TATA CONSULTANCY SERVICES | Discovery EDUCATION

IGNITE MY FUTURE

THINK SOLVE CREATE CONNECT

LESSON TITLE

The Smell Test

Guiding Question: What will our future look like?

SUBJECTS

Science
Computer Science

COMPUTATIONAL THINKING PRACTICE

Developing and Using Abstractions

COMPUTATIONAL THINKING STRATEGY

Abstraction
Decomposition

MATERIALS

Building Blocks of Smell capture sheet

Abstracting Scent capture sheet

Whiteboard, projector, or other central location

The Science behind the Smell of Fall (Teacher resource)

FeelReal Sensory Mask (VR mask with smell – how does it work?) – (Teacher resources)

Ignite Curiosity

- What will movies be like in the future?
- How can we create smells to accompany movies?
- What smells would we need to create to cover any possible experience?
- How can we incorporate smells into virtual reality technology?

Three virtual reality films at the 2017 Tribeca Film Festival integrated smells into the presentation. Collaborators sprayed chemical mixtures around viewers, to mimic the smells associated with the film scenes. In the near future, it may be possible to use virtual reality headsets to create and dispense these smells, without human aid. In this lesson, students will discover the chemical basis of smell, by applying principles of chemistry and molecular structure to the growing field of virtual reality. In **THINK**, students act as chemists challenged to identify the chemical building blocks that make up everyday smells. In **SOLVE**, students compile a list of smells that might enhance the experience of a moviegoer. Students then cross-reference this list with the information they identified and integrated in Think. In **CREATE**, students create a table, using their lists of common smells to abstract the general categories and components of scent. In **CONNECT**, students identify how virtual reality enhances career opportunity and helps deal with the real-world problems of tomorrow.

Students will be able to:

- **Understand** the composition of smells by decomposing their chemical structure,
- **Apply** that knowledge by identifying patterns and extracting common features in the molecular structure of smells, and
- **Create** a table that abstracts common smells into categories.

Students act as chemists who have been tasked with identifying the building blocks (groups) of chemicals that produce scents.

1 **Read** the following scenario to students:
Imagine that you are a team of chemists challenged to create a virtual reality program which incorporates everyday smells into the moviegoing experience. You will first identify the building blocks (groups) of chemicals that produce scents. Then, you will hypothesize what combinations of these building blocks would produce certain results. If you are successful, viewers will have an incredibly realistic experience. If you are less accurate, viewers may experience some pretty unpleasant smells. Let's see what you come up with!

Elicit from students a few of their favorite scents, and write these scents in a column on the board. Next, elicit several of their least favorite scents, and write these in a separate column. Explain that, no matter how pleasant or unpleasant we find certain scents, they all come from the same basic building blocks. At the smallest level, these building blocks are elements, which combine into compounds. Compounds are the molecules that we smell.

2 **Lead** students to consider the importance and basis of smell using the following guiding questions (if students are unfamiliar with elements and molecules or with the anatomy of the nose, you may wish share this video with them before moving any further (first 2 minutes):

- How many scents do you think there are? (Humans have identified over 10,000 scents.)
- How do humans experience smell? (Inside the nose are olfactory epithelia, which contain millions of receptor cells. These fit together with scent molecules, like locks and keys.)
- How does an object "give off" a smell? (What we smell is actually evaporating molecules.)
- What objects don't have a smell? (those that don't evaporate)

3 **Distribute** the Building Blocks of Smell capture sheet to familiarize students with the basic aroma compounds. Guide students through Part I of the handout, in which they review each aroma and where it occurs in nature. Next, highlight Part II of the sheet. Review with students that, to complete this part of the handout, they will combine categories of scent from Part I and hypothesize what resulting smells would emerge. Students should be able to identify that the ratios of one compound to another will affect the overall scent produced.

4 **With partners,** students should work through Part II of the Building Blocks of Smell capture sheet. When they have finished, regroup as a class and discuss student responses.

Students will brainstorm scents that could enhance a moviegoer's experience, cross-referencing their lists with the aroma categories listed in the Building Blocks of Smell capture sheet, to abstract the most important components of common scents.

1. **Ask** students to consider scenes from their favorite movies. Invite students to brainstorm with a partner, responses to the following guiding questions:
   - What scents might enhance the viewer's experience of these scenes?
   - What other common scents might enhance the viewer's experience at this movie?

2. **Return** to the larger group to discuss students' responses to the questions.

Students will abstract general categories and components of scents, creating a map of the Scientific Model to hypothesize how they could design a virtual reality headset that could generate many different smells.

1. **Create** groups of five or six students, separating those who were partners in the previous activity. Tell students that they will now create a communal list of common scents that a person might experience in a film, categorizing and abstracting the general categories and components of these scents, based on their work in the previous task.

2. **Explain** to the groups that they will use the information they have abstracted to create a table of the chemical components and smells a headset must contain in order to provide an immersive moviegoing experience. Ask a group, they should explain how FeelReal created a VR experience with smell? Ask students to find out if there are any other technologies using smell to enchance the user experience.

3. **Guide** students to read the Abstracting Scent capture sheet, and invite them to work individually to categorize the scents they have listed. Their lists should include at least 30 scents. Ask students to turn to a neighbor and discuss their categorizations. Clarify with students that this process is called *abstraction*: it takes the details of phenomena to make generalizations that allow a solution to work in a variety of scenarios. Computer scientists use this technique to simplify complex computer systems.

4. **When students have completed their individual lists,** have them work in their groups to combine their individual lists into a master list, removing duplicates.

5. **When groups have completed their master lists,** reconvene as a class and create a master list on a whiteboard, on a projector, or in another central location, removing duplicates as you compile the list. Summarize the activity with the following critical thinking questions:
   - What steps would you take to begin designing a prototype of a virtual reality headset with scent capabilities?
   - Why are ratios important in creating realistic scent technology?
   - What are some other applications of virtual reality scent technology?
   - Considering that the senses of taste and smell are closely related, do you think this exercise could be modified to create virtual reality taste instead of smell? Why or why not?

Select one of the strategies listed below to help students answer these questions:

- **How do this problem and solution connect to me?**
- **How do this problem and solution connect to real-world careers?**
- **How do this problem and solution connect to our world?**

1. **Write** the three questions on PowerPoint or flip chart slides and invite students to share out responses.
2. **Display** pieces of chart paper around the room, each with one question written on it. Ask students to write down their ideas related to the questions on each sheet.
3. **Assign** one of the questions to three different student groups to brainstorm or research, and then share out responses.
4. **Invite** students to write down responses to each question on a sticky note, and collect them to create an affinity diagram of ideas.

How does this connect to students?

Students are likely familiar with moviegoing and advances in technologies in this area (e.g., 3D, IMAX). They may also be familiar with virtual reality, which is becoming increasingly popular in video games and other experiences. There are now virtual reality games for numerous devices, including Android phones, iPhones, personal computers, and game consoles. Virtual reality headsets and games have become less expensive as more companies produce them, making them more accessible to students. Even though students may be familiar with virtual reality through games and entertainment, the technology is already available for students to use for more practical matters, such as when their parents are ready to buy a house and can tour it virtually. Virtual reality is also currently used for social good, for example, to show the public what it would be like to experience the effects of climate change. This can affect students indirectly.

How does this connect to careers?

Chemists study the molecular structure of scents, and the use of scents in experiments and exploration.

Engineers create new technologies that allow us to experience virtual reality in increasingly realistic ways.

Perfumers explore scent combinations to identify the most tempting mixture for potential consumers.

Film Producers search for ways to keep movies relevant and exciting in an era of streaming and high-quality TV programming.

How does this connect to our world?

Virtual reality is an emerging technology that is changing the way we work, watch movies, and play games. Video game designers, chemists, and computer engineers work together to transform 2D games into 3D (and even 4D) gaming experiences!

Today, scientists are working with virtual reality technologies to study everything from empathy to flexibility, from racism to environmental sustainability. Within their lifetime, it is likely that students will find virtual reality playing an important role in different aspects of their lives, from shopping for a home to traveling, as it continues to become more realistic and applied to different areas.

Furthermore, virtual reality may help shift society's perceptions of issues such as race or climate change, improve education, and make the human body more resilient, as researchers continue to explore the boundaries of the technology.

TATA Consultancy Services is involved in developing emerging technologies like Multisensory VR. Learn more about their running simulation by clicking here.

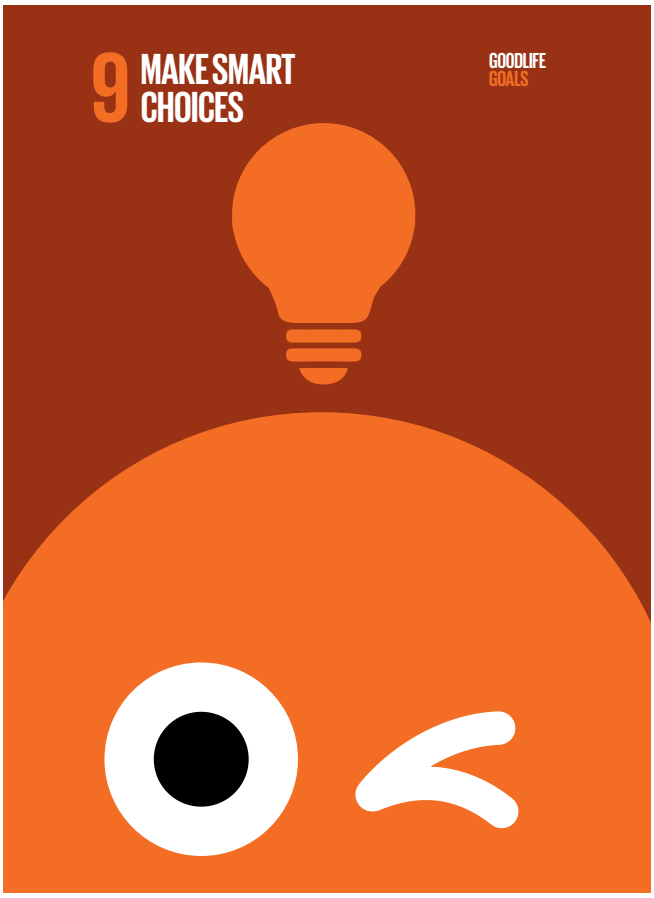
Curriculum Connections

UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

"For the goals to be reached, everyone needs to do their part: governments, the private sector, civil society and **people like you**."
–The United Nations

"The Sustainable Development Goals are the blueprint for a better future. And together we can reach them. By following the Good Life Goals, we can all help make tomorrow better than today. Let's do this! #GoodLifeGoals"



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Global Competencies

CMEC (Council of Ministers of Education, Canada) Pan-Canadian Global Competencies Descriptions

Highlighted sections apply to this lesson

Global Competency	Definition	Student Descriptors
Collaboration	Collaboration involves the interplay of the cognitive (including thinking and reasoning), interpersonal, and intrapersonal competencies necessary to participate effectively and ethically in teams. Ever-increasing versatility and depth of skill are applied across diverse situations, roles, groups, and perspectives in order to co-construct knowledge, meaning, and content, and learn from, and with, others in physical and virtual environments.	Students participate in teams by establishing positive and respectful relationships, developing trust and acting co-operatively and with integrity. Students learn from and contribute to the learning of others by co-constructing knowledge, meaning, and content. Students assume various roles on the team, respect a diversity of perspectives, and address disagreements and manage conflict in a sensitive and constructive manner. Students network with a variety of communities/groups and use an array of technology appropriately to work with others.
Communication	Communication involves receiving and expressing meaning (e.g., reading and writing, viewing and creating, listening and speaking) in different contexts and with different audiences and purposes. Effective communication increasingly involves understanding both local and global perspectives, societal and cultural contexts, and adapting and changing using a variety of media appropriately, responsibly, safely, and with regard to one's digital footprint.	Students communicate effectively in different contexts in oral and written form in French and/or English through a variety of media. Students communicate using the appropriate digital tools and create a positive digital footprint. Students ask effective questions to acquire knowledge, listen to understand all points of view, voice their own opinions, and advocate for ideas. Students gain knowledge about a variety of languages and understand the cultural importance of language.

Global Competencies cont.

Highlighted sections apply to this lesson

Global Competency	Definition	Student Descriptors
Global Citizenship and Sustainability	Global citizenship and sustainability involve reflecting on diverse worldviews and perspectives and understanding and addressing ecological, social, and economic issues that are crucial to living in a contemporary, connected, interdependent, and sustainable world. It also includes the acquisition of knowledge, motivation, dispositions, and skills required for an ethos of engaged citizenship, with an appreciation for the diversity of people, perspectives, and the ability to envision and work toward a better and more sustainable future for all.	Students understand the ecological, economic, and social forces, their interconnectedness, and how they affect individuals, societies, and countries. Students take actions and responsible decisions that support quality of life for all, now and in the future. Students recognize discrimination and promote principles of equity, human rights, and democratic participation. Students understand Indigenous traditions and knowledge and its place in Canada, learn from and with diverse people, develop cross-cultural understanding, and understand the forces that affect individuals, societies, and nations. Students engage in local, national, and global initiatives to make a positive difference. Students contribute to society and to the culture of local, national, global, and virtual communities in a responsible, inclusive, accountable, sustainable, and ethical manner. Students as citizens participate in networks in a safe and socially responsible manner.

Global Competencies cont.

Highlighted sections apply to this lesson

Global Competency	Definition	Student Descriptors
Critical Thinking and Problem Solving	Critical thinking and problem solving involve addressing complex issues and problems by acquiring, processing, analysing, and interpreting information to make informed judgments and decisions. The capacity to engage in cognitive processes to understand and resolve problems includes the willingness to achieve one's potential as a constructive and reflective citizen. Learning is deepened when situated in meaningful, real-world, authentic experiences.	Students will solve meaningful, real-life, complex problems by taking concrete steps to address issues and design and manage projects. Students will engage in an inquiry process to solve problems as well as acquire, process, interpret, synthesize, and critically analyse information to make informed decisions (i.e., critical and digital literacy). Students will see patterns, make connections, and transfer what they have learned from one situation to another, including in real world applications. Students will construct, relate, and apply knowledge to all domains of life such as school, home, work, friends, and community. Students will analyze the functions and interconnections of social, economic, and ecological systems.
Innovation, Creativity and Entrepreneurship	Innovation, creativity, and entrepreneurship involve the ability to turn ideas into action to meet the needs of a community. The capacity to enhance concepts, ideas, or products to contribute new-to- the-world solutions to complex economic, social, and environmental problems involves leadership, taking risks, independent/unconventional thinking and experimenting with new strategies, techniques, or perspectives, through inquiry research. Entrepreneurial mindsets and skills involve a focus on building and scaling an idea sustainably.	Students formulate and express insightful questions and opinions to generate novel ideas. Students contribute solutions to complex economic, social, and environmental problems or to meet a need in a community in a number of ways including; enhancing concepts, ideas, or products through a creative process, taking risks in their thinking and creating, making discoveries through inquiry research, and by hypothesizing and experimenting with new strategies or techniques. Students demonstrate leadership, initiative, imagination, creativity, spontaneity, and ingenuity in a range of creative processes and motivate others with an ethical entrepreneurial spirit.

Global Competencies cont.

Highlighted sections apply to this lesson

Global Competency	Definition	Student Descriptors
Learning to learn and to be self-directed and self-aware	Learning to learn and to be self-directed and self-aware, means: becoming aware and demonstrating agency in one's process of learning, including the development of dispositions that support motivation, perseverance, resilience, and self-regulation. Belief in one's ability to learn (growth mindset), combined with strategies for planning, monitoring and reflecting on one's past, present, and future goals, potential actions and strategies, and results. Self-reflection and thinking about thinking (metacognition) promote lifelong learning, adaptive capacity, well-being, and transfer of learning in an ever-changing world.	Students learn the process of learning (metacognition) (e.g., independence, goal-setting, motivation) and believe in their ability to learn and grow (growth mindset). Students self-regulate in order to become lifelong learners and reflect on their thinking, experience, values, and critical feedback to enhance their learning. They also monitor the progress of their own learning. Students develop their identity in the Canadian context (e.g., origin and diversity) and consider their connection to the environment. They cultivate emotional intelligence to understand themselves and others. They take the past into account to understand the present and approach the future. Students develop personal, educational, and career goals and persevere to overcome challenges to reach these goals. They adapt to change and show resilience to adversity. Students manage various aspects of their lives: physical, emotional (relationships, self-awareness), spiritual, and mental well-being.

Find more easy-to-implement resources to integrate computational thinking practices into your classroom by visiting **ignitemyfutureinschool.ca**

Building Blocks of Smell Part I

Review the following table of common smells and their chemical compound names. When you have finished, answer the questions following the table.

Smell	Where It Occurs in Nature	Compound Name	Molecular Structure Category
Fruity (rose)	Flowers	Geranyl acetate	Ester
Fruity (apple, pineapple)	Pineapple	Methyl butyrate, Methyl butanoate	Ester
Fruity (orange, pineapple)	N/A	Ethyl butyrate, Ethyl butanoate	Ester
Fruity (banana, pear)	Bananas	Isoamyl acetate	Ester
Fruity (pear, apricot)	N/A	Pentyl butyrate, Pentyl butanoate	Ester
Fruity (apple)	N/A	Pentyl pentanoate	Ester
Fruity (orange)	N/A	Octyl acetate	Ester
Fruity (grape)	N/A	Methyl anthranilate	Ester
Fruity (strawberry)	Strawberries	Benzyl acetate	Ester
Sweet (wine)	Wine	Ethyl acetate	Ester
Woody (complex)	Verbena	Myrcene	Linear terpene
Woody (lavender)	Lavender	Linalool	Linear terpene
Woody (bark)	Ginger	Nerolidol	Linear terpene
Flowery (rose)	Geraniums	Geraniol	Linear terpene
Flowery (sweet rose)	Neroli, lemongrass	Nerol	Linear terpene
Lemon	Lemongrass	Citral	Linear terpene
Lemon	Lemongrass	Citronellal	Linear terpene
Lemon	Lemongrass	Citronellol	Linear terpene
Orange	Oranges and lemons	Limonene	Cyclic terpene

Menthol	Menthol	Mentha	Cyclic terpene
Lilac	Lilacs	Terpineol	Cyclic terpene
Violet	Violets	Alpha-ionone	Cyclic terpene
Mint	Juniper	Thujone	Cyclic terpene
Almond	Bitter almond	Benzaldehyde	Aromatic
Clove	Clove	Eugenol	Aromatic
Cinnamon	Cinnamon	Cinnamaldehyde	Aromatic
Cooked fruit, caramelized sugar	N/A	Ethyl maltol	Aromatic
Vanilla	Vanilla	Vanillin	Aromatic
Anise (licorice)	Anise	Anisole	Aromatic
Anise (licorice)	Anise, sweet basil	Anethole	Aromatic
Tarragon	Tarragon	Estragole	Aromatic
Thyme	Thyme	Thymol	Aromatic
Fishy	N/A	Trimethylamine	Anime
Fishy	Belladonna	Pyridine	Anime
Rotting flesh	Rotting flesh	Putrescine	Anime
Rotting flesh	Rotting flesh	Cadaverine	Anime
Human waste	Human waste	Indole	Anime
Human waste	Human waste	Skatole	Anime

- Which smell is most common among the esters/can be produced by the most compounds?
- Which smell is most common among the linear terpenes/can be produced by the most compounds?
- Which smell is most common among the cyclic terpenes/can be produced by the most compounds?
- Which smell is most common among the aromatics/can be produced by the most compounds?
- Which smell is most common among the amines/can be produced by the most compounds?

Building Blocks of Smell Part I (answers)

- Which smell is most common among the esters/can be produced by the most compounds? (fruity, specifically apples and pineapples)
- Which smell is most common among the linear terpenes/can be produced by the most compounds? (lemon)
- Which smell is most common among the cyclic terpenes/can be produced by the most compounds? (No cyclic terpene scent appears more than once.)
- Which smell is most common among the aromatics/can be produced by the most compounds? (anise)
- Which smell is most common among the amines/can be produced by the most compounds? (They are equally divided: fishy, rotting flesh, and human waste.)

Building Blocks of Smell Part II

Using the table from Part I, create scent combinations from the smells given. Describe how much of each scent you would put in the mixture and what resulting smell—and possible uses for the movies—this combination could have.

Scent #1 Compound Name	Scent #2 Compound Name	Percentage of Scent #1 and Scent #2	Resulting Smell and Possible Uses
[Ethyl butyrate]	*[Methyl butyrate]*	*50%, 50%*	*Pineapple with apple and orange undertones: could be used for fruit salad or tropical environment.*

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Abstracting Scent

In the following table, identify scents that could be used in movies to enhance the virtual reality experience. Then, hypothesize what categories of compounds these scents might fall into.

Useful Scent	Component Scents	Possible Compound/ Molecular Category
[Cookies]	*[Caramelizing sugar, vanilla]*	*[Aromatic]*

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