



Constructivism in the Shade of Racial, Ethnic, and Special Needs Diversity Students

George Kaliampos

University of Patras, Greece

Abstract: The last decades the population of learners has dramatically changed in the majority of western societies. Students with diverse ethnic and racial backgrounds as well as students that fall into the scope of special education needs have enrolled in schooling without being able to perform competitively in science compared to the mainstream students. A prominent reason, among others, lies on the fact that the cultural origins of these pupils are often not taken into account into the teaching process. It seems that these children are taught science in school without any consideration, from both their teachers and the curriculum, about their diversity background and their unique life experiences that have inevitably affected their way of viewing the natural world around them. The present paper aspires to shed light on this issue and act as a call for science education pioneers to expand constructivism theory in order to address student diversity in science classroom.

Keywords: *Diversity students; Science education; Special needs.*

Introduction

Since its creation, our world was mainly characterized by inequalities which played a decisive role in its course over time. Our history is full of accounts where nations with power used to dominate and colonized other states. The locals were usually treated as slaves without any social and educational right. In addition, the nations themselves were characterized by distinct social orders, with the ones being at the top of the pyramid enjoying the full of goodness and the others being at the bottom suffering for survival. Education was almost out of the frame for all these social inferior pupils. While these inequalities have never disappeared, it is the last decades that these pupils have managed to get access to the education system either as immigrants or as socially disadvantaged people. As a result, a number of students with a wide range of characteristics such as race, ethnicity, religious beliefs and culture have entered schools (Azam, 2020).

The changing populations of learners is even more apparent, if we account students with special education needs (Villanueva et al., 2012). That is students that face difficulties in the basic psychological processes that govern spoken and written language (Moin et al., 2009). Although different countries attribute diverse definitions to special education needs, the spectrum of special needs is mainly characterized by disorders such as intellectual disabilities, learning disabilities, autism, emotional/ behavior disorders, physically dependent and deaf/blind (Brigham et al., 2011; Villanueva et al., 2012). In June 1994, the Salamanca Declaration was signed in partnership with The United Nations Educational, Scientific and Cultural Organization (UNESCO), according to which a philosophy of acceptance and respect for all children irrespective of their disabilities should govern every educational movement. Within it, people with disability are not excluded from the general education system. Far from it, inclusive education is adopted, and it becomes compulsory and extremely important for all, both for

typical development students and students with learning disabilities under the umbrella of ‘School for All’ (UNESCO, 2009). Consistent with the above is that almost 11% high school pupils in the US are classified as having specific learning disabilities (Moin et al, 2009).

In an attempt to fulfill its role towards the growing changing population of learners, a number of enactments and policies have been emerged within science education field, 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). In the core of all these movements lies the need for providing opportunities for all students, irrespective of their skills and abilities, to accomplish success in science (Villanueva & Hand, 2011). More specifically, science education should not limit its effort only for the gifted and few selected students who will become scientists and engineers. Instead, an attempt should be made to enhance all the students with the necessary aptitudes that will enable them to attain high levels of scientific literacy (Lee, 1997). This movement was fully reinforced by the latest undisputed successes of science that gave public respect and understanding of science and led policy makers to reform curricula accordingly (Turner, 2008).

Research Objectives and Methodology

While the changing population of learners has raised the need of teaching science in well-structured lectures that address student’s diversity, this seems not to be the case in everyday school practice. Students with diversity background face difficulties in science classrooms and teaching science to them is rarely ruled by relevant academic theory background. The present

study aspires to explore science achievement of these students and illuminate the need of incorporating constructivism theory in their science schooling. In particular, it tries to answer the following two research questions

1. what is the performance of racial, ethnic and special needs diversity students in science
2. what is the role of constructivism theory in the shade of racial, ethnic and special needs diversity students in science.

In order to fulfill this purpose, a literature review methodology was adopted. It is a fact that quite a few people hold the view that doing a literature review means that you have to read a number of books and then discuss both their advantages and disadvantages. In contrast to this simplistic point of view, Hart (1998) states that literature review is a proper way of conducting a research. He defines literature review as ‘the selection of available documents (both published and unpublished) on the topic, which contain information, ideas, data and evidence written from a particular standpoint to fulfil certain aims or express certain views on the nature of the topic and how it is to be investigated, and the effective evaluation of these documents in relation to the research being proposed’ (Hart, 1998, p.13).

Within this study, literature review encompassed the systematically analysis of a number of articles with the aim of identifying the empirical evidence that supports the core ideas of the manuscript. Indeed, literature review of this kind provides the basis for formulating and dealing with the research questions of an article (Snyder, 2019). Having identified the research questions, search terms such as ‘diversity students’ and ‘alternative ideas of racial, ethnic and special

needs students' were used on appropriate academic databases i.e. Scopus. This led to the collection of a multitude of articles which were thoroughly analyzed and studied. Data were abstracted from them in a descriptive manner and were reclassified in order to be compliant with the research purposes (Pare & Kitsiou, 2017). By so doing the structure of the manuscript was illuminated and the research questions were scrutinized in order to be answered. In what follows the aforementioned answers are elaborated.

Results

First Research Question

Science performance of diversity students: Despite the call for 'Science for All', researchers and science educators seem to agree that the above-mentioned aim is far from being accomplished (Villanueva & Hand, 2011). Indeed, a number of researches clearly show that students with special needs score significantly below their peers in science achievement (Cawley & Parmar, 2001; Villanueva et al., 2012). An exemplar paradigm is the study by Donohoe and Zigmond which stated that almost seven out of ten 9th grade pupils with learning disabilities failed to be graded by their teachers with a grade above D (Cawley & Parmar, 2001). In addition, in a suburban school located outside Chicago only one student with learning disabilities on grade 6 and no one on grade 8 were placed at higher levels of science achievement. In contrast, four disabled students on grade 6 and eight disabled students on grade 8 were rated below middle levels of science attainment (Carlisle & Chang, 1996). In line with this, the results of US national assessments in 2009 revealed that students with disabilities performed significantly lower in science than their non-disabled peers (Villanueva et al., 2012).

Moreover, racial/ethnic minorities often lag behind in their science performance compared to the natives. Such a case is Latinos/as, one of the largest minority group in the United States. According to Zuniga et al. (2005), these pupils are not achieving science at the same level as non-Latino on a number of educational measures. In addition, as Lee (2005) points out, poor science performance of minority racial/ethnic group is also evident through the low rates of science course enrollment and career choice among this group of people. In particular, enrollment in school science courses as well as graduation from higher education science departments is still less usual for racial/ethnic groups compared to their local peers. Moreover, high rates of high-schools dropout are often recorded for pupils who are part of these minorities (Zuniga et al., 2005).

There are some exceptions where students either from the educational needs' spectrum or from the racial/ethnic group achieve significant performance in science. As for the former, experimental studies have shown that pupils with high-function autism spectrum disorder performed significantly better than the control group on the Intuitive Physics test, which comprises 20 questions all of which were drawn from everyday real, physical-causal world experiences (Baron-Cohen et al. 2001; Krajmer et al. 2010; Paganini & Gaido 2013). As for the latter, Asian Americans in the United States act as model minority that often performs better than the local American peers in science and mathematics (Lee, 1997). Factors such as the overrepresentations of Asian Americans students among the most prestigious American Universities as well as the stories of academic success that often portrayed on mass media totally support the above-mentioned view. Nevertheless, as Lee (1997)

points out these children are often enduring great pressure and stress in order to reach their level of success. To quote him ‘the model minority label is a burden for Asian American students, often producing complex pressures... teachers perceive that these students, especially academically successful students who live up to expectations, do not require any help, while ignoring their social and emotional needs, such as perfectionism, stress, and anxiety’ (Lee, 1997, p. 109). What is more, this overrated success often masks the learning needs of other members of the group that fail to catch such high standards of learning achievements.

A number of factors account for the poor performance of students with racial/ethnic backgrounds and/or special needs. It is a fact that teachers often feel inadequate to meet the needs of diversity students (Moin et al., 2009). As Norman, Caseau and Stefanich (1998) state, teachers often lack support to enhance inclusion effectively and teach disabled students accordingly. That is, they are not aware of the distinct disabilities as well as the basic elements that characterize the spectrum of these disabilities (Brigham et al., 2011). Added to this, they often hold the view that it is not their responsibility to adjust their teaching strategies and methods to meet the needs of students with learning difficulties. According to them, this should rest in the hands of special-education teachers. Nevertheless, these teachers often lack a science background and therefore feel vulnerable and inefficient during the teaching process (Moin et al., 2009). ‘The challenge get even more significant when they are teaching historically difficult science topics, such as force and motion’ (Azam, 2020, p. 141.).

Another factor that justifies the poor performance of diverse students in science has to do with the reading and linguistic difficulties that these students often have (Cawley & Parmar, 2001). Unfortunately, school science textbooks require reading skills that aimed at students with standards that are difficult to be reached by students with racial/ethnic or special needs diversity (Parmar et al., 1994). In addition, the language problems often encountered by these pupils undermines their physics performance as language plays a key role in learning science and largely determines one’s ability to argue about science (Villanueva & Hand, 2011). In the poor performance of diverse students should undeniably be added the fact that schools in rural areas that encompass inclusion education and enroll students with diversity backgrounds have often limited human resources, special education services, translators, equipment, facilities and generally suffer from low levels of funding (Lee, 2005; Zuniga et al., 2005). This has an undeniable effect on teaching and learning processes of these pupils.

While all the above-mentioned factors hold true for the poor performance of diversity students, an even prominent reason lies on the fact that the cultural background of these pupils is often not taken into account on the teaching processes. As Lee (2005) points out, teachers generally undermine the cultural and linguistic differences of their students. Moreover, curriculum materials rarely incorporate cultural experiences and ways of thoughts of nonmainstream pupils. Indeed, whenever a curriculum was built for teaching students with diverse backgrounds, as Third Worlds’ national curriculums, this happened without any consideration of the origins of all those pupils. That is, instead of being in line with the cultural

background of Africans pupils, it was completely based on Western science assuming a complete transferability in content and methods (Ogawa, 1986; Ross & Clive, 1982). To quote Ingle and Turner (1981) 'it was rather like international air travel; once inside the aircraft, one loses sense of time, place and culture' (p. 361). In some cases, the process was even more problematic, as it was intentionally subversive to the indigenous culture which had to be abandoned in favor of western science (Dart, 1972). Even in the cases where an adaption process was adopted, this was mainly confined on exchanges of textbook examples or photographs such as depicting a black scientist instead of white, without addressing any underlying assumption (Cobern, 1996).

Second research question

Constructivism in the shade of diversity students

with special needs: Constructivism is a prominent theory in science education field that stresses the role of culture in the process of teaching and learning. According to this theory, pupils hold their own ideas about a number of natural phenomena such as gravity, electricity and heat and temperature in advance of their schooling (Borgerding & Raven, 2018; Driver, 1989; Kalampos & Ravanis, 2019; Ravanis, & Boilevin, 2009). These ideas, which are usually called misconceptions or alternative conceptions, vary from place to place and have their origins in the prevailing culture, the ideas from the media and the folklore of each country (Cobern, 1996; Driver et al., 1985; Remountaki et al., 2017; Zuniga et al., 2005). Therefore, it is important for the teacher to be aware of students' misconceptions and be ready to adjust their teaching into these conceptions. Putting it differently, teachers should be aware of the traditional

beliefs, value systems and practises that govern students' everyday lives and draw his/her teaching methods along this path (George & Glasgow, 1999; Patel, 1997).

Nevertheless, while constructivism extensively refers to the role of culture and determines to a large extent the curriculum development in Western countries, it does not seem to be able to play a prominent role in inclusive education for students with disabilities and non-mainstream racial/ethnic backgrounds (Scruggs & Mastropieri, 1994). As for disabled students, there seems to be little effort among the academic pioneers of science education to expand constructivism theory into the wilderness of special education spectrum. One of the few researchers who had moved toward this path, Maleza and Kalogiannakis (2012), found out that secondary schools' chemistry and biology lessons planned on constructivism theory had beneficial effects on students with autism. Particularly, the student of the study actively participated in teaching and learning process, while his additional outbursts were to a limited extent. In addition, Kalampos et al. (2020) explored alternative conceptions on impetus theory and projectile motion of students with high functioning autism spectrum disorders and found out they use the same alternative conceptions with those used by students of typical development, on a different frequency though, whilst in some cases they used completely novel alternative conceptions. Another similar study investigating alternative conceptions of force and gravity on three secondary students with autism, aged 13-14 years old, led to the same conclusion that autistic pupils hold almost the same alternative ideas with the ones that are encountered in the literature that count for typical development students (Kalampos, 2015).

A number of other studies have dealt with the development of specific strategies and techniques to address barriers to science content learning for pupils with special needs, without making explicitly reference to constructivism theory though (Aydeniz et al., 2012; Gaddy et al., 2008; Kim et al., 2004). 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).

Constructivism in the shade of diversity students with racial/ethnic backgrounds: The last 40 years a variety of studies have tried to illuminate the relationship between the role of culture and science understanding of non-western pupils. In these studies, it is clearly shown that these pupils hold traditional world views, religion beliefs and value systems that totally influence the way they conceptualize science (Cobern, 1996; Driver, 1991). This knowledge, often called indigenous knowledge, is usually useful to them into their daily lives and to a large extent guides their actions and decisions (Baquete et al., 2016; Horsthemke, 2004). It has its origins into ancient myths which act as a bridge with the present and have the capability to explain great human concerns such as death, creation, the evolution of living things, the universe and all its components (Jaja, 2014).

So, for example George and Glasgow (1999) conducted a research studying the beliefs held by citizens of three Caribbean nations, namely

Jamaica, Trinidad and Tobago. Their findings suggest that inherent themes concerning 'cause and effect' as well as 'generalizations' issues run throughout their way of thinking. As for the former, there seems to be a linear, direct connection of the two modes without any physical or physiological intermediate process. An illustrative paradigm is their belief that a pregnant woman that eats plenty of ochros will give birth easily. According to them, as cooked ochros are slippery, eating those will help the woman to deliver her child in an easy manner. African people also attribute to the concept of causality a meaning that deviates from the scientifically accepted one. Thus, the cause of disease is often ascribed to diabolical motives of enemies or devil misfortune (Ogunniyi, 1988).

With regard to 'generalizations' issues, Caribbean pupils tend to generalize without strong evidence supporting their assumptions. Hence, they may hold the belief that a spell of very hot days will lead to an earthquake, while major earthquakes occur rarely in their area (George & Glasgow, 1999). In addition, Caribbean pupils use to attribute special power to particular conditions and objects. The moon and the female body hold a prominent position. In particular, the moon is considered to influence plant growth and productivity while femaleness is regarded in a dual light, depending on whether it is associated with menstruation or with pregnancy (George & Glasgow, 1999).

In addition, Mashoko (2014) investigated teachers and students' indigenous knowledge practices of medical plants in Chivi, Zimbabwe. The participants of the study pointed out a number of different medical plants to cope with conditions such as snake bites, stomach aches, wound healing and infertility. Research

findings suggest that this experiential knowledge is particularly important and can form the basis for the development of a biology school lesson.

A rich oral tradition exists in Africa places concerning lightning. This is due to the fact that this natural phenomenon constitutes a real danger for African people, as many of them are killed or injured every-year from lightning strikes. Specifically, lightning is often considered to be a bird sent by Gods down to earth. Peoples that get killed by lightning are supposed to be cursed and should be buried in damp earth, away from their houses as the land otherwise will become infertile. Other myths claim that lightning is attracted to things that are white or shiny. Therefore, white cattles and fowls are often driven away during a storm while objects of this colour are covered with coloured blankets (Tregrove & Jandrell, 2011). Quite odd folk beliefs about lightning seems to exist in Austria, too. As Keul et al. (2009) point out, people hold views such as all lightning flashes ignite a fire quickly, draught and open windows may attract lightning and that lightning never strikes twice at the same place.

Hewson and Hamlyn (1984) explored the way the conception of heat is formulated by Sotho people, an African tribe that is located in the South. The members of that tribe live in a hot, arid area where an adequate supply of water is not to be taken for granted. The harsh environment of this region has given rise to a powerful metaphor concerning heat that 'coolness is good' and 'hot is bad'. That is, coolness is supposed to imply health and social harmony, while hot implies sickness and social disharmony. Therefore, the metaphor of heat is often used in a variety of instances in everyday life in order to attribute to them negative

feelings such as unhappiness, sadness and sorrowfulness. For example, a person who is exhausted from travelling a long distance is described as hot. A woman who is menstruating is depicted as hot. Moreover, an angry person who is potentially dangerous to others is characterized as having hot blood. A person is also described as hot when he is suffering from a sickness involving pain. Finally, people who attend a funeral are described as hot due to feelings of grief and sorrow. In contrast, coolness is attributed to a number of positive daily instances and cooling is the basic characteristic of treatments in Sotho medicine (Hewson & Hamlyn, 1984).

The concepts of heat and temperature are also conceptualized in difficulty by Nigerian students who use Tiv language as their mother tongue. This is due to the fact that no word representing a 'degree of hotness' or its measurement exists in their language. Therefore, heat is rarely connected with energy. Instead, it is usually associated with 'things that are hot' (Ross & Clive, 1982). Quite interestingly people in Choqwe, Mozambique, seem to have a deep indigenous knowledge about thermal physics. In particular, they demonstrate a practical knowledge of the low thermal conductivity of clay and wood as well as knowledge that heat flows from a hotter to a cooler material. This is well reflected in the following quotation '*after cooking if you leave food in a clay pot it remains hot for a long period... but the same does not happen with hot food in a metal pot because metal pot doesn't retain heat*' (Baquete et al., 2016, p. 6)

In addition, research suggests that pupils in Sierra Leone believe that they can collect untreated water from running streams due to the traditional belief that angels cleanse running streams every Friday

(McKinley et al., 1992). Moreover, in Third World countries pupils' alternative conceptions about earthquakes seem to be powered by the mythological belief that a big fish carries the Earth on its back. Each time the fish got tired it shifts its weight which leads to the vibration of earth (Ingle & Turner, 1981). In addition, in the West Indies the traditional belief that a pregnant woman has to drink milk in order to give birth to a white child undermines the scientific concepts of digestion and assimilation and consequently leads to the formation of informal ideas about those two concepts (George & Glasgow, 1988). Finally, the indigenous people of New Zealand, namely Maori, often attribute to inanimate objects such as a sculpture, river or a mountain a living spirit. As a result, many Maori students describe greenstone, a type of nephrite jade often found in New Zealand rivers, as a fish (McKinley et al., 1992). In parallel, in this tribe it is common to transfer information through generations by naming storms, mountains, rivers, streams and bays in ways that reveal information about local hazard history and risk (King & Skipper, 2006). Along this line, after the tragic drowning of 16 children and two adults who tried to cross a river with a canoe, the river was renamed to 'Matemoana', meaning 'deadly water' (King et al., 2007). In addition, this tradition inevitably influences the way Maori pupils conceptualize the natural world around them.

Discussions

The last decades the changing of learners' population is apparent in the majority of western societies (Villanueva et al., 2012). Students with diverse ethnic and racial backgrounds as well as students that fall into the scope of special education needs have enrolled into the education system of many western countries. 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 Salamanca Declaration signed in partnership with UNESCO in order to ensure the educational rights of these minorities groups (Aydeniz et al., 2012). Nevertheless, as academic literature explicitly shows, racial/ethnic minorities along with disabled students often lag behind in their science performance compared to their mainstream peers (Lee, 2005; Zuniga et al., 2005). Indeed, according to the results of the first research question, a number of factors such as the linguistics barriers of these children, their teacher's inadequacies as well as the lack of adjustment of the curriculum contribute to their poor school science performance (Brigham et al., 2011; Cobern, 1996; Cawley & Parmar, 2001; Moin et al., 2009; Villanueva & Hand, 2011). A prominent reason, among those, lies on the fact that the cultural background of diverse pupils is often not taken into account into the teaching processes (Lee, 2005). Particularly, teachers generally undermine the cultural and linguistic differences of their students and the curriculum materials rarely incorporate traditional beliefs, value systems, cultural experiences and ways of thoughts of nonmainstream pupils.

With regard to the second research questions, it seems that constructivist has not been fully extended in inclusive education for students with disabilities and non-mainstream racial/ethnic backgrounds. As for the former, few researchers have tried to explore alternative ideas of students who lie in special needs spectrum (Kaliampou et al., 2020). What is more, few of them have proposed specific teaching interventions which draw on constructivism theory in order to address their student's barriers (Chia, 2011; Maleza, & Kalogiannakis, 2012). As for the latter, it is a fact that

the last decades a number of researchers have studied the traditional world views, religion beliefs and value systems that are expected to influence the way that students with racial/ethnic backgrounds conceptualize science (George, & Glasgow, 1999; King et al., 2007). However, their findings are rarely incorporated in western education curriculums and adopted by the teachers (Cobern, 1996; Ogawa, 1986).

It is time therefore for science educators to take action and focus their research on areas that will help teachers to address student diversity in science classroom. Prominent role in this endeavor should be attributed to constructivism, a theory that dominates science education and stresses the role of culture in teaching

and learning science (Fragkiadaki et al., 2021). Particularly, the present paper aspires to act as a call for researchers in order to try to incorporate constructivism theory into the wilderness of special needs spectrum and explore alternative conceptions of disabled students. In addition, it aims to encourage researchers, along with the useful findings of the literature on non-western science education studies, to explore alternative conceptions hold by pupils of Asian and African tribes that have immigrated into the west and enrolled into the education system of these countries. By so doing, constructivism will move toward the path of addressing student diversity in science classroom and help science educators to achieve science equity for all.

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Corresponding Author Contact Information:

Author name: George Kaliampos

Department: Educational Sciences and Early Childhood Education

University, Country: University of Patras, Greece

Email: gkaliampos@upatras.gr

Please Cite: Kaliampos, G. (2021). Constructivism in the shade of racial, ethnic and special needs diversity students. *Journal of Research in Science, Mathematics and Technology Education*, 4(2), 93-105.

DOI: <https://doi.org/10.31756/jrsmte.423>

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Received: 10 January 2021 ▪ Accepted: 25 April 2021