Low threshold: how inclusive is Constructionism?

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Abstract
The paper discusses the degree of inclusiveness of the Constructionist theory when disabilities and special needs are concerned. It shows the impact of both technology and pedagogy used inside the regular curriculum when good inclusive practices are the goals. A complete case study is described to discuss this point, showing the experience, the materials, the supporting means and the approach. A brief state-of-the-art of Constructionism in the Italian educational system is also provided. In the discussion some answers are given to questions related to the educational approach and to the integration of technology, namely educational robotics, to support curricular disciplines in an inclusive scenario.

Keywords Constructionism, Educational robotics, Special needs, Inclusion, Key Competences

1. Introduction
In spite of its long history from when it was proposed, constructionism is still recalled when, in the context of best-practices at school and educational experiences, project-based learning, learning by doing, the try-and-error approach, an inquiry based science education are concerned. Obviously after such a long period, it is reasonable to (critically) ask for a re-thinking of the pedagogy and for a technological update [1]. And also some justified criticisms on constructionism extended from a learning theory to a teaching method might be taken into account [2]. Among the others, current authoring environments like Scratch/Snap [3][4] and Alice [5] and educational robots like Lego Mindstorms [6], Romer [7] and Arduino [8], just to mention some, are claimed as known 21st century examples of the vitality of the Papertian intuition.

One of the specific aspect in education we would deal with in this paper is the degree of inclusion one educational approach can achieve. Real inclusion is an effort oriented to integrate pupils with either limited learning potential or special needs into a 'normal' class, not only with the minimum of contraindications for the teaching activity and the maximum of benefit for the impaired pupil(s) but, on the contrary, also with expected positive results in terms of sharing of good experiences, collaboration and a different perception of differences among pupils.

Constructivism/Constructionism is often presented as a pedagogy able to promote successful forms of inclusion. [9] mentions that educational robotics was advocated to facilitate the learning of minority students. Constructivist theory implies a type of instruction which, being more related to real life and experiences, can be closer to the educational needs of learning disables who have

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difficulties in generalizing and are negatively influenced by repeated failure experiences [10]. In [11] Stager presents experiences with the particular category of young people under or after detention. Moreover a constructivist perspective may alter the understanding of individual differences and deeply influence changing in the teaching practice [12][13].

Modern technological tools may promote inclusion but their introduction in the teaching/learning process does not automatically guarantee good results without suited pedagogical approaches. For example the Web 2.0 related activities emphasize interactivity, which can be partly hindered or special for disabled pupils. Therefore another aspect worthy of attention is the relationship between an inclusive educational approach and the specific qualities of technological elements designed for special needs. How much do technical aids influence the pedagogical approach? According to [14] accessible design approaches should always be underpinned by effective pedagogy. How much do technical aids influence the establishing of more or less strong social sharing among pupils in the same class? For example technological rich environment can promote diverse student grouping strategies [15] and influence the reciprocal attitude among pupils with and without disabilities [16][17]. What kind of collaboration should be requested to the support teacher when present? Inclusive practice requires new specific transdisciplinary preparation for facing inclusion challenges [18].

The paper will try to provide an answer to these questions reporting some recent experiences at the level of an Italian junior secondary school (6th-8th grades). In section 2 we recall some challenges a teacher must face when inclusion demands are concerned. In section 3 we briefly present how Constructionism is currently declined in Italian schools, whereas section 4 presents some details on our direct experience. The final 5th section contains an overall discussion and some conclusions.

2. Inclusion and teaching challenges

World is changing and European industries and society are facing with a lack of STEM professionals. Statistics show that it is necessary to prepare students also for future jobs that maybe don’t exist yet when they attend a school: it means that we don’t really know what skills will be required for future employees. It is obvious that schools need to give students those competences that will allow them to develop their full potential, in order to find a job. Even if the final target is clear, it is not always easy to make students’ competences grow, especially because there are still some obstacles.

The first difficulty a teacher faces in Italy, at any level, is related with the number of students per class: 25 – 28 in the first mandatory cycle of education (1st to 10th grade). Our educational system is oriented to the personalization of learning, in order to rise best opportunities for each student. In each class there are usually 8 – 10 students with deeper and special needs, in terms of learning potentiality: students with learning difficulties (dyslexia, low Q.I., ADHD [19]), immigrants with language difficulties, children at risk of social exclusion, girls with difficulties in STEM subjects and also gifted students that often are not enough stimulated.

Because of this heterogeneity, it is really important for teachers taking in account different needs that they can find in their classes.

In each class is common to find one or more dyslexic students. Dyslexics tend to be more curious, creative, and intuitive than the average. They tend to be highly aware of the environment, inventive, and good at real world tasks. Their special mode of thought also produces the gift of mastery: once they have learned something experientially, they understand it on such a deep level that they know how to do things intuitively without thinking about how [20]. For them the multi-dimensional thinking (using all the senses) takes place much faster than verbal thinking.

Every teacher finds some problems in his/her lessons because of some students who have problems in waiting their turn, or present difficulties in paying attention or staying focused on a task or activity. It can be the case of students who present attention deficit disorders or, sometimes, even
attention deficit hyperactivity disorder (ADHD). People with ADHD have so much trouble staying focused and controlling their behaviour that it affects their emotions and how well they do in school or other areas of their lives. In fact, ADHD is often viewed as a learning disorder because it can interfere so much with a person’s ability to study and learn. The most productive mentoring relationships a teacher can undertake are those that are focused on a specific outcome, such as the completion of a project. Once students know what they want to learn, they should put together a query package that contains a short biography, a description of the project they wish to pursue along with a summary of what they already know about the particular topic [21].

Before planning successful activities, teachers should take into account also the gender distinction in the class, especially in the junior high school, that is the period in which these differences are more evident. Boys differ from girls not only biologically, but also in the way they perceive one another and the way they behave [22]. One difference in behaviour may derive from the effects of the hormones oxytocin and testosterone. Testosterone makes a male want to compete with others. When a boy wins, his testosterone levels rise. This suggests that competition could be a good motivator for boys to learn. Meanwhile, oxytocin has been found to affect social behaviour. Women have a higher level of this hormone, which stimulates them to establish relationships and to please others. And this suggests that girls may be more motivated when they work together on tasks or when a task is placed in a social context. But if teachers are aware of the possible behavioural differences between boys and girls and know how to respond to them, the education of the whole class could be significantly more effective [23].

Besides the abovementioned behavioural differences, there are also differences in their own ideas about how they should behave: what things are “boyish” and what things are “girlish”? One of the fields in which these gender stereotypes are particularly obvious is Science & Technology. In 2012, the European Commission has launched the campaign "Science: it’s a girl thing!” to encourage girls aged 13-18 to study STEM subjects [24][25]. That is the age range when young people tend to choose major school subjects that will influence their future career. At this point in their education they gravitate towards or away from science and technology studies. Through a partnership with Scientix, the community for science education in Europe [26], the campaign is now addressing teachers as well to promote gender equality in the classroom. In our case study we will explain in which way we tried to differentiate requires in order to improve the inclusion of girls in activities.

Sometimes it happens in a school to find students who score high on achievement tests, most often in the 95-99 percentile range, love to learn, learn quickly and easily; however, they may be perceived as a problem in the class for their bored or hyperactive behaviour. These students could be gifted students, but often teachers don’t recognize them and treat them as jammers, stopping their curiosity, instead of promoting their intelligence. For highly gifted students, advanced curriculum in a self-contained classroom with intellectual peers would be the best environment for meeting their educational needs. In Italy we don’t have self-contained classes: moreover, we think that school must be a mirror of the real society. If gifted students must be placed in a regular heterogeneously grouped classroom, one that focuses on individual strengths and utilizes flexible strategies is essential [21].

In Italy national and curriculum guidelines provide the framework for introducing and supporting ICT within the 1st cycle of education; furthermore there are specific initiatives from INDIRE, part of the Digital School Plan, to support schools in setting innovative learning environments (Interactive Whiteboards, Cl@ssi 2.0, Scu@la 2.0, repositories for content sharing). Despite of all these initiatives, technology is just one part of the whole environment and teachers must be able to conjugate contents, technology and methodology. Teaching has to adapt to rapid changes in digital technology innovation and in students’ needs, capabilities and expectations and teachers have to discover how to integrate pedagogy with technology for high quality independent learning [27].
To achieve a real inclusion in the class, it is necessary that all teachers of the class collaborate as a team, putting together all professionals. Special supporting teachers are a powerful resource, when they are part of the team, as they can be supportive, with their experience, for all the students in the class. In our experience we found that, to create the best environment to learn, also the contribute of other specialists (psychologist, speech therapist, psychiatrist) is fundamental.

3. Constructionism in the current Italian school context
In many Italian schools of all type and level there are teachers who use design, conception, construction and programming of robotics kits (Lego Mindstorms, Lego WeDo to mention some) as a teaching ‘accessories’ capable of consolidating or facilitating the comprehension of curricular disciplinary concepts, because they allow the user to build objects with different behaviours.
Robotics kits are learning mediators, as they are commonly associated with playing. An iconic programming language allows a fast and intuitive approach to programming; the organization of the software allows the introduction of individual constructions within a narrative structure that motivates students to create small differently shaped robots. Indeed, robots go beyond the recreational aspect, combining the reconstruction of the knowledge they got during the various school activities, with creation, invention and new keys in the revival of acquired concepts and techniques. In this way it is possible to achieve multiple types of intelligences that characterize our pupils: linguistic, logical-mathematical, interpersonal, just to mention a few ones [28].
The use of educational robotics as learning methodology can be effective especially by using robots as didactical mediators, but is really involving also when using software like Scratch programming. When educational robotics or other inclusive technologies are used with regularity, moreover, it becomes natural to rethink spaces in the class.
There are various ways of introducing educational robotics in regular maths and science curriculum, but each method respects certain universal learning values that can be reassumed in the key competencies at European level.
Key competences for Lifelong Learning are a combination of knowledge, skills and attitudes appropriate to the context, as identified by the European Parliament [29]. They are particularly necessary for personal fulfilment and development, social inclusion, active citizenship and employment; in fact these skills are based on three fundamental aspects of the life of each person:
- self fulfilment and personal development (cultural capital);
- active citizenship and integration (social capital);
- the employability (human capital).
The use of educational robotics as a teaching methodology encourages students in guided discovery and in problem solving; students get used to work in groups to solve problems, find solutions and verify the results.

4. A case study
In this section we present some details of our experience giving the basis for the following discussion.
When you decide to integrate robotics in your curricular discipline, first lessons have the aim to make students aware that a proper language is essential for any subject, scientific, linguistic or humanistic it might be. We split the class into groups of two students: each couple receives a ‘package’ composed by a few assembled bricks; they analyse what they received, dismantled in order to understand the assembly instructions and write down instructions for its replacement. Finally they give both instructions and disassembled bricks to the contiguous couple of students. The contiguous couple should be able, with the instructions and disassembled Lego pieces received, to re-assemble the object as it was originally. At the end of the activity students are invited to
analyse the final product and they usually report that it is difficult to write correct building instructions if each piece has not a specific name. It is also difficult to rebuild the object if instructions are not clear and detailed. All the students in the class take part easily to this activity, with the only exclusion for physical disables, but they can be responsible for the instructions. Designing, building and assembling robots means having to share ideas, drawings, collaborating, team-working. These activities require continuous exchange of ideas among the members of the group with the various intelligences that emerge during construction and problem solving. The comparison with diversity enables the improvement of the communicative skills of the students at different levels: through design, written texts and oral communication.

Educational robotics projects foresee the need for students to relate with pairs from abroad, in a world that does not use their mother language for sharing information. In order to be able to conduct research and be able to build robots, students understand the importance of learning foreign languages. It is useful giving students a little dictionary before starting the activities. Considering the difficulties for dyslexics to study written materials and the lack of attention typical of students with ADHD disorder, it is preferable preparing activities for the class, working with the Interactive Whiteboard (Fig. 1).

We had several experiences of collaboration with schools from other countries, working on videoconference through the use of Interactive Whiteboards (Fig. 2). These interactions are perfect ways to involve all students in the work, as communication skills are different from written skills that are often cause for concern for students with learning difficulties.

For students it is very important understanding that foreign languages, English especially, are the way to communicate inside a scientific community, so maths and science teacher would work together with the English teacher, explaining things in Italian language and giving them videos or other material to study in the English version.

There is an obvious link between robotics and mathematics, science and technology. Working with robots grows inclusion, because helps all students to re-process abstract concepts, facilitating the connection with reality. Educational robotics enables the mediation of the scientific contents from various points of view, comprehensible to different intelligences and different ages. To stimulate the participation of all students it is helpful giving some real tasks or missions to manage (Fig. 3).

In the lessons that employ educational robotics class is split into mixed groups of 3-4 students. This is especially important in the 6th grade or during first lessons with robotics, because each group can take advantage from the building skills of boys and the precision of girls in programming (Fig. 4). After the first lessons it is necessary to divide groups taking into account the students’ gender, to be sure that each member of the group take part both into the building phase and in the programming.
session. Girls, especially, seem to dislike the building phase, maybe because of less time spent on playing with bricks and need to learn to become more precise.

To achieve best results from everybody, it is convenient sometimes let students with ADHD working alone; but to give importance to their work they can be asked to present their own results to the whole class (Fig. 5).

The use of IWB to present tasks or to discuss results involves all the students and is useful both in the brainstorming phase and in the elaboration of the final work. IWB is even more precious when working with Scratch programming to present final work or collaborate on the debug of projects with some mistakes.

Using Scratch programming is possible to make students construct their own rules on some part of the maths or science curriculum, like when working with multiplications and divisions. When asking 6th grade students to adapt the initial Scratch project realized for multiplications to a second one useful for divisions, also students with learning difficulties realize the need to change variables. Furthermore, the conception of error changes radically: the error is no longer seen as a judgment but as an incentive to change one's own skills (Fig. 6).

Since October 2011 our junior secondary school is one of the 10 Italian schools that take part to inGenious Project, the European Coordinating Body in Science, Technology, Engineering and Mathematics (STEM) Education [30], coordinated by European Schoolnet. Scratch Programming is one of the inGenious practices tested in several schools across Europe, like other practices, with the aim to increase students’ interest in STEM education and careers. At the beginning and at the end of
each school year all the students who worked with Scratch are requested to fill in some questionnaires, to study the effectiveness of this practice. The work is still in progress and results will be available at the end of the project, in autumn 2014. The work done till now, anyway, showed a great enthusiasm by students, who regularly use Scratch programming inside the regular curriculum of maths and science, as a way to learn mathematical and scientific concepts.

In order to program robots and to be able to report on the work done, it is necessary to use computers. Students of the 6th grade, usually, even appearing ‘digital natives’, quick learners and very good in gaming, have a poor digital competency. When students arrive from the primary school they are just able to write, save and open some text files. The best way to grow digital competency is to enable students to work as a community and take the lead in their learning, helping them to explore and develop their natural curiosity [31]. One good way to make students learning and sharing their ideas in a safe environment is using Edmodo [32], a social network for didactics (Fig. 7). The experience with Edmodo showed that every student, included those with special needs, get the chance to try, if there is not the direct competition with peers. Furthermore, teachers can personalise their action towards the single needs of students, even finding the way to stimulate gifted students or giving help to minority students.
5. Discussion and conclusions

A premise: this contribution is the result of a collaboration between a maths and science junior secondary teacher, already involved in several EU Projects related with the promotion of STEM subjects and the reduction of gender gap, and a professor in information engineering, expert in educational robotics [33] and trainer in teacher training course on the subject [34].

Teachers must be prepared to recognize and face all students’ needs and, more, they need to have a specific transdisciplinary preparation for facing inclusion challenges: one size doesn’t fit all! Our experience confirms that technological tools may promote inclusion and may enable collaborative ways of working which, in some sense, provides a new challenge for schools. Nonetheless a suitable pedagogy urges. While, giving a further example, the use of Interactive whiteboards in conjunction of constructionist approaches [35] can reinforce the learning process, educational robotics offers considerable support for an inclusive education. It permits to reach different kind of intelligences present in a class and to generate competences through the involvement of practical activities, also inside the regular curriculum, giving a cooperative dimension of the class work. Teachers become facilitator and students are actively constructors of their own competences.

The design/construction/programming of robots enables the students to represent the world independently, to be able to build their own aware and explicit way of learning, to be able to create a learning process linked to observation, experimentation, abstract and theorization in a continuous cycle that foresees that each stage intervenes with the other.

The use of educational robotics inside the regular maths and science curriculum push teachers to find new solutions, not only in term of changing class spaces, to allow collaborative working, but it is necessary also to rethink timing, contents and interaction with students. In Italy a maths and science teacher in the junior high school works 6 hours per week in each class. Even if there is no prescription about the contents, it is necessary to follow what Ministry of Education suggests (i.e. “Nuove Indicazioni Nazionali”, namely “new national indications”), in order to certify the competences acquired by each student at the end of the 8th grade. Working with robotics means working to grow competences so, for a teacher who has a clear idea of what he want to achieve and is able to program his activity, the results are really satisfying. Teachers, anyway, have to understand that it is not possible to give students the same number of contents that they can give with face to face lessons. Sometimes it is necessary also adopting other solutions, like flipping the class, to be able to have enough material for a students’ brainstorming before starting to work on a new topic. The flipped classroom, furthermore, allows all the students of the class to learn with their own time, constructing their own knowledge and learning to learn, using the school time for sharing their opinion, being able in this way to construct their knowledge in an inclusive way.

Students are able to change their attitude for STEM and for school in general, working in a collaborative environment, constructing their competences. Next challenge we are looking to is to be able to use educational robotics to give new hopes for interaction to one of our student who uses AAC (Augmentative and Alternative communication) (Fig. 8). For this purpose, students from the 8th grade are taking part to a project with two Austrian Schools and one Hungarian School working with robots, too.

Constructionism has always been strictly related to the used technological components and tools, but in a certain sense it has never been slave of the latter, because pedagogy and didactical approach take precedence over technology and tools. This is particularly true in case of a student with special needs using specific technological media, which require the teacher to make some relatively easy adaptations to fruitfully integrate such media and their interactions with the student into the overall teaching proposal.
We explicitly showed that a constructionist approach promotes social skills and a new type of relationships between the group of ‘able-bodied’ pupils and those with special needs. It is full of meaning to observe that these phenomena spontaneously occur when initially triggered. Moreover, we also observed that, when pupils discover something that helps them to learn, they autonomously involve other teachers, for example teaching them to use within a different discipline a new tool they learned. Special supporting teachers usually work in a sort of ‘coordinated concurrency’ with the main teacher but in a constructivist view they enhance their role of powerful resource when they are really part of the team and therefore their help is also extended to the whole class.

As a final remark, regarding the attention required for minorities, it is nice to observe that every methodology that satisfy the needs of the weakest students, can fit much more better and happily for the others.

References


