Inclusion of Children and Adolescents with Mild Disabilities in the Scientific Area Through a Novel Workshop as a Didactic Strategy

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Abstract

Despite the effort to provide equal scenarios and a higher inclusion for students with mild disabilities, few experimental activities intended to improve their science performance were reported during the last decades. This work presents different ludic-experimental activities and their impact on children and adolescents with special educational needs and/or disabilities related to the chemistry in the human body. The workshop was specifically designed considering contents included in the curriculum design of different schools with special modality. The constructivism strategy proposed in this workshop enhances the inclusion of children and adolescents with mild disabilities in the scientific area. The idea of educational inclusion transcends the concept of integration-physical inclusion and implies the use of the same scenarios for everybody. The workshop showed that students participated in the different activities observing, reproducing, and understating phenomena of daily life. This contribution improved their self-esteem and socialization with their peers and tutors. Finally, this workshop is a novel didactic strategy in the natural science for special education modality.

Introduction

The educational system in Argentina is regulated by the National Law of Education N° 26206 (2006). This law assigns to the State the responsibility of providing free education opportunities. In addition, it supports the access to qualified education and equal opportunities to students without considering the social backgrounds. The educational system consists on initial; primary; secondary; and superior education levels that comprise different modalities, including special education. The aim of special education is to ensure education for individuals with temporary or permanent disabilities. This modality also attends to specific difficulties not provided by common education (National Law of Education Nº 26206).

The concept of disability refers to persons with cognitive limitations and adaptation difficulties (Stavroussi et al., 2010). In Argentina, 10% of the total population presents disabilities representing around 4 million people, including those with disability certificates and those who declare to have permanent difficulties or limitations to see, hear, move, understand, and/or learn (Padin, 2013; National Institute of Statistics and Censuses of Argentina –INDEC-, 2012 and 2018).According to INDEC (2018), people with disabilities report to present one (59.0%); two (18.3%); three or more (12.2%); or any difficulty even though having a certificate of disability (10.5%). Regarding the number of individuals with only one impairment, the difficulties reported are distributed in: motor (42.7%); visual (23.3%); hearing (18.6%); mental-cognitive (12.7%); speech/language (1.5%); and self-care (1.2%).[5] Motor impairment prevails on population aged 65 and over, while mental-cognitive or mild impairments are predominant for children between 6 and 14 years old (48.3%). It is important to note that special modality of Argentina's educational system imparts education for children and adolescents between 6 and 21 years old.

Nowadays, around 120,000 students receive special education (National Educational System of Argentina, 2017) distributed in 3,502 educational centers: a). initial (28.2%); b). primary (40.0%); c). secondary (12.7%); and d). comprehensive training (19.1%) (Padin, 2013; National Educational System of Argentina, 2017). The progress of inclusive education for children with disabilities in all levels has received extensive academic attention (Shogren et al., 2012). As a consequence laws, resolutions, and practices were legislated and performed worldwide (Ferguson, 2008). In Argentina, Law of Education and FCE (Federal Council of Education) attends children and adolescents with disabilities. The advantages of implementing these regulations include: a). the access to education for a higher number of individuals with disabilities; and b). the integration of disabled to the regular classrooms, achieving a higher level of educational inclusion (Padin, 2013). These achievements should be complemented with appropriate teaching methods and education programs.

In the last decades, there was a growing interest in implementing teaching practices through construction of scientific knowledge in special modality. This educational philosophy enhances students to construct knowledge out their own experiments, the connection with real life (environment and society), and the use of technology (Salend, 1998; Kirch et al., 2005; Villanueva et al., 2012; Cersonsky et al., 2017). Constructivism not only provides knowledge about nature (Scruggs & Mastropieri, 2007) but also develops the skills and attitudes necessary for life in society (Salend, 1998). The effort on the development of didactic strategies based on constructivism for children with mild disabilities is an interesting topic of research in special education. According to Scruggs and Mastropieri (1999), students with mild disabilities can be coached to actively construct scientific knowledge, increasing their academic performance.

The activities proposed in literature for disabled are mainly focused on persons with blind or motor disabilities (Lusfor & Bargerhuff, 2006; Neely, 2007; Reglinski, 2007; Stender et al., 2016; Kumar et al., 2018; Jagodzinski et al., 2015). Lunsfor & Bargerhuff (2006) proposed a project that promotes chemistry topics (physical properties, periodic table, reactions balancing, acids and alkalis) during different summer workshops. Neely (2007) has implemented technology support and different assistive strategies for students with physical and visual impairments in the science lab setting, and all educational centers involved in the activities clearly recognized the value of empowering each student throughout the education process. Reglinski (2007) presented pictorial representations of chemistry concepts as test questions requiring students to "give a detailed explanation of the diagram", and as a result there was a significant increase in student performance, including those with learning disabilities. Kumar et al. (2018) proposed four modules that discuss data analysis, electrical conductivity, optical lenses, and endothermic/exothermic reactions for blind persons.

This work proposes a workshop for children and adolescents with special educational needs and/or disabilities related to the chemistry in the human body, and based on contents included in the academic contents. This workshop presents ludic-experimental activities distributed in four modules: a). An introduction to learning senses. Everybody is different; b). How good it is to eat! The digestive system; c). Heart race!; and d). Breathing hard. Each module consists of didactic resources specific and adequately produced according to the topic. In addition, this workshop is a novel didactic strategy in the natural science for special education modality.

Workshop and Implementation

The activities were carried out in primary and secondary schools from Santo Tomé, Santa Fe, Argentina, which offer the modality of special education. The educational resources of the schools visited were relatively limited, although one of the centers provided job training in bakery area. The program was also implemented in private institutions of early stimulation and in therapeutic centers. The students were distributed in small groups accompanied by a special teacher and three assistants. A tutor guided the classes. Assistants and tutors were researchers and professors belonging to local research institutes (INTEC and INCAPE) and universities (UTN); and students from different careers including teacher training in chemistry, biotechnology, history, and medicine. The staff involved eight people. The success and impact of this workshop on the students was measured though anonymous surveys of both primary and secondary teachers at the end of the workshop.

The pros and cons of the workshop were discussed in order to improve future workshops. The details of the lesson modules are presented below, and can be tailored for students with different disabilities to promote science education. This workshop could also be suitable as model for future workshops.

Presenting Skeleton! The modules presented in this work used a synthetic skeleton as didactic resource (See Figure. 1). In the first lesson, the skeleton was presented to the class, and students proposed a name. The tutor stated that the body is supported by bones. In this context, the following comments were introduced: a) the ear is constituted by small bones; b) even though bones stop growing when persons are around twenty, new bone cells are rebuild; ic) the spine is made up of thirty three bones; d) the red bone marrow can produce around 5 billion red blood cells each day; e) if the body doesn't have enough calcium, it will take it from bones making brittle bones.

In addition, the tutor mentioned that the body is also constituted by organs, explained some aspects related to organs, and then introduced the importance of the five senses (the topic of first module).

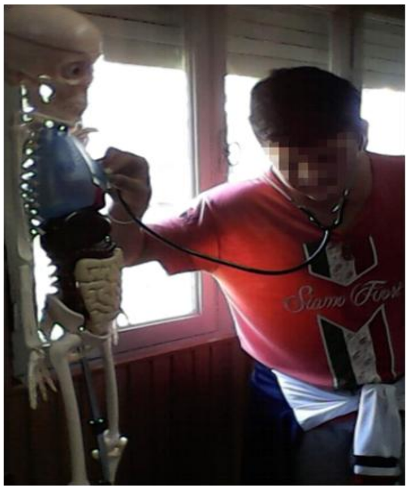


Figure 1. **Presenting skeleton**

Module 1. An introduction to learning senses. Everybody is different.

The first module intends to introduce the students to the five senses by focusing on the relation with brain, emotions, the effect of light, and the differences between humans. The module consists of five activities.

Activity 1. Hearing, touch, sight, smell, and taste

Persons understand and perceive the world using the five senses: taste, smell, touch, hearing, and sight. The stimuli from each sensing organ in the body are related to different parts of the brain.In this activity, students used colored circles to indicate the organs involved in the five senses by adhering them onto the skeleton. Then, the tutor joined the circles with the corresponding area onto the skull by employing a new circle. Figure 2 illustrates the three steps of Activity 1.

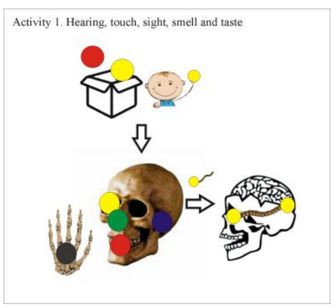


Figure 2. **Recognizing senses**

Activity 2. What are we touching?

The sense of touch describes if something is hot or cold, dull or sharp, rough o smooth, wet or dry. The sense receptors of skin are responsible for the different sensations. In this activity, the tutor presented cards representing familiar objects (jelly, sand, rice, sponge) that were previously placed into black closed boxes. Students were divided into two groups and one student per group alternated taking *turns*. The selected student had to describe the object characteristics assisted only by the sense of touch. The rest of the group had to match the object inside the box with the corresponding card.

Activity 3. What are we smelling?

The sense of smell, or olfactory system, is sensible to millions of different odours. The olfactory system also has direct nerve connections into parts of the brain that deal with memories and emotions.This activity was similar to activity 2, but considering the following objects: chocolate, coffee, perfume, and citric fruit.

Activity 4. The cow taste!

The gustatory system comprises tongue, papillae, taste buds, and receptor cells. In particular, the texture of the tongue is very rough because its surface consists of about ten thousand taste buds, found on the papillae. Each taste bud has about a hundred receptor cells connected with the brain. For this reason, the tongue presents different taste zones. In this activity, students observed and took pictures of cow tongue with a USB microscope.

Activity 5. Let's recognize the eyes!

The eyes are constituted by different parts: a) eyebrows prevent sweat, and other foreign objects from falling down into the eye socket; b) *eyelashes* protect the *eye* from foreign objects and are sensitive to being touched, thus providing a warning that an object is near the *eye*, reflexively closing; c) levator palpebrae superioris muscle voluntarily or involuntarily retracts the eyelid to open the eye; d) *nasolacrimal duct* carries tears from the *lacrimal* sac into the nasal cavity; and iv) iris changes its shape to control how much light goes through the pupil. In this activity, students first recognized the different parts of the eye by looking at their partners eyes with flashlights and magnifying glasses.

In the second part of the activity, the student learns about the color perception and the use of Newton Disk. The perception of a picture or a color remains in the human brain for a fraction of a second. Newton's color disk is a mechanical device that rotates an array of colors arranged as petals or gradients around an axis at a high rate in order to change the perception of the colors to white. Colors exhibit different wavelengths and due to the high speed, light of all wavelengths is mixed and perceived as white. The students identified different colors on the Newton's disk paperboard clamped in a fan. The tutor turned on the fan and they observed that the disk became white.

Finally, students learned about the unique and different patterns (pupils and fingerprints) that human exhibit. The tutor took photographs of the eyes of each student and showed that each pupil is different. Also, in order to obtain fingerprints, the following procedure was carried out: 1) a small amount of talc was spread into a dish and students pressed their thumbs onto the talc; 2) a piece of packaging tape was used to cover the entire fingerprint revealed by the talc; and

3) the fingerprints of each student were presented in a black cardboard. All students observed their pupils and fingerprints, and concluded that everybody is different.The special teachers implemented at their classes the new concepts acquired during the workshop and constructed Newton disks with recycled materials.

Module 2. How good it is to eat! The digestive system

The second module intends to illustrate the chemical reactions involved in the digestive system. The module consists of 5 activities.

Activity 1. Recognize the digestive system!

The digestive system is a series of organs that break down food in order to provide energy. It is comprised by: a) mouth: produces physical and chemical digestion; b) oesophagus: passes food into the stomach by peristalsis; c) stomach: begins protein digestion; d) small intestine (six meters long): absorbs nutrients into the blood; e) pancreas: contains digestive enzymes; f) liver: produces bile (for the digestion of fats); g) large intestine: absorbs water from food remains; h) rectum: stores food and water; and i) anus: removes no essential nutrients. In this activity, the class was divided in two groups and students raced in order to make a puzzle with pieces of the digestive system. Then, they marked the organs involved in the digestive system onto the skeleton presented at the beginning of the workshop.

Activity 2. The power of saliva!

Enzymes are naturally produced in the body by the pancreas, stomach, and small intestine. In addition, the salivary glands produce digestive enzymes to start breaking down food molecules. The enzymes found in saliva are essential for beginning the digestion process of dietary starches and fats. For example, starch is hydrolyzed into glucose units. The students recognized the mouth, teeth and tongue as the organs involved in the first step of digestive system.

In this activity, the tutor introduced the following topics: what happens when food is placed over their dry tongue, and which is the function of the tongue. Then, students dried their tongues with paper tissue and put a cookie over the tongue. This activity allowed understanding that saliva and tongue are important to distinguish flavors and textures, respectively. Then, the tutor asked whether the unique function of saliva is to recognize flavor, and subsequently asked whether saliva helps to triturate food with teeth. In order to answer these questions, the following experiment was carried out by each student. Students received two transparent glasses and a slice of bread; they crushed bread with their hands, put pieces of bread into one of them, and chewed and salivated bread and put it into the other glass. Then, they added into both glasses two or three drops of Lugol (a iodine solution) that turns blue in presence of starch; and finally observed and marked changes. Starch turns into a blue colour upon addition of Lugol, due to the formation of an intermolecular charge-transfer complex. In the absence of starch due to enzymatic action, the brown color of the aqueous solution remains.

Activity 3. Stomach to the attack!

The stomach digests food using acid and enzymes while its muscles periodically contract, churning food to enhance digestion. The pyloric sphincter is a muscular valve that opens to allow food to pass from the stomach to the small intestine. In this activity, the students carried out the following instructions. They fill three glasses with water, and added two tablespoons of biological washing powder to two of them, and left the third as a control with just water. Then, they cut the white of the hard-boiled egg into lumps of similar size, and put a lump into each jar and leave them for 2-3 days in a template place. After that period, at regular classes the special teacher showed the differences observed between the eggs and made conclusions with the help of the students. Enzymatic activity of biological washing powder degrades food in tiny parts.

The special teachers also developed an activity about the importance of minerals in the consumption of food. They placed an egg in a cup filled with vinegar, so that the egg was completely covered. The students made hypotheses about what could happen and then observed if they were right or not.

Activity 4. Far, far away intestine!

The intestines are a long and continuous tube that connects the stomach with the anus. In this activity, the tutor questioned about the length of the intestine before using a 9 m cord to show that the length of intestines is greater than the student's height. Then, different organs from the digestive system of cows were observed at microscope.

Activity 5. Art with digestion

This activity was coordinated with art special teachers and consisted of representing the digestive system with modelling clay. Then, they explain the path of food through the digestive system.

Module 3. Heart race!

The third module intends to present to the students aspects related to the circulatory system, such as blood color, and oxygenation. The module consists of 4 activities.

Activity 1. The blue blood

The circulatory system allows blood to circulate and transport oxygen, carbon dioxide, hormones, blood cells, and nutrients such as amino acids and electrolytes to and from the cells. Blood absorbs light at different wavelength although skin does not absorb much light. Red light absorbs at 564-580 nm (a high wavelength of visible spectrum), and for this reason it color reflects easily. However, the red light of veins is absorbed by hemoglobin (the protein that makes our blood red). On the other hand, blue light does not penetrate the skin as well as red light. If a vessel is near the surface of the skin, almost all blue light is absorbed by the vessel, so even though only about 1/4 of the red light is reflected, the ratio of red light reflected to blue light reflected is about 10:1. And thus, this vessel appears red. If the vessel is deeper (about 0.5 mm or more), not as much blue or red light will be absorbed. Importantly, this effect will be more pronounced on blue light than on red light since blue light does not penetrate skin very well (the ratio of red light reflected to blue light reflected is about 3:2 or less). This is the case for the "blue veins" observed in skin. Once the vessel is deep enough, it won't be seen at all, as light of all wavelengths will be reflected before it can interact with the blood. Consequently, this 0.5-mm-deep vessel appears blue despite reflecting slightly more red light than blue light. This is where relative color perception comes into play. The surrounding skin reflects more red light than blue light (by a ratio of about 5:3), and it does not absorb as much of either type of light as a blood vessel does. Since vision is influenced in part by relative perception, if something purple is placed next to something red, the purple object will appear blue.

In this activity, students observed their arm veins, and the tutor explained that the blue color of blood is caused by a light effect. Then, students marked the pulse in the blood vessel and the heart in the skeleton; and they heard the heart matter using a stethoscope.

Activity 2. Wholeheartedly

This activity consists of playing a game intended to reproduce the blood path. The idea of this game is to show that the contaminated and clean blood does not mix and that the heart acts as the connector of different types of blood. The game is for turn and for two students (Fig. 3).

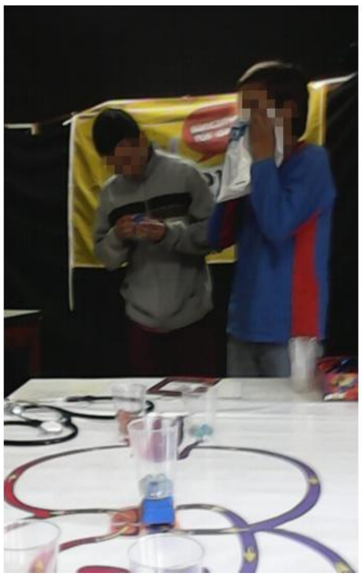
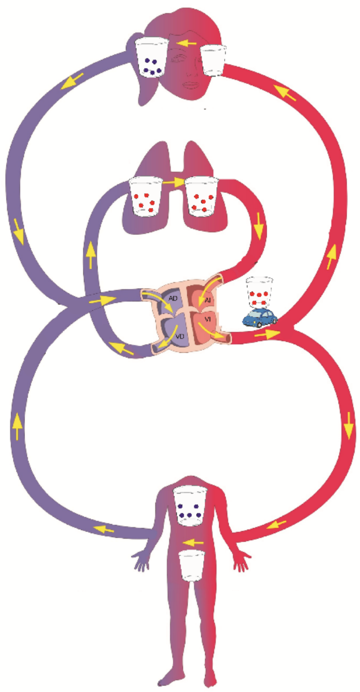


Figure 3. The experience in the workshop.

A cars track consisting of blue and red paths is a simplified scheme of circulatory system including the heart, head, and lungs. The blue path represents the circulation of low content oxygen blood with high content of residues, while the red path represents the circulation of clean blood. There are two types of cards: “Oxygen load” and “Oxygen unload”. The car represents the blood, and red and blue pellets respectively represent the oxygen and the residues. At the beginning of the game, the car and a plastic glass with red pellets are situated in the heart; and six glasses (with and without pellets) are divided in pairs in the lung, head and body. Red pellets are initially contained in the lung, while blue pellets are contained in head and body. One student takes an “Oxygen unloads” card, and reads it, and the other student executes the indicated action and moves the car. See the indications in Fig. 4. The game finishes when all the cards are read.

Activity 2. Wholeheartedly



"Oxygen Discharge" Cards

- o Eat a cookie: your stomach needs oxygen to digest food. Move the car to the body, unload 3 red pellets and load 3 blue pellets, and return to the heart.
- o Jump three times: your legs need oxygen to move fast. Move the car to the body, unload 5 red pellets and load 5 blue pellets, and return to the heart.
- o Make hula-hula with one arm: your arms need oxygen to move quickly and coordinate. Move the car to the body, unload 5 red pellets and load 5 blue pellets, and return the car to the heart.
- o Write your name on a piece of paper: your brain needs oxygen to think. Move the car to the head, unload 4 red pellets and load 4 blue pellets, and return the car to the heart.
- o Lie down and rest on the floor: your body needs oxygen to maintain the body warm. Move the car to the body, unload 2 red pellets and load 2 blue pellets, and return the car to the heart.
- o Try to see or hear something happening outside the classroom: your brain needs oxygen to use senses. Move the car to the head, unload 4 red pellets and load 4 blue pellets, and return the car to the heart.

"Oxygen Load" Cards

- o Breathe deeply two times, inspiring air through the nose, inflating the belly and exhaling through the mouth: you oxygenated your blood well. Move the car to the lungs, unload 5 blue pellets and load 5 red pellets, and return the car to the heart.
- o Breathe quickly three times, inspiring and exhaling air through the nose: you oxygenated your blood a little. Move the car to the lungs, unload 3 blue pellets and load 3 red pellets, and return the car to the heart.
- o Cover your nose and mouth and do not breathe for a while: you did not oxygenate your blood. Move the car to the lungs, unload 2 blue pellets but do not load any red pellets, and return the car to the heart.
- o Breathe normally three times: you oxygenated your blood. Move the car to the lungs, unload 4 blue pellets and load 4 red pellets, and return the car to the heart.
- o Cover your nose and mouth with a bag and breathe: you oxygenated your blood very little. Move the car to the lungs, unload 1 blue pellet and load 1 red pellet, and return the car to the heart.

Figure 4. Schematic representation of the car path and instructions for Activity 2. Wholeheartedly

Activity 3. Open heart

In this activity, the students looked at the microscope slides with samples of cow heart that they had previously prepared. Then, they took photos of different slides.

Activity 4. Foam of blood

Hydrogen peroxide (H_2O_2) is degraded into water (H_2O) and oxygen (O_2) by the catalase enzyme. H_2O_2 has been used as an antiseptic since the 1920s because it attacks bacteria by destroying their cell walls. Unfortunately, H_2O_2 also destroys healthy skin cells. This is why many physicians and dermatologists currently advise against using H_2O_2 to clean wounds, as it has been found to slow the healing process and possibly worsen scarring by killing the healthy cells surrounding a cut. Despite its negative effect on healthy cells, the body naturally produces H_2O_2 to produce energy.

In this activity, a glass is filled with cow blood, and students add oxygen water into the glass. Then, they measure the reaction temperature with a thermometer in order to observe that reaction is exothermic.

Module 4. Breathing hard

This module presents different activities intended to comprehend the respiratory system. The module consists of 3 activities.

Activity 1. Oxygen to live!

A pulse oximeter is a medical device that indirectly monitors the oxygen saturation of a patient's blood. Normal values are higher than 95%.

In this activity, each student, assisted by a tutor, used an oximeter to measure the oxygen saturation of a partner, and compared it to the normal values.

Activity 2. Danger smoking

Individuals with mild disability experience poorer health than those in the general population, with even delays in access to diagnosis, investigations and treatment (Lodge et al., 2011). Consequently, people with an intellectual disability who smoke are particularly vulnerable to the detrimental impact of smoking on their health, and on their financial and social wellbeing.

In this activity, the harmful effects of smoking are highlighted employing a smoking robot. This device consists of a cigarette, a pump, a smoke collecting chamber, and a filter pad. As the cigarette burns, smoke is pumped through the filter. Students compared the clean and dirty filter and discussed the differences observed.

Activity 3. The total lung capacity

The total lung capacity is measured through body or lung plethysmography, one of many pulmonary function tests that help to determine how much air is present in the lungs when a deep breath is taken and how much air is left in the lungs after exhalation is performed.

In this activity, students followed the instructions provided by the tutor to measure lung capacity using a homemade water displacement method. This method consists on replacing the air lung by the place of water in a transparent bottle. To use the water displacement method, is necessary to take a big, deep breath and then blow it fully into a tube connected to a container filled with water. The resulting volume (amount) of water that is pushed out is equal to the volume of air the lungs can hold. Finally, students compared the different marks.

Results and Discussion

The special teachers were surveyed about their experience thorough out the Workshop. The questions were related to different aspects of the performance of activities, such as motivation, and increases of self-esteem of students. One question was even related to the use of experiments, in order to promote the incorporation of these kinds of activities into regular classes. In general, the responses were very positive.

Regarding to the workshop in general, from thirty surveys, 86.7% of teachers answered that the workshop could be adapted to children with mild difficulties of all years, and that it could also be incorporated as a modality in the curriculum design. The rest of surveyed teachers answered that the workshop could be repeated considering a different place specially destined to carry out these types of activities and that students can be selected according to similar disabilities. In addition, one of the teachers commented that it would be interesting to perform the workshop including children with and without disabilities.

Regarding to the performance of activities, 59% and 33% of surveyed teachers were very satisfied and satisfied with the activities proposed in the workshop. The rest answer that the activities were moderate safe, and that some of them could be improved. These results are very positive taking into account that the activities were develop by researchers and professors that are not in daily contact with children and adolescent with disabilities. Adaptations of the activities could be performed in order to increase the acceptability among surveyed teachers.

The answers about the motivation and self-esteem of students were very positive (see Fig. 5).

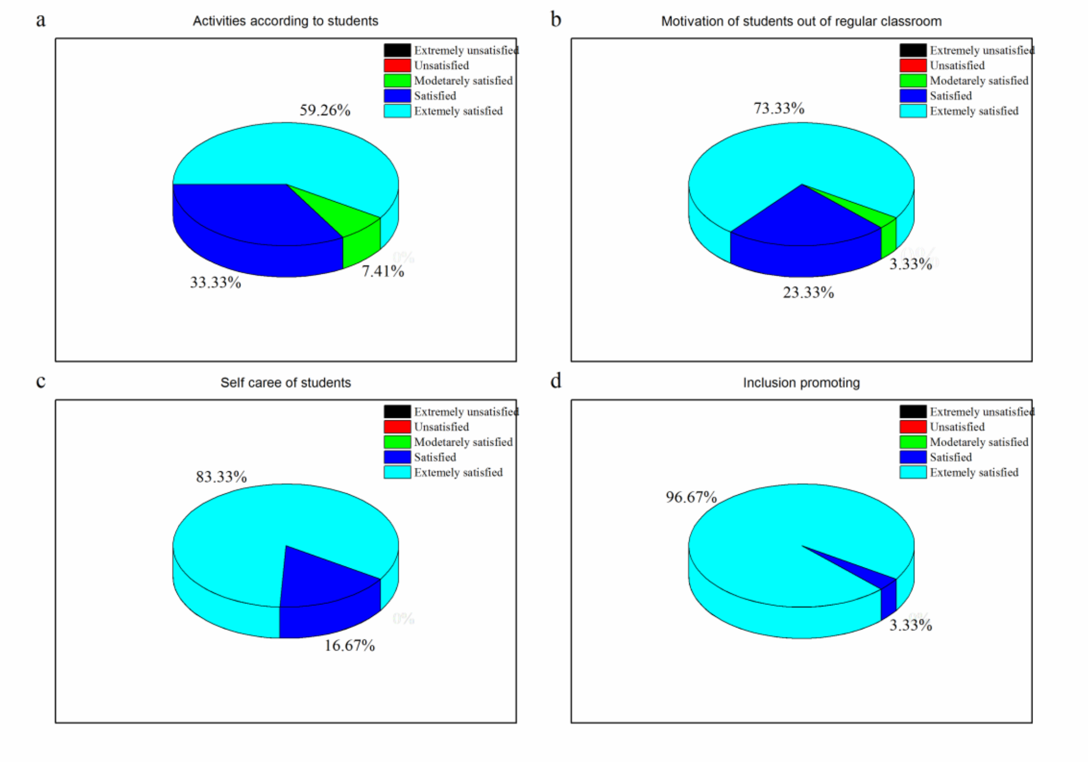


Figure 5. Responses of surveys.

The students accomplished different objectives related to senses and human body systems. The experience of workshop allow them improve their self-esteem and socialization. They also had the opportunity to demonstrate what they learned to society in science and books exhibitions (events that are intended for the general public). Adolescents from one of the secondary schools performed the activity of the cigarette and the harmful effects of smoking in a primary school.

The inclusion promoting was acceptable. It is important to continue with these activities in order to adapt them to children with blindness and motor problems.

Another topic was discussed in another course that includes concepts of chemistry and the chemistry of different foods. Finally, we believe that these modules could be applied and improved by the readers of this journal from a pedagogical and didactic point of view.

Conclusion

The constructivism strategy proposed in this workshop enhances the inclusion of children and adolescents with mild disabilities in the scientific area. The idea of educational inclusion transcends the concept of integration-physical inclusion and implies the use of the same scenarios for everybody. The workshop showed that students participated in the different activities observing, reproducing, and understating phenomena of daily life. This contribution improved their self-esteem and socialization with their peers and tutors.

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