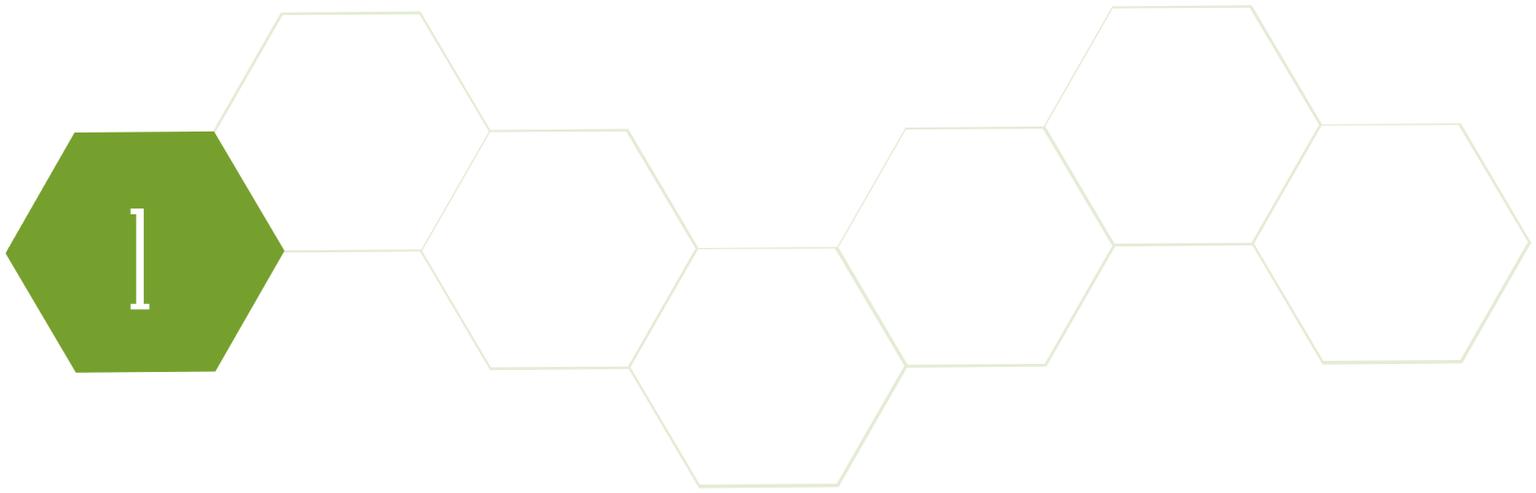


Begginer's guide to:

LEGO EDUCATION  
MINDSTORMS EV3  
ROBOTICS LESSONS



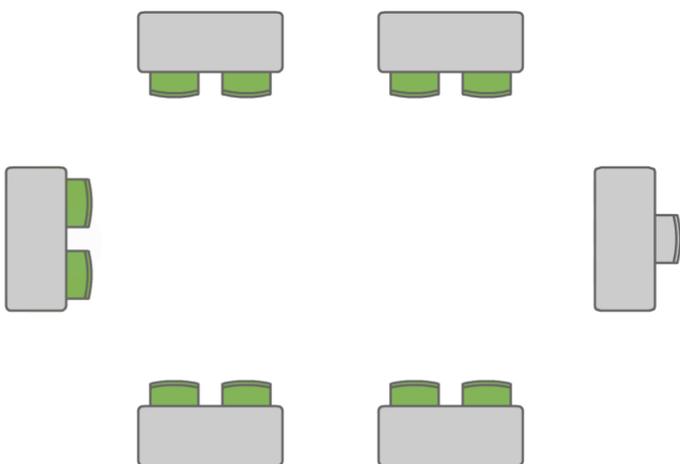
[www.robocamp.eu](http://www.robocamp.eu)



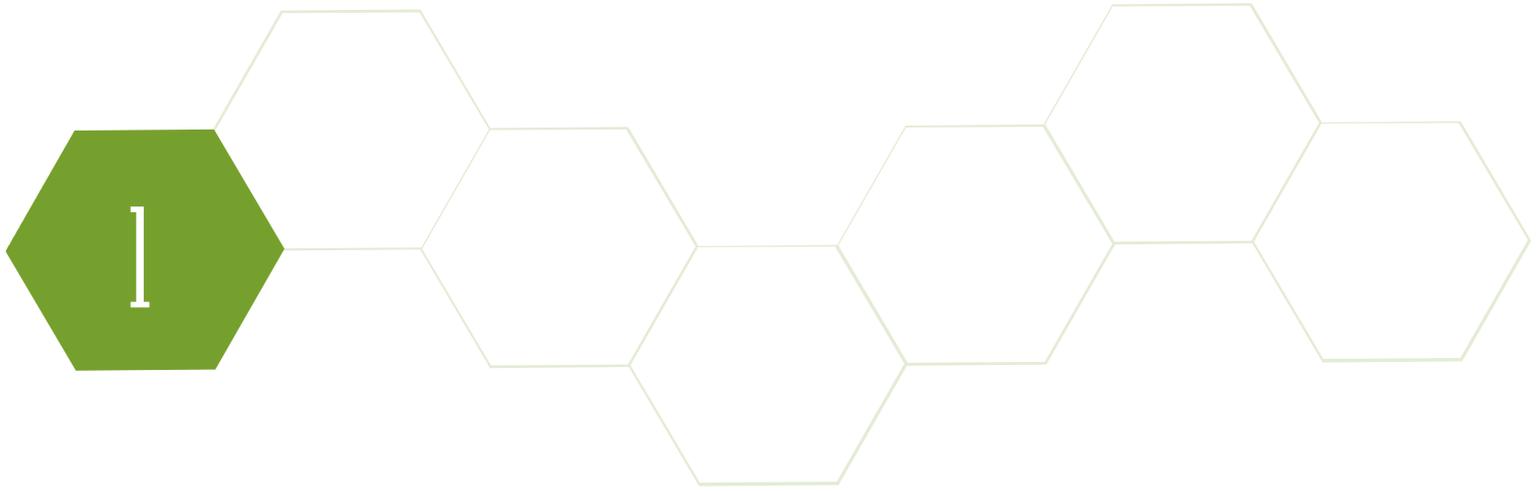
## Classroom layout

The right classroom layout is essential for lesson development. With the proper arrangement of workstations in the room, you can create a learning environment that will facilitate effective and safe learning.

We recommend a layout, in which the workstations are placed near the walls of the room to give a clear space in the middle for group activities and fun. The teacher's desk faces the middle of the classroom, which allows her to see all the groups easily. The main screen should be mounted behind the teacher's desk.

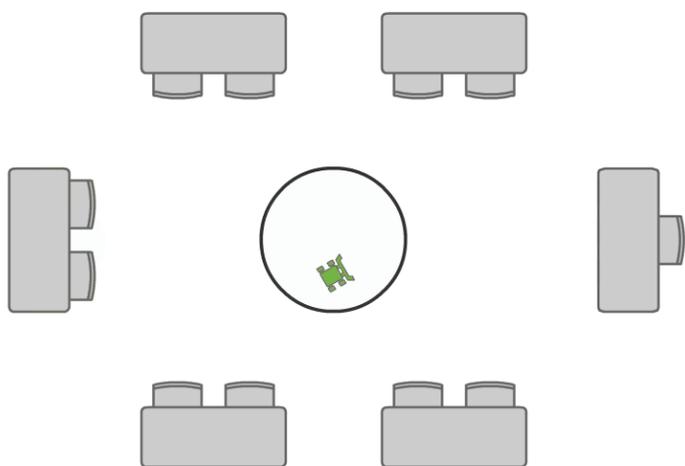
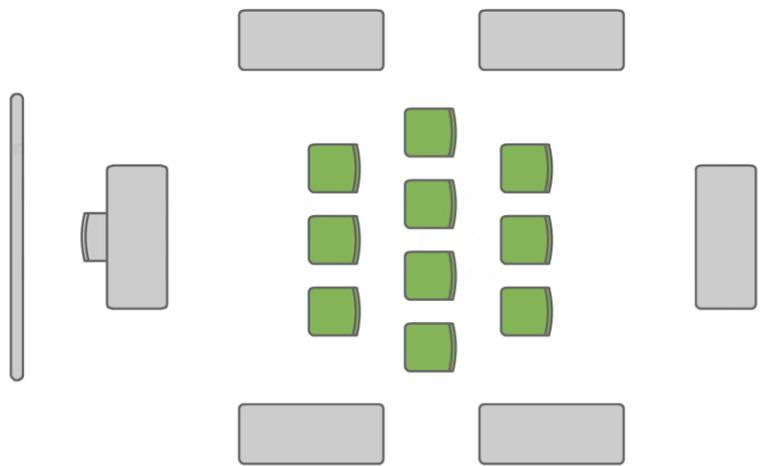


This classroom layout has many benefits for the teacher. First of all, the computer screens of all the students' workstations are visible from any part of the classroom. This allows the



teacher to supervise the progress of each pair of students easily and quickly diagnose any potential problems.

When you want to bring your students' attention to the main screen or discuss some crucial issues with a whole group, it's good to gather in the middle of the room while leaving the robots behind. This will help your students to focus better.



Free space in the middle of the robotics lab can be also utilised in the testing phase of the lesson. Since some of the robots are mobile, there is a great need for free space to safely test their operation.

## 2

# Classroom organisation

To improve the functioning of the robotics workshop, a good work organization is essential. In the robotics lab, you will usually work in pairs, which stimulates creativity of your students and helps them develop crucial communication and collaboration skills.

Every workstation should, therefore, consist of a relatively large desk or a table, and two chairs and suitable equipment. The key pieces of equipment are the robotic LEGO sets. Each group should have access to one complete LEGO Education Mindstorms EV3 set, and a compatible computer. Avoid using tablets since the software available for those devices has much smaller possibilities.



## Classroom organisation

To improve the functioning of the robotics workshop, a good work organization is essential. Start by preparing the kits properly. Use the sorting system prepared by the manufacturer, utilising the sorting tray and stickers.

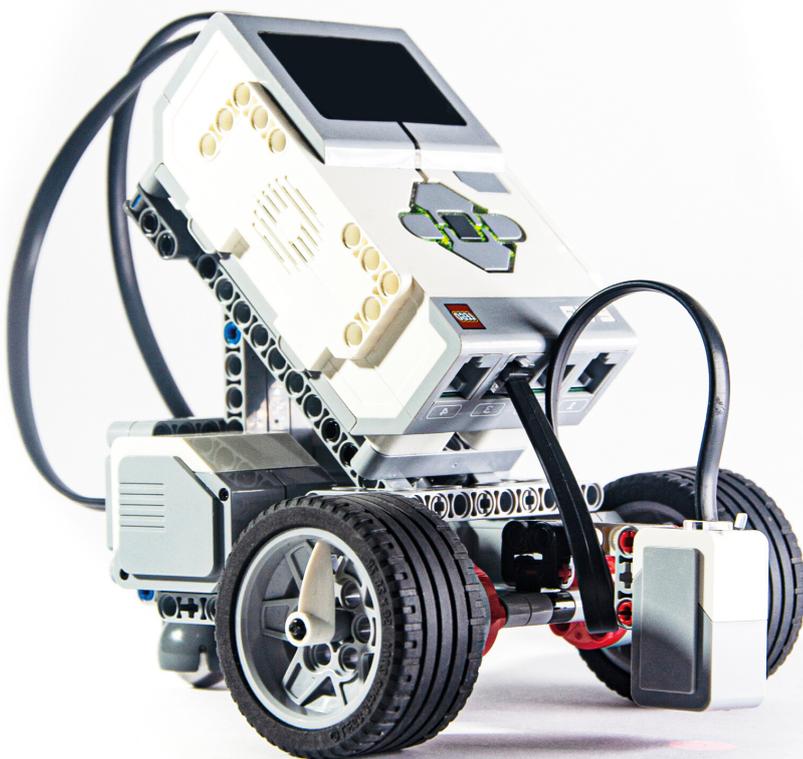
Set the rules for working with sets with the students. After work, they should dismantle the robots and sort the elements into the appropriate compartments.



2

Don't forget to power the sets. For the robotics lab to function efficiently, you need a constant supply of charged batteries. In practice, ordinary AA rechargeable batteries work better than dedicated solutions from LEGO.

These batteries do not increase the size of the EV3 bricks, so it's easier to use them in robot constructions. Thanks to their low price, you can stock up on them, providing easy access to power for robots. It is also worth remembering that AA batteries will also be used for purposes other than just powering Mindstorms robots.



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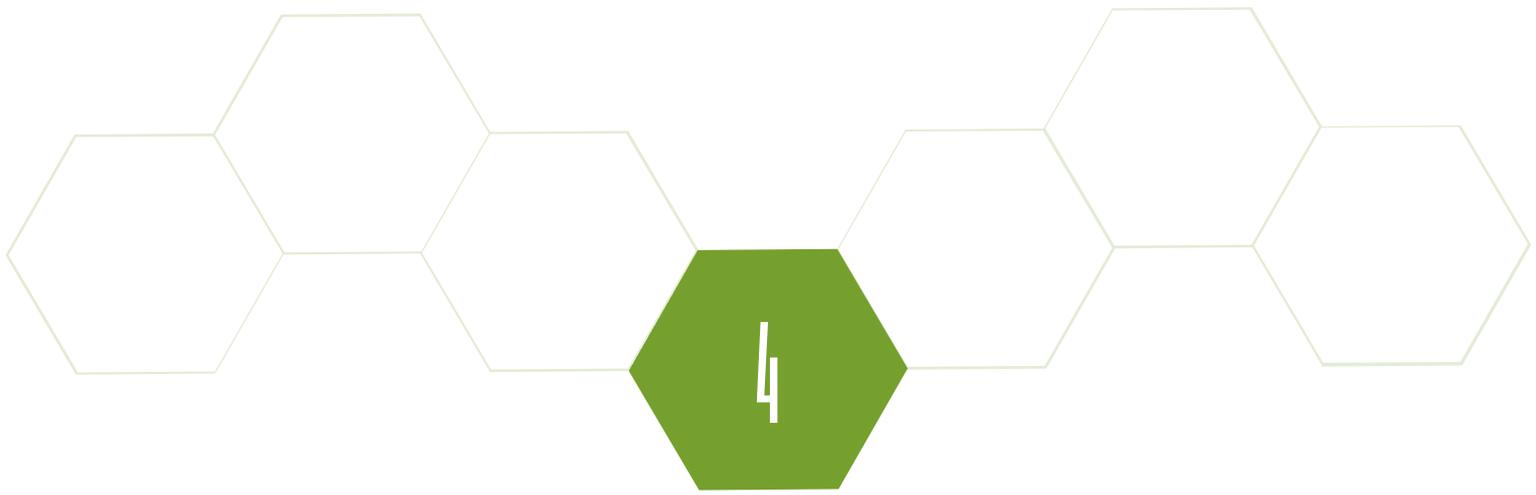


## LEGO Mindstorms EV3 set

The first LEGO Mindstorms set was revealed to the public in 1998, However, prototypes of the key element of the set – programmable brick – were being developed even earlier, in 1987.

At that time, in MIT Media Lab, Seymour Papert was leading the team working on this very project. He also introduced constructivism into the world of education (learning by creating) and designed the very first educational programming language, Logo. The overall success of the Mindstorms series is therefore founded on many years of research and development.

Interestingly, the principle behind the sets never changed. Every set combines the popular LEGO Technic bricks, great for building miscellaneous mechanisms, with specially fitted electronic modules, such as motors, sensors and the microcontroller, also referred to as the control brick. Robots created with these elements can be programmed in a simple and kid-friendly programming environment.



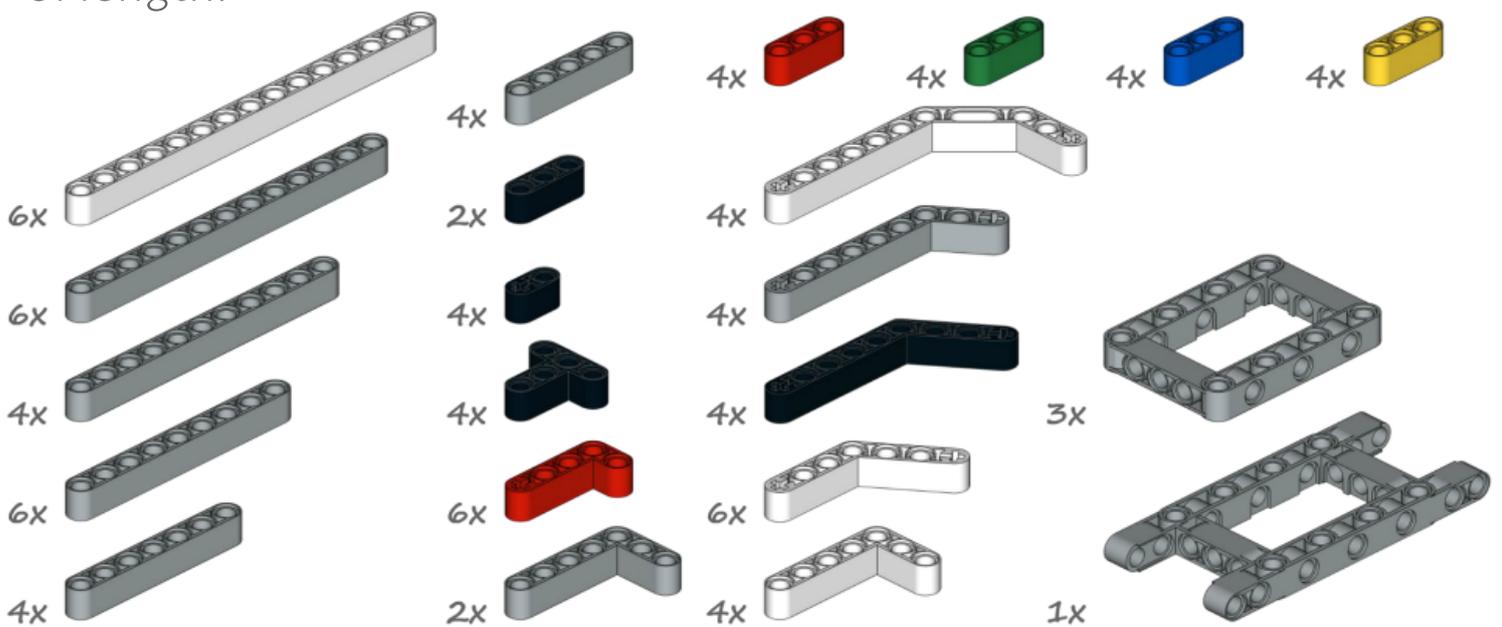
## Building elements

All 541 bricks of the Education set are dominated by white and gray, with sparse tinges of red, black and other colors. Here, you'll find straight Technic beams in 8 different lengths, 7 types of bent beams and two kinds of beam frames. Three studs long Technic beams are available in 5 base colors (red, green, blue, yellow, black), so you can surely use them for experimenting with the color sensor. The set also contains axles of 10 different lengths and 3 types of axles with end stop.

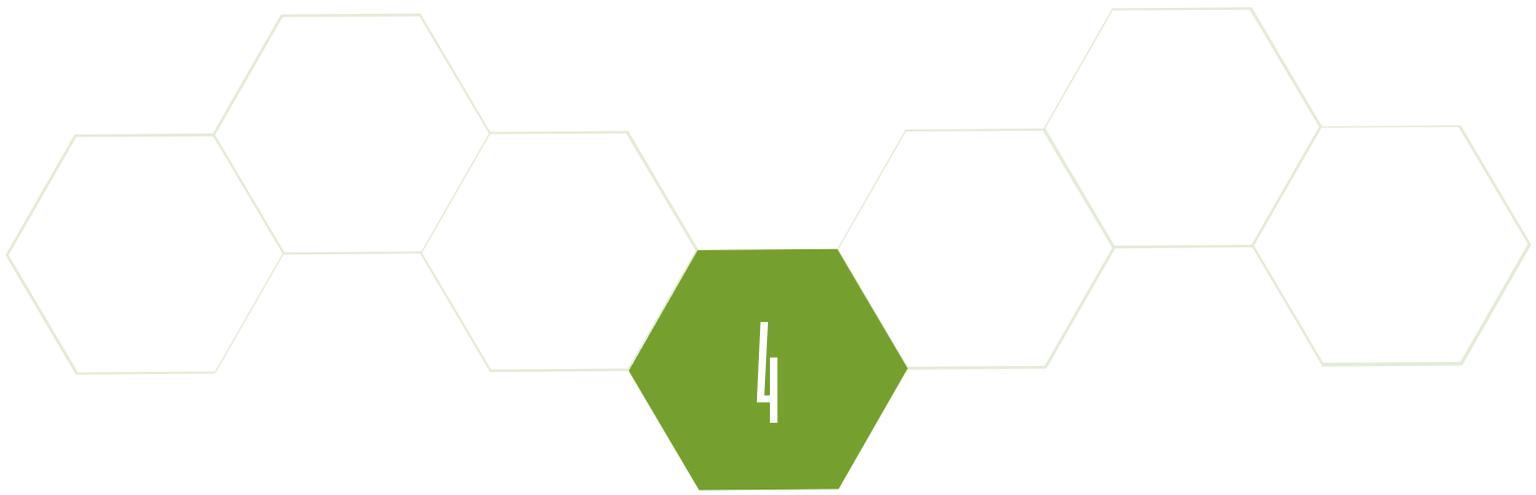
In order to connect axles with beams and frames, you can use 7 types of pins (which include smooth and friction pins for creating connections of varying strength), or one of 18 types of connectors, axle to pin ones included. For blocking, or separating bricks on an axle, you can choose from 2 types of bushings, or pin joiners (also known as tubes). What's more, you'll find that the Education set has 10 different kinds of gears (normal and bevel ones) and two small turntables. In total, there are 30 elements for creating gear mechanisms, so you can design models with miscellaneous transmissions and ratio.



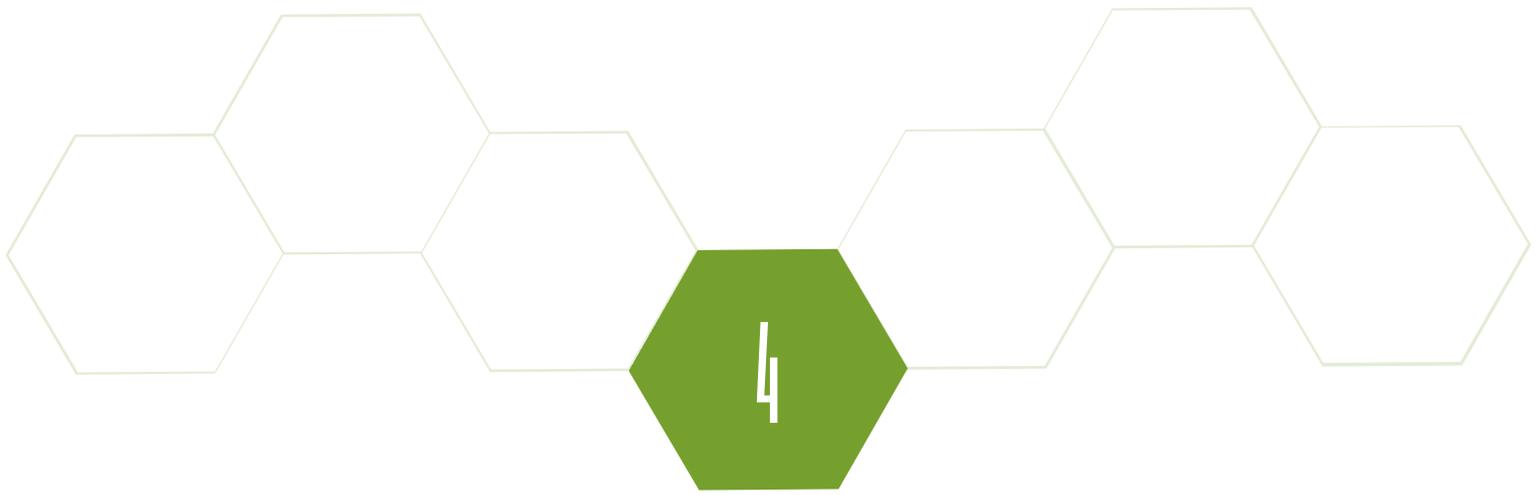
Beams (Beams) are the basic building blocks not only in the LEGO Mindstorms kits but also in a whole series of Technic sets. The length of the beam is determined by the quantity of the mesh – the beam is one stitch length of about 8 mm in terms of a standard unit of length.



Beams are widely used to create lightweight and durable constructions with built-in angles (contained in the beam "L", "T", and the double-curved beam 3x4x7 - angle beheaded). They are also one of the more reliable elements to use when the structure needs to be made stronger. It should be noted that beams can have one or two cross holes. The illustration shows all the EV3 beams included in the LEGO Education Mindstorms EV3 set.

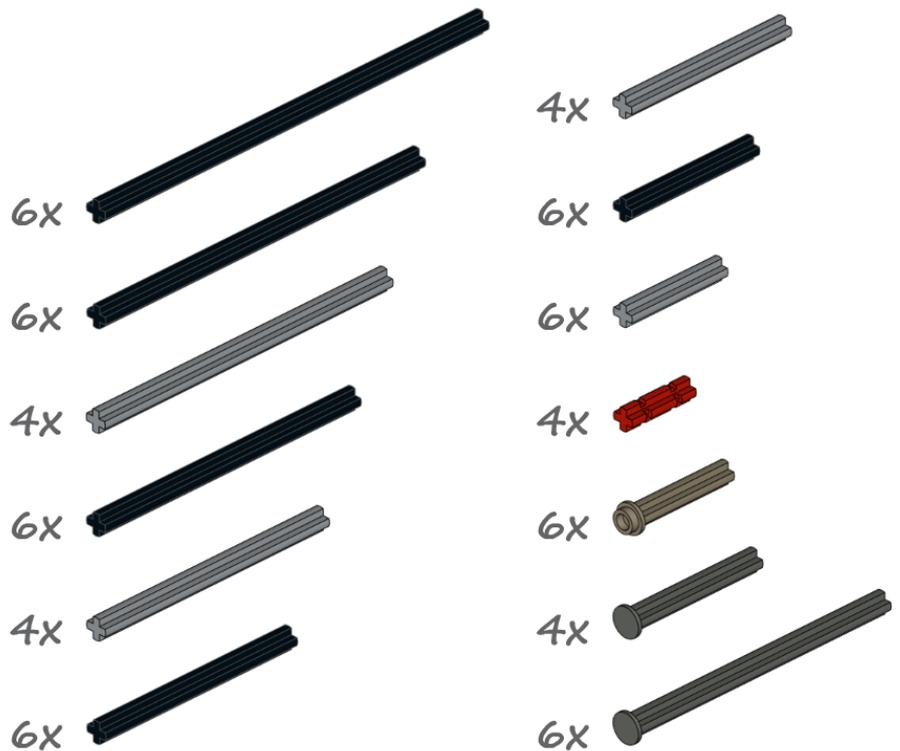


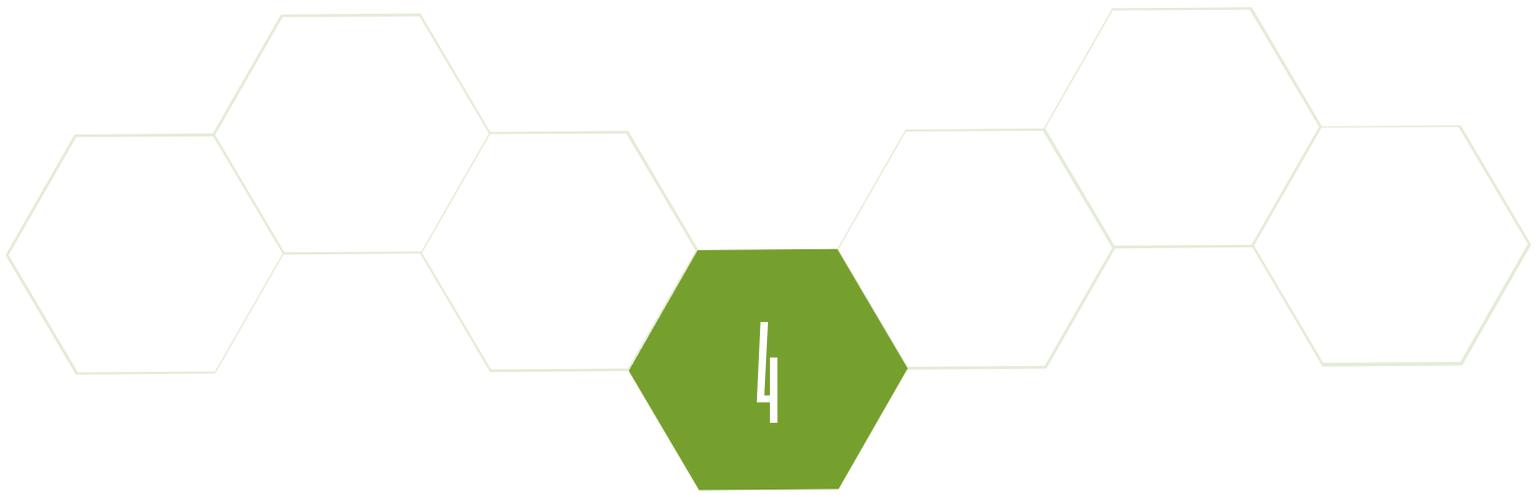
The largest group of parts in the kit are the numerous types and colours of connectors (Connectors). In the construction of LEGO Technic, their function is similar to nails, screws and hinges in standard constructions of wood or metal. The selection of a connector depends mainly on the type of connection you want to achieve. The set point is very high, which results in an unlimited number of possible combinations. pins and axle pins There are many diverse resource pins (Pins) in the LEGO Mindstorms EV3 kit. There is a variety of colors so you can identify the type and function easily and quickly. In particular, there are short pins with a length of two units in two variants – black (E), equipped with piping to increase friction, guaranteeing a rigid and strong connection; and gray (A), smooth, used for free calls, which are characterized by a high degree of mobility.



Axes (Axles) are a very useful element of the set. First of all, they can be used to transfer power from the engines included in the kit to all moving parts of the structure; in particular, wheels or tracks. In addition to this function, the axes play the roles of connectors, serving for bonding and strengthening structures using holes, the cross section located in the beam function, gears, and other components of the kit. Axes are of different lengths – in contrast to the beams, the set includes axles with an even and odd number of modules. Even axes are usually black, and the odd are

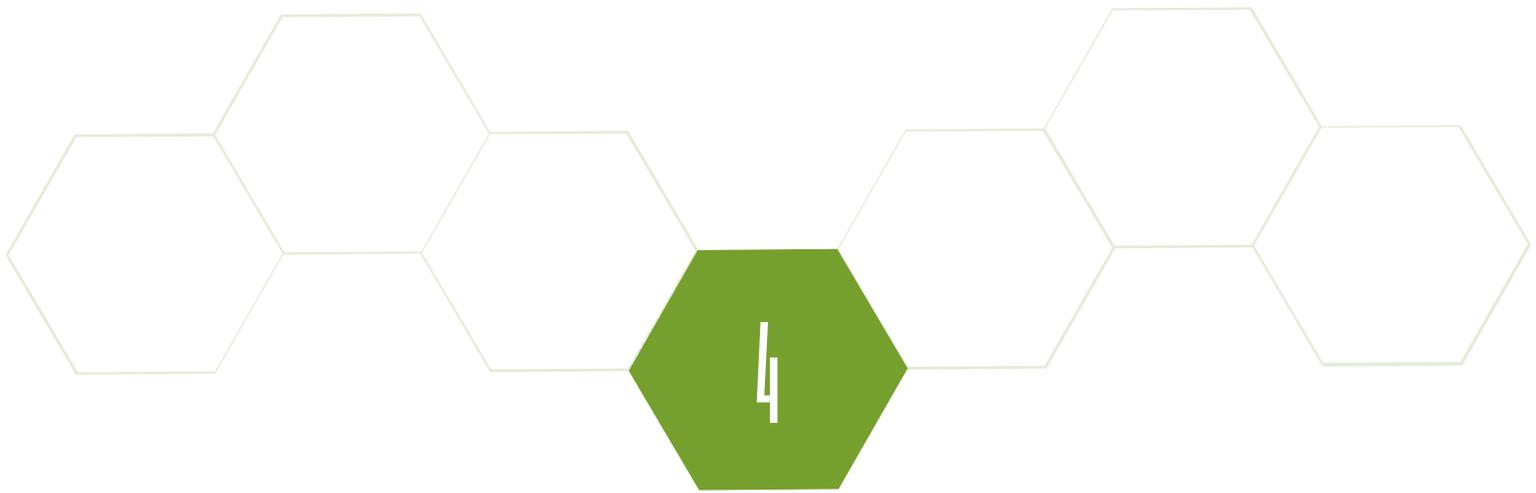
gray, making it easier to find the length of the axis you need. To check the length of the selected axis, you can use the supplied rulers, or simply put the long axis along the beam and count the number of meshes, which match.





If you want to piece together a vehicle, you can use two large wheels with wide tires, smaller wedge belt wheels, or a steel ball placed in a plastic socket – a remarkably useful element. For example, it can serve as a great support wheel for two-wheel drive robots. The tracks included in the set are made of multiple plastic track links joined together. Connect them with sprocket wheels and you'll create a perfectly functional chain drive. Vehicles with such a caterpillar drive advance well enough, but since the plastic surface is smooth, some gliding may occur. The easy solution is to purchase rubber attachments. Inserting them into holes of the track links noticeably increases traction. These attachments are available in the extension set produced by LEGO Education, purchased additionally. Nonetheless, you can always buy these elements separately.

Gears differ in terms of their size, the number of cogs and intended use. Gears are necessary when constructing such mechanisms as cogged and worm drives. Thanks to them it is possible to mechanically change the parameters of motors movement such as the speed, torque, direction and plane of rotation. The set LEGO Mindstorms EV3 contains the whole selection of gears.



Their thickness is usually equal to the thickness of one LEGO module. The exception are beige angular gears with the thickness of half the module.



Apart from classic gears, the set also includes knobs – a type of gears with four insets performing the function of cogs. Knobs can be connected both in the same plane and perpendicularly. Worm Gear is a threaded sleeve laid on the axis, length: 2 units. Block is the basic element of a worm gear. Ratio of a gear depends on the applied gear and amounts to 1 to the number of cogs. The gear can be driven only on the part of the worm. The gear changes the plane of rotation.



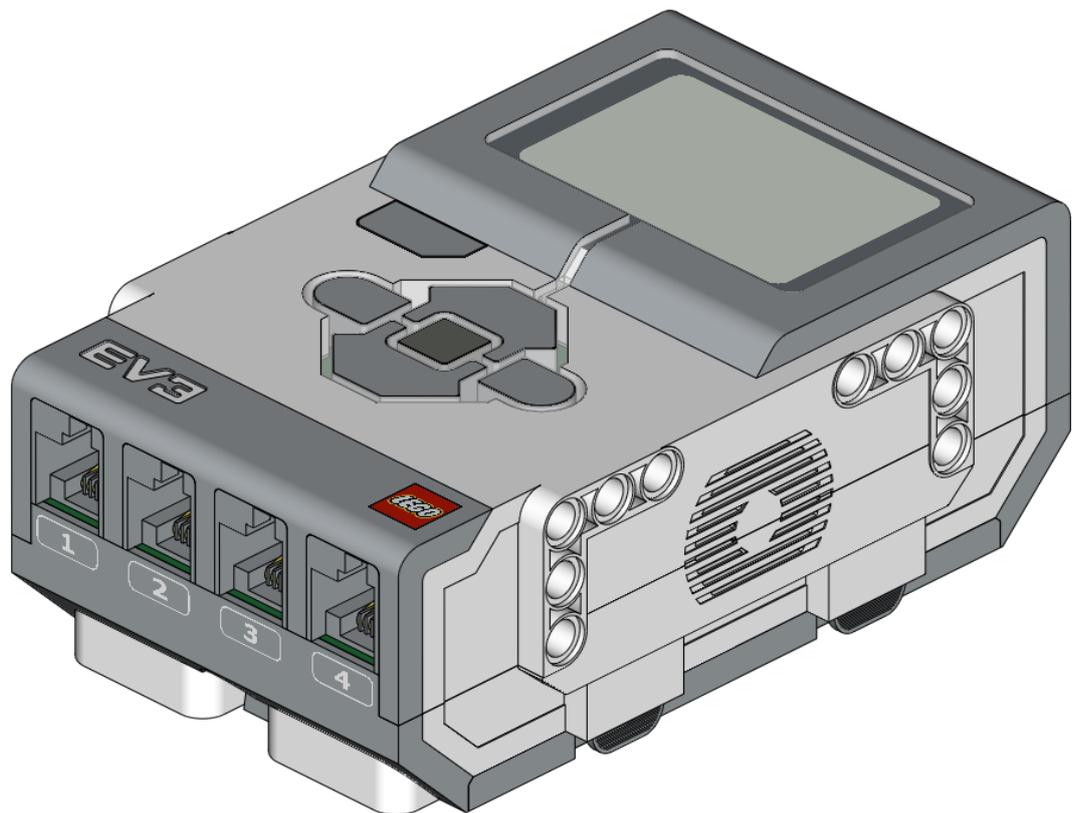
## Electronic parts

The set provides two large DC motors and one smaller one, as well as a microcontroller, known as the EV3 Brick. You also get a number of different sensors. Motors and sensors can be connected with the brick by means of cables with plugs. Cables constitute the only element that wears out considerably soon, because plugs get damaged easily. You may think about stocking up – LEGO Education distributors can often help with that.

The main function of the EV3 Brick is to control created robots. As a matter of fact, the Brick is a microcontroller based on the ARM9 processor with Linux OS packed into one large LEGO brick. It's equipped with display, speaker, 6 buttons (5 programmable ones, highlight included), 4 input ports, 4 output ports, mini USB port for computer connection, USB port, Micro SD port (up to 32 GB) and battery case. Communication with the device is possible via USB cable, built-in Bluetooth module, or WiFi (if you plug the external WiFi module into the USB port of the Brick).



In use, the Brick performs quite well. However, its menu is not exactly user-friendly and start-up takes a bit of time (around 30 seconds), which may be irritating for some. From time to time errors do occur; the Brick may crash or turn off on its own accord. In such cases, it usually helps to update the firmware, or reset the Brick. If you're having other problems with the Brick, [this](#) article might help you out.

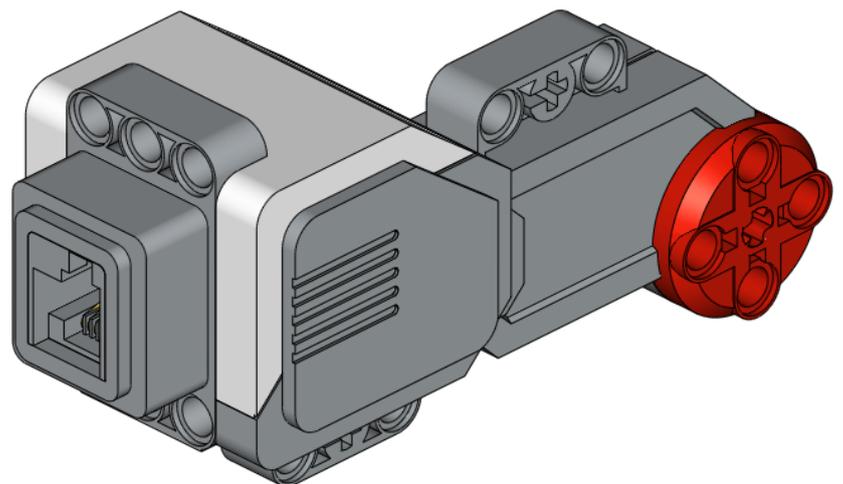
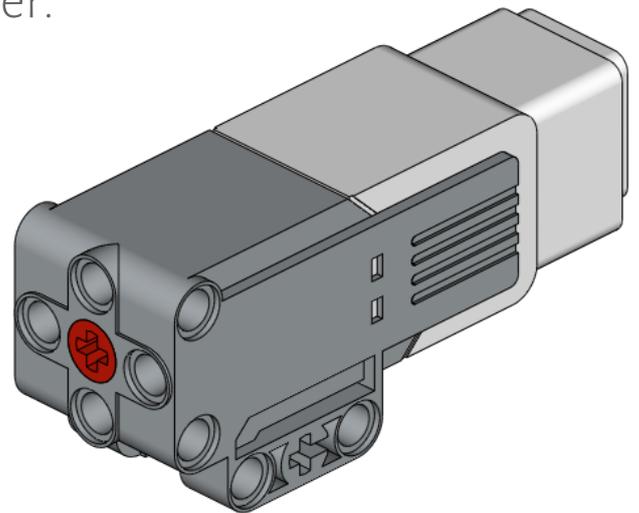




In both versions of the EV3 set you'll find two large and one medium DC motors. All motors have a built-in rotation sensor. One of its possible uses is to coordinate two motors present in one construction, so that the robot advances straight forward. Sensor readouts can also be used in programming exercises, i.e. as control levers. Rotation control in both types of motors is very precise (up to  $1^\circ$ ), thanks to the built-in tachometer.

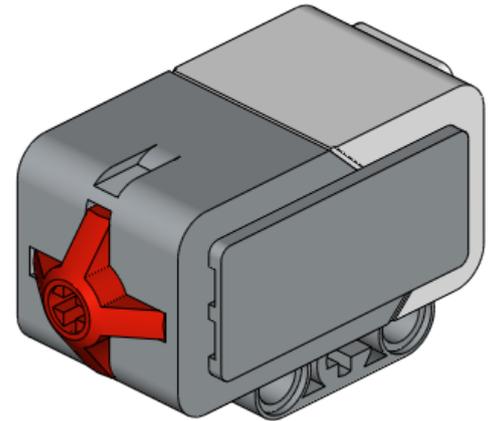
Large motors have higher power and a big rotating head, which facilitates drive transmission. They reach 170 rpm. The smaller motor is capable of higher speed (up to 250 rpm) at the expense of the power available.

Thanks to its size, it can be easily incorporated into numerous constructions.

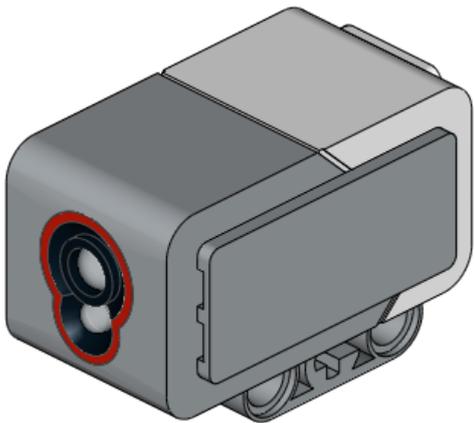




Touch sensor is included in both versions of the set. It's a simple analog sensor, which detects whether the button is being pressed, or not. You can use it to run or stop operation of a construction, to create bumpers, or to count button presses.



Together with 5 buttons on the EV3 Brick, they are touch sensors as well!), you may even create an advanced system to control your robot.

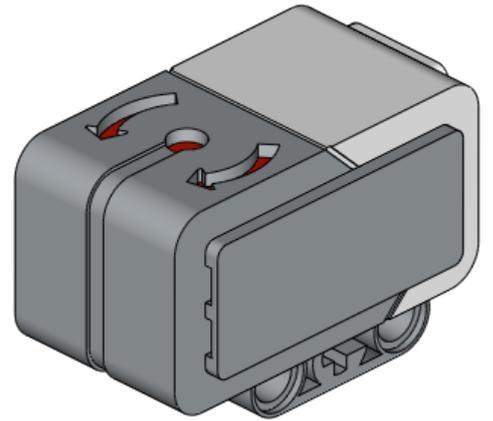


Color sensor is included in the Home and Education version of the LEGO Mindstorms EV3 set. It collects data concerning colors (distinguishes 8), or light intensity (ambient, or of a reflected beam). It can be useful in line followers, sumo fights, or sorting devices.

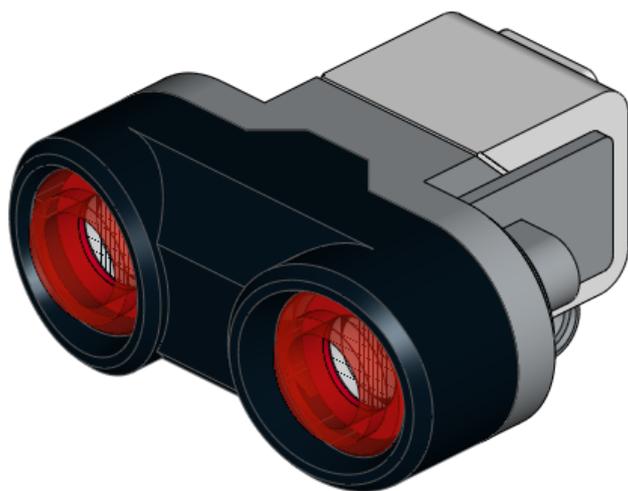
The gyro sensor is available only in the Education version. Composed of several accelerometers, this sensor measures angular position and can detect changes in the position of an object with the accuracy of  $3^\circ$  in all axis of rotation. It can prove especially helpful when creating balancing robots, or controllers reacting to changes in tilt.



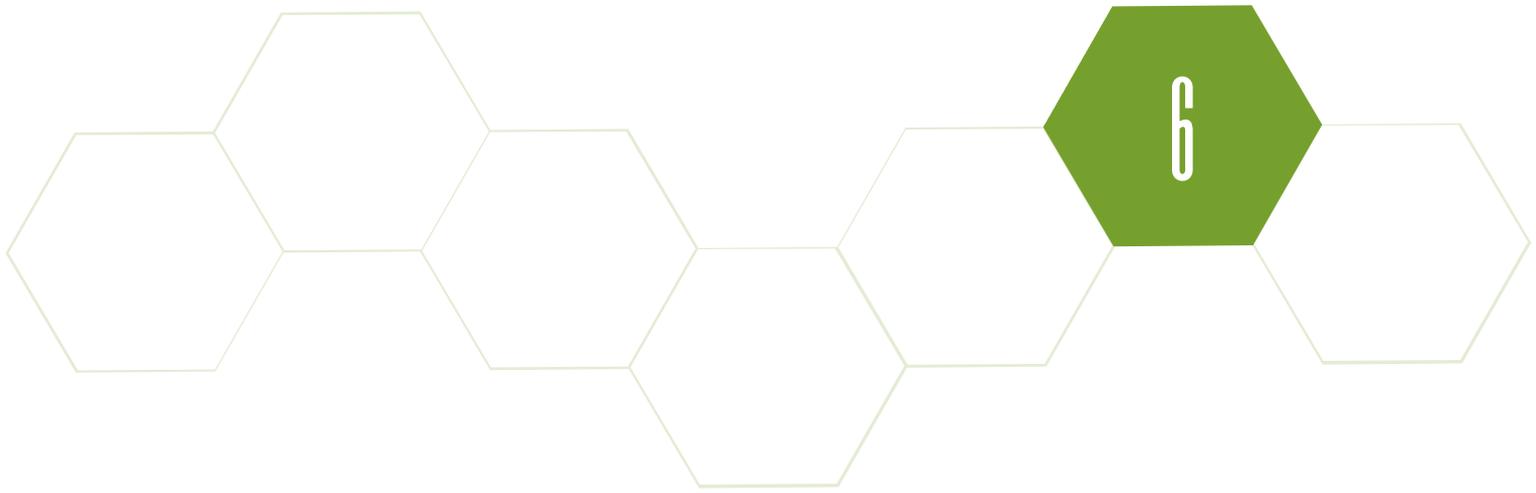
The ultrasound distance sensor, produces ultrasonic waves, which upon encountering an obstacle rebound and return to the sensor. The time elapsed between sending and retrieving of the signal is used to estimate distance from



the obstacle. The measurement is quite precise ( $\pm 1$  cm); the measuring range covers 1 to 250 cm. In addition to distance, the sensor can produce ultrasounds and detect ultrasounds in its environment. Thus, this element can be used to measure distance, pass through labyrinths, or detect objects.



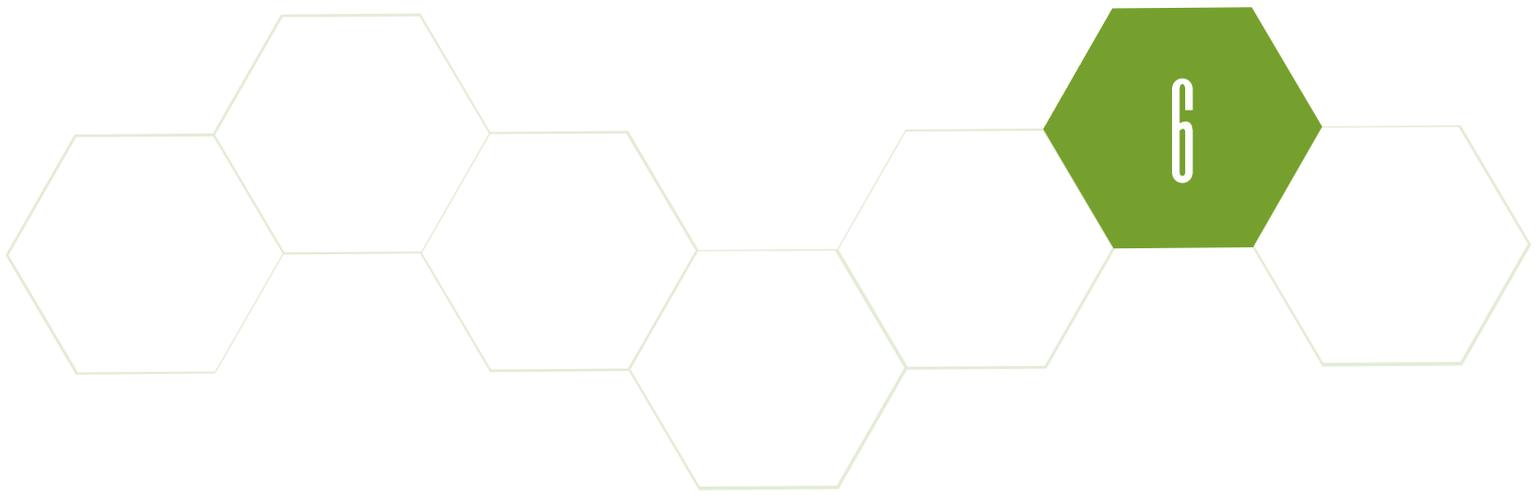
All electronic elements are good-quality. The very first problems appear only after a few years of intense use. Purchasing additional cables (they break down first) and individual electronic modules is definitely worth considering. Other producers have even more sensors in their offer and they are definitely worth checking out.



# Programming

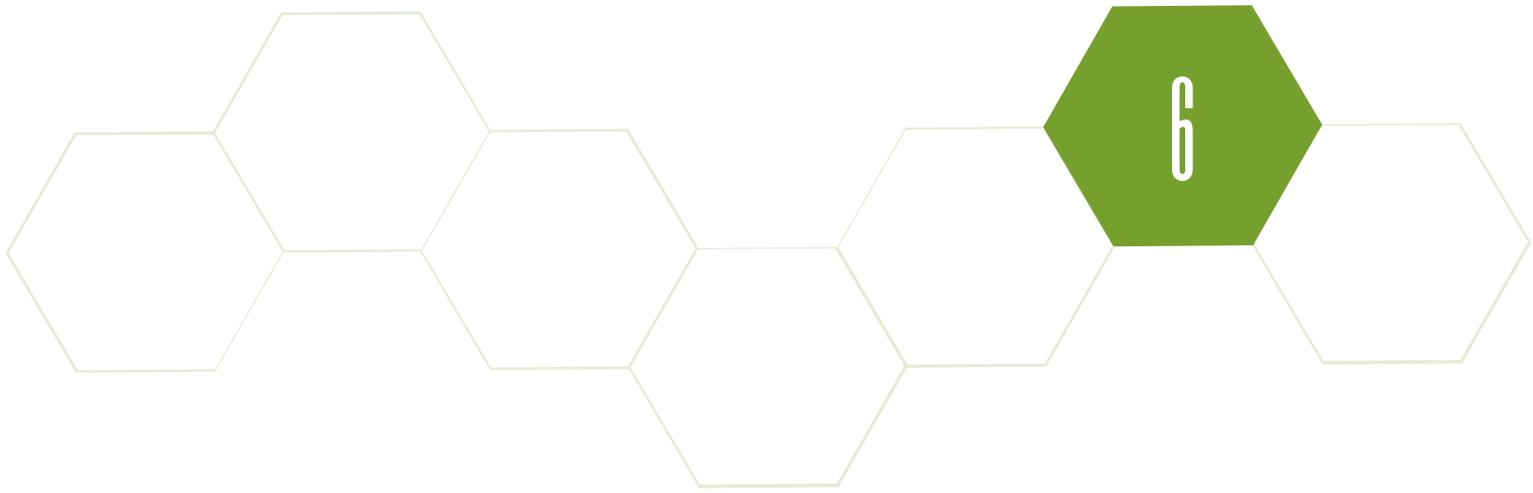
LEGO Mindstorms EV3 sets can be programmed through the dedicated app, based on LabView. You can access it on computers and tablets.

The EV3 software allows to program robots in an intuitive graphic language. Programs are created by dragging individual instructions to the start block. Once completed, the program must be uploaded to the EV3 Brick. When you activate it, the commands included in the program will be executed from left to right. Every instruction block can be adjusted through various options. Overall, the environment is good for controlling LEGO robots in a simple and precise manner. Programs are created easily, almost intuitively, and all block options are visible right away. The only problem concerns the size of the blocks. Longer, more complex programs don't fit on the screen, which forces users to scroll the preview. This flaw makes the process of creating advanced programs slightly inconvenient. However, it's rarely a problem for projects executed during school robotics classes.

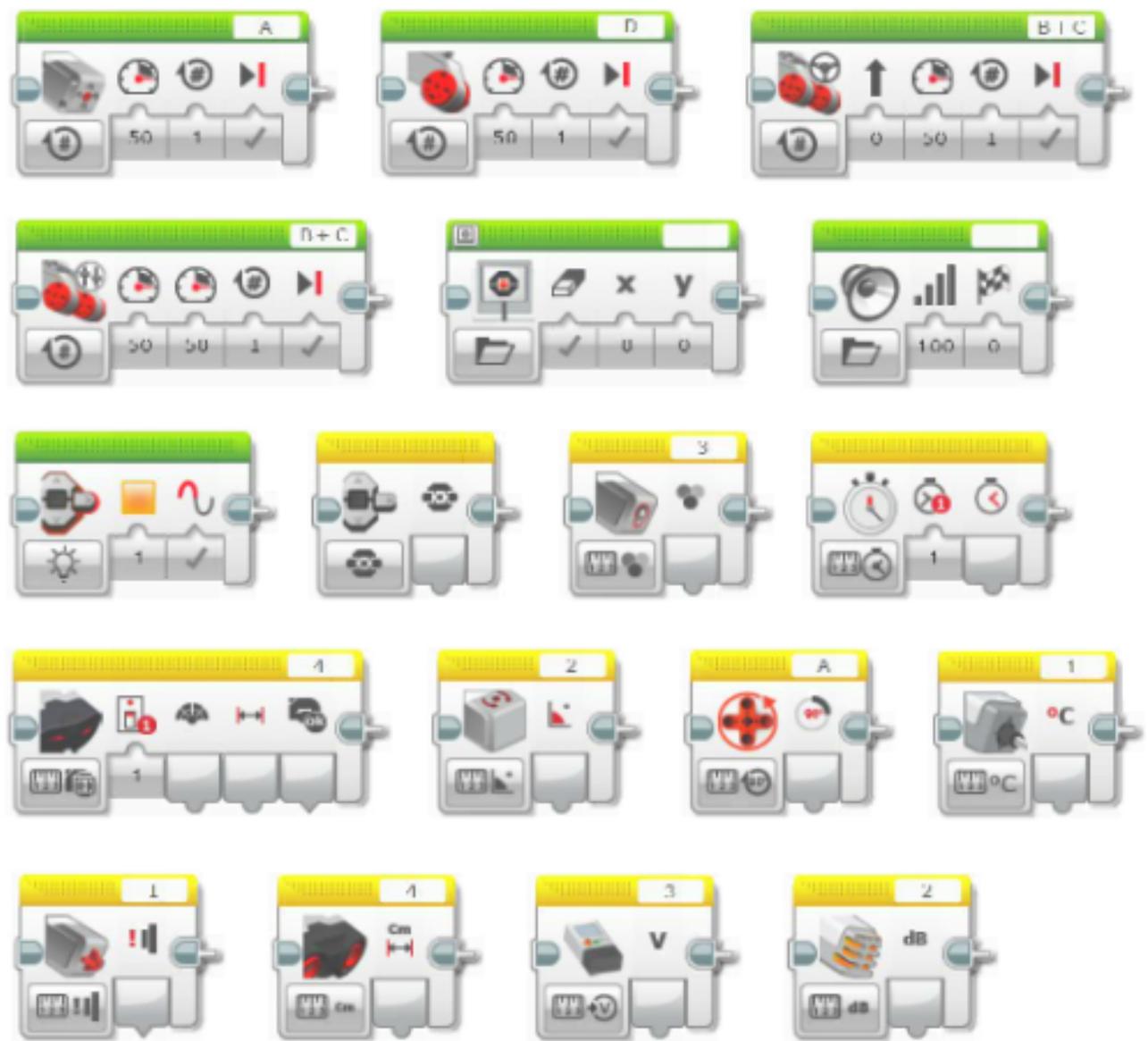


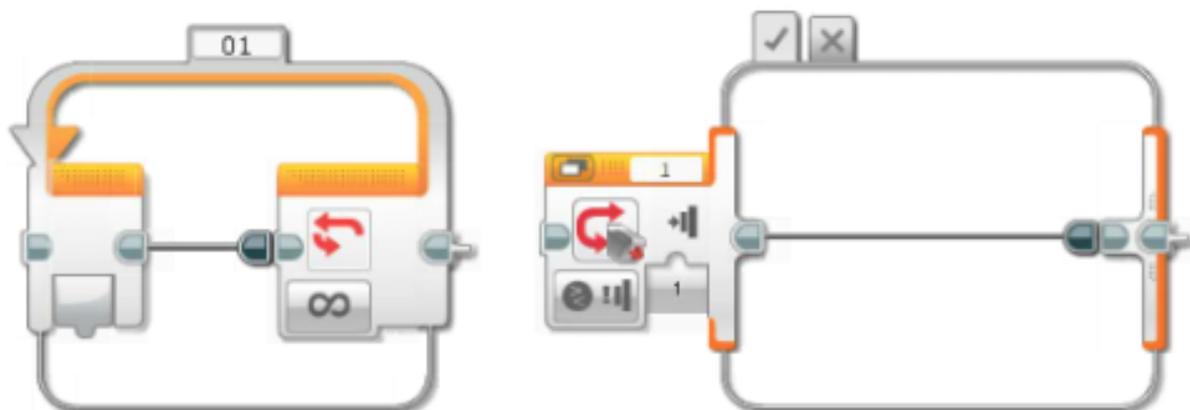
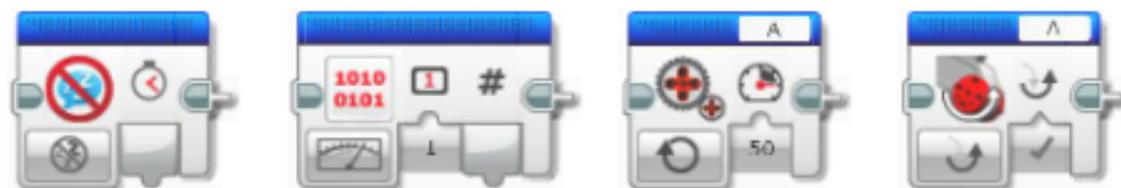
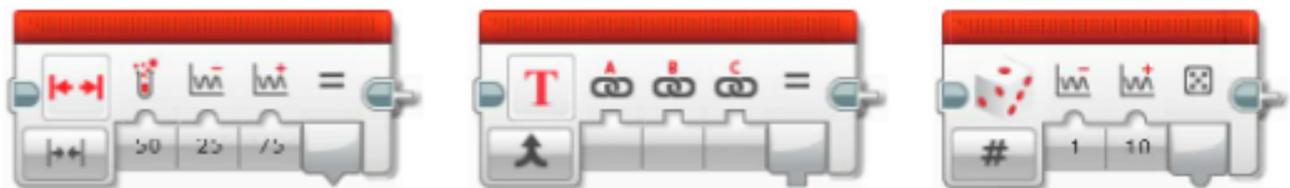
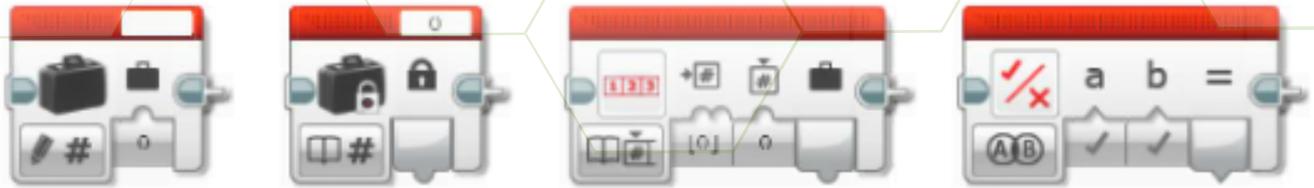
At a later stage of education, it's possible to introduce text programming of the EV3 robots. The language selection is quite wide. You can choose from the dedicated languages: EV3Basic and Robot-C, or even take up one of the classics, e.g. Java or Python (after you install a new OS on the EV3 Brick – more on [ev3dev.org](http://ev3dev.org)). The EV3 Brick connects with the computer, or tablet, by using Bluetooth technology, WiFi (if you attach the external WiFi module), or USB cable. The last method is perhaps plain, but trouble-free. Once you upload a program to the Brick, you can disconnect the USB cable and the robot will operate autonomously.

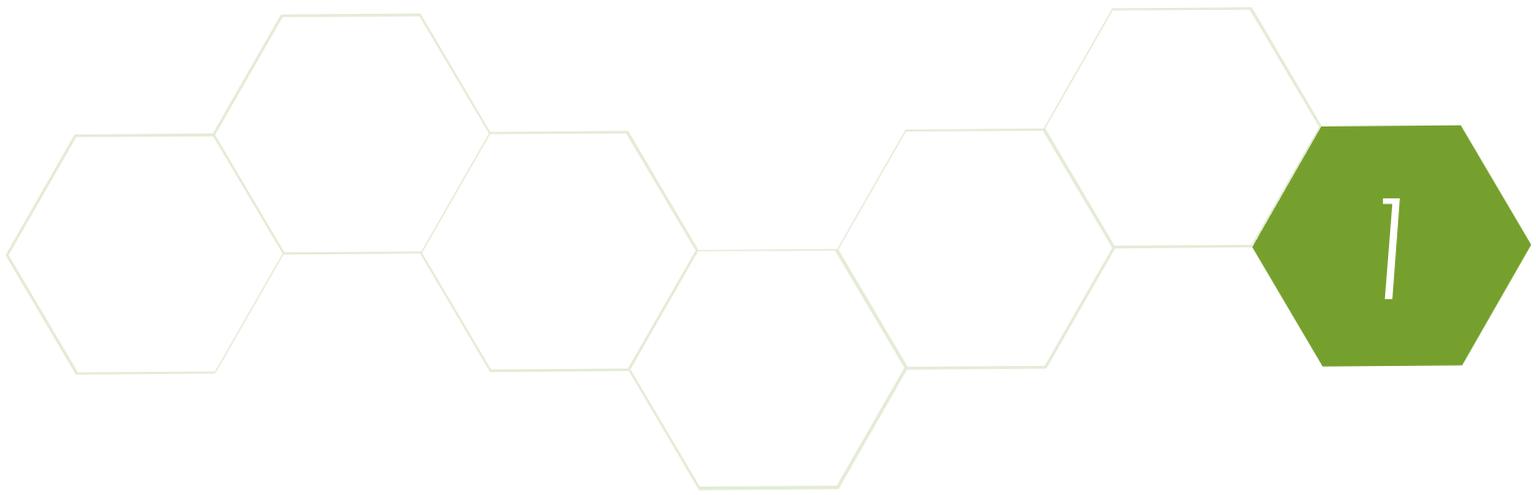
Programming the EV3 sets on a computer provides the most possibilities and enables you to fully exploit their potential. You get access to a full palette of programming blocks, which are grouped into 6 categories. You'll be able to browse action blocks (controlling motors, display and highlight of the Brick buttons), flow control blocks (waiting, conditions, loops), sensors blocks, data operations blocks (variables, lists, mathematic operations), advanced blocks and finally, blocks created by the user.



The Education app works on computers with Windows (7, 8 and 10), or with Mac OS in version 10.6 or newer. You can download the app [here](#).



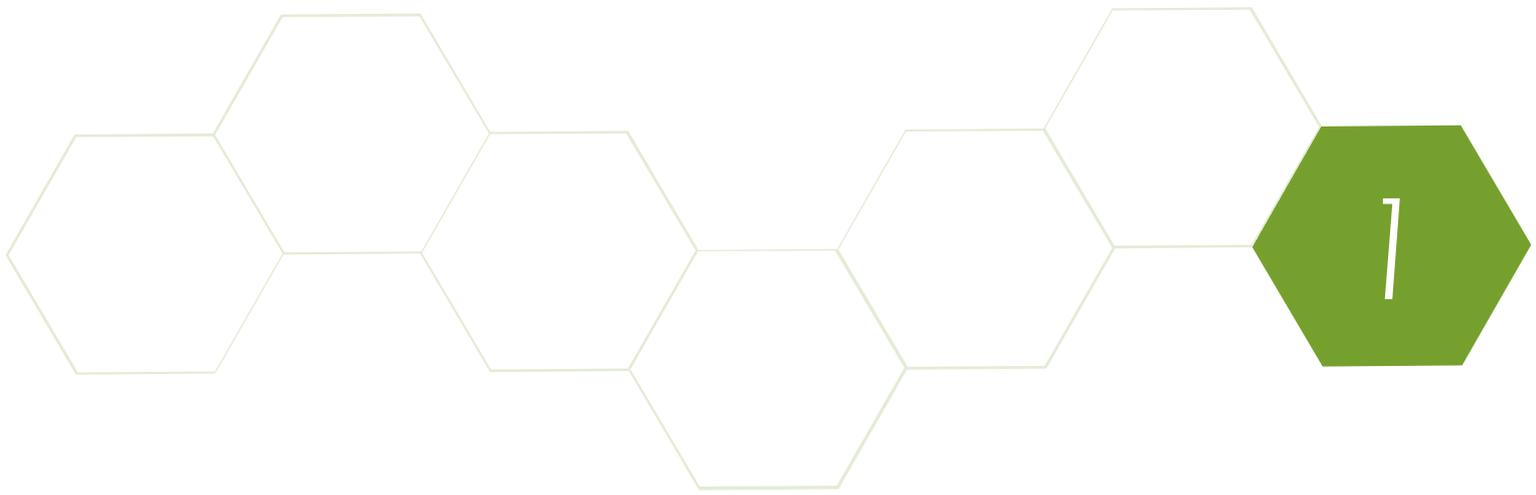




## Conclusions

LEGO Mindstorms EV3 sets have many assets and stand out among competitors, regardless of the version. The building system is easy and quick, the elements are durable. Since the entire set is founded on LEGO bricks, all constructions can be assembled in a nice, easy way and most importantly, very swiftly. Construction and electronic elements are diversified, which equips teachers with basis for earnest teaching of elementary mechanics and physics. These sets also develop creativity, because they encourage testing out individual ideas. Undeniably, they have wide possibilities and can be used even on higher levels of education. Many colleges and universities decided to adopt the EV3 into their robotics and mechatronics labs.

The software for programming robots (especially in the PC version) is a great tool for learning basics of programming. It allows users to create advanced programs easily, in an intuitive manner, which fosters computational thinking and helps beginners to understand basic concepts without any need for learning complicated syntax of text programming languages.

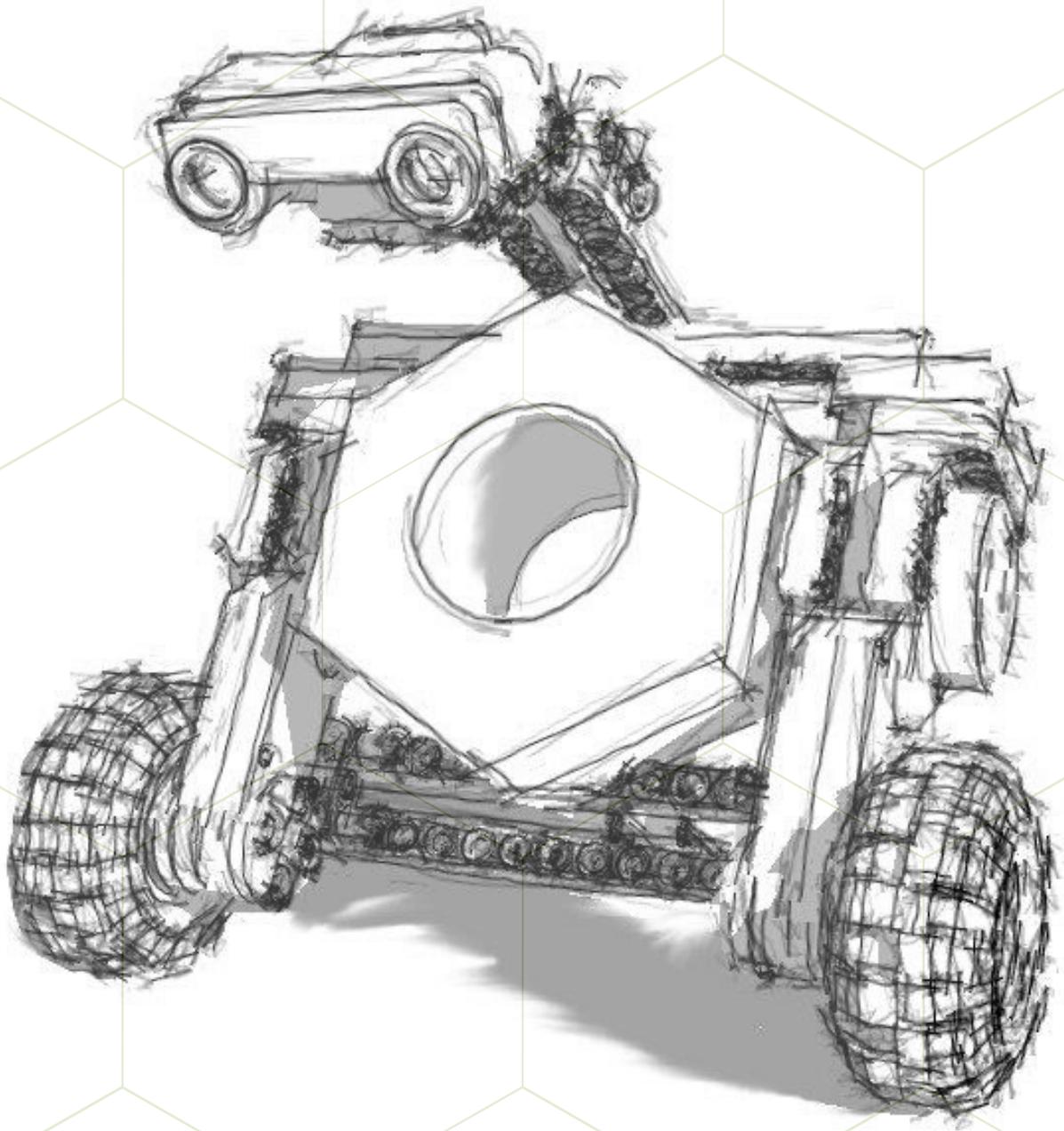


Although they can be a little messy and require some planning and forethought, robotics classes using LEGO Mindstorms EV3 sets are a fun way to teach children essential STEAM skills in a way that will fire their imaginations and that they'll remember for years to come.

If you're interested in running a robotics workshop and would like some more advice on how to make it a resounding success, register for one of our free webinars.

In addition to plenty of time-saving and organizational tips the webinar will include information on where to find new robotics lesson ideas. You'll find out which kits are our favorites and how to pick the right kit for your students. Plus, you'll get the chance to watch a demo robotics lesson and meet a functioning robot.

To register for the free webinar, click [here](#). In the meantime if you have any questions or you would like some advice about how to introduce robotics into your school's curriculum please email us at [support@robocamp.eu](mailto:support@robocamp.eu) and we'll respond as soon as we're able. Good luck!



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