STEAM and Inclusive Education: Hands-on Science Experiments Using Static Electricity

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Abstract. Education policies progressively reflect the need for an improved and generalised scientific literacy. STEAM (Science, Technology, Engineering, Arts and Mathematics) education embraces this goal and many programs have been implement to target the need for an active and effective STEAM education at all school levels from kindergarten through high school.

This study was implemented in the Room 1 of the Learning support centre of the school, attended by eleven students (one girl and ten boys), six of those with Autism Spectrum Disorders (ASD), in which we apply structured teaching methodologies. The results of this study aim to reveal the potential for creativity and the role of inclusion and STEAM education. Experiments using static are fun. When most people consider experiments using static electricity, then visualise the one involving hair and a balloon. Though, many further experiments will amaze people of any age and can effectually also exemplify how physics and chemistry are used in creating illusions.

The present paper presents the analysis of data that involved one teacher and students working in Learning support centre context, during work group. The paper reported simple science hands-on activities on static electricity, through the lens of creativity. Most students showed enthusiasm and joy during the experimental activities being much more focus and committed than usual. The activities herein reported are the extension and follow up of an experiment developed in the 2021-2022 academic year with another set of ASD students that was previous reported at the HSCI2022 conference. A comparative analysis of the results will be provided and discussed.

Keywords. Inclusive Education, Autism Spectrum Disorders (ASD), Static Electricity Experiments, STEAM, Creativity.

1. Introduction

Electricity is present in a large part of our daily lives. Without it we would not be able to engage in any important daily activities. We often don't know exactly how precious it is until we experience a power outage. In the work herein we explore static electricity through a series of simple and diverse experiments that illustrate this natural phenomenon at a level adequate to the age level and the particular characteristics of the students involved.

Most of us agree that experiments using static electricity can be fun. When thinking about static electricity most of us envision experiments involving hair and, or, a balloon. However, many more different experiments can amaze children, of any age, and can effectively illustrate the science involved including while creating illusions [1].

In Portuguese basic schools the "Static Electricity" topic is introduced to students in grade 4. The first approach is often to show that static electricity is the energy that can make hair literally stand up! It is said static electricity to be a phenomenon where charged particles are interact from one object to the other. When two objects are rubbed against each other, in a dry surrounding, the objects acquire equal & opposite charges thereby developing a "static electricity" force between them [2].

Inclusive education is the most effective way to give all children a fair chance to go to school, learn and develop the skills they need to acquire in order to be able to prosper and be active members of the society.

Inclusive systems value the unique contributions students of all backgrounds bring to the classroom and allow diverse groups to grow side by side, to the benefit of all [3].

Incorporating science experiments into learning in inclusive education is a great way to involve children and make lessons more hands-on, actively participated and fun. While autistic students may have different and particular needs in the classroom, they also enjoy science experiments. However, there can be some sensory needs that need to be taken into consideration when planning science experiments, to ensure that autistic children are as comfortable as every other student.

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Many children on the autism spectrum have sensory processing disorder or struggle with certain sensory issues. A very oversimplified definition of this is just that their brain processes sensory inputs (touch, taste, sight, smell, sounds) from the environment around them differently than most children. For some children this can mean they crave extra sensory input and for others it can cause an aversion to certain stimuli all together [4].

This paper contains seven activities, documenting examples of exploring science through the lens of creativity. In this study, the activities will be complemented by photography that will illustrate the advantages of using creativity in science and, or, arts in inclusive education. The activities, its design and planning, were drawn from selected observations and supported by information gathered through several types of data, non-verbal communication, and communication tables.

This study was developed in a learning' support centre with structured teaching, enrolling six students with autism spectrum disorders (ASD). The findings of this qualitative study aim to reveal the potential for creativity of science education in the classroom of students with ASD.

This study is the follow up of a study reported [10] at the HSCI2022 conference. Based on our previous experience we have designed seven "clean" science experiments that are "quiet" not requiring students to get their hands messy, since these can be typical triggers for autistic children.

2. Instruments and methodology

2.1. Instruments

The instruments used to record and to analyse the data were: the field notes [5] and photographs [6] taken by the teacher; reflections of the teacher [7]; and, inputs collected from the children [8].

2.2. Methodology

The objective of the observation during the activity of this pedagogic experiment is to spot and to characterize students' creativity [9], interest and interaction while exploring science.

The notes taken include the students' interventions, observation facial expressions, the emotions, the actions the events occurred. The pictures taken, enable to better identify and to characterize the quested creativity.

3. Characterization of the class

The school, located in Lousada, a small village in northern Portugal, is a public educational institution covering preschool and basic school levels up to the ninth grade; The Portuguese education system is divided into pre-school education (from the age of three until the start of basic education), basic education (six to fifty years old).

The activities were developed at the Room 1 of the Learning support centre, with students aged eleven to fifty years old. This room is a wide one with well identified functional areas endowed with suitable materials, and we follow a Structured Teaching method. This is based on the unique learning needs of students with ASD, including those with difficulties in visual information processing and with social communication, attention and executive function.

Eleven students participated during the so-called work group area. Only three of the autistic students are verbal (one boy of the fifth grade, one of the ninth grade and one boy of the eighth grade). The others (one of the fifth grade and two of the ninth grade) are non-verbal.

4. STEAM activities

The main underlying goal of the STEAM activities implemented is: to introduce and foster to recognize that objects are made of different materials and the materials differ in surface, shape, colour, size, etc.; to develop science investigation skills, mainly observation and categorization skills in simple inquiry activities; to develop the ability to construct simple tasks, to be able to draw basic conclusions from the inquiry activity; to develop basic knowledge, to serve as correct preconceptions, about static electricity.

The used materials were balloons; confetti; pieces of wool; plastic spoon; ruler, tissue paper; plastic bag; stone; plastic cup; glass cup; eraser; metal spoon; pencil; ice cream stick; wooden comb; plastic pen; coloured Styrofoam; salt;

pepper; PVC tube; dish; plastic tray; straw and dishwashing soap.

4.1. Static electricity hands-on activity #1 – Snake

Static electricity experiments are fun to do. It incorporates both the principles of physics and chemistry into something very simple. It is an interesting way to initially engage any child in STEAM education while teaching them that learning can indeed be fun.

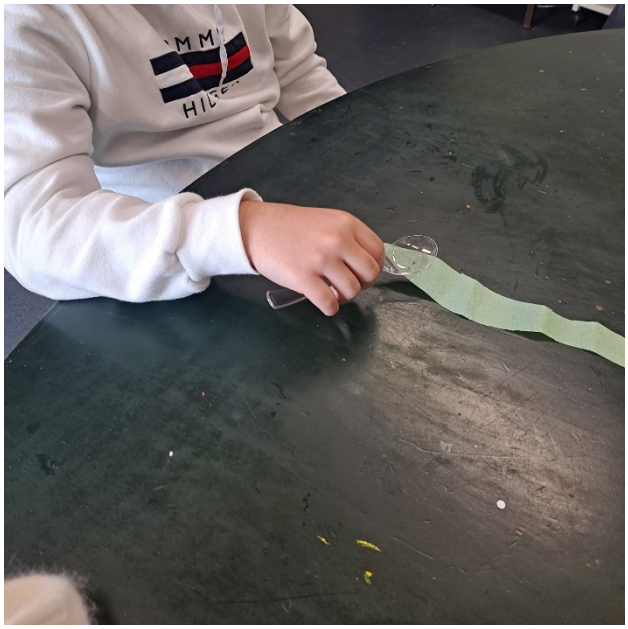

Figure 1.1. Student Z "whispering" the snake with static electricity

This first activity (also applied last year – and reported at HSCI 2022 [10]) is mainly focus on teacher scaffolding. The intention is to captivate students' attention, introduce materials and workspaces, and engage them for the following activities.

Teacher has the ability to guide the group through the "static electricity" concept. Two students have already previous knowledge about this theme, others haven't.

In this activity creativity was present when teacher encourages children to make connections between previous ideas and cross curriculum concepts. For instance, one of the students recognized one situation from out of the school learning when he says: *"The car's door sometimes gives a shock in my hand."*

The teacher asks the students to cut a snake in paper tissue. Then asks the students to rub the plastic spoon with a piece of wool and "whisper" the snake...

Figure 1.2. Student Z "whispering" again the snake with static electricity, through new friction

Figure 1.3. Student M "whispering" the snake with static electricity

4.2. Static electricity hands-on activity #2 - Balloon

The teacher induces the pupils to think like an inquiring person which is looking for an answer to the identified question (what kind of objects can cause static electricity; in what kind of case we can experience the effect of static electricity?). The teacher asks the non-verbal

pupils to point the pictogram √ (yes) or X (no) to an object, considering what they think about the behaviour of the balloon when it will be rubbed against a piece of wool (making a prediction). The verbal ones said it orally. Teacher gave to the students a worksheet to write down their predictions and verifications about the several materials besides the balloon.

Further the teacher offered the pupils balloons and other material for verification of their predictions. She explained that it is important to rub all the tested material against the piece of wool in the same direction and the same number of times, to get comparable results.

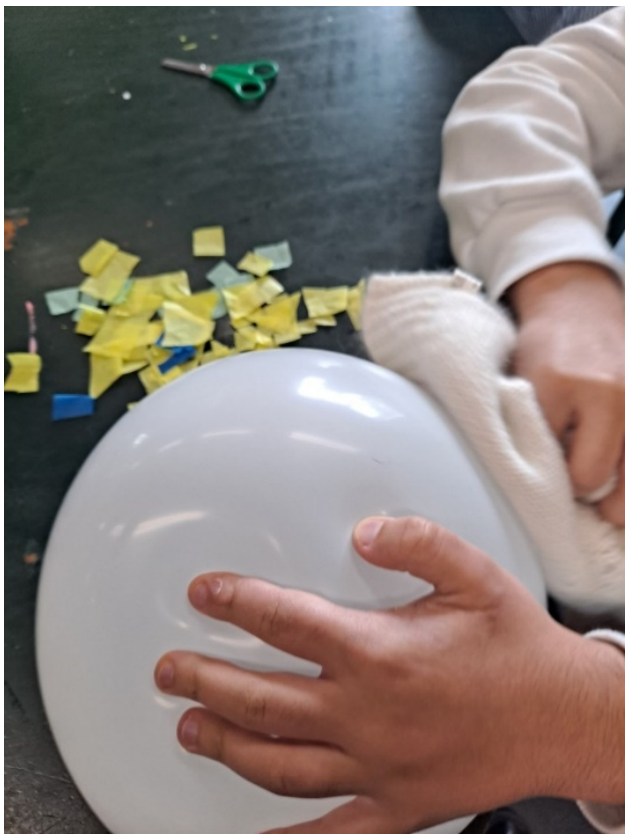

Figure 2.1. Rubbing a balloon with a piece of wool

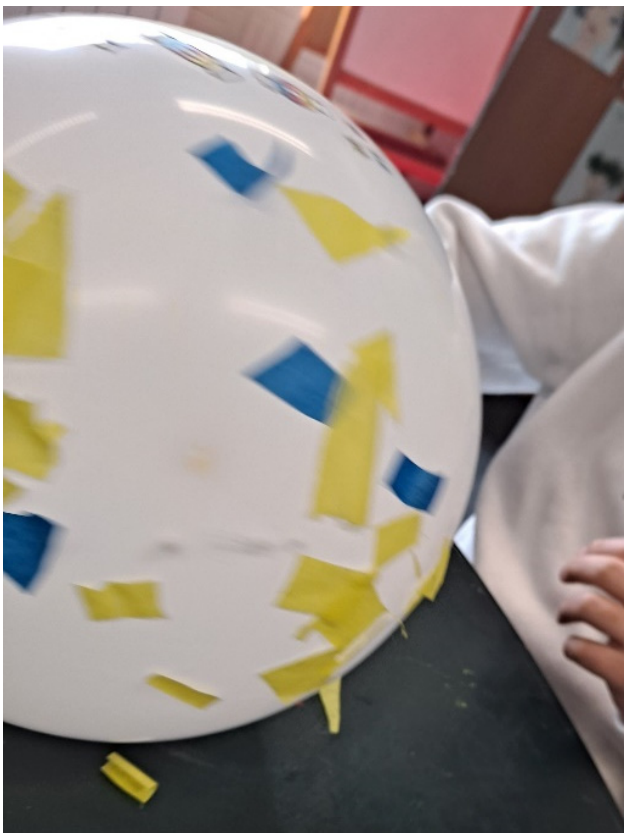

Figure 2.2. Student Z rubbed balloon attracting small pieces of paper

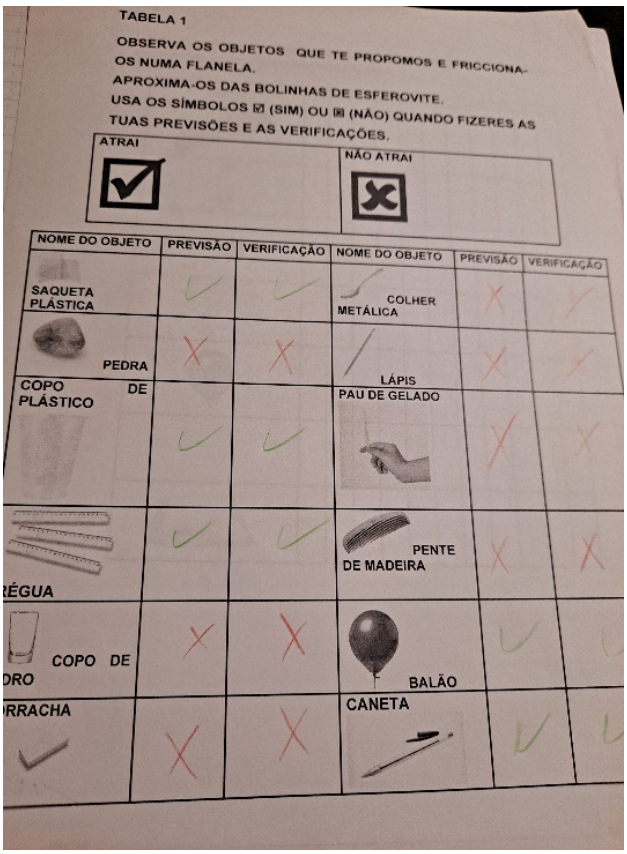

Figure 2.3. Worksheet of predictions and verifications of several materials

4.3. Static electricity hands-on activity #3 – plastic spoon and styrofoam

The purpose of this activity is to measure the "attracting power" between a plastic spoon and tiny pieces of Styrofoam. To achieve this goal, pupils should rub a plastic spoon in a piece of wool and put it near to the small pieces of coloured Styrofoam.

The more functional students counted how many pieces of Styrofoam were "attracted by the spoon" and then, in the worksheet, painted the equivalent number of squares, as many balls of coloured Styrofoam that were attracted to the spoon (figure 3.3). In this way, in this activity the students worked maths, numbers and quantities as well as arts while painting.

Figure 3.1. Student Z with a rubbed plastic spoon attracting Styrofoam

The activities presented in the following chapters, were implemented this year in order to compare with the same activities developed in the previous year and reported at the HSCI2022 conference [10], because this year students are older and some of them are more functional.

Figure 3.2. Child H with a rubbed plastic spoon attracting styrofoam

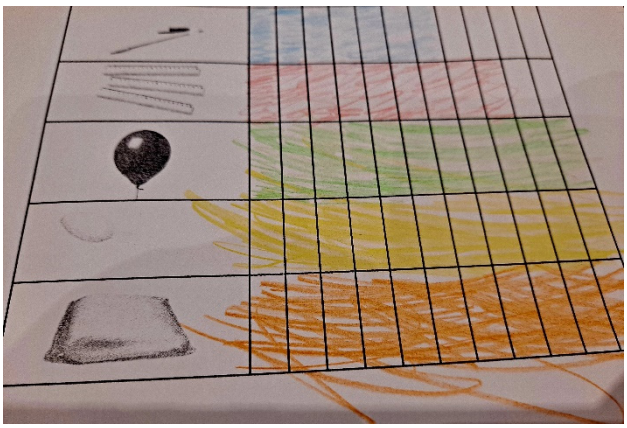

Figure 3.3. Worksheet with as many squares coloured in the table as many pieces of paper the rubbed object attracted

4.4. Static electricity hands-on activity #4 – plastic spoon or balloon and salt and pepper

Students made a mixture of pepper and salt. Then they rubbed a plastic teaspoon and a balloon on the piece of wool for about 40 seconds. They placed the plastic teaspoon over the salt and pepper mixture and observe. All of the students observed that the pepper was attracted by the teaspoon and by the balloon. Student H said: "Pepper jumped and sticks to the teaspoon and to the balloon."

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Figure 4.1. Plastic teaspoon attracting pepper, separating pepper and salt

Figure 4.2. Balloon attracting pepper, separating pepper and salt

4.5. Static Electricity hands-on activity #5 – butterfly

After the snake activity described in 4.1., the teacher continued to explore the static electricity concept in order to verify if students could apply previous knowledge to a new situation.

This new experiment intended to demonstrate how static electricity can move the wings on a tissue paper butterfly. The used materials were glue stick, balloon, scissor, pencil, tissue paper and cardboard. The student drew butterfly wings on a piece of tissue paper with a pencil, cut the butterfly, and then glued it by the middle of the cardboard. The wings needed to be loose, in order to have motion, to demonstrate the effects of static electricity.

Teacher showed the students the balloon, a piece of wool and the cardboard with tissue paper butterfly shape. Teacher asked students to make predictions, if they rub the balloon and get it near to the butterfly. Referring to this new situation, student E. answered: “The wings of the butterfly will raise when we approach the rubbed balloon.” This points out that this child carried out significant learning as he transferred knowledge into a new situation.

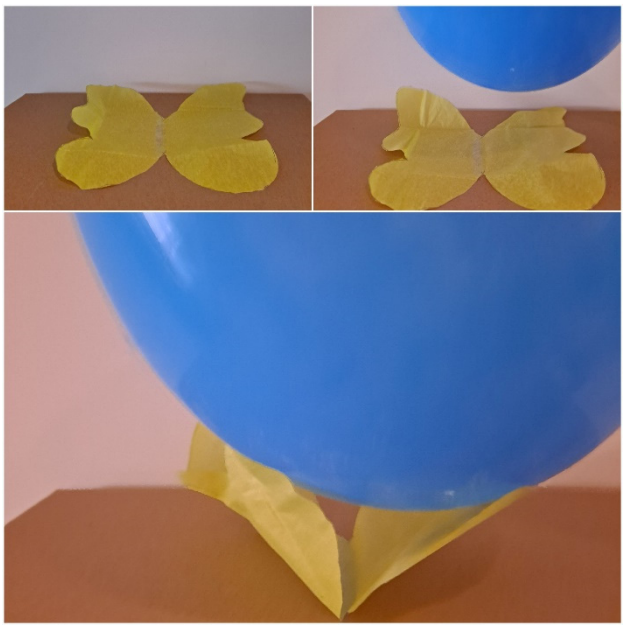

Figure 5. Photo sequence Static electricity butterfly

The balloon should be close but shouldn’t touch the butterfly. They saw the wings lower and raise as the balloon is moved closer and further in distance. The pull of the charged attraction enables the paper to move towards the balloon.

4.6. Static electricity hands-on activity #6 - bending water using static elect ricity

In nature, water can bend due to the moon exerting tidal forces [1]. The same bending effect can be accomplished by using static electricity.

The materials used in this activity were running water, piece of wool, balloon and PVC tube. Students used the wool to rub the surface of the PVC tube for 40 seconds. They created a stream of water by turning the tap on slightly and placed the PVC tube close to the water and watched with amazement as the stream bends.

Figure 6.1. Bending Water Using a rubbed PVC tube

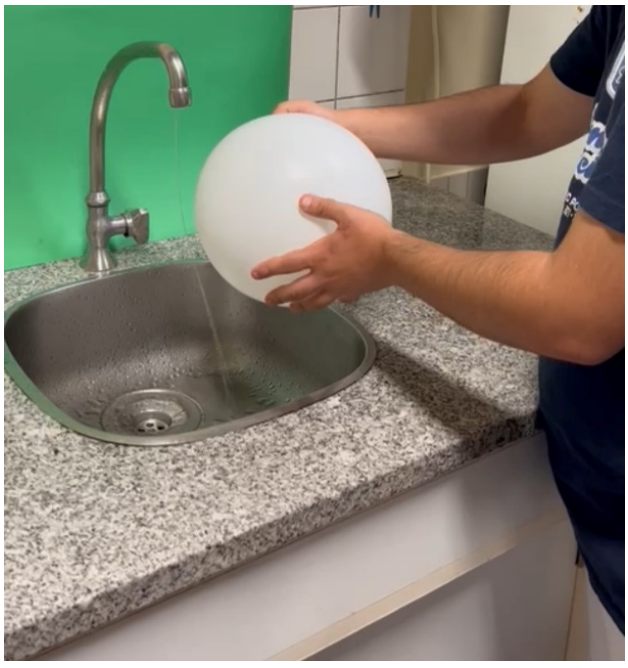

Figure 6.2. Bending Water Using a rubbed balloon

Rubbing the material on the PVC tube generates negatively charged ions. This repels the electrons found in the water. The water closest to the positioning of the rod receives positive charges from it. The attraction between positive and negative charges creates a force on the water, allowing it to appear as if it were bending [1].

In order to verify if students made significant learning, teacher asked: “And if you rub the balloon and bring it closer to the water, what will happen?" Two students answered: “The water would approach the balloon.” The students’ answers showed that they made connections and transferred knowledge.

4.7. Static electricity hands-on activity #7 – bubble moving tube

Static electricity may also be used to move soap bubbles in another rather appealing experiment.

The materials used were plastic tray, dishwashing soap, PVC tube and a piece of wool. Students spread the bubble solution on a plastic tray. Blowed larger bubbles on the tray with the straw. Charged a PVC tube by rubbing it. Students placed the object near the bubble and observed [1].

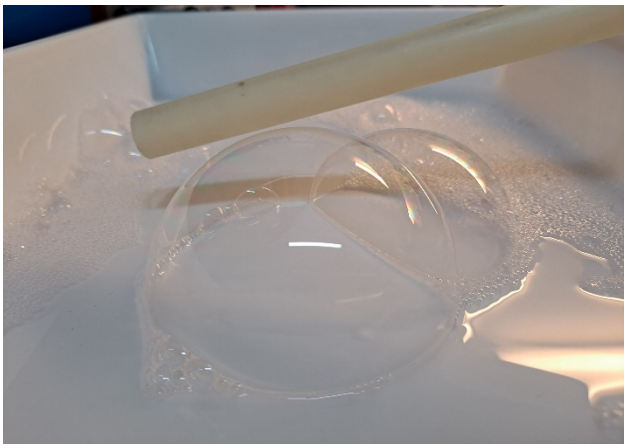

Figure 7.1. Bubble near a PVC tube

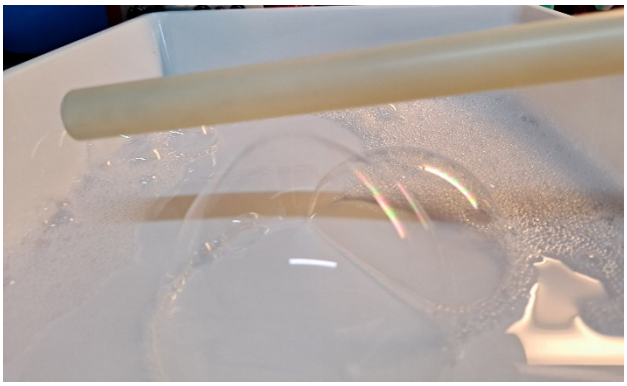

Figure 7.2. Bubble attracted by a rubbed PVC tube

Students observed that the soap bubbles followed the charged PVC tube.

At this point, teacher asked if they reached any conclusion of what they observed. The most functional verbal students answered: "When we rub plastic objects, they gain the power to attract."

In all of these experiments, we are manually moving electrons from one material to another [11].

All matter is composed of three types of particles: negatively charged electrons, positively charged protons, and neutrally charged neutrons.

Normally, the electrons and protons present in an atom are balanced, which is why most matter is neutral. But electrons are tiny and very light. That's why friction manages to give mobile electrons enough energy to bond their atoms and cling to others, migrating between different surfaces.

When this happens, the first object has more protons than electrons and has a positive charge, while the second object has more electrons than protons and has a negative charge.

And when one of these new bodies comes into contact with another material, the mobile electrons take the first opportunity to leave the material with a negative charge and incorporate the material with a positive charge. It is this movement of electrons that makes us feel small shocks, hear clicks or even see little lights when we come into contact with some people or objects [11].

5. Summary and conclusions

Incorporating science experiments into learning is a great way to engage children and make lessons more hands-on and fun. The teacher initiated the activities explaining and making demonstrations to the students. Encouraging observation by the students in simple science activities was fostered.

The proposed activities showed creativity through student's action, curiosity, engagement and enthusiasm. Rich motivating contexts for play and exploration were fostered, by the utilization of everyday materials, besides the whole classroom organization and the knowledge of student's functional profile. Collaboration was promoted by the use of group work in a group work area, and played an important role in involving students, specially, the ones with autism spectrum disorders.

The students showed enthusiasm and joy during the experimental activities, being much more focus and committed than usual, except two of the students due to their severe autism.

The above-mentioned activities contributed to engage students on STEAM education.

Across the episodes there were stated many examples of students participating, observing, and making connections.

The teacher emphasised the need to foster motivation and collaboration and to provide a rich environment with space and time for exploration, especially in what concerns a group of ASD students.

Comparing these results with the ones reported previously [10], these students were able to make more predictions and verifications and their predictions and verifications were mainly correct. This means that significant learning was achieved. These students being older and verbal, know how to ask questions, make connections, prove results and know how to communicate them.

In addition to the three activities on static electricity carried out by primary school students (ages between 6 and 9 years), in the past year [10], this year' older students carried out four activities more and have more autonomy, also because they are older and three of these students are more functional and verbal.

6. Acknowledgements

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