NANOWARE Foundry recommendations pack

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NANOWARE

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REVISION HISTORY

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1.0	XX/XX/XX	Organisation	Creation	C	TBS

(*) Action: C = Creation, I = Insert, U = Update, R = Replace, D = Delete

REFERENCED DOCUMENTS

ID	Reference		Title
1	2021-2-PL01-KA220-SCH-000051200		NANOWARE Proposal
2			

APPLICABLE DOCUMENTS

ID	Reference		Title
1			
2			

Contents

1. The NANOWARE Foundry Recommendations Pack

The Nanoware Foundry Recommendations Pack is designed to take you into the fascinating world of nanotechnology education. It has been created to meet the needs of students aged 11-17, providing them with an exciting educational experience. This space has been created to guide users step by step in the exploitation of the results and materials of the NANOWARE project. The Foundry offers this experience in four languages: English, Romanian, Polish, Greek and Turkish.

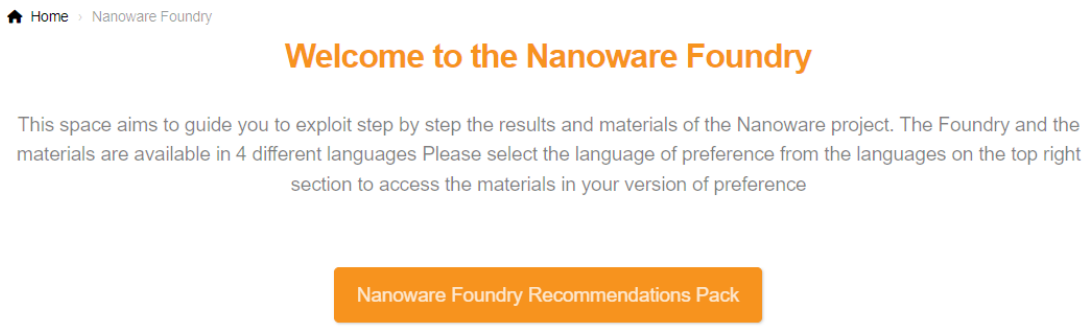
Usage:

Nanoware Foundry serves as a dynamic hub for both teachers of secondary school and students as well as for Individuals seeking general knowledge on nanotechnology. For teachers, it is a tool to facilitate the teaching of nanotechnology concepts interactively. Nanoware Foundry serves to make nanotechnology accessible to students by immersing them in the field of nanotechnology. Students can explore and experiment with the results and materials of the NANOWARE project.

Scope:

The scope of Nanoware Foundry extends beyond traditional education. It aims to transfer knowledge related to nanotechnology to students. Its scope is broad and aims to extend the educational experience to users in an interactive way.

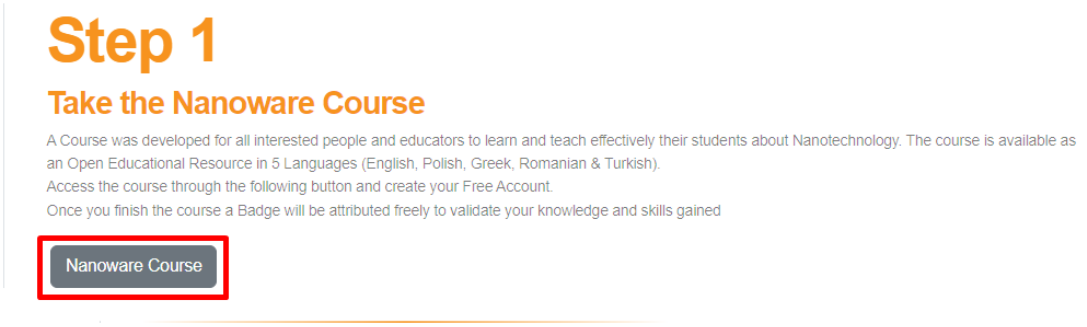
Once you have discovered the Nanoware Foundry page you can proceed to the project results which are described step by step and will show you how to take the knowledge and pass it on to the students.



STEP 1

At this stage, you will find a comprehensive range of courses aimed at individuals and teachers interested in teaching their children Nanotechnology. This Open Educational Resource is accessible in five languages: English, Polish, Greek, Romanian, and Turkish. You can click the “Nanoware Course” button to access the course and create your free account. Upon completion of the course, a badge will be awarded to validate the knowledge and skills you have acquired.

We suggest that you start from the first step, as the course will equip you with the right knowledge about nanotechnology and prepare you to pass this knowledge on to your children and students.



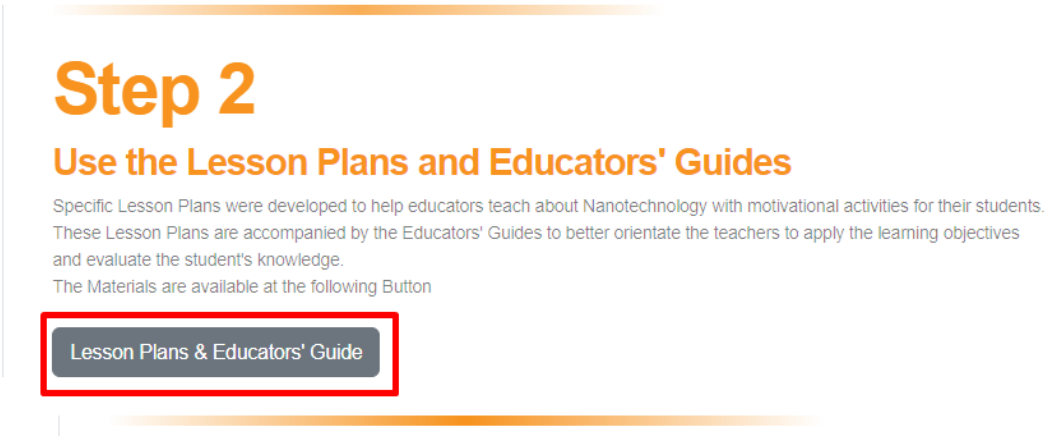
Specifically, in these courses you will first learn basic knowledge such as what nanotechnology and nanomaterials are and what their characteristics are. Next, lessons are presented on the size of nanoparticles and how we can see them. The course concludes with the role that Nanotechnology plays in our lives and how it is applied.

This course can also be taken by students who want to validate their knowledge. Keep in mind that each user must have an email and create a dedicated account to subscribe to the course.

Upon successful completion of the course, you are invited to proceed to Step 2.

STEP 2:

At this stage, you will find Specific Lesson Plans developed to help educators teach Nanotechnology with activities that motivate their students. In addition, you will find the Educator's Guides that accompany these Lesson Plans to better guide teachers in implementing the learning objectives and assessing student knowledge.

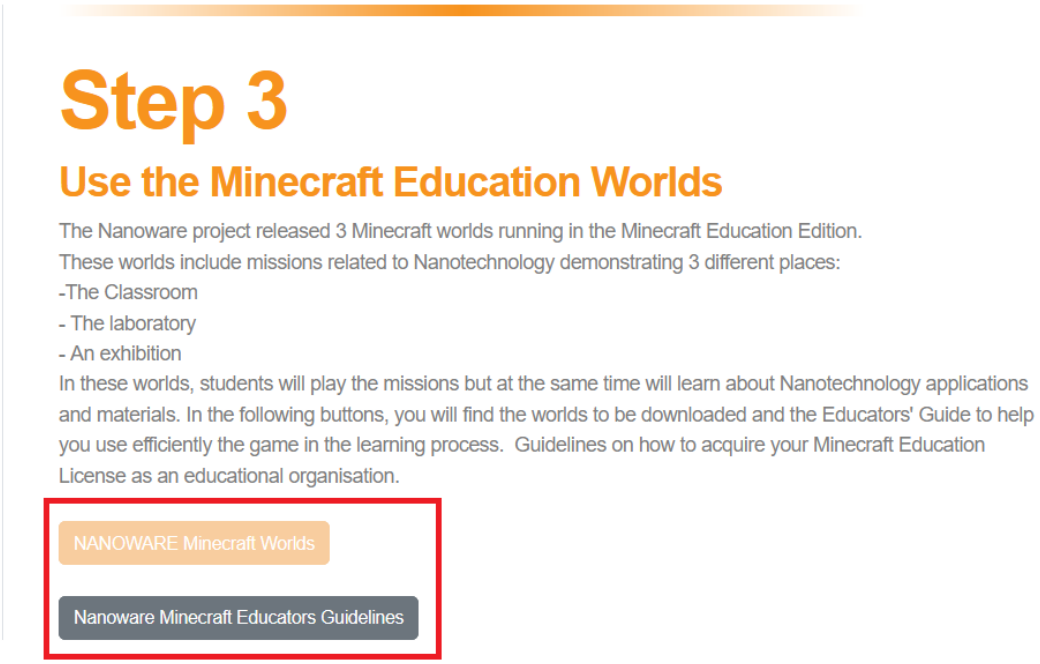


These materials are available at the “Lesson Plans & Educators’ Guide” button. More specifically, within the Nanoware educational package you will find the Nanoware curriculum for secondary education, the Nanoware common glossary, the Teachers' Guide and the online repository for hosting the educational material and providing knowledge preservation.

Upon successful use of the training program, you are invited to proceed to Step 3.

STEP 3:

At this stage, you will find the 3 Minecraft worlds for Nanoware running in the Minecraft Education Edition. These 3 worlds demonstrate respectively 3 different places (the classroom, a laboratory and an exhibition) and include missions related to nanotechnology. In these worlds, students will learn about the applications and materials of Nanotechnology simply by playing with these missions.



In the “Nanoware Minecraft Educators Guidelines” button, you will find the Guidelines on how to acquire your Minecraft Education License as an educational organization and how to use the game in the learning process. The other 3 orange buttons are linked to the 3 Minecraft worlds that need to be downloaded.

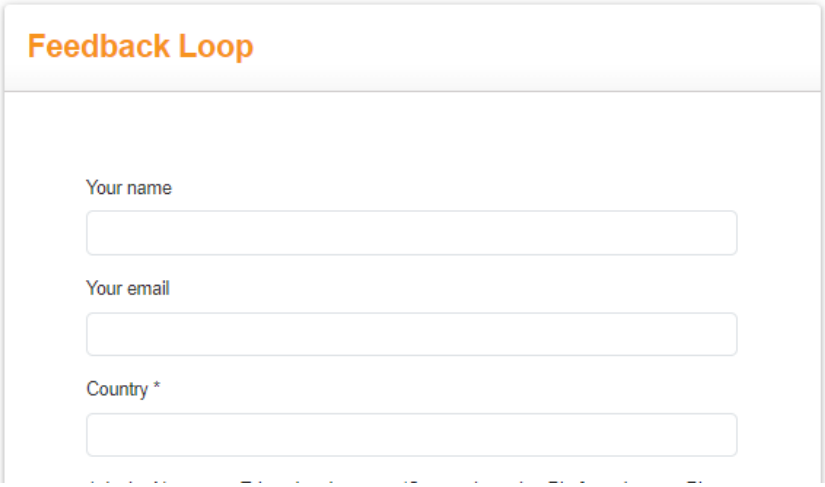
STEP 4:

At this stage, you will find the Minecraft Badges Framework. The Framework contains details about the badges.

The number of badges is three and you can earn a badge after you complete each of the three Minecraft Education Worlds in the NANOWARE platform. This is the time for the students' appraisal moment. The badges can easily be downloaded through the platform and can be added to your achievement portfolio. On the platform, there is also a feedback questionnaire that anyone can answer after playing and completing NANOWARE Minecraft Worlds.

Feedback Loop:

After Having Completed all the steps it is important to proceed with the Feedback Loop. This part of the platform will provide us with the ultimate feedback. In terms of continuous improvement of the NANOWARE Results, this last part is very valuable for our team since we collect your feedback and improve the provided materials.



It is not obligatory to add your Name and Email but we need your country so as to refer to the responsible partner of our consortium and reach you in case that you need more help.

2. NANOWARE Results in the classroom

2.1 Introduction

The "NANOWARE Results in the Classroom" section delves into the practical integration of NANOWARE results in the classroom context. Here you can explore how nanotechnology can be practically integrated into the classroom experience. Teachers have a tool at their disposal to turn theoretical learning of nanotechnology into practice. NANOWARE Results in the Classroom presents you with real-life applications of nanotechnology, demonstrating its relevance in everyday life. The areas covered are the practical applications of nanotechnology in Mathematics, Social Sciences, Physical Sciences, Natural Sciences, Creative subjects, Computer Sciences and Physical education.

2.2 How to use the Nanoware results in the classroom

Topic 1: How NANOWARE results can be used in the Mathematics Course

Mathematics is a science focused on the logic of shapes, quantities, is about patterns, structures, calculations, and logic. It contributes to the wealth of the world, as a process of thinking, deriving, applying, and rethinking. It is the foundation of logical and critical thought.

Students must develop a willingness and confidence to explore and persevere through mathematics. Integrating science, technology, engineering, and other disciplines with mathematics requires students to apply it in their daily lives, allowing students to associate mathematics as relevant and useful.

NANOWARE can be applied in a Mathematics class, as a way of acquiring, reflecting, and applying knowledge in daily life. It is STEM environment that requires active engagement, reflective thinking, problem solving, strategic reasoning, and academic communication. Topic of NANOWARE to be applied in a Mathematics class requires a community of stakeholders who are committed to behaving as critical thinkers by demonstrating a willingness to be introspective as well as perceptive. Students must be willing to question ideas, challenge assumptions, explore concepts, examine points of view, and analyze implications. Encouraging students to be involved in Nanoscience activities and Minecraft resources in school it will create behaviors lead to deeper understanding and better application of

knowledge. Students will be fully equipped to explore, understand, and apply the knowledge and skills learned in the classroom. In turn, students will be well prepared to live, work, and play in our global society.

Applying the Minecraft worlds to Insert Subject math, science, etc.

Minecraft is an educational game full of mathematical concepts. The use of Minecraft as a tool for teaching has become increasingly popular recently.

Minecraft is very attractive for this design as a large proportion of children are familiar with the basic gameplay. Game components can be linked together allowing their effect to be experimented with easily and thus offering great potential for investigating children's use of the tool in educational settings.

Applying the Minecraft worlds to insert subject math or science in class, it will provide practice at all the major topics with emphasis on division, addition, subtraction and relationships among fractions, decimals, and percentages. Spatial awareness, area and volume measurement are covered too. The idea is to make it easy for teachers or parents to supplement what kids are learning in school with complementary math problems that are more engaging and fun.

Some simple early understanding of numbers and counting can easily be achieved using Minecraft. Since the game is a building block-style activity, students have a task to create a row or a pile of a particular number of blocks.

Examples:

- make me a row of seven white blocks
- can you make rows of blocks from 1 to 10 each with a different color
- how many different shapes can you make with 12 blocks
- how many blocks are in this shape
- which of these rows is the biggest or smallest (ordering)
- which of these different shapes has the most blocks

Teachers can teach really simple addition and subtraction by giving them tasks where students join objects, or where they add on to an object a certain number of blocks and then count the total. It's usually best to start with addition and then move on to the subtraction examples.

Examples:

- make one row of three blocks and another row of four blocks (How many blocks are there together?)
- make a pile of 10 blocks. Can you add another 5 blocks to the pile? How many are there now?
- here is a line (or shape) of 10 blocks, if you destroy 6, how many are there left?
- multiplication - to build three towers with 10 blocks each and work out what the total is …

Area and Volume

This is another area that lends itself to exploration in Minecraft as it is such a geometrical game. Learning the basic formulas for the area of rectangles and squares and estimating and units. Volume then follows as well by multiplying the height of an object and your kids can explore what happens when it's not a regular shape. Students can practice the sums in 3-D by removing some blocks from the object.

Examples:

- turn 1/2 of this object to red
- make at Tower which is 1/3 blue and 1/3 red and 1/3 green
- here is a row of 20 blocks … Could you move a few blocks to break it into 1/4s
- can you make it a tower of less than 20 blocks … Now can you make it 50% taller than it was

Minecraft has a big impact on the classroom culture and attitudes about education. Playing Minecraft in the computer lab enhances metacognition by increasing students' memory storage capacity. With Minecraft, the blocks are digital so the kids can't mess each other up. The structures they've just made make a lot of fun things to hide behind, like funky-looking trees based on prime factorization or stacks of blocks in patterns that represent long division. It's kind of a conceptual math world. The game itself creates a relatable enjoyable experience that can be internalized and shared in a community of learners. The students are incredibly engaged.

Topic 2: How NANOWARE results can be used in the Social Sciences (History, Geography)

Nanotechnology is important because it is changing the world. Almost all fields are impacted by nanotechnology and can benefit from it. That's the reason why it is important to study Nanotechnology in Social Sciences, for example in History and Geography.

Nanotechnology in History:

- This is a small historical background of the history of Nanotechnology: **4th Century:** Early examples of nanoscale materials usage can be traced back to Roman artists who discovered that adding gold and silver to glass created unique effects. The Lycurgus Cup, a ceremonial vessel, is a famous surviving example.
- **Medieval Period:** European stained-glass windows showcased a premodern use of nanomaterials. Artisans incorporated varying amounts of gold and silver in glass to produce vibrant reds and yellows.
- **1959:** U.S. physicist Richard Feynman, considered the father of nanotechnology, introduced key ideas and concepts in a talk titled "There's Plenty of Room at the Bottom." Although not using the term "nanotechnology," he envisioned scientists manipulating individual atoms and molecules.
- **1981:** Modern nanotechnology took a significant step forward with the invention of the scanning tunneling microscope, allowing scientists to observe and manipulate individual atoms. IBM scientists Gerd Binnig and Heinrich Rohrer won the 1986 Nobel Prize in Physics for this groundbreaking invention.
- **1980s-1990s:** Nanotechnology gained momentum with companies and governments investing in research. IBM's Don Eigler led an effort to spell out "IBM" using 35 individual atoms of xenon, showcasing the precision achievable at the nanoscale.
- **2006:** Modern microscopy revealed that Damascus steel, used in South Asia and the Middle East, incorporated carbon nanotubes. The legendary strength, durability, and sharp edge retention of Damascus steel swords were attributed to nanoscale materials.
- **Various Periods:** Artists from China, western Asia, and Europe utilized nanoparticles of silver and copper in pottery glazes, imparting a distinctive luster to ceramics such as tiles and bowls (Source: https://education.nationalgeographic.org/resource/nanotechnology/).

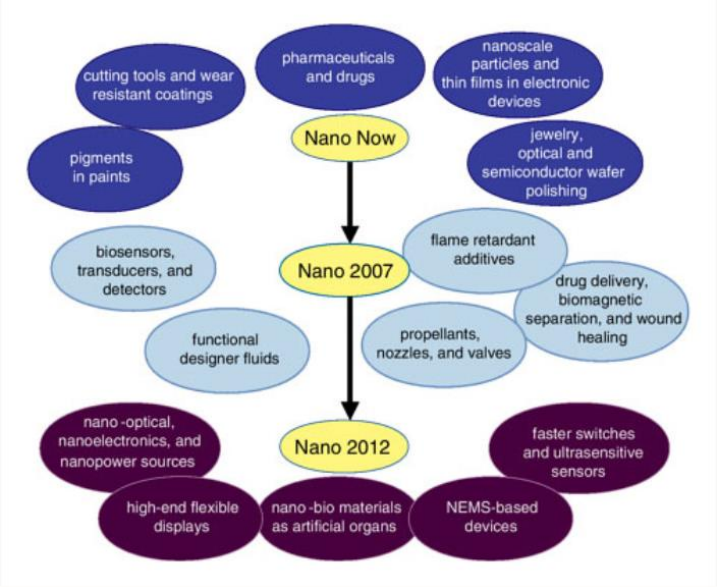
The History lessons are usually more theoretical than other lessons. However, there is a way that this lesson can be attractive to students. The way that you can use the NANOWARE results in the classroom is as follows:

1. **Learning through diagrams & tables:**

The History Lesson about Nanotechnology can become attractive through diagrams and tables that will contain the basic chronologies, faces and facts. It is easier to learn when everything is categorized. For this activity you will need:

a. Paper
b. Scissors
c. Glue

At first, you need to create a diagram or a table with the information needed like these:



Source: https://nap.nationalacademies.org/read/10395/chapter/3#6

or this:

Evolution Timeline of Nanoscience and Nanotechnology.

Year	Event
4th Century	Lycurgus Cup (Colored glass).
500–1450	Cathedrals (Stained glasses windows).
1450–1600	Deruta Pottery (Iridescent/metallic clusters).
1857	Michael Faraday (Synthesis of colloidal ruby gold nanoparticles).
1908	Gustav Mie (Light scattering nanoparticles).
1928	Edward Synge (Near-field optical microscope).
1931	Max Knoll and Ernst Ruska (invention of transmission electron microscope (TEM)).
1936	Erwin Müller (Invention of field electron microscope).
1947	William Shockley, Walter Brattain and John Bardeen (Discovery of the semiconductor transistor).
1951	Erwin Müller (Invention of field-ion microscope, first to see atoms on the surface).
1953	James Watson and Francis Crick (Discovery of DNA).
1956	Arthur Von Hippel (Molecular Engineering).
1958	Leo Esaki (Electron tunneling).

Source: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6982820/table/molecules-25-00112-t001/?report=objectonly

When you create the diagram or the table you can delete some columns or spaces like this:

Evolution Timeline of Nanoscience and Nanotechnology.

Year	Event
	Lycurgus Cup (Colored glass).
500–1450	
	Deruta Pottery (Iridescent/metallic clusters).
	Michael Faraday (Synthesis of colloidal ruby gold nanoparticles).
1908	
1928	Edward Synge (Near-field optical microscope).
1931	Max Knoll and Ernst Ruska (invention of transmission electron microscope (TEM)).

Write separately the hidden answers and print them. Also, print the table or the diagram (one copy per student). When you print them, cut the hidden answers with the scissors and provide each student with the table, the answers and glue. The students have to think which date suits the fact and the opposite and stick each hidden answer to the correct spot.

At the end of this procedure, the students and the teacher will have the opportunity to discuss the choices, possible questions or mistakes that had made.

Nanotechnology in Geography:

Geography can also be an extension of History, as students can study the impact of Nanotechnology in each country or continent or study the history of Nanotechnology in each country.

For example, these nations have made significant investments in nanotechnology.

- United States
- China
- Russia
- Japan
- Germany (Source: https://education.nationalgeographic.org/resource/nanotechnology/)

The History Lesson about Nanotechnology can become attractive through Research:

2. Learning through Research:

At first, you can divide the students into two or three groups or more (depending on how many students there are in the classroom).

Each group should research the impact of Nanotechnology in one country or continent or study the history of Nanotechnology in one country. For example:

- Team A: Research the impact of Nanotechnology in America
- Team B: Research the impact of Nanotechnology in Europe

  Or
- Team A: Research the History of Nanotechnology in Germany
- Team B: Research the History of Nanotechnology in the Netherlands

The Research will include articles, videos, images, statistics, etc. After the research, each group should prepare a presentation to share their findings in the classroom.

After each presentation, organize a discussion where students can ask questions and discuss the findings of each research.

Topic 3: How NANOWARE results can be used in the Physical Sciences (astronomy, physics, chemistry, and the Earth sciences)

Nanotechnology, the most important technological development of the 21st century, is a developing technology and its applications are increasing day by day. In fact, understanding nanotechnology is only possible by understanding the fundamentals of the applied sciences such as physics and chemistry. In particular, understanding the quantum world.

It is possible to see various applications of nanotechnology in the Physical Sciences such as Astronomy, Physics, Chemistry, and the Earth sciences. Through the NANOWARE Project, students will have the opportunity to learn about the applications of nanotechnology in physical science through hands-on and minds-on activities and students will witness closely that nanotechnology is an interdisciplinary field of science and will realize that nanotechnology is related to every field of science.

In astronomy research, astronomers use nanotechnology to develop nano sensors to detect and measure light from distant objects. Nanotechnology is also used in nanosatellites developed for space research in astronomy. Today, nanomaterials are used to create more powerful and sensitive telescopes and instruments.

Physics (for example quantum physics) plays a very important role in the development and understanding of nanotechnology because physics is the basis of nanotechnology. The importance of physics in nanotechnology lies in providing the basis for the understanding, tools and techniques required for the design, production and characterization of nanoscale materials and systems. First, physics provides the fundamental principles that govern the behavior of nanoscale materials and systems. It is possible to explain the unique properties of nanoscale materials such as high surface area, enhanced reactivity, and enhanced thermal and electrical conductivity by these principles. Physics also provides the tools and techniques necessary for the production and characterization of nanoscale materials and systems. For example, physics-based imaging techniques such as transmission electron microscopy (TEM) and scanning probe microscopy (SPM) are used to visualize and analyze nanoscale structures. Within the scope of the content included in the NANOWARE project, students will have the opportunity to get to know these imaging techniques closely.

If we talk about the relationship between nanotechnology and chemistry, we encounter Nanochemistry, which is a branch of chemistry, and the main research subject of Nanochemistry is the chemical reactions, chemical structures and bonds between these nano-sized structures. It reveals how the

electronic, magnetic, chemical, optical, mechanical and physical properties of a nanoparticle are related to its nano size. Nano chemistry involves the synthesis and characterization of nanomaterials at the nanoscale level. It basically studies how atoms and molecules behave and react at the nanoscale. UV protective sunscreens are one of the most common examples of Nano chemistry we encounter in daily life. Zinc oxide nanoparticles are used in sunscreens. These nanoparticles absorb UV rays, protecting our skin from UV damage. Another common example of Nano chemistry, which has become a common part of our daily lives, is hand washing agents/disinfectants/bandages, which generally consist of zinc or titanium nanoparticles. These nanoparticles show antimicrobial properties. Another example is beverage bottles. Nano clay coating is applied to them to increase their resistance to oxygen, carbon dioxide and moisture.

Today, nanotechnology has various applications in detecting and cleaning environmental pollutants. Some of these practices include providing clean drinking water, improving the quality of air, developing new energy sources, and removing hazardous and toxic substances from the environment we live in. Other important applications of nanotechnology are in the field of energy, which is one of the most important topics that concern all people. There are also applications of nanotechnology in matters related to the efficient use, storage and production of energy.

NANOWARE project results offer students an opportunity to get to know nanotechnology closely and improve their knowledge, thinking skills and awareness of this subject. In addition, with the Minecraft game, students will be able to use the information they have acquired in the digital environment and thus their digital skills will improve. Thanks to the NANOWARE project results, teachers will have a rich resource about nanotechnology.

Topic 4: How NANOWARE results can be used in the Natural Sciences (Biology, Chemistry, Human Anatomy)

NANOWARE results can be used in the Natural Sciences (Biology, Chemistry, Human Anatomy) offering opportunities for students to conduct practical work in physics, chemistry and biology, using understanding possible scientific experiments.

Students will learn to ask questions about the natural world, to set up experiment to answer their questions, to observe and record results, and then to draw conclusions. This methodology can be used to teach scientific thinking in contexts where no laboratory facilities are available. The NANOWARE approach not only helps to develop scientific thinking in students but also provides new teaching tools.

In NANOWARE activities students will formulate issue-hypothesis, reviewing literature as primary reading sources, differentiating between subjective/objective data and their usefulness to the issue, examining applicable existent surveys, impact studies, or models.

Developing NANOWARE activities students will be able to:

- differentiate resources and understanding when to use each type
- summarize, analyze and reflect scientific investigation
- develop their research plan and share it with their peers
- develop their complete experimental procedure, begin experimenting in the lab
- organize, graph, discuss and statistically analyze the data
- write their conclusion and debate
- prepare an oral presentation that summarizes their research; presentation will use of a digital presentation program (PowerPoint, Keynote, Google Presentation etc.)
- find the relevant computational formulas
- compare the recorded data to determine the grade level for the inclusion of the topic
- present their work to their peers, teacher and community (at competitions, at the regional science fair)
- apply the concepts, principles, and processes of scientific inquiry.

The NANOWARE assessment has to include:

- Class presentations
- Online discussion forum
- A logical conclusion based on the data will be drawn.
- Various competitions.

Teachers will promote Nanoscience methodologies to support student-centric activities in research and discovery learning. In addition, students will transfer STEM skills in order to understand the importance of nanotechnology in society.

NANOWARE lessons are created to connect and allow young students to explore science, technology, engineering, math, outdoor garden, and literacy as a thematic unit. Students can become experts in a piece of equipment and teach this to the rest of the class.

Teachers will invite students are to explore the NANOWARE topic, to investigate information about the benefits of nanoscience. They should prepare activities to set up a debate and keep their audience engaged.

Using the NANOWARE materials model, the students are expected to build their own knowledge through a series of thinking processes in order that they can develop the critical thinking ability and science process skills continuously; and in the future they can prepare themselves to compete in international job market.

Application of nanomaterials in several areas of biomedical field has shown remarkable progress and provided a lot of opportunities for the future of nanomedicine. Among these, polymeric and ceramic nanoparticle systems proved to be versatile nanocarriers and exhibit numerous biomedical applications. PNPs play an important role in the diagnosis and treatment of a wide range of diseases, for instance, viral infections, cancer, cardiovascular diseases to pulmonary and urinary tract infections. They not only carry the drug to the target site but also increase the efficacy of drugs in treating diseased tissue.

Similarly, ceramic nanoparticles also exhibit numerous applications in the field of dentistry, orthopedics, anticancer drug delivery, and tissue engineering. They offer several advantages like good biocompatibility, biodegradability, osteoinductivity, resorbability, and hydrophilicity. The ease with which these nanoparticles systems can be prepared and implemented endorses students' future development.

Biocompatible ceramics, also known as bioceramics, consist of both macro- and nanomaterials, and their development has hastened in the last few years. Bioceramics are mainly used for bone, teeth, and other medical applications. Inorganic material can be classified into ceramic and metallic nanoparticles.

Researchers have developed various methods for the preparation of nanoparticles for drug delivery depending on how to load the drug onto the nanoparticle. Understanding their potential biomedical applications at the molecular level students will provide major insight into areas of health and medicine.

Teachers will invite students are to explore the NANOWARE topic, to investigate information about the benefits of nanothechnology. They should prepare activities to set up a debate and keep their audience engaged. Students will follow teacher presentation and the case presentation, they will raise arguments, finding advantages and disadvantages of learning about impact of nanoscience.

Students will learn to generate and evaluate knowledge, clarify concepts and ideas, seek possibilities, consider alternatives and solve problems. Critical and creative thinking are integral to activities that require learners to think broadly and deeply using skills, behaviors and dispositions such as reason, logic, resourcefulness, imagination and innovation in all learning areas at school and in their lives beyond school.

Science process skills, observation, prediction, communication, classification and measurement. The NANOWARE learning materials will increase the possibility of developing even more versatile materials that can be fine-tuned for specific applications, at both experimental and theoretical scales.

STEM is a learning area that helps to find new solutions to the problems that may be encountered in daily life. Students with high career interest, science achievement and motivation continue to participate in STEM fields over the years, while students with low career interest, science achievement and motivation tend to leave more over time.

Students' attitudes and interests towards science and mathematics in secondary school will also affect their career choices in the future. Determining the interests and career goals of secondary school students in STEM fields is very important in terms of preparing the future of the STEM workforce.

Topic 5: How NANOWARE results can be used in the creative subjects (Art, Music, etc.)

1. Nanotechnology in Art:

In the realm of paint innovation, nanomaterial integration serves to heighten efficiency and introduce novel functionalities. Various nano-enhanced paint variants have already entered the market, prompting recent scrutiny into their advantages and potential hazards. Analyzing the benefits and drawbacks in the nascent phases of nano-paint development is crucial for mitigating risks and capitalizing on opportunities.

Nanotechnology aids in art conservation by addressing flaky paint issues caused by degraded binders. Traditional synthetic polymers, though easy to use, can harm artworks by stressing surfaces and degrading over time. Restorers have turned to water-based microemulsion systems containing esters and surfactants to remove problematic polymers from murals, such as those in Mayapan, Cholula, and the Annunciation Basilica in Nazareth. Nanosized ester containers effectively interact with flaking coatings, facilitating their removal without compromising the original paint intensity.

In art restorations, hard, stable inorganic nanoparticles such as calcium hydroxide and silica, alongside nanodroplet emulsions, are utilized. Calcium hydroxide nanoparticles, due to their tiny size and strong surface interactions, penetrate porous surfaces effectively. They react with atmospheric carbon dioxide within object pores, transforming into calcium carbonate to restore mechanical properties. This process ensures the preservation of original artworks for future enjoyment. Nanotechnology offers exciting prospects for art restoration and preservation. However, before widespread adoption, environmental and health implications must be carefully considered. Implantation techniques are used to control nanoparticle release from silica-based stone artifacts, ensuring stable attachment to surfaces. Functionalizing nanoparticles with silica-based groups facilitates fusion with stones. The future development of nanotechnology in art restoration holds great promise and warrants close observation

<u>Classroom activities for art observation</u>

1. **How to Make pH Paper with Cabbage**

(Source: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://susnano.wisc.edu/wp-content/uploads/cabbage-paper-instructions2.pdf)

Science concepts you will learn about in these experiments:

1. Acid/base/pH

2. Plants contain chemicals, and color can be an indicator for other chemistry concepts

Background: Have you ever considered how some fruits, vegetables, and flowers are so brightly colored? The answer is CHEMICALS! Plants contain a variety of different natural pigments which can help the plants protect themselves against harmful insects and bacteria, encourage or discourage certain herbivores (plant eaters) from eating them, and protect the plant against damaging sunlight and extreme temperature! As humans, we can also appreciate the variety of plant colors for more than their beauty. First, eating all these different colored fruits and vegetables helps indicate that you're eating a bunch of different nutrients (which is another word for chemicals that are healthy for you). Plants contain a variety of vitamins, minerals, and antioxidants, some of which are colorful. There are numerous different kinds of plant pigments, but some of the most well-known are carotenoids (red, orange, and yellow color), anthocyanins (red, blue, and purple), and, of course, chlorophyll (green). But even as humans, we also can use plant colors to indicate the chemical characteristics of plants. For instance, consider a banana. Banana peels can range in color from bright green, yellow, and dark brown. When you prefer a certain color of banana, you are selecting a banana that is at a different stage of ripening. During ripening, there are a lot of chemical changes that are happening in the fruit—it gets softer (changes in the structure of the walls of all of the cells), becomes sweeter (chemical conversion from starch to sugar), and a color change (break down of chlorophyll and production of anthocyanins or carotenoids). We use color to indicate chemistry concepts all the time! Just like you, scientists can also use color to indicate different chemical properties when they are doing research in a laboratory.

What you will need:

- Red cabbage
- Sharp knife
- Surface to cut on
- Water
- Stove and pan
- Tray or container for dying paper
- Paper
- White vinegar
- Baking soda
- Cups
- Paint brush or another tool to paint with

- Optional: clear cups

Instructions:

1. Obtain a red cabbage.
2. Slice the red cabbage as thinly as possible.
3. Then, in a pot or high-sided pan, combine your sliced cabbage with enough water to cover about half of your cabbage (around equal parts cabbage and water).
4. Simmer for around 10 min, stirring occasionally. You will notice the cabbage lose its bright purple color and the water will turn purple. These are the anthocyanins coming out of the cabbage. This is called an extraction in a chemistry lab because you are extracting the anthocyanin from the cabbage into water. You can let this simmer longer to extract more purple color, but after a while there is a diminishing return.
5. Let the cabbage and water cool.
6. Once the cabbage extract is at room temperature, collect the purple or bluish water from the boiled cabbage. You can us a fine metal mesh colander/strain to separate the liquid and solid or pour this off slowly using a spatula to hold the cabbage back.
7. Dying the paper works best in a wider, flat surface, like a sandwich Tupperware or a baking sheet (if you made a lot of cabbage liquid). Any paper should work for dying. If you happen to have watercolor paper at home, this paper works the best for trapping more of the anthocyanin pigments to give you a more intense color change.
8. Submerge your paper in the purplish pigment liquid. (Note: if your cabbage extract is not purple, most likely bluer, it's still okay to use as is. But, to improve visual result, you can color correct by stirring in a little bit of vinegar until you've achieved your desired purple) Soaking for longer than 5 seconds does not improve the color intensity, so a quick dip is just fine. Put the wet paper to the side to dry. The paper should be completely dry before using, so you might need to turn it over part way through drying to ensure both sides are dry. If you want an even more intense color change even after dyeing is complete, you can continue to spray cabbage juice onto the papers.
9. While the paper is drying, fill one cup with a small amount of vinegar (a couple of tablespoons is all you need to start) and another with baking soda and water (one teaspoon of baking soda to around a quarter cup of water). Baking soda does not dissolve in water very well (a principle called solubility. For example, table salt is very soluble in water, but pepper is not). Give the

baking soda and water a good stir to mix them up. The baking soda will eventually settle to the bottom and this is fine! One of these cups contains an acid—the vinegar. The other contains a base—baking soda.

10. While the paper is continuing to dry you can begin investigating the color-changing properties! Take the leftover cabbage juice and pour a small amount into several small cups. Add different amounts of acid (vinegar) and base (baking soda) to the cups and try to make a rainbow from pink to blue! If the colors look a little dark, adding a bit of water to the colored liquids can help make the colors more obvious.
11. Once the paper is dry, and a purple color, take a paintbrush or whatever utensil you have, dip it into the vinegar and paint on the paper. You'll notice a color change from purple to pink. Next, dip the brush in the liquid portion of the baking soda cup and then paint on the paper. You'll notice a different color change, this time from purple to greener/blue. If when you extracted your cabbage juice into water and it appeared a little bluer than purple, then your water is likely basic. Or, if your cabbage juice extract was purple, but turned blue after contact with the paper, then it means your paper has basic properties as well!
12. Go wild and paint a picture!

2. Holographic chocolate (Ages 5+)

(Source: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://susnano.wisc.edu/wp-content/uploads/Chocolate_SciFest-Sept9.pdf)

In this experiment, we will make some edible art!

Materials:

- Oil
- Water
- Soap (or egg yolk as an alternative)
- Emptied water bottle with a cap

Directions:

1. Place some water in the bottle.
2. Add oil to the water.
3. Shake the bottle to mix the two layers.
4. Observe if the two layers mix.

5. Add some soap or egg yolk to the bottle.
6. Shake the bottle to mix.
7. Observe if the two layers mix.

Here is what we observed; did you see the same thing? • We observed that the two layers are now not two layers anymore — we have formed an emulsion!

Continue:

1. Cut the grating film into any shape and size that you want your chocolate to be.
2. Place the grating film onto the parchment paper with the “grooved” side facing up. (To figure out which side contains the grooves, scratch each side gently with your fingernail. If you hear a high-pitched noise, that’s the side with the grooves.)
3. Chop up ¼ of the chocolate bar into small pieces
4. Transfer half of the chopped amount into a small bowl
5. Heat the chocolate bowl in the microwave in 5-10 seconds intervals (depends on the power of the microwave, small intervals are recommended). Stir the mixture as needed.
6. Once the chocolate is melted (around 110°F), add the other half of the chopped chocolate to the bowl. Mix well. The addition of the solid chocolate should bring the temperature down to around 93°F)
7. Reheat the chocolate bowl again, for another 5 seconds until all the chocolate is melted.
8. Spread the chocolate onto the grating film on top of the parchment paper and let solidify.
9. Peel off the grating and see how your chocolate diffracts light!

Here is what we observed. Did you see the same thing?

Once the chocolate solidifies, you should now have shiny and colorful chocolate that is still just as tasty as before!

Explanation:

The holographic effects come from the tiny grooves from the grating film that get imprinted onto the chocolate as it solidifies. This roughness bends the light at many different angles as it bounces off the surface – this is known as diffraction. The angle at which the light bends is proportional the wavelength of light, hence violet light will bend more than red light because, in the visible wavelengths of the

electromagnetic spectrum, red has the longest wavelength and violet has the shortest wavelength. The different amount of bending caused by the roughed surface gives the chocolate holographic colors.

3. Chromatography

(Source: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://susnano.wisc.edu/wp-content/uploads/Chromatography.pdf)

Description: Chromatography is the separation of substances in a mixture. The word “chromatography” is derived from the Greek words “chroma” for color and “graphy” for writing or recording

In paper chromatography, separation usually involves a liquid mobile phase & solid stationary phase (here, paper). Depending on substances' greater affinity for either the stationary or mobile phase, substances will separate.

Materials:

- Paper
- Scissors
- See-through cup
- Sharpie or colored pen/marker
- Water
- Rubbing alcohol

Procedure:

- Cut the paper into a strip to fit into the cup.
- Pour water and rubbing alcohol into the cup in a 1:1 ratio. Pour enough to make a depth of 1 inch.
- Draw a line using a pen/marker parallel to the water on the strip of paper, but high enough to be above the liquid layer when the paper is placed into the cup.
- Place the strip into the cup and cover the cup to slow down evaporation.
- Watch the ink separate!

Topic 6: How NANOWARE results can be used in the computer sciences and Technology Subjects

Computer science is the study of the theoretical foundations of information and computation and their applications in computer systems. Various computer-related disciplines such as cognitive science, linguistics, mathematics, physics, biology, earth science, statistics, philosophy, and logic may be considered within the context of computer (related) sciences. Digital learning platforms, gamification software, and digital data structures are among the most typical software application areas of computer science. All these application areas are emerging means for innovative and technological education. Games engage people, make learning fun, and motivate students and help them pay attention and stay focused on a subject. Games allow students to focus and learn better. A lesson formatted as a story transformed into a game may significantly improve the learning performance of children. Computer games enhance learning through visualization, experimentation, and creativity. Visualization in computer games plays an important role in discovery and problem solving. The efficiency of computer-generated visualizations enhances students' understanding of complex scientific topics such as molecular structure. Visualization via animations, simulations, images, and games can help students visualize how a concept or a system works.

The main results of the Nanoware Project are:

1. Nanoware Educational Pack, comprising the Nanoware curriculum, glossary and online repository, the Nanoware Educators Guide and a Learning Motivation Environment to deliver the training materials to the users,

2. A collection of educational challenges in Minecraft and the Nanoware Minecraft world which will comprise the resource packs and mods for the educational challenges. (Instructional materials and guides for parents and teachers will support Minecraft World.)

3. Nanoware Foundry, which is a virtual space designed to power a community of adopters and provide a feedback loop mechanism to retain an open channel between the implementers of the Nanoware package (partners) and the adopters (school community) to drive the evolution (corrective, perfective, evolutive maintenance) of the Nanoware package.

As can be seen, all the main results of the Nanoware project are software applications of computer sciences and are products of software technologies. They can primarily be used within the science and technology classes of primary/secondary/high schools as technological teaching materials.

Secondarily, they can be referenced and studied as best computer software practices in higher education institutions offering computer sciences and technology classes.

In computer science and especially in computer engineering, computer hardware (and related electronics) is a sub-area of study, in parallel to computer software. Computer hardware is closely related to computer architecture, which is defined as the structure of a computer system made of sub-components. There are various types of computer architectures, among the most recent of which are microcomputers (contemporary microcomputers/desktop computers, etc.), single-board microcomputers (tablets, mobile phones, etc.), and nano computers. Nano computers utilize nanoscale components, such as nanowires, nanotubes, or quantum dots, to perform computations and manipulate data. The scanning tunneling microscope in is a crucial milestone in the development of nano computers, since it enabled researchers to observe and manipulate individual atoms with precision. Nano computers might be built in several ways, using mechanical, electronic, biochemical, or quantum nanotechnology. The Nanoware Project's main results provide teaching materials focused on nanotechnology, and these materials may provide the fundamentals/advantages of nano computers and their current/future usage areas. Below are the links to sample videos related to nanotechnology in computer sciences:

https://www.youtube.com/watch?v=oCugfZEwgj8

https://www.youtube.com/watch?v=bAd16XG91Ek

https://www.youtube.com/watch?v=2voX3fjMGjA

https://www.youtube.com/watch?v=-gdILnzYZEg

Topic 7: How NANOWARE results can be used in Physical education and Athletics

Nanotechnology has transformed sports venues, with nano-films preventing rust and defects in stadium flooring and walls, while nano-paints purify indoor environments and protect against UV radiation. Sports equipment, like tennis racquets and bicycles, utilize nanoparticles for enhanced performance and durability. In the textile industry, nanotechnology has revolutionized sportswear, offering multifunctional properties without sacrificing comfort.

Sporting manufacturers continually strive to enhance athletes' performance through innovative equipment, leveraging the latest technologies. For over a decade, nanotechnology has been a key component in the products of numerous sports brands and companies. Let's explore some top sports where nanotechnology is utilized to provide athletes with a competitive edge.

Nanotechnology has revolutionized sports performance across various disciplines, including golf. Its impact spans from tennis to football and beyond, transforming equipment, safety measures, and overall athlete performance. By integrating nanotechnology into sporting gear, athletes gain a competitive edge, pushing the boundaries of what was once deemed achievable.

Nanotechnology in textile industry:

Nanotechnology has had a significant impact on the textile industry, which is mainly categorised into three segments: nanofibers, nanocomposites and nano finishing of textiles. Nanofibers, with a diameter of less than 100 nm, offer large surface areas and excellent mechanical properties, finding applications in sports goods and footwear, such as waterproof and windproof items for canoeing, cycling and mountaineering. Electrospinning and electrostatic spinning methods produce these fibres, which offer water resistance, breathability, and water vapor penetration. Nanocomposite fibres, which incorporate nanofillers such as nano clay and carbon nanotubes, improve physical and mechanical properties, offering conductivity and antibacterial benefits. They are used in sports equipment such as tennis rackets and baseball bats, providing improved durability and performance. The nano-finish on the fabrics imparts specific properties such as water resistance, antibacterial activity and UV protection. It involves the treatment of the fabric with nanoparticle precursors or nanoparticles synthesised in the presence of the textile material. Nano fabrics are used in sportswear, such as swimwear, diving suits and outdoor clothing, offering properties such as waterproofing, antibacterial action and UV protection.

These developments play a key role in the design of sportswear with high moisture transfer properties to keep athletes dry during activities.

Nanotechnology in sport flooring:

Nanotechnology plays a crucial role in the textile industry, particularly in the development of stadium floor coverings, which significantly impact athlete performance and safety while enhancing durability and cleanliness. Nanomaterials applied on gym floors offer strong water and oil-proof properties, ensuring cleanliness. Sports engineering utilizes nanomaterials like nanocarbon and nanometal oxides such as SiO2 and Al2O3. Calcium carbonate nanoparticles dispersed in polyurethane fibers enhance the elongation and thermal resistance of sports turf. Running tracks treated with nanoparticles exhibit excellent properties including rebound resilience, compressible recovery, elasticity, hardness, durability, and resistance to flaming, mildew, and static electricity. Experimental evidence suggests that nano-enhanced field tracks exhibit twice the mechanical strength of normal polyurethane tracks.

Nanotechnology in sport clothing and sport shoes:

Nanotechnology has revolutionized the textile industry, particularly in sportswear, through the development of nanofibers, nanocomposite fibers, and nano-finished textiles, offering a multitude of properties. Numerous fabric companies have leveraged nanotechnology to create a diverse range of sports apparel.

Nanotechnology has significantly enhanced the properties of sport clothing and shoes, focusing on several key aspects:

- Water-proof: Nanotechnology has facilitated the development of waterproof breathable fabrics preventing water penetration while allowing moisture vapor diffusion. Electrospinning techniques have been utilized to create ultrathin, flexible membranes with excellent barrier and comfort properties, ideal for outdoor sportswear.
- Antibacterial: The incorporation of silver nanoparticles into sportswear has provided effective antibacterial properties, reducing the growth of microorganisms and unpleasant odors. Silver nanoparticles damage microbial cell membranes, ensuring the wearer's comfort and hygiene during physical activities.

- UV protection: Semiconductors like TiO2 and ZnO nanoparticles offer effective UV protection, reducing the risk of UV radiation-related skin lesions during outdoor sports. Layered fabric systems with functional zinc oxide polyurethane nanocomposite fibers provide both UV protection and antimicrobial properties.
- Self-cleaning: Nanotechnology has enabled the production of sports clothing and mountaineering tents with self-cleaning properties. Photocatalytic nanoparticles such as TiO2 and ZnO facilitate self-cleaning by degrading stains and contaminants under light irradiation.
- Protection from heat and cold: Phase change materials (PCMs) incorporated into textiles offer thermal regulation, absorbing excess body heat during physical activity and releasing it when necessary, ensuring comfort in extreme climates.
- Moisture management: Nanotechnology enhances moisture transport properties in sportswear, facilitating the transfer of sweat and moisture from the skin to the fabric surface for rapid evaporation. Plasma technology and electro-spun nanofibers improve moisture transfer and comfort levels during sports activities.
- Enhanced blood circulation and muscle recovery: Far-infrared radiating materials containing germanium and ceramic powders promote enhanced blood circulation and muscle recovery during physical activities, offering therapeutic benefits in sportswear such as knee bands and elbow support (Informative resource & PPT: https://slideplayer.com/slide/6100647/).

Activity: Research and Presentation

- Divide the students into small groups and assign each group a specific aspect of nanotechnology in sports, such as nanofibers, nanocomposite fibers, nano-finished textiles, or nanotechnology in sport flooring.
- Ask the teams to do research for resources such as articles, videos, and research papers related to their assigned topic and instruct the groups to research their topic thoroughly, focusing on how nanotechnology is utilized, its benefits, and its impact on sports performance and safety.
- Have each group prepare a presentation to share their findings with the class. Encourage them to use visual aids, diagrams, and examples of products incorporating nanotechnology in sports.
- After each presentation, facilitate a class discussion where students can ask questions and discuss the implications of nanotechnology in sports.

4. References

- Art Conservation and Nanotechnology. Sustainable Nano. Retrieved from https://sustainable-nano.com/2017/05/12/art-conservation-and-nanotechnology/
- Chocolate Experiment. Retrieved from extension://efaidnbmnnnibpcajpcglclefindmkaj/https://susnano.wisc.edu/wp-content/uploads/Chocolate_SciFest-Sept9.pdf
- Chromatography. Retrieved from https://susnano.wisc.edu/wp-content/uploads/Chromatography.pdf
- Evolution of Nanotechnology in Sports Equipment. SportsVenue Technology. Retrieved from https://www.sportsvenue-technology.com/articles/evolution-of-nanotechnology-in-sports-equipment#:~:text=Nanotechnology%20in%20sports%20equipment%20also,second%20counts%20towards%20the%20victory
- Evolution Timeline of Nanoscience and Nanotechnology, Table 1, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6982820/table/molecules-25-00112-t001/?report=objectonly
- How does STEM work? https://stem.education.tas.gov.au/how-does-stem-work/
- Locke Edward, Proposed Model for a Streamlined, Cohesive, and Optimized K-12 STEM Curriculum with a Focus on Engineering (2009) https://scholar.lib.vt.edu/ejournals/JOTS/v35/v35n2/locke.html
- Nano at Home (2024, January, 24). chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://susnano.wisc.edu/wpcontent/uploads/Chocolat_SciFest-Sept9.pdf
- National Geographic, Nanotechnology, https://education.nationalgeographic.org/resource/nanotechnology/
- National Standards: STEM standards, http://www.clexchange.org/curriculum/standards/stem.asp
- New nanotechnology approaches for tuberculosis treatment. Nano Magazine. Retrieved from https://nano-magazine.com/news/2017/7/7/228q4lr8rr5orforgaord750aqs26b

- Paint.org. (2024, January, 24). Nanotechnology in the World of Paints and Coatings. CoatingsTech Magazine. Retrieved from https://www.paint.org/coatingstech-magazine/articles/nanotechnology-in-the-world-of-paints-and-coatings/
- Sampson, R. J., & Loeffler, C. (2016). Punishment's place: The local concentration of mass incarceration. Criminology, 54(2), 248-281. https://doi.org/10.1177/1528083715601512
- SlidePlayer. (2024). Nanotechnology in sports [PPT]. Retrieved from https://slideplayer.com/slide/6100647/
- Small Wonders, Endless Frontiers: A Review of the National Nanotechnology Initiative (2002), Chapter: 1. The Importance of Nanoscale Science and Technology, https://nap.nationalacademies.org/read/10395/chapter/3#6
- The New York Times Learning Network. (2001, April 6). When Arts, a Craft. Retrieved from https://archive.nytimes.com/learning.blogs.nytimes.com/2001/04/06/when-arts-a-craft/
- Why STEM practices should be taught across the entire curriculum (November 2017), https://www.sciencedirect.com/science/article/abs/pii/S1871187122000037

Videos:

https://www.youtube.com/watch?v=oCugfZEwgj8

https://www.youtube.com/watch?v=bAd16XG91Ek

https://www.youtube.com/watch?v=2voX3fjMGjA

https://www.youtube.com/watch?v=-gdILnzYZEg