A small scale, qualitative study on exploring alternative conceptions of mechanics in students with autism

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ABSTRACT
This paper investigates alternative conceptions of force and gravity on students with autism. For this reason, a number of digital tasks were given to 3 secondary students with autism, aged 13-14 years old, who were recruited from an urban, national school in Greece. Results showed that students with autism hold almost the same alternative ideas with the ones that are encountered in the literature that counts for typical development students. This finding supports the concept of inclusion on teaching and learning science to pupils with autism.

KEYWORDS
Special needs, autism spectrum disorder, science education, alternative conceptions on mechanics

RÉSUMÉ
Cet article étudie les conceptions alternatives de la force et de la gravité chez les élèves autistes. Pour cette raison, un certain nombre de tâches numériques ont été confiées à 3 élèves autistes du secondaire, âgés de 13 à 14 ans, qui ont été recrutés dans une école nationale urbaine en Grèce. Les résultats ont montré que les élèves autistes ont presque les mêmes idées alternatives rencontrées dans la littérature pour les élèves de développement typique. Cette constatation soutient le concept d'inclusion des élèves autistes dans l'enseignement et l'apprentissage des sciences.

MOTS-CLÉS
Besoins spéciaux, trouble du spectre autistique, éducation scientifique, conceptions alternatives sur la mécanique

THEORETICAL FRAMEWORK

The last decades a large part of research in science education has focused on the study of misconceptions about concepts and phenomena, as well as on teaching interventions on the basis of which we can modify them in alignment to the scientifically accepted ideas. However, it is only in recent years that academic research has turned into the exploration of strategies for teaching science in students with special needs. Noteworthy, while constructivism has dominated science education for students with typical development, this has not been the case for students who face learning and other difficulties. Indeed, very few researchers have dealt with the exploration of alternative ideas in students with disabilities. In this paper, we investigate alternative conceptions of force and gravity in three adolescents' boys with autism.

Teaching science in students with special needs

The issue of achieving educational opportunities for all children has been extensively raised the last decades. Along this path a number of educational laws and policies have been emerged, among them the No Child Left Behind act (NCLB) of 2001, the Science for All and the National Science Education Standards (Aydeniz et al., 2012). From this perspective, a major goal of science education should be undoubtedly to produce curricula that improve the learning of all students (Doppelt et al., 2008). The policy of inclusive education falls into this trend, as teachers should cater equally for all pupils along the spectrum of abilities where at one end stands those with savant skills and on the other those that are defined as having special educational needs. As Gebbels, Evans & Murphy (2010) point out, children in either group may become our future scientists.

Specific interventions and teaching strategies have been developed the last years by the pioneers of science education in order to address barriers to science content learning for pupils with special needs. In these strategies the center of gravity lies in hands-on and inquiry-based activities that are likely to assist students to acquire skills and promote their deeper understanding of natural phenomena (Scruggs & Mastropieri, 1994; Aydeniz et al., 2012). Other science teaching methods encompass reading comprehension strategies, text structure strategies, textbook adaptations and study guides (Bergerud, Lovitt & Horton, 1988; Bhattacharya, 2006; Gaddy, Bakken & Fulk, 2008). Concept mapping seems as well a prominent technique for teaching science into students with special needs (Guastello, Beasley & Sinatra, 2000). An alternative form of concept map in its semi-structured form is proposed by Kim et al. (2004) where students with learning difficulties can facilitate their learning process through the completion of the map structure. This was the case for a secondary student with autism spectrum disorder who managed through the usage of ICT, to construct and expand a concept map on food chain and mutated products (Maleza & Kalogiannakis, 2013). Of particular interest stands the experimental pedagogical approach incorporated by Chia (2011) in order to teach magnetism on pupils with autism. This approach, based on Autistic Logic Analysis/Synthesis (ALA/S), is making use of the three basic characteristics of autistic thought, namely autistic thinking and logic, in-the-moment thinking and black-and-white thinking. So far, research findings of the above implementation are positive and very encouraging (Chia, 2011).

Nevertheless, while the above-mentioned strategies have undoubtedly provided teachers in the special needs spectrum with useful tools, little effort has been made world-wide to expand constructivism on this sector. It is well known that constructivism stands as one of the most prominent theories in teaching and learning school science. This theory posits that learners build new knowledge under the foundation of prior knowledge. In this perspective learning becomes an active process where science meaning is primarily constructed by the student itself within and beyond the classroom, while the role of the teacher is limited to scaffolding support (Pantidos, 2008; Kalogiannakis & Violintzi, 2012; Ravanis, Christidou & Hatzinikita, 2013). In the core of this theory lies alternative conceptions; these are the ideas that students form about a number of natural phenomena due to their interaction with both the natural world and the prevailing culture. What is noteworthy here is that alternative ideas differ from scientifically accepted ideas and is likely therefore to play a negative role in learning science. Thus, teaching science implies the knowledge of these ideas and requires the effort to modify them according to the scientifically accepted ones (Stylos, Evangelakis & Kotsis, 2008; Ravanis, Zacharos & Vellopoulou, 2010; Zoupidis et al., 2010; Plakitsi, 2013).

It is therefore time for academic literature to try to incorporate constructivism theory into the wilderness of special needs spectrum. One of the few researchers who had moved toward this path, Maleza and Kalogiannakis (2012), stated that it is crucial to take into account both the particular needs as well as the prior knowledge of the student with special needs. Their research findings clearly showed that lessons planed on constructivism had beneficial effects on students with autism. In particular the student actively participated in teaching and learning process, while the extra outbursts of the student were to a limited extent. In another study, Tselfes et al. (2006) explored alternative conceptions of force on students with learning difficulties and concluded that their ideas did not differ significantly to those of typical development. The present study aspires to contribute to the expansion of constructivism theory in special needs spectrum by investigated alternative conceptions of force in adolescent boys with autism.

METHODOLOGICAL FRAMEWORK

The Sample

For the current study 3 students with autism, aged 13-14 years old were recruited from an urban, secondary national school in Greece. They had all received a special educational needs statement, having a diagnosis of autism from the official Diagnostic and Support Centre of national ministry of education. All the subjects were reported to have an IQ in the normal rage according to their score on WISC-III. They were attending the same class in the school and therefore it was considered that they had all been exposed to the same teaching methods in science. For all cases, students' participation in the research had been ensured with the written consent of the parent by signing a suitable form.

The overview of the analytic procedure

The investigation of alternative conception of adolescents with autism were carried out through directive, individual interviews. During these interviews, the subjects were presented with a series of digital tasks and were promoted to express their ideas about the physical phenomena depicted there (indicatively, some of the tasks are listed in the appendix below). The content of the tasks was drawn from the academic literature on science education and specifically on the exploration of alternative ideas of mechanics in students with typical development (Prescott, 2004; Clark, D'Angelo & Schleigh 2011). Though, a computerized form was given to the tasks, as pupils with autism benefits greatly from ICT teaching (Maleza & Kalogiannakis, 2013). All interviews took place in students' school, in a small, quite classroom beyond headmistress office. Each student was sitting in front of the computer screen with the researcher trying to enhance a warm environment and be ready to offer positive feedback whenever needed. For each task, the children were asked to talk about the forces exerted on each body (i.e. ball, ax, balloon ect). In the cases where children did not correspond to the question and therefore the development of a discussion about their ideas was not possible, the researcher modified the question into the following form 'do you believe there is force in' the object. This formation of the question was chosen as it corresponds to a dominant alternative conception in the relevant academic literature. The whole procedure was audio recorded by a mobile phone device. Having finished the whole process, a qualitative analysis of the transcripts was carried out by the researcher.

RESULTS

A qualitative analysis of the data was made through the models of force that were used in previous studies on science education (Ioannides & Vosniadou 2002; Ozdemir & Clark 2009). Four main force models appear in these studies, namely are the internal model (I), the acquired model (A), the push-pull model (P) and the gravity force model (G). The internal force stands as an internal property of stationary objects, related either to their size or to the damage/noise it can cause while the acquired force as an acquired property of inanimate objects that is closely related to motion. On the other hand, the push-pull force represents the interaction between an agent and an object while gravity force stands for the force between the earth and the object (Ioannides & Vosniadou, 2002).

The acquired force model dominated subjects thinking when they had to deal with the force on a ball. This is well reflected in the two following statements '*yes (there is force in the ball) because it makes it move, that's why*' (Subject 2) and '*no (there is no force on the ball) because it stands immobi*le' (S. 3). In the same line another student with autism stated '*yes, there is (force in the ball) because you kick it and then it gets pushed, that is, someone kicks it on you, you kick it and then the ball gets force and moves*' (S. 1).

Nevertheless, the case was different when the same students were asked about force on ax. Now the students seemed to adopt either the internal model or the gravity force model. Specifically one student stated that '*yes (there is force in the ax) because it helps us cut things*' (S.2) while another pointed out '*yes, there is force in the ax, gravity*' (S. 3). Things get more complicated when students were asked whether there is a force on a balloon. One of them argued '*this (the balloon) does not have any force; it will slowly go up*' while another indicated that '*no, (there is no force in the balloon), but I don't know why… I can't explain it*' (S. 2).

Of particular interest was the task were students with autism came across a large ax, a small ax, a large balloon and a small balloon. All three students answered that there is force only on the axes. Indicative of their responses are the following statements '*in axes (there is force), they need force, we take the axes and boom… this is how an ax gets force*' (S. 1) and '*in axes (there is force), because the ax is pulled by gravity while the balloon is lighter and can be carried away by the wind*' (S. 3)

In another task, subjects presented with a large stone and a small stone falling freely to the ground. The acquired model can be easily traced in the following statements '*yes, there is force in both stones, though the force is bigger in the large stone as it falls faster*' (S. 2) and '*yes (there is force in the large stone), the faster it goes down the more the air resistance doesn't work and so it falls with more force. The force in the small stone is less as it now receives more resistance from the air*' (S. 3). However, the gravity force was used by another student. To quote him '*there is force in both stones… the forces are different; a meteorite falls from space, a small one and a big one… it enters atmosphere, it catches fire and we know what happens. … it depends on the weight, the wider the meteorite is the more is its weight… the heavier the meteorite the more the earth pulls it down. So, there is more force on the big stone*' (S.1). It should be noted that when students came across a broomstick pushes a large armchair, all of them adopted the gravity model pointing out that yes, there is force in the armchair… that is the force of gravity (S. 3).

Quite surprisingly, autistic students did not refer to push-pull model when they came across an anime figure pushing a table, without being able to move it though. Instead, their answers were indicative of acquired and gravity force model such as '*no, there is no force in the table as it remains stable*' (S. 2) and '*yes, there is force in the table, the gravity force*' (S. 3).

While students with autism often referred to gravity, it was not clear whether they have formed a scientifically accepted concept of gravitational force. This was investigated in the following two tasks depicted an anime monkey throwing a basket into the air and an apple falling freely from a tree to the ground. Data analysis showed that students with autism interpreted gravity in ways inconsistent with the scientific view. So, for example a student stated that '*yes (there is gravity in the basket), the gravity differs in each place...it is greatest in the highest point of its trajectory*' (S. 1). Moreover, another student pointed out that '*yes, there is gravity in the basket as much as it is in the air because it moves; in position c it falls down faster and so there is the greatest gravity*' (S. 2). While another students argued '*yes, the basket has weight as it falls down; its weight increases as it falls down*' (S. 3). Indicative answers of alternative conception on the gravity force was also the following '*yes (the apple has gravity on the branch); the closer it gets to the ground the more it is likely to break into pieces, so it loses strength; In the ground the apple has less gravity, the higher it is the more force it has*' (S. 1). Finally, a student argued that '*no, the apple has no gravity as long as it is on the branch or it lies down on the ground. There is gravity only as soon as the apple falls towards the ground*' (S. 2).

DISCUSSION

Judging from the above it can be concluded that alternative conception of students with autism on mechanics did not differ from those referred to academic literature. Indeed, in the tasks presented on the current study students with autism mainly used the acquired, internal and gravity force models that are also commonly used by the vast majority of typical development students. Nevertheless, as it was found students with autism often attributed to gravity characteristics that were inconsistent with the scientific view. Moreover, they seemed not to use push/pull model to deal with tasks were a person was pushing with his hands an inanimate object.

The above-mentioned findings are in line with Tselfes et al. (2006) and Palinscar et al. (2001) findings. As for the former, Tselfes et al. (2006) explored alternative ideas of Newtonian Physics in a sample of 31 secondary students who faced learning difficulties. The students were randomly recruited from a number of different schools across Greece. Their findings clearly showed that overall, students with learning difficulties hold the same alternative ideas with the ones that are encountered in the literature. As for the latter, Palinscar et al. (2001) found that students with learning disabilities often bring similar funds of knowledge with typical development students. That is, their prior knowledge does not differ among these two kinds of groups.

At the methodological level, of particular interest was the difficulty that students faced when the researcher addressed to them the question about forces using the scientifically correct terminology. On the contrary, when the researcher used the linguistic formula 'do you believe there is force in' which corresponds to a specific alternative conception, students seemed to conceptualize its meaning and started to freely talk about their ideas.

Teaching implications and study limitations

As it was stated above, constructivism theory clearly states that alternative conceptions of students should be taken into account if teaching science successfully is to be our goal. To be more specific, any teaching strategy for conceptual change should have its basis in students' misconceptions. Therefore, current findings are likely to contribute to the basis for teaching Newtonian Physics to students with autism. That is, the identification of the informal ideas of those children is the first and most important step for designing specific teaching interventions for teaching them the notions of force and gravity. Moreover, a number of other teaching processes, such as constructing a lesson plan or a conceptual map for children with ASD could be based upon these research findings.

Moreover, it is clearly safe to state that the current finding supports the concept of inclusion for teaching and learning science to pupils with autism. The argument goes that as long as students with and without difficulties share almost common alternative ideas, their teaching in the same classroom is feasible. Other researchers have also promoted inclusive education for teaching and learning science to students with difficulties (Palinscar et al., 2001; Ferentinou, Papalexopoulos & Vavougios, 2009; Moin, Magiera & Zigmond, 2009; Gebbels et al., 2010; Maleza & Kalogiannakis, 2012, 2013).

Undoubtedly, a weakness of the current study was the limited size of the sample and the absence of a control group. Despite these limitations, research findings illuminated a dark area so far; that is alternative conception on mechanics of students with ASD. Further research on this topic, with larger samples expanding on other physics domain such as heat and temperature, electricity and magnetism should be conducted in the future in order to get a deeper understanding of the alternative conceptions that govern autistic thinking

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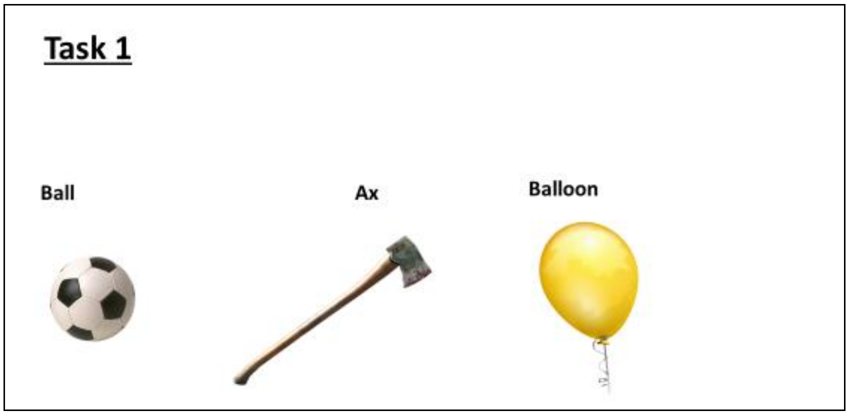
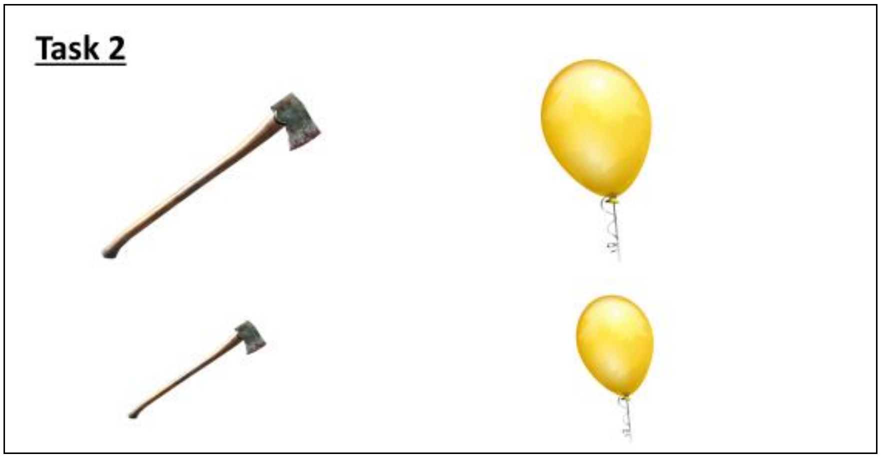
APPENDIX

FIGURE 1



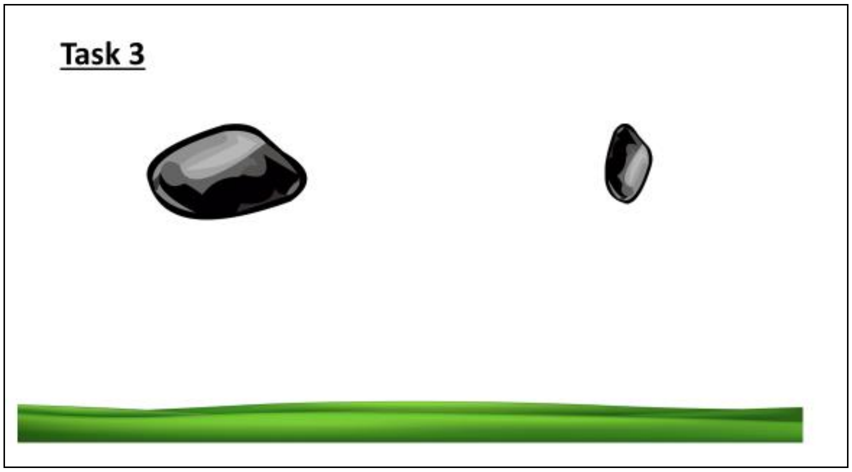
A ball, an ax and a balloon

FIGURE 2



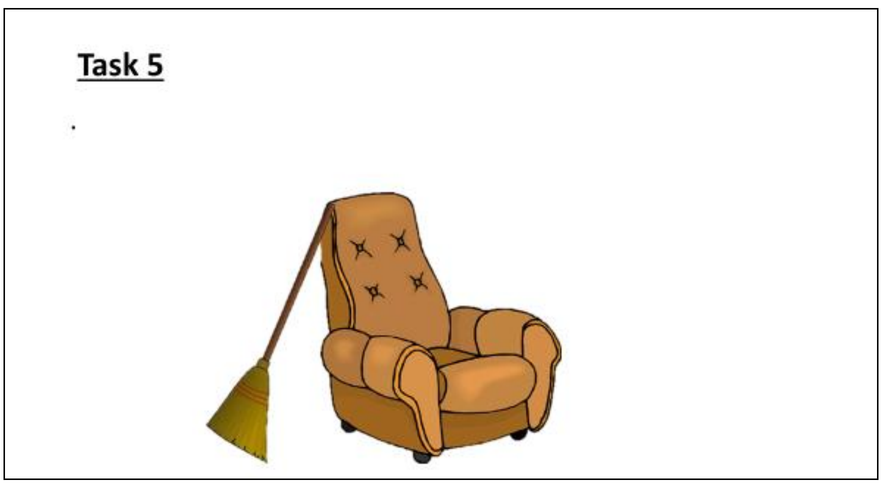
A large ax, a small ax, a large balloon, a small balloon

FIGURE 3



A large stone and a small stone fall freely to the ground

FIGURE 4



A broomstick pushes an armchair