A two years informal learning experience using the Thymio robot

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Abstract Technology is playing an increasing role in our society. Therefore it becomes important to educate the general public, and young generations in particular, about the most common technologies. In this context, robots are excellent education tools, for many reasons: (i) robots are fascinating and attract the attention of all population classes, (ii) because they move and react to their environment, robots are perceived as close to living beings, which make people attracted and attached to them, (iii) robots are multidisciplinary systems and can illustrate technological principles in electronics, mechanics, computer and communication sciences, and (iv) robots have many applications fields: medical, industrial, agricultural, safety ... While several robots exist on the market and are used for education, entertainment or both, none fits with the dream educational tool: promoting creativity and learning, entertaining, cheap and powerful. We addressed this goal by developing the Thymio robot and distributing it during workshops over two years. This paper describes the design principles of the robot, the educational context, and the analysis made with 65 parents after two years of use. We conclude the paper by outlining the specifications of a new form of educational robot.

1 Introduction

Robots have already proved to be successful educational tools. At university level, the e-puck robot [12] is a standard open-source educational tool that is used as a plat-

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form in dozen of universities and in several courses. Other robots like the Roomba Create from iRobot[9], the Robotino from Festo [2], the Khepera robot [13] and its successors are robots used for engineering education. At a younger age, as robotics is quite a new topic and is generally not part of the school's curriculum, interested students learn by themselves with kits such as Lego[1] Mindstorms [7], the BoeBot [4], or more generic kits like the Arduino [5]. Nevertheless, there is increasing interest for this field and more and more courses are available to teenagers, either out of school or as facultative lessons. The Roberta Initiative, for instance, has provided both materials and methods for teaching robotics in a gender-balanced way [10, 1]. Those workshops allow especially but not only girls to realize that technology is not as complicated and inaccessible as they might think.

To give opportunity to a wide audience to discover more about technology and robots, we have organized a robotics festival at EPFL since 2008 [6]. It has attracted a wider audience every year: 3'000 people in 2008, 8'000 in 2009, 15'000 in 2010. The festival is a free event including exhibitions, shows, talks, industry and lab presentations, and workshops for children. Those workshops include a wide range of activities such as robot building, soldering, or programming. For this occasion, we wanted to create affordable workshops introducing robotics to young children. In that aspect, engineering tools like the e-puck robot are too complicated and expensive for children. The Mindstorms NXT is better suited for a young audience but is still very expensive, and while schools can afford them, most parents cannot afford to buy such tools for their children. Therefore we decided to develop a robotic kit at very low price, adapted for young children, promoting creativity and learning. Combining this requirement with some ideas generated by the School of Art of Lausanne (écal), we developed the Thymio robot, a modulable robot for children.

2 The Thymio robot

The main goal of this development was to create a mobile robot encouraging creativity and promoting the understanding of technology. At the same time, the robot had to have a sufficiently low cost to be distributed among the participants of the workshops for a very reasonable price (less than 50 Euros). Finally the robot had to be entertaining with some non-trivial behaviors.

During a joint workshop between EPFL and écal, Julien Ayer and Nicolas Le Moigne had the idea of a kit allowing children to build their own robot out of any type of object, without having to program or solder anything. Figure 1 illustrates this first conceptual idea. The inspiration behind this idea was the concept of Mr. Potato[8]. With basic elements (legs, arms, nose and eyes) any object, even a potato, can be turned into a character. Similarly, having a kit with some sensors, wheels and buttons should allow to create a robot around anything.

[1] Lego is a registered trademark of Lego Corporation.

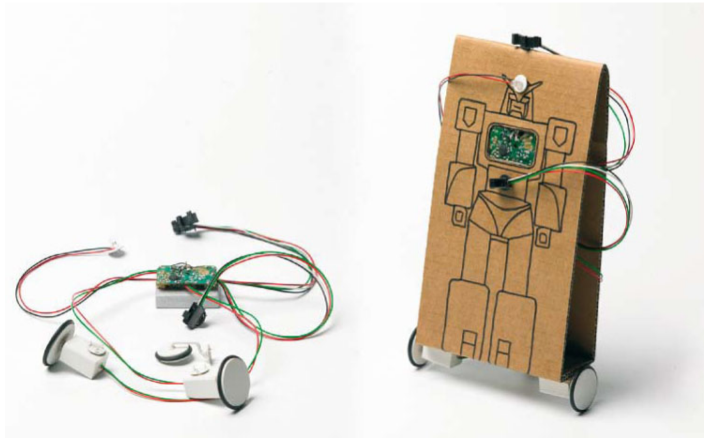

Fig. 1 The first abstract idea was to have a connected set of sensors and actuators that could be adapted around any type of shape to create a new form of robot.

A first functional kit (Figure 2 left) was designed at EPFL, consisting of five electronic boards connected by cables. The five modules were two wheels, one infrared proximity sensor module, one battery module and one button module for switching on and off and for choosing some parameters. The robot performed line following and a track was available to children to test their creations. This first prototype was used in 2008 at the robotics festival workshops, but as there were only 15 kits, children had to destroy their robots to give back the electronics at the end of the session. Because of several technical choices such as removable connectors and sensors, it was difficult for children, even with their parents, to assemble the robot correctly without the help of a trained teacher. The workshops were however hugely popular.

Based on this first success, we decided to build a kit simpler to operate and better respecting the regulations for toys. In particular we designed plastic cases around the components to fulfill the security requirements (see Figure 2 right). Despite the better design and simplified interface, this second prototype had the same problem as the first: assembling a robot is not a trivial task. Putting the wheels and the sensors in the right position, balancing the weight etc. is a non-trivial task for beginners. Therefore we decided to keep the modular concept but change the assembling approach. Instead of having a kit becoming a robot, we decided to have a robot that could become a kit. This resulted in the final version we called “Thymio”, illustrated in Figure 3, top. Thymio is a small mobile robot which is approximately 15 cm wide, 12 cm long and 4 cm high and can be separated into four parts. Two parts drive the wheels, one includes the batteries and the speaker, and a last one has the main control button and the infrared proximity sensors. When disassembled, the parts have a transparent side to reveal the internal components, supporting technological explanations. The disassembled parts can then be reassembled around something else, such as a cardboard structure.

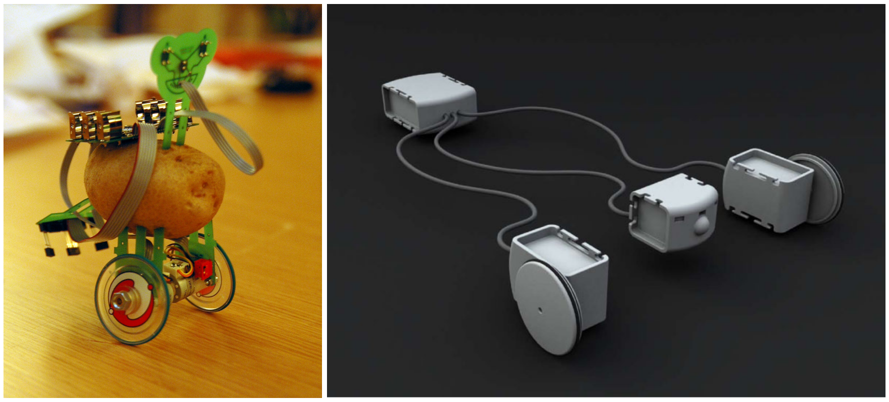

Fig. 2 The first functional prototype and the first design prototype were based on the original idea illustrated in Figure 1, but were difficult to assemble.

The infrared proximity sensors -five instead of three in the first prototype- are now oriented towards the user for a more interactive behavior. While the first prototype would just follow a line, Thymio has three different behaviors, all based on obstacle detection by the infrared sensors and presented as ”moods”: it can be either (i) friendly, following the object in front of it still keeping a given distance, (ii) curious, making obstacle avoidance, or (iii) shy, going backs if one tries to touch it on the front. In addition, a series of LEDs and simple sound effects enhance those moods. Switching between the moods is made with the button. Those behaviors give a pet-like aspect to the robot and help attracting the children’s attention. They are also used as example to explain to children how we can implement different controls on a robot based on the same set of sensors and actuators.

Finally, as we wanted to promote creativity, the robot case is white and can be used as drawing support. It has also the advantage of being gender-neutral. The box itself is also white and has clever dimension that makes it convenient to use as a construction base for the robot.

The final production price, including packaging, was close to 20 USD, therefore perfectly in our target price.

3 Workshops

Workshops at the EPFL robotics festival provide an excellent opportunity to introduce robotics to children in an informal and fun environment. They allow us to create a framework where we give the basic information about Thymio and we encourage the children to learn more about robotics by building their own robot. The target children age is between 6 and 12 years.

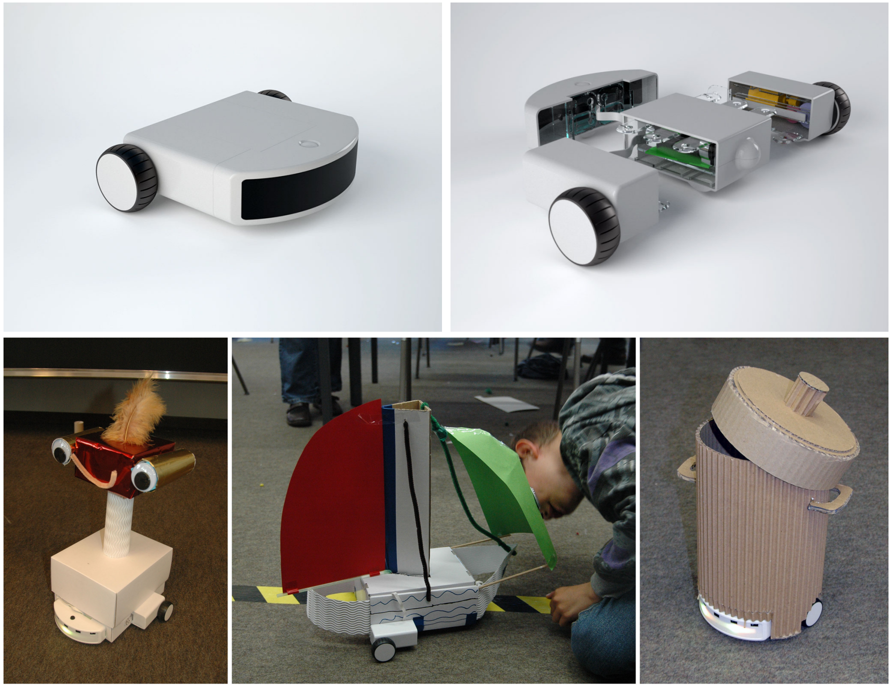

Fig. 3 The Thymio robot is introduced as a full mobile robot (top left) that can be disassembled into four main part representing sensors, motors and batteries (top right). This kit can be assembled around several objects to create very different robots like those illustrated in the three bottom images.

Workshops take place in a classroom, organized specifically for the workshop. In the middle of the classroom there are work places for the kids. Each table is shared by two children and supervised by a trained staff member. On tables against the walls children can choose and take DIY materials such as cardboard, color papers, feathers, etc. The front part of the room serves as playground for the children so that they can test their robots.

Children can chose the workshop based on a short description and a picture. Workshop places can be booked in advance via the festival's website or on the day of the festival at the welcome desk. The subscription fee for all Thymio-based workshops, including materials and the robot kit, was 49 swiss francs (around 50$), the workshop itself being free of charge. When the children arrive in the workshop, they receive a new robot in its box each. The parents are welcome to stay but do not need to, as we provide strong coaching. The workshop starts with some information an basic explanation about the robot. After this, the most important part of the workshop is dedicated to building and decorating Thymio with the provided materials. Once the participants are finished, they test their robots and play with the other kids on the playground.

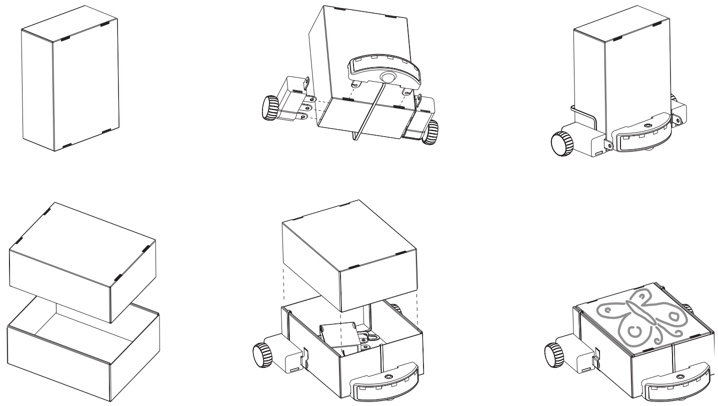

Fig. 4 Some basic constructions using the robot's packaging box as alternative body.

In 2009, we had only one workshop with 50 children, and a duration of one hour. This was quite short and the room, though quite big, was obviously overcrowded. No specific directions were given on what to build with the robot. We noticed that most children would build the same basic robot using the packaging box and decorate it (see Figure 4), probably influenced by the assistants and the lack of time. So in 2010, we decided to make three different workshops with different topics:

1. Animals: This workshop was about making a robot with the shape of an animal, mostly by decorating the Thymio robot. The workshop goal was to promote creativity in this robotic context.
2. Obstacle passing: This was closer to an engineering challenge. Kids had to adapt Thymio to help him passing bigger obstacles, learning about techniques to improve this particular capability.
3. Cardboard workshop: This third workshop was centered around learning the specific technique of cardboard-based construction (see as example the bottom right robot in Figure 3).

The rooms were smaller and offered only 15 places each. The duration was extended to one hour and a half. This proved to be successful, as the kids would learn a specific aspect and could finish their robot before the end of the workshop, allowing to test it on the playground. In 2009 this has not been possible, because we had to rush them out of the room to make space for the next group. The three different themes naturally attracted different age and interest groups.

4 Evaluation and analysis

Within the festival, the workshops were in general a huge success every year. For each edition we had a general survey to understand which activity (among exhibi-

	Strongly disagree to somewhat disagree	Somewhat agree to strongly agree	**TOTAL**
The worskshop is of good quality	3.1%	96.9%	**100%**
Your child is satisfied with the workshop	4.6%	95.4%	**100%**
The workshop is cheap (CHF 50 including the robot)	4.7%	95.3%	**100%**
From your point of view, the workshop is educational	10.8%	89.2%	**100%**
From you point of view, the workshop is fun	15.4%	84.6%	**100%**
After the workshop, your child has shown greater interest for robotics	21.5%	78.5%	**100%**
All together	**10.0%**	**90.0%**	**100%**

Fig. 5 The questionnaire shows that the visitors are very satisfied with the workshop.

tions, shows, workshops, talks) was the most appreciated. In all three editions the workshops have been ranked first in the preferences.

The Thymio-based workshop were particularly appreciated. Several people came back from year to year and almost all the workshop places were taken (356 out of 400 places in 2009, 341 out of 360 in 2010). After two years of use of Thymio, a study was conducted in collaboration with the School of Engineering and Business Vaud (HEIG-VD) by sending an online questionnaire to 346 parents who had brought their children to the Thymio workshop. We got 65 answers. The data shows that the parents are very satisfied with both the quality and the price of the workshop (see Figure 5). To the question ”Do you intend to return to the festival in 2011?” 63.9% answered yes, 29.5% answered maybe and only 6.6% said no.

The workshops themselves have evolved through the years: now every child can go home with his own robot and the different topics allow to work on a specific competence, addressing more specifically the needs of different age groups. The duration of one hour and a half has proven to be a good choice as most children are naturally finished with their construction and start playing with the other participants and their robots.

However we identified several problems. First, we suspected that once they got back home, the children would not really play anymore with their robot. Contrary to our basic idea that they would create other robots with their kit, apparently once they got back home they would display their robot somewhere but they did not want to destroy it. This was confirmed by the study: most children play occasionally or rarely with their Thymio at home (see Figure 6). Even for the children who play often the playing sessions are quite short, generally under 30 minutes.

We investigated the reason for this loss of interest. What came out clearly from the parent’s feedback is that the 3 behaviors are not sufficient. In the workshops already there were many demands for changing or reprogramming the behaviors. Though during the activity the kids would enjoy the behaviors, this was motivated by the fact that there are other robots to interact with, making the behavior richer. For example, they always found that a train can be created by putting one Thymio in obstacle avoidance mode and several others behind it in follower mode. Once at home there is nothing more to discover with the behavior, so the kids use it more as decoration. However, it was stated by several parents that children get really attached to their Thymio and are for example reluctant to let someone else use it.

Related to this problem, a technical issue made the robot consume energy even while off, so when it was left for several days the batteries needed to be changed before the child could play again. This waste of disposable batteries was a serious drawback for the parents and for us. And because the robot was decorated, the exchange of batteries often required the destruction of part of the decoration, discouraging the kids to change the batteries.

Another surprising effect was that the children would not be very impressed by the modularity of the robot. Most of them built a very basic shape with the packaging box (see Figure 4), and many would simply decorate the robot without separating the parts. For the parents also, the modularity and usage of the box is among the less popular features (see Figure 7).

The parents were also asked what new features they would add to the robot. The most popular ideas were compatibility to lego parts, possibility to program it, and use of rechargeable batteries instead of disposable ones. (see Figure 8). The Lego compatibility was tested in a focus group realized in a class of 14 seven-year-old children (see Figure 9). They were given modified robots that had Lego bricks added on top of them and lots of Lego brick to play with. As a result, the kids were immediately comfortable with building the robot. We noticed that with the Lego, they can easily assemble something, then destroy it to build something else. They do not have the same scruple as with destroying something they built out of cardboard and paper.

5 Toward a new Thymio version

After this first experience with Thymio we designed a new version, Thymio II, taking advantage of the lessons learned, which generated a new set of specifications. Some aspects of Thymio were convincing and were not changed: the price range, the neutral shape and color, the geometry of the wheels, the size, the activities using the robot in a specific context with clear learning goals.

As the modular shape did not bring sufficient added value, it was abandoned. Simple Lego connectors are cheaper and offer the support for construction, allowing moreover an easier destruction and reuse. The budget for the electronics was

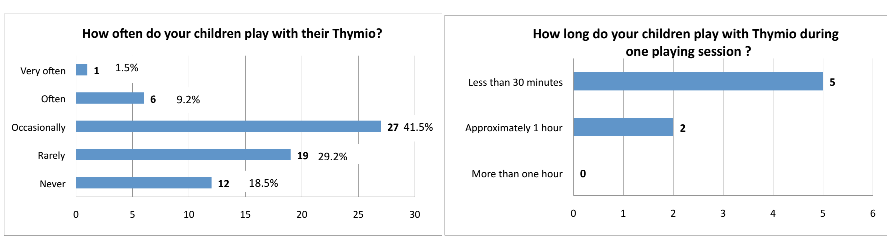

Fig. 6 The children rarely play with their Thymio at home.

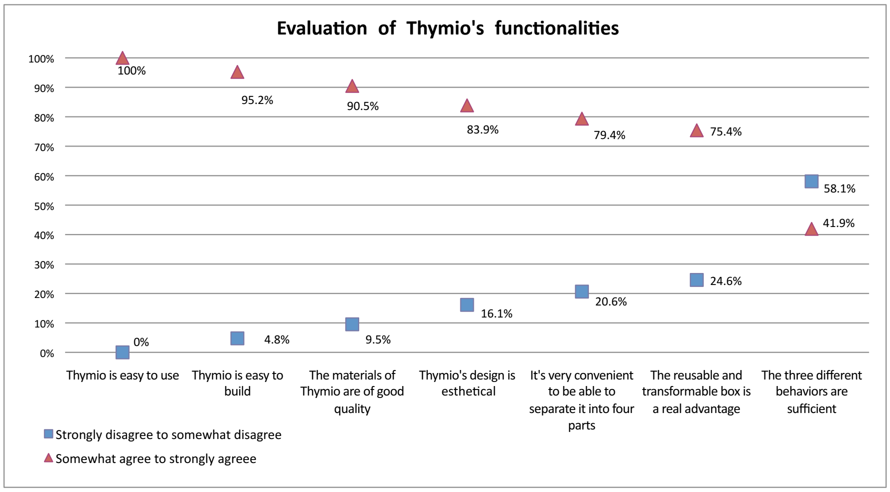

Fig. 7 The modularity and and usable carbord box are not as sucessful as the other characteristics, but what stands out clearly is that the 3 behaviors are not satisfying.

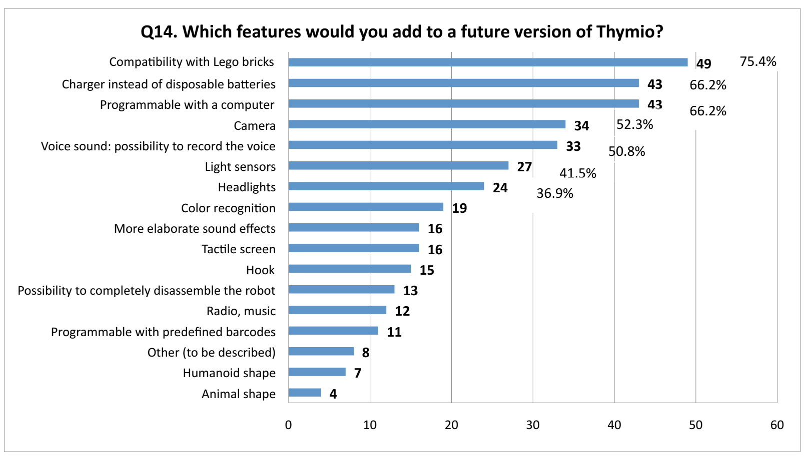

Fig. 8 People would like compatibility with the Lego system and reprogrammability of the robot. They also care about the waste of batteries. Other attractive features would be a camera or the possibility to record one's voice. It is interesting to note that a humanoid or animal shape -very frequent in robot toys- is not appealing to them.

increased (total production cost around 40 USD instead of 20) to improve the programming possibilities: a larger set of sensors (accelerometer, more proximity sensors in different directions, temperature, IR receiver module, microphone... see Figure 10) and a better processor that permits confortable programming.

The programming environment is based on Aseba, which was successfully validated at the robotic festival with kids [11]. Aseba Studio allows easy modification

Fig. 9 Left: a creation with a modified Thymio and Lego made by children during the focus group. Right: a creation with the new Thymio II and Lego.

of the behaviors and real-time visualization of all sensors and actuators. To further support understanding and debugging, all sensors are highlighted by an LED to illustrate their activity. This way, the sensor's activation is shown both as a numerical value in the programming environment and as a light instensity next to the sensor itself. Finally the batteries were replaced by an internal accumulator rechargeable by a USB connector, supporting at the same time a link with the computer where the program is developed. By adding the programming possibilities while keeping the price range, we plan to keep the activities with young kids making simple decorations, but enabling at the same time activities with older kids who can start programming. This new version has been distributed at the EPFL Robotics festival 2011 to 300 children and has encountered a real success.

In parallel, we will develop teaching materials such as instructions on how to reproduce activities like the festival workshops in class, providing ready-to-use exercises for the teacher. We set up a wiki containing several examples of use along with all basic information on usage and programming of Thymio II [3]. Also the basic software is downloadable for free for teachers and children who wish to try new applications.

6 Conclusion

This two year adventure allowed us to have a first experience with a widely distributed robot (approximately 900 Thymio I robots were distributed during two festivals and other smaller events) and collect the feedbacks to generate the specification for a new generation of robots. The workshops were successful and proved to be a good way to introduce technology to children. The vast majority of the interviewed parents are very satisfied with the quality of the workshop and its price. However we identified two main problems: the children do not reuse their robot at home and the modularity is not the incredible feature we had hoped it would be. Our goal to promote creativity and understanding of technology was partly fulfilled by

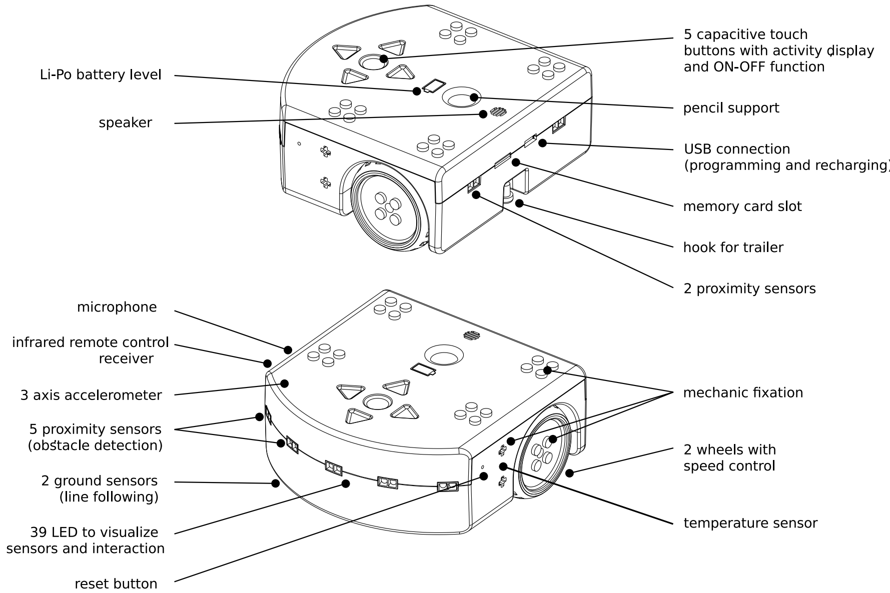

Fig. 10 The new Thymio II has a much larger set of sensors and actuators.

the success of the workshop. But we really want now to add value to the robot and give it a long-term edutainment potential.

To achieve this we released a new version of Thymio that is reprogrammable, rich in sensors and actuators, rechargeable and supporting Lego modularity. Finally, we hope to create a community around the robot so that users could find new programs to run on their robot and share their ideas. This new robot should serve as a basic tool, accessible to all, to teach robotics or other fields to young generations.

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