

# CHEMICAL AND PHYSICAL CHANGES AND THEIR EFFECT ON OUR ENVIRONMENT

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**Abstract** Chemical and physical changes are essential to man and the environment. Understanding how to differentiate between chemical and physical changes is an essential skill that secondary school students must acquire. Additionally, it is important for students to understand how the interference of man has caused some chemical and physical changes to become harmful for the environment, society and the economy. This article presents a lesson plan that aims to enhance student understanding of chemical and physical changes, and to encourage students to analyze how chemical and physical changes can have a harmful effect on the environment. The article also presents an explanation of inquiry-based learning and context-based learning, which were the main teaching techniques used throughout the lesson. The lesson plan includes instructions to carry out four experiments at varying levels of inquiry. The students are required to analyze the result of their experiments in relation to the environmental problems we face today. Assessment methods that incorporate the use technology are presented as well.

## 1 Introduction

Chemical and physical changes are an essential part of life. Unfortunately, some of the physical and chemical changes that occur daily, due to the intervention of man, are harmful for the environment.

After much research and planning, a lesson plan on chemical and physical changes and their effect on our environment was designed. The aim of the lesson was to promote students understanding of chemical and physical changes, and to enhance their ability to differentiate between chemical and physical changes. The lesson also aimed to educate students on current environmental issues, by additionally enhancing student's ability to make connections between laboratory experiments and real life issues (context-based learning). These objectives were achieved by carrying out four inquiry-based experiments, the experiments conducted were mainly varying levels of guided inquiry.

The lesson plan takes into consideration the Finnish National Curriculum. The curriculum specifies that students must "learn to know about the physical and chemical

concepts that describe the properties of substances and learn to apply those concepts” (Finnish National Board of Education, 2004). Additionally, the curriculum states that students must learn to carry out scientific investigations and to interpret their results. Further, the curriculum also indicates the importance of introducing aspects related to environmental issues to the students. (Finnish National Board of Education, 2004)

## 2 Theory

### 2.1 Chemical and Physical Changes

Chemical changes result in the production of new chemical substances. At a molecular level, chemical changes involve making or breaking bonds to create the new chemical substance. Examples of chemical reactions include: rusting where iron oxide is produced, or burning gasoline where water vapor and carbon dioxide are produced. (Tro, 2011)

A physical change does not involve changing a substance's chemical identity. Physical changes do not produce new substance, even though the starting and ending substances may look different from each other. Examples include: phase changes, such as the melting of snow or creating mixtures, for example, mixing water and sugar. (Tro, 2011)

It is possible to tell chemical and physical changes apart by a couple of clues. There are a few signs that indicate that a chemical reaction took place, such as, color change, formation of precipitate, formation of a gas, odor change, temperature change, sound, and light. Generally chemical reactions/changes are irreversible and physical changes are reversible. Yet some chemical reactions are reversible. For example, heating ammonium chloride forms ammonia and hydrogen chloride gas. However, when the gases are trapped and cooled, a white solid of ammonium chloride is reformed. Likewise, some physical changes are irreversible. For example, breaking or damaging some materials is irreversible, such as cutting down a tree. (Tro, 2011; Baxter & Dilley, 2014)

### 2.2 Chemical and Physical Changes and the Environment

Chemical and physical changes occur all around us all the time. These changes are essential parts of our daily lives, for example, digesting food, combustion, osmosis, and phase changes. However, a few of the chemical and physical changes that occur daily are harmful for the environment. This project introduces four physical/chemical changes that are related to the following environmental issues: plastic decomposition, global warming, effects of acid rain, and oil spills.

Plastic waste is a widely recognized source of pollution. Most plastics produced are non-biodegradable; hence their disposal causes environmental damage in land and water. Non-biodegradable plastics take hundreds of years to decompose; thus, when plastic products are disposed off in landfills, rivers, and oceans, it contaminates the soil, water, marine life and the air. Plastic pollution is a serious threat that can be prevented by recycling, using biodegradable plastic, reducing consumerism and promoting better waste-collection. (Owen, 2004)

Global warming is the unusually rapid rise in the average global temperature on earth. The main cause of global warming is the drastic increase in the emission of carbon dioxide by the burning of fossil fuels. The climate change affects not only the atmosphere and land creatures but also the ocean. About a quarter of the carbon dioxide emissions are absorbed by the earth's oceans. Much of it becomes fixed and is stored in sea plants and grass. However, the carbon dioxide that is not fixed dissolves into the sea water altering the chemistry of the water. (Lavelle, 2016; Bishop, 2012)

Acidic gases are produced when fossil fuels such as coal and oil are burned in power stations, factories and homes. These acidic gases such as sulfur dioxide and nitrogen oxide react with water molecules in the atmosphere causing rain and snow to become more acidic. This acid rain then causes harm to forests, lakes, oceans and marble/limestone buildings. (National Geographic, n.d)

Oil spills occur when liquid petroleum is released into the environment by human interference, causing damage to marine ecosystems. Oil spills and their effects have become a widely discussed issue since it causes numerous problems for the environment. Oil spills float on water and prevent sunlight from passing through it, this makes it difficult for plants and sea animals to survive. Oil spills also kill birds as it can penetrate into the plumage and fur of birds. Oil spills are quite difficult to clean up because the wind and ocean currents break the spills and cause it to expand into large areas. Oil spills could be prevented by ship safety and regulations, as well as a reduction in the consumption of oil. (Kukreja, n.d)

### 2.3 Inquiry-based Learning

Inquiry-based learning engages students in scientific investigations. Rather than presenting students with a clear path to knowledge, inquiry-based tasks require students to engage in inquiry, in learning to think scientifically, and in understanding the relationships between evidence and theory. The most important aspect of inquiry is the process used rather than the outcome of the inquiry (Watson, 2000). Inquiry tasks involve students actively making observations, collecting and analysing data, organizing information, and drawing conclusions.

Thus, through inquiry students develop useful problem-solving skills, analytical skills, manipulative skills, social skills and creative skills. Inquiry tasks additionally facilitate a deep understanding of chemistry concepts. (Kubieck, 2005; Annenberg Foundation, 2013)

There are three main levels of inquiry that can be utilized for secondary school students depending on the student's inquiry abilities and their understanding of the concepts of chemistry. *Structured inquiry*, involves the teacher providing students with the question and the procedure. Requiring the students to generate an explanation utilizing the evidence they collect. *Guided inquiry*, involves the teacher providing students with the research question. Requiring the students to design the procedure (method), to test it and produce an explanation. Teachers are encouraged to further guide the students as to whether their design is suitable. *Open inquiry*, involves giving students the opportunity to operate as scientists, deriving questions, designing, carrying out investigations, and communicating their results. This requires scientific reasoning and high order thinking. (Banchi & Bell, 2008)

## 2.4 Context-based Learning

Context-based learning (CBL) in chemistry involves teaching chemical concepts by starting with observations of everyday situations and relating them to chemical phenomena. Context-based learning has many acknowledged advantages; however, there are a few difficulties linked to the use of CBL as well. (Broman & Parchmann, 2014)

One of the main advantages of using CBL is that it is more interesting and motivating for students. According to research conducted by Osborne and Collins (2001), students like to relate chemical principles to everyday situations. Seeing the point in what they are studying enhances student's ability to engage in the lesson and thus they learn more effectively. Students often find chemical concepts difficult due to a lack of relevance. Additionally, context based learning also supports student's ability to remember and apply what they have learnt in class. Finally, the use of CBL aims to produce scientifically-literate citizens capable of making sense of the ways in which science influences their life. (Broman & Parchmann, 2014; King et al., 2008; Bennett & Holman, 2002)

The difficulty students might face with CBL is that, they must simultaneously consider chemical concepts as well as the contextual situation. This might prove to be challenging for learners, requiring them to operate at a higher level of thinking. Therefore; the content knowledge must be the foundation. Context-based tasks must be designed with chemistry content areas and their concepts as the first consideration. (Broman & Parchmann, 2014)

### 3 Implementation of the project work

#### 3.1 The lesson plan

The 75-minute lesson is designed for 7<sup>th</sup> grade students, the topic being chemical and physical changes and their effect on our environment. The lesson plan includes, an introduction to chemical and physical changes, an introduction to the earlier mentioned environmental issues and the carrying out four experiments. Each experiment has the potential to develop different inquiry skills.

The lesson plan is designed taking into consideration four main learning objectives. The first objective of the lesson is to strengthen the student's ability to differentiate between physical and chemical changes. The second objective is to promote student's ability to make connections between laboratory experiments and real life issues. The third learning objective is to educate students on the immense effect our actions have on the environment. Finally, the fourth objective is to enhance student's inquiry skills.

The entire lesson plan revolves around sustainable development. One of the main aims of the lesson plan is to introduce students to real life problems/issues, such as, plastic pollution, global warming, acid rain, and oil spills. In addition to promoting student's ability to make links between real life situations and experimental work, introducing the mentioned issues will also educate students on the various environmental issues we face today. Additionally, discussing such issues in class will provide students with the opportunity to critically analyze such problems and discuss solutions to the problems. Solutions that are in their control as well as solutions that could be implemented by certain authorities.

The lesson was planned and then implemented with 7<sup>th</sup> grade students at Kulosaari Secondary School. The procedure of the lesson was designed to optimize student productivity. Table 1 below presents the teaching process, time management and an explanation for each step of the lesson. The lesson plan included the carrying out of four different experiments. For each experiment, students were required to decide whether the changes occurring were physical or chemical changes, in order to practice differentiating.

Table 1 Lesson plan

<b>Process</b>	<b>Explanation</b>
Prior homework	Prior to the lesson students were required to carry out a research inquiry on the above mentioned environmental issues. Students were provided

	with questions to be answered based on their research. Websites to acquire the information from were also provided (appendix 1).
Introduction to chemical and physical changes (5 min)	At the beginning of the lesson students were introduced to the concept of chemical and physical changes. After which, the connection between chemical and physical changes and the environmental problems were introduced (presentation, appendix 2) The order of the introduction was to encourage students to focus on the concepts of chemistry primarily. Later relating it to real life issues, as suggested by Broman & Parchmann (2014)
Discussing the previous lessons homework (10 min)	The discussion was carried out in order to ensure that students had grasped the concepts regarding the environmental hazards (previous lessons homework) and to reinforce the concepts (presentation, appendix 2)
Experiment A (15 min) experiment instructions (separate file)	The decomposition experiment required students to design their own experiment having been given the research question as well as the material. After this the results of a pre planned experiment were presented to the students for analysis. They were then required to relate the experiment to the decomposition of plastic and plastic pollution. This experiment was a form of guided inquiry.
Experiment B (10 min) experiment instructions (separate file)	The dry ice experiment, required students to mainly observe and analyze the results of a demonstration experiment. The students were then required to related the experiment to global warming.
Experiment C (15 min) experiment instructions (separate file)	The chalk erosion experiment required students to design their own experiment, carry it out and then analyze their results in relation to the effect acid rain has on limestone buildings. A form of guided inquiry
Experiment D (15 min) experiment instructions (separate file)	The oil spill experiment required students to carry out the experiment based on provided instructions and to then analyze their results in relation to the effects of oil spills in oceans.
Homework (5 min)	The homework required students to create a one-page report on the experiments. The students were also required to share these reports with their peers and their teachers and to read and comment on at least one of their peer's reports. For further details see section 3.2 assessment

### 3.2 Assessment

During the implementation of the lesson at Kulosaari Secondary school, the students were not evaluated. However, the lesson plan does include a plan for assessment. Both formative and summative assessment could be utilized for inquiry tasks (Harrison, 2014), summative assessment is easier to carry out than formative assessment. However, it could be more productive to utilize both forms of assessment. The summative assessment could potentially be used as a supporting tool to reinforce observations made during formative assessment. The designed lesson incorporates the use of formative and summative assessment.

The formative assessment for the lesson could be carried out by the teacher in the form of assessing student discussions, their inquiry skills and their productivity/motivation. This will provide teachers with the opportunity to observe the students journey throughout the task. Teachers will be able to observe if the students are thinking, applying and analyzing; thus, providing the teacher with rich data on student's progression. However, teachers must also keep in mind the flaws related to formative assessment. Teachers will not always be able to assess every student's progress for every inquiry task. Additionally, a student may perform poorly at some point during the lesson and really well at another point during the lesson, and the teacher might miss one or the other. Thus coming up with the wrong conclusion regarding the student. Furthermore, when working in groups, students have an effect on each other performance, positively and negatively. Hence occasionally creating unfair assessment situations.

The summative assessment for the lesson could be carried out by asking students to create a one-page report on the experiments conducted in class. The students should also be required to share these reports with their peers and their teachers, and to read and comment on at least one of their peer's reports (someone who hasn't already received feedback from a peer). This will present students with the opportunity to reflect on what they have learnt, reinforcing the thoughts and ideas they developed during the lesson. Additionally, providing the teacher with the opportunity to reflect more thoroughly on the student's learning. Sharing the report with their peers will facilitate peer assessment. Peer assessment will allow students to receive potentially useful feedback regarding their own work. The peer assessment could also encourage students to learn from each others reflection and reports. Furthermore, teachers will be able to carry out summative assessment of student's work based on the peer feedback as well as the student's reports.

The reports could be created as a google document; thus allowing students to easily share and comment on each other work in an environmentally friendly manner. Google documents is a web-based application in the google docs suite. It is a streamline word processor, featuring essential tools. The strength of google documents as a teaching and learning tool resides in its web-based collaborative capabilities and in its ability to provide an easily accessible collaborative platform for students to work on a variety of tasks. Additionally, providing support for group and teamwork. Furthermore, it provides a flexible format for teacher and peer feedback, allowing teachers easily to observe their students' progress and learning. (Gyorke, 2010)

#### 4 Discussion

The implementation of the lesson at Kulosaari Secondary school went quite well. The lesson was conducted after the students had already studied the concept of chemical and physical changes, this could have been a contributing factor. Thus, highlighting the importance of building a strong foundation of the concepts of chemistry when integrating context-based learning.

The experiments incorporated various levels of inquiry. The students seemed to enjoy the inquire tasks and were productive throughout the process. The students also seemed to have developed their inquiry skills well throughout the lesson. For example, the first time they had to design the experimental method themselves, they found it a bit challenging. However, when designing the experimental method for the second time, they were much more efficient, productive and creative.

Based on discussions with the students during the lesson, it was evident that most of the students were able to relate the laboratory experiments to the required environmental issues quite well. For example, after observing the effect that acid has on chalk, the students began to relate the experiment to the effects that acid rain has on limestone buildings. Thus, understanding the detrimental effects of acid rain, for buildings as well as forests etc. Students were also then able to identify economical losses due to acid rain.

The students understood what chemical and physical changes are, and were able to successfully differentiate between the two. The students also seemed to grasp the effect that these chemical changes and physical changes have on our environment. The lesson plan could be further developed to prompt students to reflect on the solutions of these environmental issues that we face. The students were required to briefly reflect on this during the previous lessons

homework. However, students could benefit from a more detailed exploration of the solutions to these problems.

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## Indices

### Appendix 1: Homework

#### **Homework questions:**

Briefly research the following questions from the mentioned sources:

1.
  - a) What threat does plastic pose to the environment?
  - b) What can we do to prevent plastic pollution?

Resource: [https://www.youtube.com/watch?v=\\_6xlNyWPpB8](https://www.youtube.com/watch?v=_6xlNyWPpB8)

2.
  - a) What is acid rain?
  - b) Why is acid rain a problem?

Resource: <http://www.clean-air-kids.org.uk/acidrain.html>

3.
  - a) Why are oil spills so detrimental to the nature?
  - b) What do you think should be done to prevent them?

Resource: <http://www.conserve-energy-future.com/effects-of-oil-spills.php>

4.
  - a) What does climate change mean?
  - b) How is carbon dioxide related to it?

Resource: <https://www3.epa.gov/climatechange/basics/>

### Appendix 2: Presentation

Link to presentation:

<https://docs.google.com/presentation/d/1X8J2z4f7MXsyQzqoFIF3PsDeeOkVjMRMM3zWE3YazEs/edit?usp=sharing>