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# Introducing Educational Robotics through a short lab in the training of future support teachers

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***Abstract*—This paper discusses the design and evaluation of an introductory laboratory in Educational Robotics during a specialization course in support teaching for special needs. The trainees were mostly in-service teachers. We provided various practical examples with different robotic platforms (essentially Mindstorms EV3 and Bee-bot) on the basis of the level. The evaluation was based on a questionnaire the trainees filled at the end of any session: the paper contains some summarizing results of the analysis of the questionnaires.**

***Keywords*—Educational robotics; Learning Support Teachers; Teacher training; Course evaluation**

## I. Introduction

The inclusion of special-needs students in a 'normal' class is more and more a common case. In our context we consider in this category of students not only those with severe disabilities but also with mild forms of dislexia, dysgraphia, dyscalculia and ADHD. The responsible school system adopts all the specific interventions to allow a significant intellectual and practical development of these students, while a good and coordinated formulation of the didactical work of all the involved teachers may take advantage, and not suffer limitations, of this apparent inhomogeneity [1] [2].

Some of these interventions need the specialized and dedicated help of a *Learning Support Teacher* (LST) who collaborates with the other teachers to fully respond to the above-mentioned needs. This kind of teachers need to be specifically trained in order to be able to effectively apply special approaches and specific technologies [3] [4]. The School of Human and Social Sciences of the University of Padova is in charge of providing such training to young teacher students or in-service teachers eager to receive this specific competence. The one year course is organized in different disciplines, seminars and laboratory activities, presenting a wide spectrum of methodologies and tools oriented to special-needs [5].

This year, in the framework of the so called TIC (Tecnologie Informatiche e della Comunicazione – ICT) labs the authors have been asked to start a new experimentation consisting in an introduction to educational robotics, i.e. the use of robots in the class as inclusive teaching/learning tools. The idea was to offer a more up-to-date element of educational technology during this practical part of the course to be used in class, possibly as a coordinated action of the general curricular teachers and the LST.

In spite of the numerous experiences of the authors in teacher training, this was the first case where we had to adapt the usual introductory arguments we present in more general frameworks, to this specific purpose. The paper describes the preparatory activities and how the expected issues related to the specificity of the course should have been faced. Section II shows some motivations of the described activity, section III is a detailed description of the lab, section IV deals with its evaluation and finally section V contains some conclusions.

## II. Robotics in a classroom with special needs

### A. Motivations and challenges

Educational robotics (ER), though not widely known and adopted in the Italian school system, is no more a sort of exotic technology. Experiences in literature and good practices show its relevance as a valuable multidisciplinary tool for any age and any kind of school, from kindergarten to university and beyond [6]. It strongly motivates project-based learning and team working in open teaching/learning scenarios, whatever specific activities are designed, from simple laboratory experiences to structured robotic competitions [7] [8] [9]

Apparently ER seems precluded or seems to offer too hard tasks to disabled students, or at least to be discriminating when different cognitive potentialities are present in the class. Actually literature mentions several counterexamples which show that, not only these problematics are essentially unmotivated scruples of the teacher, but on the contrary ER provides new and interesting occasions for better forms of inclusion [10] [11] [12].

Consequently a claim of specific teacher training arises in order to overcome the initial mistrust a teacher can feel and to provide suitable cues to make both the 'normal' and the future LSTs aware of the real possibilities they can exploit.

### *B. Keypoints*

One of the first conquests a trainer should aim to is to make the trainee aware of the natural attractiveness of a robot with respect to any kind of observer or practitioner [13]. The best way to reach this objective is to start with a very simple problem which requires a very little technical knowledge to realize the solution, both for the construction and the programming of the robot. Because the practical result can be tested very soon, the usual reaction of a not previously experienced trainee is such an enthusiasm that this is the best proof of what she can expect from her students as a good premise of future satisfaction and interesting experiences. Obviously this is just a first step and some other and more demanding examples must be presented to improve sufficiently her technical familiarity and, above all, for having pretexts to introduce typical problems/solutions that have learning meaningfulness.

In the frame of classes with special-needs students, the specific training regards the attitude of the LST and the knowledge of specific limitations and opportunities ER may imply. Just to provide an example, when pupils with autistic spectrum disorders (ASD) are requested to interact with robots, they often reveal improvements of their degree of concentration, their communicative richness and their social skills [14] [15] [16]. Another example, coming from one of our direct experience, is that very young pupil with an apparent cognitive disease or some social interaction difficulties, may reveal an unexpected capacity in term of problem solving, personal initiative and manipulation abilities when requested to construct a robot, with a further improvement of her social capabilities.

In the case of a pupil with more or less severe physical disabilities, this must not prevent her to participate actively to a group in a project-based learning activities. The collaboration between the LST and the group of teachers of the different disciplines (or at least with that or those who are actually involved in ER) must find a good balance between the role of the disabled pupil and the others of her group [17]. The aim is to obtain, on the one hand a fruitful contribution of the disabled and on the other hand a good synergy which makes it possible to promote spontaneous help in favor of the disabled which does not limit the effectiveness of the experience for the entire group. Again the experience of the authors shows that this is not only feasible but it can lead to unexpected improvements in term of social skill for the whole class [10].

Another keypoint is the choice of a suitable robotic platform. Ignoring economic or other not controllable constraints, the choose of the robot, available on the market, should be strictly inspired by educational and methodological issues, possibly with a eye of attention for the specific special needs. The first criterion of choice must be the age of your students which corresponds to a certain level of complexity, both for the construction and the programming point of view. In our presentation we show the different educational platforms the market offers emphasizing that some robots do not require a computer to be programmed (like Bee-bot and Roamer [18]), some of them are bundled with an icon-based programming environment, others are programmable in a wide variety of languages. So the teacher is invited to make choices in harmony with her objectives and the familiarity of the students with the proposed technological level.

## III. Design and realization of the lab

The variety of trainees suggested to divide the whole group of about 250 people in smaller groups, of about thirty people homogeneous with the school level, kindergarten, primary, junior and senior secondary. Consequently we designed a general structure with some specific objectives but together with some adaptations related to the specific group. The common part includes an introduction with general motivations which explains why in this context we are more interested in robots as tools instead of as objectives of study, and what is the common methodology acclaimed as basis of educational robotics, that is the Papertian constructionism [19].

As already mentioned, the first part of the practical lab has the specific aim to convince the trainees that the robot is worthy to be examined as an educational tool because simple to learn and exciting, and, concurrently, to overcome their initial skepticism. We found that the example of a simple *line follower* is completely suitable for this purpose: immediately understandable both in the problem and in the solution, programmed with a few but very significant commands (motion control, if-the-else, loop) (Fig. 1). The programmed solution is extremely powerful in spite of its simplicity: every small group (2-3 people), provided of a Lego Mindstorms EV3 robot and its iconic programming environment (EV3-G), very soon realizes the influence of the two parameters (steering and power/speed) on the practical quality of the solution. Moreover this example makes it also possible to smoothly introduce the concept of flow graph and why choices are often necessary in the control program to make the robot correctly react to external solicitations.

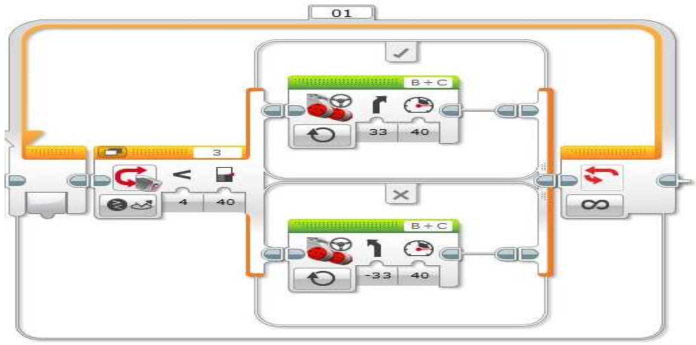


Fig. 1. A simple line follower program in EV3-G

At this point the question we ask the trainees is: did you enjoy the experience? It is a pleonastic question because we have every time already observed an increasing enthusiasm during the realization of this first simple example, but the question is useful to make them conscious of what reaction they can expect from the beginning from their students.

The following example introduces the concept of *motion profile* which shows a designing approach that considers the robot action as a sequence of behaviors. The transition from one behavior and the successive is triggered by conditions signaled by some sensor(s). The sequence and the triggering conditions can be straightforwardly represented through a state graph which can be introduced at this point in a constructivist way. In the example of Fig. 2 the profile in made by the following behaviors: approaching fast to the obstacle; when a certain distance D1 from the obstacle is reached, approaching slowly; when a second distance D2<D1 is reached, the robot must stop for at least 2s and then restarts when the obstacle is removed or moved farer. The distances are measured by an ultrasonic sensor. The state diagram can help the design of the program more effectively than a simpler flow graph: a transition between two states is labeled by the triggering condition (Fig. 3).

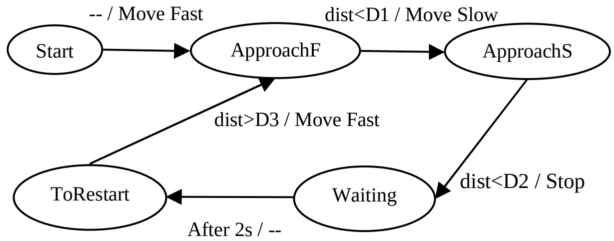


Fig. 2. Approaching state diagram

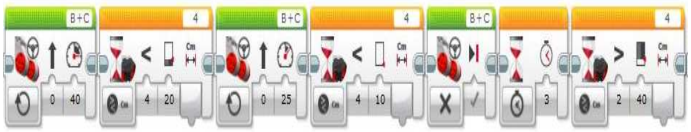

Fig. 3. Motion profile program (EV3-G)

This example leads the trainees, and eventually their students, to think in terms of state evolution. The diagram can be drawn on a black/whiteboard and it helps finding the correct control solution. Depending on their age, after the experience the students could be asked to reproduce on a cartesian space/time plane the motion to reflect on the already observed robot behaviors.

At this point the lab activities differentiate on the basis of the class. With secondary school teachers we go on with other more complex examples: usually they are looking for examples which can convey some math or geometry concept or some disciplinary competence for their students, particularly in the case these concepts are difficult to understand or felt not particularly interesting or useful. For example, at the junior secondary level important concepts are proportionality, angle and its measure, space and speed. All these concepts are pleasantly introduced with an example called *the metro* (a type of straight-line robot, see [20]). The robot represents a tractor of a subway moving on a straight line: it starts from a terminal station and must stop for a while on each following station until it reaches the opposite terminal station. The track in between each couple of stations has a common and known length. Pupils often apply a trial-and-error approach trying to discover, through successive approximations, the exact time to set for the motor rotation in order to make the robot move precisely along one track. After this step the teacher is invited to introduce a simple geometrical model of transformation from a circular motion to a straight-line motion, rendering the students aware of the importance of applying such models to obtain more precise settings (in this case, the model allows to derive the setting of the angle of rotation of the wheels from the track length, which entails a more precise, speed and battery charge independent, solution). At this point the adaptation to a different track length is only a matter of proportionality.

In a similar scenario but with stations at different distance each other, we suggest to identify the position of the stations with markers, put on the path, which can be recognized by a light or color sensor. Not requiring a specific geometrical model, this example is suitable also for younger students.

For trainees working in kindergartens or with pupils of the first primary cycle, a robot like Mindstorms could be too complex. For them we first emphasize the necessity to contextualize any experience using story telling and dramatization. This is very important to motivate the inclusion of a robot in a project dealing with different cultural aspects like geography, history together with math and geometry [21]. We also present various platforms which can be used at this level (Bee-bot & Pro-bot by TTS Group, Roamer by Valiant Tech., WeDo by LEGO are the most famous). We mention also Arduino as a possible low-cost hardware to be considered by the most technological-oriented of the group of trainees ([22] presents some other available options).

Though ignored so far, the economical feasibility of robotic-enhanced projects can be hard particularly for primary schools, therefore we briefly present the possibility to have robotic-like experiences also with some free authoring software, among which Scratch [23] and BYOB/Snap [24] are the most known. Effectively these environments are enriched with (the equivalent of) sensors and motion control commands which make projects realized in these environments a sort of simulation of robotic applications [25] [26]. For example, with Scratch is easy to simulate a Bee bot (Fig. 4). Some mixed solutions can be further adopted, like Arduino and WeDo (external hardware) with Scratch (the programming environment). Following these reasons, we present some examples in Scratch and BYOB, showing the relatively easiness to have robotics experiences using these environments (Fig. 5). Because their programming style is again iconic, their adoption anticipates the familiarity with other environments, waiting for a successive availability of real robots to be programmed.

To trainees going to teach to the second cycle of primary schools, we suggest an operative compromise: the teacher prepares some sub-blocks (using the myblock feature, in the case of EV3-G) which represent macro-commands, too complex to be implemented by the students, but simply understandable for using them in a higher level programming style like library components. For example these macro-commands could be the four basic commands of a Logo-like turtle plus a pause and possibly some grasping primitives if the robot is provided of a grasping arm. This allows to maintain the level of complexity already experienced with simpler robots like Bee-bot but with the prospect to skip to more challenging examples without changing the platform, in a smooth progression. For example we helped the developed of an experience of a couple of teachers with two 3rd grade classes in a context of geography, street safety, quarter life [27].

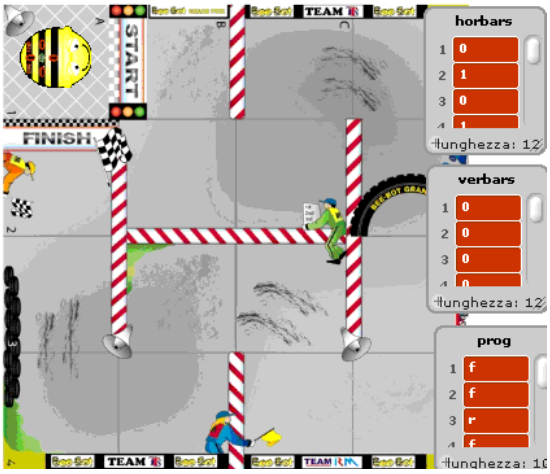


Fig. 4. Simulation in Scratch of a typical scenario with Bee-bot (notice that obstacles and the Bee-bot program are stored in Scratch arrays)

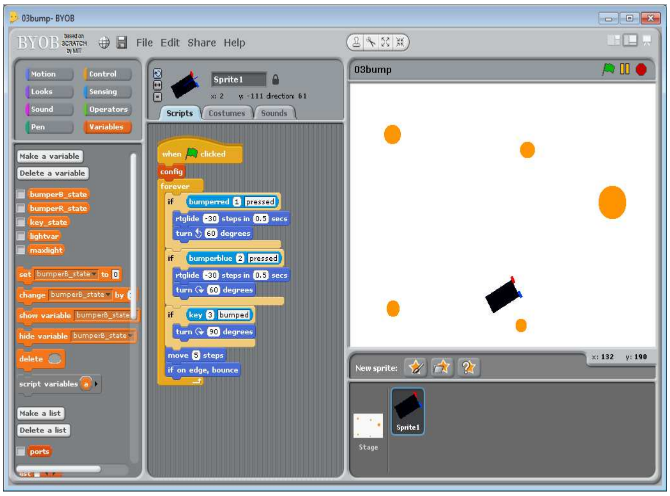

Fig. 5. Simulation of a robot with bumpers in BYOB

For older students the variety of possibilities is great and the Mindstorms platform offers a wide flexibility: apart the infinite combinations of assembling, EV3-G includes a complete set of commands for elaborating and store data and a tool for data logging, useful for more deeply examining the physical phenomena. We suggest for example to exploit the color coding, which is a native function of the color sensor, to simulate a run-time way to send commands to the robot presenting different colored plastic pieces or cardboards.

In technical vocational schools of course the examples can be much more elaborated, and the programming complexity is afforded explicitly exploiting the design of callable subcommands. For example a simple line follower can be improved implementing a simplified PID controller, and multi-actuated constructions can be controlled by multitasking solutions.

While in primary and junior secondary school it is common that a LST is asked to help the special needed student for all her general learning limitations, at the senior secondary level this may be more challenging due to the higher specificity of the taught disciplines. For this reason for the moment we focused our attention to the lower levels where, as we tried to show previously, an active collaboration among all the teachers involved can exploit all the potentiality educational robotics may express.

## IV. Evaluation of the Lab

### A. *Instruments and procedures*

A short questionnaire was administered to participants at the end of the classes. The questionnaire comprised 4 sections: (1) a semantic differential including 12 bipolar pairs of adjectives to measure the participants' perception of robotics; the respondent was asked to choose where her position lies, on a 5-point scale between two bipolar adjectives (e.g. bad-good, difficult-easy, passive-active; cold-warm) [28]; (2) attitudes toward robotics in education was rated on a 5-point Likert scale (16 items; e.g. I think that robotics can be a valid didactical tool; I think that robotics can foster autonomy in learning process, see [29] [30] [31] [32]); (3) the positive and critical issues of the course were grasped via 5 open-ended questions (e.g. In your opinion, what are the most interesting aspects of the course, e.g. the contents, the approach, the learning environment etc.); (4) Socio-demographic items such as gender, age group, school level where participants are currently teaching (e.g. primary, junior secondary), years in the position, role. Thus, the questionnaires were substantially anonymous and in such a way might be perceived by the respondent.

### B. *Participants*

The study involved 193 participants, 32 males and 158 females (females = 83.2%; missing = 3): the not surprising difference is due to the usual predominance of female teachers, particularly at kindergarten and primary school in Italian educational system. Almost 38% is less than 35 years old, 50% is from 36 up to 45, and around 10% is more than 45. 40 participants (20.7%) teach at kindergarten, 51 (26.4 %) in a primary school, 71 (57.4%) in a junior secondary school, and 24 (12.5%) in a secondary one (missing = 3). 99 of them are LSTs (51.3%) and 85 of them (44%) are teachers with other specializations (e.g.: music, mathematics, foreign languages, literature, and others; missing = 9). Almost 52% of them is teaching since more than 8 years (ranging from 1 up to 25 years; $M = 8.97$; $Mdn = 8$; $SD = 5.04$; missing = 3) (Fig. 6).

### C. *Data analysis*

According to the semantic differential, binomial test revealed that the majority of participants considered robotics is good (26/161, *Binomial* $p = 0.001$), desirable (46/140, *Binomial* $p = 0.001$), and pleasant (40/146, *Binomial* $p = 0.001$). The majority of participants affirmed robotic is difficult (145/40, *Binomial* $p = 0.001$) (Fig. 7) [33]. According to the attitude toward robotics, the majority of participants answered that robotics is a valid didactic tool, fostering students' autonomy, motivation, technical competence, and social competence (respectively: 129/63; 135/57; 171/22; 166/26; 144/48; *Binomial p's* = 0.001). The majority of participants do not think robotics is difficult for their students (128/65; Binomial p = 0.001); furthermore, they consider robotics could help students to autonomously collect didactic information (129/64; Binomial p = 0.001) (Fig. 8).

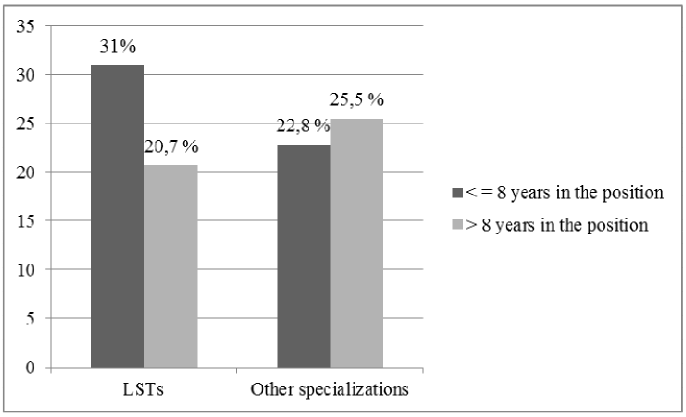


Fig. 6. Percentages of participants distributed for school role and years in the position

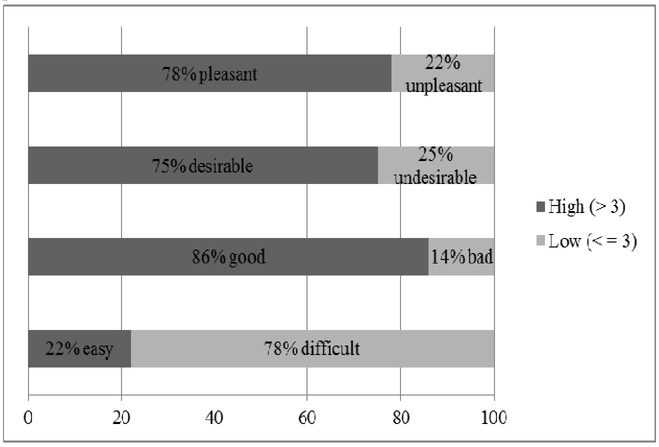


Fig. 7. Percentages of responses to the semantic differential items

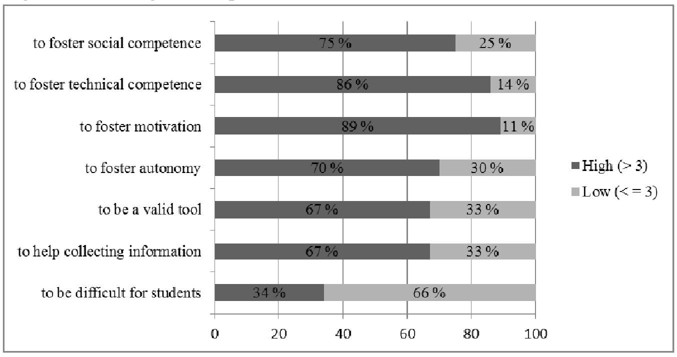


Fig. 8. Percentages of responses to the attitude items

Available data (*N* = 77) shows that participants are satisfied with the course and would advise their colleagues to take the same course in the future (*M* = 3.73; *Mdn* = 4).

One open-ended question asked participants whether they had already an idea about how to use robotics in class, in which subject, for which pupils and to reach which aims. Approximately 61% of participants declared they had already an idea on how to integrate robotics in class [34]. Specifically, they recognized that scientific disciplines such as maths, physics, geography and orienting are the most suitable ones. Multidisciplinary activities are also mentioned (e.g. together maths and physics).

*"It would be useful to teach some aspects of scientific, technical or geographical disciplines using robotics in a group context" (participant n. 67, women, between 36 and 45 years old, music teacher in junior secondary school, 7-years experienced).*

Participants declared that robotics could involve the all class as divided in small groups, including special-needs children too. As for disabilities, participants named Autism Spectrum Disorders (ASD), attention deficit disorders (ADHD), mild mental retardation, among others as needs to be properly addressed with robotics in class.

*"In maths, sciences, in particular with children with ASD and ADHD diagnosis" (participant n. 38, women, under 35 years old, German and LST in junior and senior secondary school, 8-years experienced).*

Participants underlined the importance of robotics to increase some important learning aspects.

*"To strengthen logic, activity planning and problem solving, maths. With children with attention difficulties, to improve motivation and attention" (participant n. 69, women, between 46 to 55 years old, LST in junior secondary school, 10 years experience)*

### D. *Evaluation summary*

In summary, after four-hour classes, participants revealed to considered robotics as a desirable, nice, and valid tool for learning process, fostering student' autonomy in school, their motivation in learning, technical competence, and even social competence. They consider robotics could help students to autonomously collect didactic information. Participants do not think robotics is difficult for their students, however, participants answered that teaching robotics is more a difficult than an easy didactic tool. The majority of participants declared they had an idea on how to integrate robotics in class, including special-needs children with Autism Spectrum Disorders (ASD), attention deficit disorders (ADHD), mild mental retardation. Participants underlined the importance of robotics to increase individual skills such as problem solving, attention focusing, motivation to learn and social skills such as cooperation in groups. They are satisfied with the course and would advise their colleagues to take this course in the future.

## V. CONCLUSIONS

The design and the evaluation of an introductory course in Educational Robotics if the framework of special-needs training has been presented. We showed that it is important to choose well calibrated examples to convey at least some basic general principles about how to implement robotics at school, and the training has been carefully adapted to the school level. Literature proves that ER is effective also for and with special-needs students provided a good collaboration is established between the support and the curricular teacher to promote project-based activities involving the entire class. The outcome of the questionnaire shows that there is a common awareness of the power of ER as an inclusive learning tool.

## Acknowledgment

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