A Training Course in Educational Robotics for Learning Support Teachers

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Abstract. This paper discusses the new implementation of a strengthened introductory training course in Educational Robotics for pre-service and in-service learning support teachers. By means of a final written questionnaire we compare the results of the course in 2015 with this year course, when the number of hours were doubled. This year participants expressed a higher appreciation and a better attitude towards robotics. Teachers agreed on the conviction that robotics can enhance students' motivation to learning and that educational robotics sustains a new point of view on science for teachers. Regarding the implementation in class, approximately two third of the participants declare they had already an idea on how to integrate robotics in curricula. More specifically, participants named ASD (Autism Spectrum Disorders), ADHD (Attention deficit hyperactivity disorder), learning disabilities, mild mental retardation as aspects that can be effectively addressed by ER.

Keywords: Educational robotics · Learning support teacher · Special needs education · Inclusive education · Teacher training · Course evaluation

1 Introduction

After several years of studies, experimentations, a variety of proposed approaches, an increasing need to reform the educational system, particularly at the European level, the use of Information and communication technologies (ICTs) in education is no longer under discussion. But a profound rethinking of the role of this latter in the 21st century era is the mainstream for any serious reforming attempt [1–3]. Nonetheless this generally accepted conviction includes some critical aspects when special needs education (SNE) is concerned (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, who are mixed with not affected students in ordinary classes; this is the usual case at least in Italy where special schools are very rare).

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The first question is about the applicability of ICT for SNE: are ICTs suitable also for special needs students and which are the benefits in introducing alternative technological tools in these cases [4,5]. The second question is about the awareness that actually ICTs are driving forces of a new way of spreading knowledge and promote good practices in teaching/learning especially regarding SN students [6,7].

About the first question, literature highlights some of the the potentialities of using ICT for SNE [8–11]:

- improving collaborative and exploratory learning allowing students to interact with the material;
- helping in communication;
- improving the involvement of the students and their achievement in some of the major subjects;
- furthering an inclusive education.

With these premises, if curricular teachers must be usually trained to effectively use ICT besides the sole introduction of productivity tools in their usual teaching process, there are even stronger reasons and needs to suitably train teachers who are being specialized to give support to SN students to assure the providing of an inclusive education (i.e. diverse needs without making differences).

Software interfaces and languages are aspects to be carefully considered as potential barriers for SN students: this could give the impression that choosing specific software would be advisable or even compulsory: this is actually not always the case because not compliant with an idea of real inclusion that should involve all the students in the class. Similar considerations are valid for hardware and devices [12]. Because our focus is on Educational Robotics (ER), a discipline which impacts both with software and hardware issues, this point is of crucial importance.

In the last two years, we have been organizing a training course dedicated especially to learning support teachers (LSTs) with the specific aim at introducing ER as an affordable option for their future "special" work. LSTs strictly collaborate with the curricular teacher(s), therefore our main goal was, and still is, to provide them a basic competence to promote through them the diffusion of ER as a powerful ICT tool with a special attention to inclusion. The first year experience is described in detail in [13] and that first experience is the basis of the relevant improvements we introduced this year and that are the main subject of this paper.

Summarizing, the paper describes the structure of the training course, how special needs were dealt with through the proposed activities and what changes we observed in the attitude of the trainees towards robotics after the course, thanks to a comparative evaluation with the results emerged last year. Section 2 shows motivations and challenges, Sect. 3 is a detailed description of the proposed activities, Sect. 4 presents the results of the evaluation; finally, Sect. 5 exposes our conclusions.

2 Robotics in a Classroom with Special Needs

2.1 Motivations and Challenges

Working with students with special needs and promoting an inclusive education aimed at reducing gaps between students and, in any case, at providing equal opportunities of a harmonic personal development, are some of the most challenging tasks that a teacher has to face. Among ICT tools, ER has proved as one of the most promising for supporting teachers in this job [14,15]. Besides the abovementioned benefits, common to other ICT tools, ER is particularly well-suited to create the conditions for an inclusive learning environment. Among the others, we could emphasize these relevant aspects [16–19]:

– improve social interactions and cooperative learning experiences;
– provide an inclusive and flexible learning environment, suited to bring out diverse types of skills (for instance giving relevance to the pupil's role as a constructor rather than a programmer);
– promote a self-built learning, consistent with constructivist and constructionist theories;
– transmit some complex and abstract concepts through practical situations and hand-on experiences.

These qualities, which has been often validated in usual classes, express their full potential when the teaching/learning process faces SN issues, provided the collaboration between the curricular and LS teachers adapts the proposed curricula to such needs.

Unfortunately, even if robotics has been proved to be such a useful teaching tool, it remains a subject not yet widely known and seldom adopted in schools. In part this is due to the teachers' lack of expertise in ICT and to the misconception that such activities are too complex for their personal competences [20]. In [6] the European Agency for Development in Special Needs Education, highlighting the necessity to train teachers in the use of ICT, states it is not reasonable to expect that teachers can effectively integrate these type of tools with traditional learning approaches if they don't receive any initial support from other specialists. Moreover, the European Agency underlines that the full potential of ICT in the learning process is achieved proportionally to their degree of conviction that these tools are really useful.

2.2 Keypoints of the Training Course

The proposed training course is part of a one-year course provided by the School of Human and Social Sciences of the University of Padova and offered to temporarily employed and not yet employed teachers who want to get a specific qualification as LSTs [21]. This full year training aims at presenting a wide spectrum of SN-oriented methodologies and tools including Special pedagogy, Integrated models, Developmental psychology, School legislation, Labs on Motion and Dance, just to mention some. Our course is essentially an introductory lab about ER. Trainees last year reported essentially a positive feedback to our course but one limitation, highlighted by most of them, was the amount of time we dedicated to every class (just one session of 4 h). For this reason we were asked this year to double the number of sessions per group, enlarging the total number of hours to eight. We had a total of about 200 participants: 196 of them, accepted to provide evaluation data at the end of their couple of sessions.

The first positive effect of enlarging the amount of hours was to encourage a more active participation of each trainee, but more important it gave us room for presenting a larger variety of exemplary curricula and for asking homogeneous groups of trainees to design and discuss in a plenary form a draft of didactical unit in order to deepen SN issues. In other words, we wanted to motivate the trainees to show interest in integrating robotics in a class with the presence of SN students, for example with Autism Spectrum Disorders (ASD), attention deficit disorders (ADHD) and mild mental retardation.

In the case of a pupil with physical disabilities, it is imperative that his/her difficulties cannot prevent him/her from working together with peers in project-based learning activities. The aim is to realize a good balance between the role of the disabled student and the other members of the group. In addition, in this case the wide and diverse set of skills required for ER activities allows on the one hand to make the disabled student able to provide a fruitful contribution to the group, on the other hand to compel the group to help the disabled member, creating a positive synergy. Finally, it is very important to make the trainees aware of the possibility to easily integrate any ER project designed for disabled students into a project suitable for the entire class, while promoting the collaboration between the LST and the other teachers.

The course evaluation was done through the distribution, at the end of the group of 8 h, of a short personal questionnaire. The proposed questions were very similar to the ones on which the questionnaire prepared for the previous year was based, so making it possible a sensible and useful comparison.

3 Description of the Activities

The 8 h course was designed in order to address these main aspects:

- methodology;
- engagement and familiarization;
- exemplary experiences;
- designing of didactical units.

ER is very often associated with the constructionist methodology and we briefly introduced the strongest motivations to adopt this methodology for a fruitful introduction of robots in class [22,23]. We also suggested some propedeutic readings dealing with this methodological approach [22,24,25]. But, due to the specific focus of the course, we added some cues to tackle the effects of the presence in a group of a SN student. The general principle is not to modify the essence of the experience, but to adapt the role of this student in the group regarding his/her limitations. For example, in case of a physical disability, the student could be asked to specifically participate to the design process, to the definition of the objectives, to the evaluation through visual observations. A student with ADHD could be more profitably engaged in manual constructions. Exploiting the potential inherent to the team synergy proves as the best way to promote a really inclusive ER.

Focusing on the initial engagement of the trainees it is crucial to allure the trainees with a "first taste" of ER. Most of the trainees, who come from very different disciplines and levels, are very skeptical (especially the ones teaching non-scientific disciplines) and they perceive the use of robots in the class as something strange and new, not clearly motivated and difficult to implement. It is not advisable to present the full set of commands beforehand, but the trainees should gradually be exposed to the most useful and frequent ones through the suggested experiences.

For this reason, we always start with a simple and immediately rewarding experience, the "line follower" (in its simplest form) which allows to introduce the most important programming blocks. This implementation requires just 4 commands (one loop, one switch, and two alternative "move steering" blocks). The possibility for the trainees to implement in a few minutes a correct solution and to observe the "intelligent" behavior of the robot, only tuning the two involved parameters (speed and steering factor), usually produces a strong emotional engagement and a positive effect on the degree of acceptability of the overall proposal. The other offered experiences were:

- straight motion: make the robot move for a certain distance and stop for a while, and then repeat the same actions for 4–5 times; this example offers the opportunity to reason about the relationship between rotational and straight line motions;
- polygon: make the robot "paint" a regular polygon (equilateral triangle, square, pentagon, hexagon etc.); this highlights the problem to precisely control the turning of the robot;
- obstacle avoidance (Fig. 1): by using the ultrasonic sensor, it is possible to sense the presence of an obstacle on the way and to overtake it trying to realign the robot on the same original straight line;
- stop and go: again the ultrasonic sensor makes the robot stop when the obstacle is close enough, and move forward again when the obstacle is moved beyond a certain (greater) distance; if you put more robots one behind the other, all of them programmed for this same experience, the complex of robots seems to move as a multistage vehicle.

In spite of the limited available time (8 h), we successfully showed that the ER can be used to deal with multidisciplinary themes in an amusing and team-oriented perspective.

Part of the practical lab was designed according to the school level. More specifically, with training kindergarten and primary school teachers, we suggested, and also showed through a few simple examples, the use of authoring environments like Scratch to provide a first robotic-like experience to very young

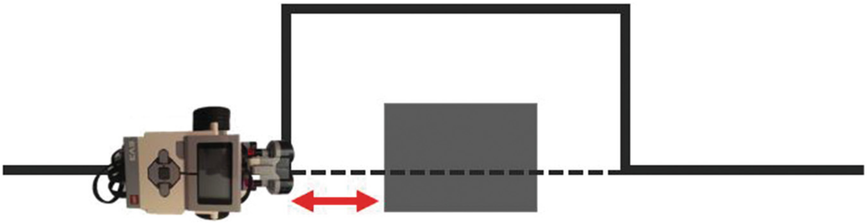

Fig. 1. Obstacle avoidance experience

kids. We have also to consider that very simple floor turtle robots like bee/blue-bot were specifically designed for these school levels. Using effectively such robots means first of all to integrate the role of the machine within a multidisciplinary 'story-told' scenario, possibly related to real life, in order to stimulate discussions, reflections, research and teamwork [26].

The last part of the course for each class was dedicated to briefly develop a multidisciplinary didactical unit. We divided the class into 5–6 groups of 4–6 people each, asking every group to find a main theme and to design the unit around this theme, imagining that in the class group of students a SN student is present. The development of a didactical unit is the moment when making the trainees more deeply aware of the inclusiveness of ER through a synthesis of the presented ideas. The points we suggested to develop were:

1. possible focused discipline;
2. theme;
3. preparatory activities (to set up the scenario);
4. role of the robot;
5. didactical objectives and expected new skills;
6. learning support issues.

Each group had the possibility to briefly present their developed unity, emphasizing what they thought to be critical aspects and new potentialities. From these presentations it came out a solicitation for further deepening the relationship between ER and SN and how the wide spectrum of applicability of ER assures to design diverse and "personalized" scenarios. Moreover it was argued that pupils with an apparent cognitive disease may reveal unexpected capabilities in terms of problem solving, personal initiative and constructive manipulation abilities. Another aspect which should never be minimized is the promotion of interactions and social skills, even in the case of severe diseases. For example, pupils with autistic spectrum disorders (ASD) may manifest a higher degree of concentration, communication and social skills during robotic-enhanced activities [27,28].

4 Evaluation of the Training Course

4.1 Instruments and Procedures

The same short questionnaire of the last year [13] was administered to the participants of this year at the end of the classes. No questionnaire was administered before attending the class, as the course was so short that we expected participants would have remembered their own answers for the first questionnaire when filling in the second one (i.e. "recency effect"). The questionnaire was anonymous and it was divided into 4 sections (Table 1).

Table 1. Description of the questionnaire

What we evaluated	How we evaluated it	Examples of items/questions
Teachers' perception of robotics	Section 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/his position lies, on a 5-point scale between two bipolar adjectives [29];	bad-good, difficult-easy, passive-active, cold-warm.
Teachers' attitude toward ER	Section 2: 16 items on attitudes toward robotics in education were rated on a 5-point Likert scale [30,31]	I think that robotics can be a valid didactical tool; I think that robotics can foster autonomy in learning process
Course evaluation	Section 3: The positive and critical issues of the course were assessed via 5 open-ended questions	In your opinion, what are the most interesting aspects of the course? (e.g. the contents, the approach, the learning environment etc.); Do you have any idea about how to use robotics in class?

The last section contains socio-demographic items such as gender, age group and school level of the institutes where participants were currently teaching, role held by the teacher and time spent on that role.

4.2 Participants

The study involved 196 participants, 154 females (females = 83.7%; missing = 12). The prevalence of women reflects the usual predominance of female teachers, particularly in kindergarten and primary school in the Italian education

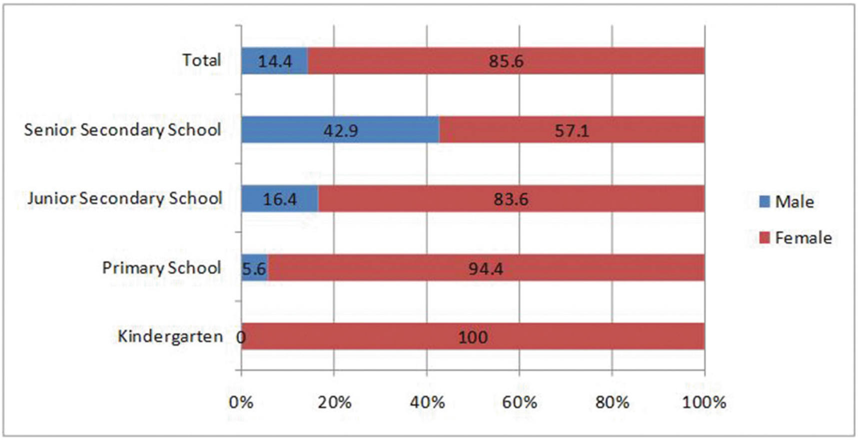

Fig. 2. Teachers by gender and school level

system. Almost 39.1% is less than 35 years old, 48.4% is from 36 up to 45, and 12.5% is more than 46. Twenty-one participants (10.7%) teach at kindergarten, 72 (36.7%) in a primary school, 58 (29.4%) in a junior high school, and 33 (16.8%) in a high school one (missing = 12) (Fig. 2). Eighty-seven of them are LSTs (44.2%) and the remaining are teachers with other specializations (e.g.: music, mathematics, foreign languages, literature, and others; missing = 12). Almost 50.3% of them has been teaching for at least 9 years (ranging from 1 up to 22 years; M = 8.45; Mdn = 9; SD = 4.12; missing = 9). The research was compliant with the Code of Ethics of the Italian Psychology Association (AIP, 2012).

4.3 Data Analysis

First, we present the data on the course evaluation and then the data on the evaluation of attitude towards robotics and attitude towards ER.

Course Evaluation. The answers to the open-ended questions on the positive and negative aspects of the course were content analysed. Participants' answers were coded according to the meaning into superordinate categories by trained judges (SDB, MP). Most frequent categories are reported in the following. As for the positive aspects, participants named:

1. the didactic approach characterised by practice: participants appreciated the chance to develop practical skills, to practice over a concrete exercise, to use robots and software by themselves; this is the most frequent category as 104 excerpts were coded into this category; e.g. *"Innovative lesson content and*

the possibility to practice immediately after the theoretical part" (participant #14, woman, junior secondary school teacher, less than 35 years old);
2. the innovative course content: participants named the theoretical content of the course dealing with ER and underlined the novelty of the course; this is the second most frequent category with 62 excerpts; e.g. *"... the introduction of a discipline that I have never considered before, especially with its practical side during classes"* (participant #15, woman, kindergarten teacher, less than 35 years old);
3. the participants' involvement into the course: as this course has a practical orientation, participants pointed out that it was intellectually and emotionally stimulating, and attending the course was fun; this category was named 27 times; e.g. *"A different way to approach the discipline, that makes it more stimulating"* (participant #28, woman, primary school teacher, less than 35 years old);
4. team working and cooperation: participants appreciated the possibility to work in groups and to exploit a cooperative learning approach among teachers; e.g. *"Team working has allowed the co-construction of the knowledge, by trying what could be introduced to school students"* (participant #29, senior secondary school teacher, woman, between 46 and 55 years old).

Regarding the negative aspects of the course, participants reported:

1. lack of time: participants complained about the small amount of hours allotted to this course; they needed more time to practice; this is the most frequent category with 66 excerpts; e.g. *"(the course is) too short. Given the modernity of these technologies, lesson hours should be more."* (participant #128, woman, junior secondary school teacher, 36 and 45 years old);
2. the complexity of the course contents: participants pointed out that the course was difficult in terms of proposed activities and concepts; this is the second most frequent category with 28 excerpts; e.g. *"completely new concepts, based on non-consolidated knowledge, to be learned in a small amount of time"* (participant #126, woman, junior secondary school teacher, between 36 and 45 years old);
3. lesson rooms: participants claimed that the lesson rooms were not fully equipped for ER lessons; participants named this category 25 times; e.g. *"The room was too big; we had few robots at disposal"* (participant #110, woman, junior secondary school teacher; between 46 and 55 years old).

Participants suggested some improvements in the same areas they identified as problematic. For instance, participants suggested to increase lesson hours to practice more with robots, and to locate this course at the beginning of school year in September, to better plan their laboratory activities. When answering the question *"Would you recommend this course to a colleague of yours?"*, 73.8% of participants replied YES (adding answers 4 and 5), showing an overall general positive evaluation of the course. When comparing the data of 2015 and 2016, we observed an improvement in the evaluation of the course (Fig. 3). Independent-sample t-test showed that 2016 participants had a more positive

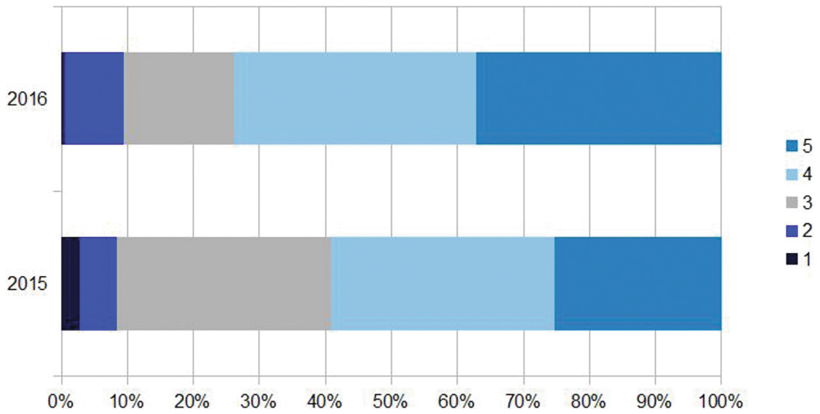

Fig. 3. Distribution of the answers to the question "Would you recommend this course to a colleague of yours?" Participants were asked to respond on a 5-points likert scale (1 = no, 5 = yes).

evaluation of the course than 2015 participants ($t(260) = -2.04$; $p = .04$; $M_{2015} = 3.73$; $M_{2016} = 4.01$). Participants appreciated more the 2016 course, where lesson hours increased from four to eight.

Attitude Towards Robotics: Semantic Differential. The semantic differential consists of a set of couple of opposite adjectives, and the respondent was asked to mark a position closer to the adjective that he/she perceives as more suitable to describe the stimulus word. One-sample T-test was performed on each couple of adjectives to test if the mean was significantly different than the average point of the response scale (= 3) (Fig. 4). After attending the course, participants considered robotics as good ($M = 4.06$; $t(190) = 19.18$, $p < .001$), beautiful ($M = 3.97$; $t(187) = 16.06$, $p < .001$), attractive ($M = 3.79$; $t(184) = 12.85$, $p < .001$), pleasant ($M = 3.91$; $t(191) = 12.55$, $p < .001$) and strong ($M = 3.63$; $t(185) = 10.26$, $p < .001$). Moreover, participants perceived robotics as warm ($M = 3.32$; $t(187) = 4.66$, $p < .001$), fast ($M = 3.48$; $t(189) = 7.61$, $p < .001$), active ($M = 4.11$; $t(190) = 18.36$, $p < .001$) and trustworthy ($M = 3.88$; $t(189) = 14.83$, $p < .001$). Eventually, robotics was perceived as difficult ($M = 2.86$; $t(188) = -2.06$, $p = .04$). No significant differences according to socio-demographic items were observed.

Attitude Towards Educational Robotics. One-sample t-test revealed that teachers agreed with the statement that (1) robotics can enhance students' motivation to learning ($M = 4.13$; $t(194) = 19.60$; $p < .001$), (2) group works with robots can improve students' social competences ($M = 4.07$; $t(194) = 16.39$; $p < .001$), (3) educational robotics sustains a new point of view on science for teachers ($M = 3.74$; $t(193) = 10.34$; $p < .001$) Fig. 5 shows the percentages of

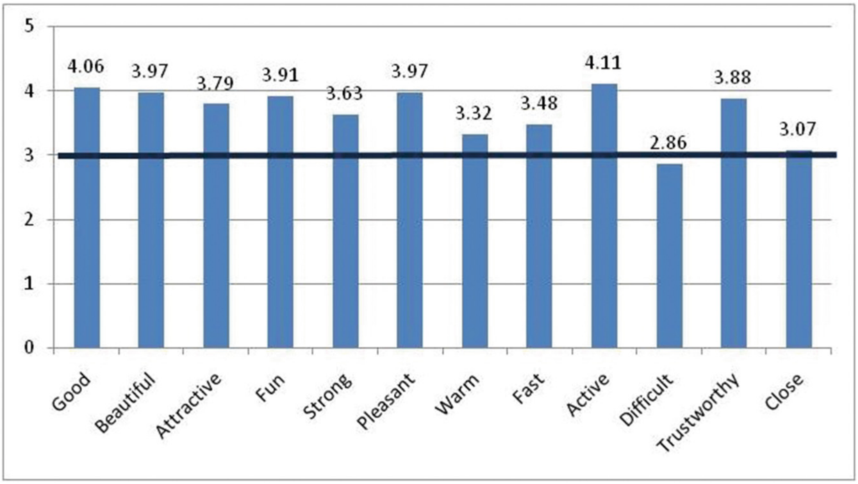

Fig. 4. Means for each couple of adjectives

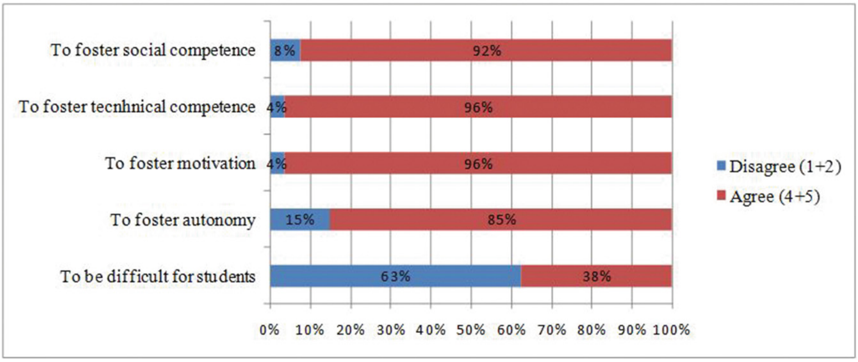

Fig. 5. Percentages of responses to the attitude items

responses for the agreement (answers = 4 and 5) and disagreement (answers = 1 and 2) to some items on attitude towards robotics. Response 3 (i.e. middle point of the response scale) was deleted from the analysis to make the data more readable. The majority of participants showed a positive attitude toward robotics, after attending the class. Moreover, a minority of teachers (38%) agreed that educational robotics could be difficult for students.

Moreover, a t-test for independent sample was run to test the influence of teachers' gender and of years of teaching experience on the attitude toward educational robotics. As for gender, male teachers agreed to the statement that ER is difficult for teachers more than female teachers ($M_M = 3.88$ vs $M_F = 3.25$; t(115) = 1.88; p = .004). Male teachers agreed to the statement that ER can distract attention from lesson themes more than female teachers ($M_M = 2.53$ vs

M_F = 1.77; t(153) = 3.09; p = .002). As for teaching experience, experienced teachers (teaching for more than 11 years; n = 43) agreed that ER can be a valid didactic tool more than less experienced teachers (teaching for less than 5 years; n = 51) (M_E = 3.91 vs M_{LE} = 3.56; t(106) = -1.986; p = .05). No other significant differences according to socio-demographic items were observed.

When comparing 2015 and 2016 answers, 2016 participants were less optimistic than 2015 ones as the possibility that robotics could foster students' autonomy (t(386) = 2.364; p = .002; M_{2015} = 4.33; M_{2016} = 4.13). As stated before, one possible explanation for this results refers to a less ideal view on robotics that participants could build after the 2016 longer course.

How to Use Robotics in Class. 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 69.9% of participants declared they had already an idea on how to integrate robotics in class (significantly more than the previous year (61%)). As for disabilities, participants named Autism Spectrum Disorders (ASD), attention deficit disorders (ADHD), learning disabilities, mild mental retardation, among others as needs to be properly addressed with robotics in class. For instance, two kindergarten teachers recognized that robotics could be used to improve learning simple didactical unit on math. As for disabilities, both teachers mentioned Autism Spectrum Disorders (ASD).

"I would use it with children with ASD, for the learning of simple didactical units on maths" (participant #7, women, less than 35 years, LST, 3-year experienced).

As for primary school teachers, they mentioned geography, geometry, maths and science as possible subjects where to employ robotics. Twelve of them (22.2%) mentioned ASD, ADHD and learning disabilities:

"... activity to be implemented with pupils with deficit of attention, with Down syndrome" (participant #28, between 46 and 55 years old, 10-year experienced).

As for junior secondary school teachers, twelve of them (28.6%) mentioned subjects such as technology, maths and informatics:

"Technology subject, for all the pupils, for pupils with ADHD, to work on attention, socialization and motivation" (participant #98, women, between 36 and 45 years old, LST, 10-year experienced).

As for secondary junior school, seven teachers (28%) mentioned maths, informatics, and geography:

"As I am a maths teacher, I would plan some multidisciplinary activities on informatics and maths, involving mild mentally retarded pupils, to learn having fun and to support their autonomy" (participant #177, women, up to 35 years, 7-year experienced).

5 Evaluation Summary and Conclusions

The outcoming results showed a general improved acceptability of ER, both as a feeling and as an analytic judgment. Not surprisingly ER was still perceived as difficult for the trainees but this is something that can be smoothed with a real activity in class and implementing a constructionist teaching/learning process during it. They also transferred this perception to the students' side according to their general experience. Nonetheless most trainees agreed on considering ER a powerful tool for promoting all the relevant skills showed in Fig. 5 also for SN students. Our personal conviction is that the new structure of the course this year amended some limitations observed during the last year course and more specifically increased the trainees' perception of being able to make a good implementation of robotics in future classes.

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