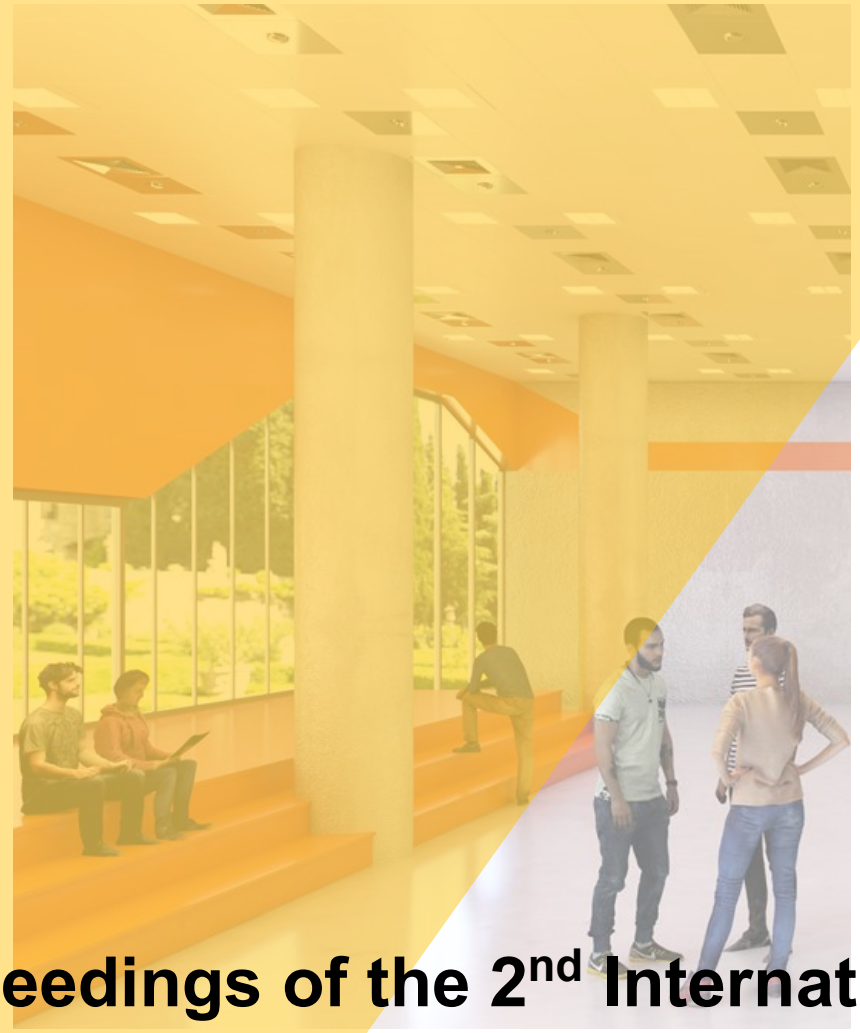

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Science Disciplines and School for All, a Challenge

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ABSTRACT: *Scientific disciplines represent a particularly interesting field of study for the education of young people, including those with disabilities. The idea of developing science education for students with disabilities has been around since the 1990s and has gradually taken on the connotations of inclusive education. Inclusive science has also become a topic of academic research on school practices. Around inclusive science there is a shared view among school teachers worldwide that it is a discipline that should be taught. Teachers require support and teamwork in order to best develop inclusive science projects. However, some systematic literature points to some critical issues: in particular, the difficulty of developing inclusive science projects with children and young people with more complex disabilities. This work stems from our participation as a research group within the European Horizon project (2020-2023) Community for science, the aim of which is to disseminate the idea of inclusive science in the educational community and civil society, but also to identify forms, procedures and tools for science to be a learning discipline for all, including young people with more complex disabilities.*

KEYWORDS: inclusive science, disability, education, pedagogical approach

Introduction

This paper stems from our direct involvement in the research group of the European Horizon (2020-2023) Community for Science (C4S) project, which aims to research and promote inclusive science practices with the involvement of young people (age 0-16) belonging to population groups at high risk of exclusion and marginalisation from social and learning processes. Our specific interest concerns disability, a theme that has long involved us as researchers and lecturers at the University of Milano-Bicocca.

In particular, this text focuses on a first literature review of academic work that has addressed the issue of inclusive science for young people with disabilities. The approach we have followed is a genealogical one: to make the history of a discipline in order to understand the themes and issues that led to its emergence. We have tried to understand when and how the topic of inclusive science became a legitimate field of study on a scientific level. Since it is a rather recent, but booming field of study, we

tried to understand: what have been the main epistemological and conceptual evolutions on the research level, what reception has this approach had in the educational community, what are the main results.

Let's reveal the ending right away. The topic of inclusive science garners a lot of interest; it is unanimously considered a strategic issue for the schooling of young people with disabilities, especially in inclusive environments. The results, however, show that academic research and school practice encounter many difficulties in doing inclusive science with young people with complex disabilities. The challenge posed by this field of research is therefore how to achieve a scientific approach that is useful for the development of children and young people with complex disabilities. This is a challenge we want to take up in our field work with children with and without disabilities, with teachers, pedagogues and experts.

1. Early developments in inclusive science education

Ideas and projects for science education intended for students with disabilities began to develop more fully in the early 1990s, especially in the American context. The world of disability is therefore also recording the completion of the hegemony of scientific knowledge initiated after the Second World War.

An initial literature review (Mastropieri, Scruggs, 1992) identifies some lines of development already underway and developed since the second half of the 1970s:

1. Instructional strategies (text adaptations, mnemonic strategies) prove effective in facilitating knowledge of scientific phenomena);
2. Construction of science curricula oriented according to activities that promote manipulative skills and abilities about developments in the scientific process.

We are still at the stage of declaring intent and developing ideals. Therefore, science education is considered useful in developing knowledge for some types of disabilities.

2. From the idea of rehabilitation to the idea of inclusion

The need to think about science education for students with disabilities is also linked to the significant increase in this type of student in public schools.

In 1998, the Journal of Science Education for Students with Disabilities (JSESD) was founded in the United States (New York), under the impulse of the Department of Science and Mathematics of the Rochester Institute of Technology and the National Technical Institute for the Deaf.

The idea that scientific disciplines are also crucial for students with disabilities is thus firmly established.

Researchers contend that the subject of science serves as an effective vehicle for students with SEN (i.e. special education needs) to engage in disciplinary understandings as most students, irrespective of achievement level, are able to develop an awareness of, and interest in, themselves and their immediate surroundings and environment through science. Additionally, the practical and social aspects of the discipline, e.g. hands-on activities and working with peers, provide students with opportunities to illustrate ideas through investigations, and develop an understanding of cause and effect (Villanueva et al, 2012, 189)

It is with the new millennium that a concept of 'inclusive science' is more fully developed, linked also to new ways of considering disability, as emblematically indicated by the Classification of Functioning and Disabilities (ICF, 2001) and the UN Convention on the Rights of Persons with Disabilities (2006). These new paradigms for considering disability intersect with the inclusive dimension at the school level as well.

The world of education and academic research take on board some of the decisive values of the convention, in particular:

With a view to realizing this right without discrimination and on the basis of equal opportunity, States Parties shall ensure an inclusive education system at all levels and lifelong learning directed to:

> (a) The full development of human potential and sense of dignity and self-worth, and the strengthening of respect for human rights, fundamental freedoms and human diversity;
>
> (b) The development by persons with disabilities of their personality, talents and creativity, as well as their mental and physical abilities, to their fullest potential;
>
> (c) Enabling persons with disabilities to participate effectively in a free society.
>
> […] In realizing this right, […]:
>
> (a) Persons with disabilities are not excluded from the general education system on the basis of disability, and that children with disabilities are not excluded from free and compulsory primary education, or from secondary education, on the basis of disability;
>
> (b) Persons with disabilities can access an inclusive, quality and free primary education and secondary education on an equal basis with others in the communities in which they live;
>
> (c) Reasonable accommodation of the individual's requirements is provided;
>
> (d) Persons with disabilities receive the support required, within the general education system, to facilitate their effective education;

> (e) Effective individualized support measures are provided in environments that maximize academic and social development, consistent with the goal of full inclusion. (UN Convention on the Rights of Persons with Disabilities, article 24)

The literature itself brings up the idea of inclusive science in ordinary classrooms. Increasingly, the question of inclusive science for students with disabilities in university is also being raised.

The question of different modes of learning also arises in science: science and social studies are identified as effective tools that enable students with disabilities to access learning and training useful for success in school and in daily life (Scruggs et al., 2008). Some strategies for students with learning disabilities prove particularly effective: supports for verbal learning of declarative information; processing information in texts; activity-based instruction/experiential learning (Brigham et al., 2011).

The concept of science education is becoming more and more established within the ordinary school curriculum, as also stated in the UN Convention on the Rights of Persons with Disabilities (art. 24 and 30). The literature brings up the idea of inclusive science in mainstream classrooms (Mutck-Jones et al., 2012) also in terms of equal opportunity (Bargerhuff et al., 2010) and social justice.

Without denying the difficulties, the theme of inclusive science highlights particularly significant dimensions of learning for all students with and without disabilities

In all cases, certified teachers implemented the science instruction over extended time periods to their students with and without disabilities. Additionally, the science curricula were adapted as necessary to promote the successful participation and learning of students with disabilities. Activities-based curriculum materials were used solely, in combination, or in comparison with textbook-based curriculum materials. Findings across all classroom implementation indicated that students with special needs successfully learned more when taught with the adapted activities-based science curriculum materials. Additionally, students with special needs overwhelmingly reported enjoying the activities-oriented instruction more than textbook instruction. Teachers noted that during activities-oriented instruction, students appeared more motivated to learn and to participate in class, and demonstrated more on-task behaviors. However, teachers also reported that activities-oriented instruction involved considerably more teacher preparation time, behavior management skills, and organizational skills than traditional textbook instruction. Also found evidence in support of an activity-oriented science curriculum but noted that the presence of a caring teaching construct (respecting students' talents and strengths) enhanced the effectiveness of the approach. (Mc Ginnis, 2013, 47).

The effectiveness of this inclusion option, however, depends largely on the teachers' ability to practice inclusion. This issue involves the

question of teacher training and the need for them to be supported throughout the school system. This is in fact one of the major themes that runs through all of the identified literature.

Indeed, collaboration between science teachers and special education teachers prove effective in building a supportive instructional context and adapting lesson plans to meet science learning goals for all students in an inclusive classroom. However, this does not often prove to be an opportunity that produces greater teacher knowledge about the link between science content and learning disabilities (Mutck-Jones et al., 2012).

Issues related to specific functioning such as specific learning disabilities and autism are also addressed.

Argumentation-based approaches, such as the Science Writing Heuristic (SWH), have shown that students engaged in appropriating the language, culture, practice, and dispositions of science have generally improved their critical thinking and knowledge (Villanueva, Hand, 2011). There is a need to better understand how this construct can be applied to disabilities.

3. How to do scientific inclusion? Between methods and criticalities

The notion of inclusive science education suggests that all students-regardless of achievement or ability-should engage in opportunities to understand the practice and discourse of science. Current teaching practices risk not effectively supporting all students, particularly those with more complex disabilities.

The best results are obtained for high functioning disabilities. Using a single-subject reversal design, for students with autism spectrum disorder, results say that there is an improvement in the ability to comprehend scientific text (Carnahan, Williamson, 2013). A comprehensive review of the literature on teaching science to students with intellectual disabilities and/or autism spectrum disorder reports interesting findings but raises the question of further research to explore the effectiveness of interventions capable of building science skills in students with more complex disabilities (Apanasionok et al., 2019).

Of particular interest, in a logic of inclusive science education, seems to be the possibility of focusing on the affective dimension in reference to feeling-based constructs such as attitudes, values, beliefs, opinions, emotions, interests, motivation, and a degree of acceptance or rejection. This approach may influence students' interest in science topics and their motivation to persist in learning science concepts (Abels, 2015).

Questions of method pose even more decisive questions: are science teachers positively inclined toward inclusive education? (Spektor-Levy, Yifrach, 2017). Questions of method and approach for inclusive science are posed to the underlying questions. The literature itself is divided between: a constructivist perspective, with teaching approaches that

allow students to build their understanding of scientific ideas and through hands-on experiences of scientific inquiry (inquiry-based learning) (Abels, 2014) and a behavioral model that focuses primarily on teaching more knowledge-based learning programs aimed at achieving mastery of predetermined learning goals, as is also evident in some systematic reviews (Apanasionok et al., 2019).

4. Inclusive science education: an established field in search of practices

In any case, the topic of inclusive science in the mid-2010s is scientifically established as also evidenced by the release of several volumes (Mackic, Abels 2016; Koomen et al., 2018).

However, the practice of inclusive education is one of the greatest challenges for science teachers as well. Anyway, there is a certain lack of research in science education on how to foster inclusive education of students with different learning preconditions. The possibility of building inclusion and increasing skill sets for students with disabilities struggles to find clear and defined methodologies: some research points to the need to start with a reflection on what is happening in the classroom to identify effective strategies for students with and without disabilities. Some activities using purpose-built robots with the goals of supporting/integrating usual play and social activities seem to benefit all children, including those with severe disabilities (Pennazio, 2015)

Of particular interest, in a logic of inclusive science education, seems the possibility of focusing on the affective dimension in reference to constructs based on feelings such as attitudes, values, beliefs, opinions, emotions, interests, motivation and a degree of acceptance or rejection. This approach may influence students' interest in science topics an the heterogeneity of disability conditions and the complexity of specific forms of learning makes the results less clear overall. Certainly, the idea that an approach in ordinary classrooms is needed is now well established around the world, as some case studies point out (Koomen, 2016; Asghar, Sladeczek, 2017; Reynaga-Peña, Sandoval-Ríos, 2018).

This approach continually refers, throughout the literature, to the competencies of science teachers, collaboration with teachers specialized in special needs education and more generally of an inclusive school context (Kaha, Pigman, 2017; Ricci, Persiani, 2019; Tang 2021). In the face of heterogeneous results the not always systematized, in the face of the risk that more complex situations of disability stay out of the practices of science, the idea of building a framework of inclusive science more generally arises that is able to more fully intersect the concepts of inclusive science with a more general inclusive pedagogical perspective as signaled by one of the most recent systematic reviews on the subject (Brauns, Abels, 2020).

Conclusion

Students with special needs tend to show significantly lower achievement in science than their peers. Despite this bleak picture, much is known on how to significantly improve science achievement for students with special needs (Villanueva et al., 2012). Furthermore, the analysis of the literature, of which we have proposed a review that is certainly not exhaustive, highlights the lack of scientific models and evidence related to more complex disability situations. The work we intend to carry out as part of the Horizon (2020-2023) Community for sciences (C4S) project therefore encourages us to try to field test experiences of science education that are meaningful in terms of learning for pupils with severe disabilities.

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