NANO EYE EARLY YEARS EDUCATION

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DIDACTIC GUIDE ON SCIENCE AND METHODOLOGIES IN EARLY CHILDHOOD EDUCATION AND EXAMPLES OF METHODOLOGIES BASED ON THEATRE GAMES

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Content

1. Welcome

NanoEYE

"NanoEYE: Immersion in nanoscience for education in the early years" is a project funded by the Erasmus+ programme under the call "School Education Cooperation Partnerships" that aims to create innovative educational tools that can be used by teachers to teach nanoscience-related concepts in the infant (or early childhood) education environment.

This project aims to promote equal opportunities between boys and girls in early childhood science education to ensure access, inclusion, diversity and equity in the development of personality, skills and abilities to promote their curiosity about the world around them through nanoscience.

It is aimed at pupils from 0 to 5 years of age with the following objectives:

- To increase the scientific and technological knowledge and innovative culture of schoolchildren and teachers.
- Training teachers in new educational methodologies.
- To increase the dissemination of research work carried out by women scientists and researchers.
- Encourage and develop curiosity about the environment around them.
- Develop an interest in scientific knowledge from early childhood.

With this project we aim to develop high quality early childhood education and childcare systems products to support teachers in using innovative and creative methods to teach nanoscience in the early years. Thus, as part of the NanoEYE materials, we offer a series of tools that aim to highlight the advantages of using theatre techniques to teach pupils. These materials include this guide, a handbook on theatre workshops and an example of puppet theatre with experiments.

In addition, 15 videos with associated teaching sheets explaining basic nanoscience concepts can be found in the project.

2. Why is this guide necessary?

This guide is the basic tool that guides teachers on how to put science teaching into practice with their students, especially nanoscience, through methodologies based on theatrical games, so that they can understand and experiment with these alternative forms of teaching. In addition, given the innovative approach, the materials may require contextualisation for those teachers who have not used these types of methodologies before.

We all learn throughout our lives, but children's early years are crucial for planting the seeds that will allow them to flourish later in life. In their early years, even before primary school, the foundations are laid for their personal development, social skills and later learning success.

3. Starting Point

Educational methodologies in early childhood education

The methodology in early childhood education is the set of rules and decisions that organise, in a global way, the didactic action in the stage. The methodology defines the role of pupils and educators, the use of means and resources, types of activities, organisation of time and space, groupings, sequencing and types of tasks, etc.

Depending on what we want to teach we can base ourselves on some principles in such a way that they direct our line of work, but in short they can be based on the following:

- **Globalisation** assumes that learning is the product of establishing multiple connections of relationships between new and existing learning.
- **Meaningful learning.** Its aim is to ensure that what children learn is related to their environment and daily activity, thus allowing experimentation in learning and establishing a relationship between new and previous experiences.
- **Play or gamification.** We know that play is an engine of development that helps to generate and maintain the interest of students, particularly in the early stages of life. It is not surprising, therefore, that one of the most widely used methodologies is gamification, which consists precisely of incorporating game dynamics into teaching and lessons.

- **<u>Good organisation of the environment.</u>** Taking into account the materials, spaces, times and resources used and creating a climate of security, affection and trust in the classroom that favours the development of the pupils.

Incorporating these methodologies does not imply that other methodologies should be excluded, as they are complementary methods that can be adapted to the different realities we face, both in terms of level and in terms of time and complexity.

These principles are used in different methodologies such as Montessori (where pupils are free to explore and then choose what to work on in class) or the Inverted Classroom (where pupils first seek information and then consolidate it in the classroom) lend themselves particularly well to making use of play as part of learning.

However, the one closest to this guide is the Waldorf methodology. This pedagogy is based on free instruction on the part of the pupils, that is to say, that they are autonomous when it comes to carrying out and acquiring knowledge throughout the educational process itself. Throughout this project we seek to strengthen the manual and artistic skills of the pupils through the incorporation of theatre, painting, music and handicrafts. This form of teaching not only lends itself to the incorporation of gamified activities and games, but also integrates one of the central elements of NanoEYE: theatre as a form of teaching.

How to teach science in early childhood education?

Although the infant stage is generally considered too early for science education, the truth is that the early stages of learning already have much in common with the scientific method. Children look for commonalities in their experiences through repetition to discover more about the world around them.

When confronted with new problems, they formulate hypotheses and learn from them through observation and repetition, making them "little scientists".

The curiosity inherent in this stage of life is perfectly analogous to that which brings science to life in the first place. For this reason, directing their curiosity towards science and helping them to learn and discover new knowledge in this area is easily attractive to them.

Why is it interesting to learn science in early childhood education?

The world we know is shaped by science and technology. The earlier we get to know it, the better we will learn to relate to it. For this reason, it is important that from an early age people relate to science, encouraging through experiences the construction of learning that allows students to develop in their environment.

The most appropriate methodologies

The methodology by sectors

The methodology by corners has been extensively discussed by a variety of authors of the New School, who sought to find different forms of education that would take advantage of some of the natural abilities of pupils.

In the case of the corner methodology, the central idea is the creation of a central open space in which to meet and which is surrounded by several clearly delimited and separated areas with a thematic orientation.

In this way, each of these areas, called corners, is a place for the development of free or directed activities in a specific area. The corners should contribute to the development of: creativity, autonomy, and free expression, in order to foster a good classroom climate to promote new learning.

The corner methodology seeks to promote the overall development of the child, helping them to take initiatives and develop their creativity and research. In addition, it also seeks to enhance their communication skills through the use of a central corner called the "carpet" or "assembly", where the whole class can meet seated in a semicircle to share their learning and discoveries.

This type of methodology favours learning with a certain degree of autonomy, as the class is divided into smaller spaces where work is done in groups with occasional supervision by the teacher, who has to walk around the different corners. For this reason, it is more recommendable when there is more than one tutor who can assist.

Since the students are divided into groups, there needs to be a rotation through the different corners over time so that everyone ends up doing all the activities. This means that if they are sequential, the sequential line must be able to be started at any of the stations.

It is also important to bear in mind that the role of the teacher changes with respect to the traditional idea. Their job is no longer that of the sole possessor of knowledge, and they are now learning guides who stimulate activities and cooperative learning.

Science sector

The aim of this corner is to encourage discovery and experimentation in a way that allows an approach to the scientific method. It will be essential to develop and prepare experiments (projects) that can be manipulated and from which they can draw some conclusions independently, in the same way as is done in project-based learning at older ages.

This way, the learning process consists of two phases: pupils manipulate the objects, transform them and observe the reactions they produce in them and the effects they have on other objects. In the second phase, pupils share and explain what they have discovered.

When designing the science corner, it is important to bear in mind that it is likely to require frequent use of the sink to wash materials or take care of some of the waste from the experiments. This is why its proximity is recommended. Alternatively, a clear passage from the corner to the sink can also be ensured to avoid possible accidents.

The science corner should be evaluated periodically, as is the case with the rest of the corners, so that the distribution and use of materials can be improved depending on how the students have developed the activities. In any case, the methodology of this proposal will be practical, through experiments and a subsequent debate on how they work.

How to include theatre in teaching methodologies in early childhood education

Theatre is an art, one of the main branches of the performing arts. It is a combination rich in movement, gestures, speech, dance, music, emotions, performances, etc. It is a pedagogical and didactic resource whose application is scarce in Infant Education classrooms.

Children's theatre must fulfill a series of requirements depending on the age of the children. The teacher should take into account the maturity level, interests and needs of the class. If we choose a topic of interest from the beginning, the play will be attractive and the children will be more motivated.

There are several aspects that we must bear in mind if we want to do theatre with children or for children. The first of all is the plot, which is the content and the message that a play wants to transmit. This content has to be adapted to the age of the child, so that he or she can grasp it without any difficulty. We must not forget the importance of the language and vocabulary conveyed.

Theatre is a great tool, a very useful strategy to produce changes in people, whatever their age, social condition or level of education because they are motivating and familiar tools.

It can help to develop key competences (linguistic communication, learning to learn, sense of autonomy and entrepreneurship and digital competence), to develop self-confidence, security, creativity, the ability to express oneself, both verbally and physically, the relationship between classmates, memorisation, diction... and, above all, it helps students to cope in public, to solve problems and to express and control their feelings and emotions.

4. NanoEYE Scientific Content

The scientific contents of NanoEYE are divided into three blocks, which serve to provide an overview of nanoscience and to understand some of the basic elements that make up the study of matter at this scale:

- The size of nano
- The forms of the nanoworld
- Nano-properties

The size of nano

Specific objectives

This area aims to provide an introduction to the concept of the nanoscale and the sizes at which nanoscience works. It also explains how the atomic force microscope, one of the devices used to study nanomaterials, works.

Theoretical content

When we talk about the nanoscale, we are referring to materials that have sizes in the order of a nanometre. A nanometre is one million times smaller than a millimeter, about 10,000 times smaller than a hair. These sizes are difficult to investigate because we cannot perceive things that small.

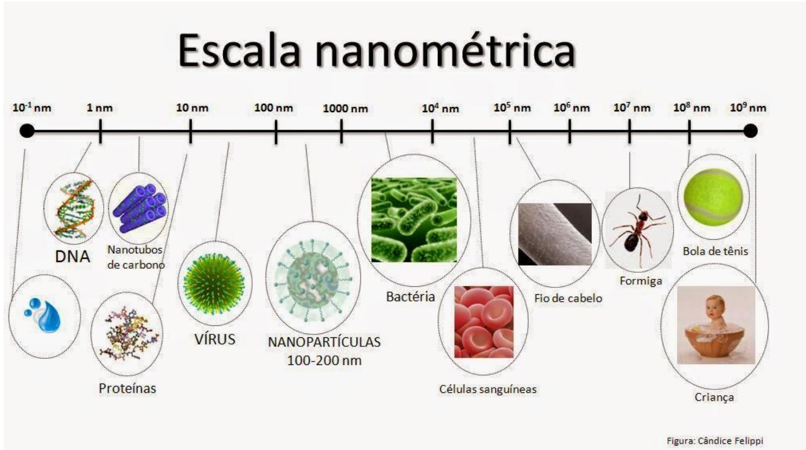

Illustration 1 Nanometre scale

In order to investigate these sizes, special equipment is required, particularly microscopes. However, the microscopes we usually know, called optical microscopes, are not suitable for studying such small things, because light does not allow us to see these sizes. We need special microscopes called electron microscopes (which do not use light to work but electrons) or atomic force microscopes, which we will focus on in this guide.

Atomic force microscopes work by passing an extremely small metal tip across the surface of the material. These tiny movements can be recorded to make a kind of map of the surface we are "touching". This allows us to have atom-sized resolutions. In other words, we can place individual atoms on the surface of a material and, using this same system, move them around.

Practical resources

See touching

Activity explained in the teaching sheets.

Specific objectives

The aim of this activity is to provide an understanding of how an atomic force microscope, which is used to view matter at the nanometre level, works.

Description of the activity

Materials and location: Can be done in the science corner or on any table. The list of materials is as follows:

- Blindfold
- Toys or items to be identified
    - Objects with recognisable shapes (balls)
- Kitchen gloves (optional)

This activity requires one volunteer, who will try to guess one of the objects by touch alone. To do this, the person will be blindfolded and given the object. They can be given a set amount of time to try to guess what they are touching or holding.

Optionally, you can complicate the activity by putting oven gloves on the people who have to hold and guess the objects. In this way, we can also introduce the concept of resolution. With the oven gloves we have less resolution because we are able to feel the surface of the material we are touching less well.

Scientific basis

Atomic force microscopes have a tip whose end is a single atom thick. This tip is passed over the surface of the nanometric material we want to analyse, so that it goes up and down following the shape of the surface. Each of these passes giving us a curve of heights, showing all the "obstacles" that the tip encounters along the way.

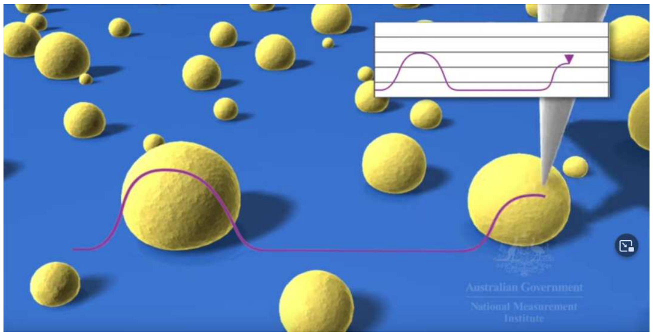

Illustration 2 Image of an atomic force microscope pass with height curve

By making successive passes we can find out the shape of the entire surface of the material, in a similar way to how we would run our hand over an object to try to identify it.

The forms of the nanoworld

Specific objectives

In this area, the aim is to understand how matter is arranged at such small scales, since geometric shapes are similar to those we see in the normal world but often have some special properties attached to them.

Theoretical content

Nanoparticle is the name we give to any nanometre-sized particle. However, the types of nanoparticles we can find are extremely varied. Some of the most common geometries found in nanoparticles are spheres, cubes and pyramids.

The applications of nanoparticles can be extremely varied, but in this guide we will only discuss one because it is the easiest to understand in a children's setting: the use of magnetic nanoparticles to target medicines in the body.

Magnetic nanoparticles have the ability to be attracted to a magnet. This way, if we associate them with a medicine, we can direct this medicine inside the body exactly where it is needed, preventing it from going to other places in the body. In this way, we reduce the amount of medicine needed and also avoid side effects because everything is in the place where it is supposed to act.

Another remarkable geometric aspect that is particularly interesting in nanoscience is that of two-dimensional films. These sheets are only one atom thick, but have significant sizes in the other two dimensions. The best known of all these lamellar structures is graphene, which is a sheet made of carbon.

Graphene is also "easy" to obtain, as it is found in pencil lead in the form of graphite, which are layers of graphene stacked with some minerals between them. However, it is true that there are currently methods for synthesising graphene that do not use this raw material.

However, it is not only nanometric structures that are of interest to nanoscience. In some larger structures, we can find nanometric pores, which are also very interesting in many applications. For example, they can be used to trap contaminants. An example of this is the use of zeolites, which has become widespread in recent years in dishwashers to improve the drying process and which are used to trap contaminants in the soil thanks to their pores.

Practical resources

What gets more wet?

Specific objectives

This activity aims to introduce the concept of porosity by explaining why different things get wet.

Description of the activity

Materials and location: It is recommended to be done in the science corner. The list of materials is:

- Plastic tray
- Water glass
- Wetting materials:
    - Piece of cloth
    - Paper
    - Thick, porous paper (watercolour paper)
    - Glossy paper
    - Plastic

In this activity, students will wet different things with water to see which ones get wet first and which ones get wet later. The substances that get wet more easily will be the most porous ones. To do this, the chosen materials are immersed in water at the same time so that it is easy to see whether they dry out at the same time or not.

Each participant will secretly put the order of the materials (this can be done by identifying each one with a number or a colour) to see if everyone agrees and if they have got it right.

Scientific basis

For a material to be permeable, there must be pores that allow liquid to pass through. A surface that is completely smooth will also be impenetrable, so it will not allow water to pass through. The size of the pores affects the ability of the material to allow liquid to pass through, as a larger pore will be able to hold more liquid and will pass deeper into the material.

These pores must also be connected to each other in order for liquid to pass through, so if they are only found on the surface, the material may get wet but will not allow water to pass through either.

These holes also have the ability to retain some substances inside (as can be seen when the porous material becomes wet), which is one of the most interesting properties in nanoscience.

Nano-properties

Specific objectives

In this topic, the aim is to show how some of the properties that we can see with the naked eye change radically when we have the same material on a nanometric scale, but also how some properties arise thanks to nanoscience and changes at this level.

Theoretical content

Materials behave differently at the macroscopic level (i.e. at the size we can see around us) and at the microscopic level. In some cases, the simple fact of changing size causes the colour of a material or compound to change, as in the case of gold. When we have it at a sufficiently small particle size, it can change colour to red, green or purple, depending on the particle size.

There are also some properties that can be used differently at these scales, such as magnetism, where we can make nanoparticles heat up by spinning a magnetic field around them, which we can use to "burn" tumors from inside the body.

Other properties are emerging thanks to nanoscience. In the NanoEYE project, we address three of these properties.

Hydrophobicity

Hydrophobicity is the ability to repel water. Thanks to nanoscience, we have been able to develop materials that are impossible to get wet, which can be used to protect surfaces such as water-sensitive monuments.
These materials work thanks to nanometric structures, which are like small "hairs" or "mountains" that are so close together that water is unable to enter. This effect is also known as lotus, after the flower of the same name on which it can be seen.

Illustration 3 Lotus effect

Thermochromic materials

Thermochromic materials are able to change colour with temperature. This is due to small changes in their structure at the nanometre level, which cause them to absorb light differently (or even stop absorbing light and become transparent). These materials are widely used in cups that show a pattern when heated, but they can also be used as thermometers or temperature indicators.

Illustration 4 Thermochromic mug

Shape memory

Shape memory is a property of some materials such as Nitinol to recover from losing their shape when temperature is applied to them. By bending these materials, we break some of their weaker bonds and create new ones, giving the material a new shape. However, there is still a strong bond structure that holds together and does not break easily.

The new shape we have given it remains because the sum of the strengths of all the weak bonds is greater than that of all the strong bonds. However, by heating the material, we break the "weak" bonds we have created and return it to the shape of the strong bond structure that was not broken when we bent it.

This property can be used to create glasses that spring back into shape if bent or stents, small devices used to enlarge the size of a blood vessel.

Practical resources

Hidden colours

Specific objectives

This activity aims to help explain how a thermochromic cup works. It is important to clarify that it will only be an exercise consisting of a colour change, not an actual thermochromic material.

Description of the activity

Materials and location: It can be done in the science corner or elsewhere in the classroom. The materials needed are:

- Sheets of paper
- Coloured pencils or hard crayons
- Dark soft wax
- Chopsticks

In this activity the students will be told that they have to colour a whole sheet of paper using the hard crayons. It is important that they paint the whole surface of the sheet of paper in different colours and that they make as complete a filling as possible, using several colours.

Once they have filled in their leaf, we will paint the entire leaf with a dark wax, preferably black, to cover all the colours.

Finally, we will have to use the chopsticks to make a drawing on the black wax. In doing so, the colours underneath will appear, giving rise to a very colourful drawing.

Scientific basis

Thermochromic materials have the ability to change colour with temperature. This is because heat at the nano-scale is actually vibration. When the material is heated, the particles that make up the material vibrate faster, resulting in a change in its structure and consequently a change in colour.

Although all substances vibrate at different frequencies when heat is applied or removed, it is important to note that not all substances change their structure, which is what causes the colour change, so not every substance will be thermochromic.

5. Contents: Theatre as a teaching methodology

All art formats have a set of internal rules for their creation and consumption. Theatre is an art form in which we are aware at all times that we are watching a performance, but we imagine it to be real as part of the process of enjoying it.

In this way, when creating a play, artistic licences are used to give life to certain elements of the play: sometimes sets are used that do not represent a single thing, the space on stage is limited...

Ultimately, theatre always enhances the imagination, because it is a necessary element for it to work. We can take advantage of this in different ways to support the teaching of scientific concepts. For example, we can use the personification of some concepts that are not tangible. By "giving them a body", we make it easier for the pupils to imagine how they behave and thus bring them closer to abstract concepts.

Theatre games

Specific objectives

The aim of this topic is to introduce the use of theatre games as a way of bringing certain concepts closer to the pupils. These games do not necessarily have to be plays but incorporate theatrical elements such as adopting a certain role.

Theoretical content

Theatrical games or dramatic games do not necessarily have to be played. They are games that incorporate elements of theatre, such as the use of the body, expressions or the personification of elements. These types of games usually work quite well because they put the participants in an active role, not just as a receiver of knowledge.

We could divide these games into two broad categories:

Mime games

Mime games involve the use of the body to imply concepts. They require some prior training so that all participants have a similar idea of the concepts that have to be guessed. However, these kind of games work very well and help to fix concepts.

They can be used as a second part of a session or as a second session after a scientific concept has been discussed. In this way, by taking turns, or in teams, students would have to guess certain scientific concepts as interpreted by their classmates.

Dramatic games

In dramatic play there is not always a need to use the body. The idea is that pupils embody a certain actor, role or character. Such games can be very complicated, but they can also be made quite simple. For example, a few pupils can be assigned to be a certain element, e.g. a magnetic nanoparticle, and another can be assigned to be a magnet. In this way they will have to behave as if they really were one or the other and achieve a certain goal.

Practical resources

Mime game:

Specific objectives

In this activity, the aim is to fix concepts through a game in which participants have to mime something related to them. It is recommended to do it after another activity (ideally, after the puppet theatre of the princess and the dragon proposed in the NanoEYE project).

Description of the activity

Materials and place of execution: No materials are needed, it can be done in an open space.

First, divide the students into two teams. Then, taking turns, one person will go out and try to mime a concept to the rest of the group until someone gets it right.

This can be done with or without a score based activity. If it is done with points, the team that guesses correctly wins a point. If it is done without points, everyone can guess and one person from the team that guessed (not necessarily the one who guessed correctly) will be selected.

As a guideline, the following proposals are offered:

- Atomic Force Microscope (Can be answered only microscope)
- Nanometer
- Hydrophobic/waterproof
- Pores
- Atom
- Lab coat

Each concept can be followed by a brief explanation of the concept to help recall the concepts and thus help to anchor them.

Scientific basis

The scientific basis of this game will vary depending on the content chosen for guessing. It is recommended to use other materials present in the NanoEYE project in order to make use of the scientific concepts already shown in the NanoEYE project.

The guiding magnet

Specific objectives

This game will be used to personify the concept of magnets and nanoparticles and thus explain the circulation of nanoparticles in the body.

Description of the activity

Materials and place of execution: No materials are needed (unless you want to put physical obstacles), it can be done in an open space. It is preferable that the space is large.

In this game you will need a volunteer, who will be the magnet, and at least one other volunteer who will represent a magnetic nanoparticle. The person playing the nanoparticle must be blindfolded and move only by following the sounds made by the magnet. The magnet will be in charge of guiding him/her through a circuit that can be made by his/her own colleagues.

The game can also be played in teams, with a single magnet guiding all teammates through the circuit. To make it more difficult, teams can do it simultaneously, which will make it noisier and harder to follow the magnet.

Scientific basis

The magnetic nanoparticles are attracted to the magnets, causing them to be directed to where the magnet is located. In this way, we can use them in the body to move medicines to the areas where they are needed, avoiding the rest. However, moving nanoparticles using magnets is a complicated process because it happens inside the body, which means there are many tissues that we don't want to pass through or break.

Theatre and puppet plays

Specific objectives

The aim of this block is to explain how puppets and plays can help to fix concepts and to give an introduction to work on them later on.

Theoretical content

Generally speaking, we can talk about having two different approaches to the same idea. We can use stories in which concepts play an important role in the plot, being triggers or solutions to the problem. Or we can make stories in which the very concept we want to explain is one of the protagonists or subjects involved.

Concepts embedded in the story

In this case, the story may not appear to be science-oriented, although we can give it a scientific setting if we wish. The important thing is that the characters develop a plot in which they have to go through the use of some scientific element that we want to explain, so that the explanation and demonstration of how it works is an integral and necessary part of the work.

Such stories are the most frequent, not only in theatre but also in cinema. Most science fiction films consist of confrontations with technology or some laws of physics. In these stories, one of the necessary elements is the scientific concept they are confronted with, but it is not one of the main characters. A well-known and very typical example of this is the film Interstellar, in which the basic functioning of wormholes, the concept of spacetime, time dilation... are explained, and all of them are an essential part of the work, which makes use of them without personifying them or giving them a corporeality.

This project proposes a puppet theatre based on this type of story: A knight who has arrived at a castle and using scientific principles manages to free them from the dragon. Science is a part of the story, but the protagonists are the knight, the princess and the craftsmen.

Concepts at the heart of the story

This type of story is less frequently encountered, but is easier for children to orientate, as it involves the personification of a concept or element. In them, we discover what the world would be like from the point of view of the element we want to explain and we show the capacities or qualities it has.

An example story could be that of a magnetic nanoparticle that is traveling through the body and suddenly feels attracted by a magnet. In the story, the nanoparticle would tell us about its journey through the body and could talk to the different elements it encounters, thus explaining more than just the concept of nanoparticle.

A well-known example of this is the series "Once upon a time... Life", in which the main characters are a series of red blood cells that travel through the organism and pass through all the organs while transporting oxygen. In this way, basic concepts of medicine and human biology were explained.

Practical resources

Within NanoEYE, a puppet play is proposed as a good example of a story with scientific concepts embedded in it. It is recommended to use these material as a practical example of theatre stories.

6. Proposal for mixed science/theatre activities

Activity 1: The structure that won't break down

Specific objectives

This game seeks to understand how shape memory works in some nanomaterials with special properties, such as Nitinol.

Description of the activity

Materials and place of execution: It is necessary to have chalk, it is recommended to do it in the courtyard to be able to paint the ground.

To start the activity, students should be divided into pairs. One person in the pair will strike a pose and the other will draw with chalk the silhouette that creates the shadow on the floor. Once they have finished drawing, they will do the same process changing people, so that both have a painted silhouette.

When everyone has their silhouette, they stand next to a silhouette that is not theirs. The teacher will then say one of two words: cold or hot. If he/she says "cold", they move on to the next silhouette. If you say "hot", they must try to imitate the pose on the floor, matching their shadow with the silhouette.

To make the activity more dynamic, music can be played, so that the pupils dance on the spot while it is playing. When the music stops, the teacher says the chosen word (hot or cold) and there is a time limit to move or imitate the pose.

Scientific basis

Shape memory materials have the ability to recover their original shape when a heat source is applied to them. See Shape memory in Nano-Properties.

Activity 2: The nanosensor

Specific objectives

One of the most important applications of nanoscience is the development of sensors (senses) that are much more sensitive than those used conventionally. The aim of this activity is to make an analogy with these sensors in order to explain them.

Description of the activity

Materials and place of execution: No materials are needed, it can be done in the assembly or in another open space.

One of the students - the detector - leaves the room, the others stand in a circle and a guide is chosen. Everyone repeats the same movement or rhythm following the guide. When the guide changes movement, everyone must do the same. The task of the detector is to identify the guide, the task of the guide is not to be identified and all the others must help the guide in his task. A time limit can be set (e.g. using a song). When the detector identifies the guide, the guide becomes the new detector and it is repeated.

Scientific basis

Certain nanoparticles, such as gold, can be used to greatly increase the sensitivity of certain tests and sensors, making them respond more readily to the presence of certain substances, thus using less sample for analysis.

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