**Learning Guide to analyze the Simulations of Lesson 3 and Complete the Respective Worksheet**

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PAFSE Project: Scenario 1: Droplets & the Physics of Viruses Transmission

LEARNING GUIDE FROM CLASS 3

Analyze the Simulations of Lesson 3 and Complete the Respective Worksheet



**Sustainable Development Goals**

**Domains of Citizenship Education**

Sustainable Development

Health

**Competencies when finishing Compulsory Schooling**

Critical and creative thinking, well-being, health and environment

Scientific, technical and technological knowledge

Languages and texts

Information and Communication

# **Guide Objectives**

With this guide, it is intended that the teacher who will teach class 3 be equipped with the necessary knowledge to fulfill this purpose. This document contains the step-by-step explanation of what it is intended to convey to students by watching the videos of the simulations of different breathing regimes prepared by ISEL for class 3 of scenario 1.

# **Video Structure**

The videos that are intended for students to analyze in class 3 were made in order to simulate three breathing regimes: situation in which one of the people in the room is talking normally, a situation where one is sneezing, and where one is coughing.

**Note:**

Out of curiosity, the CFD simulations that make up the videos were performed using 3 softwares:

* DesignBuilder (to design the room and its elements); [1]
* OpenFOAM (to perform simulations of the flow of respiratory particles for each breathing regime, inside the room); [2]
* ParaView (to be able to produce the animated videos that students will analyze in classes 3 and 4); [3]

For more information on each of these softwares, confer [1][2] and [3], present in the section “Additional literature”, at the end of this guide.

## **Simulation Room Setup**

The room where the simulations were carried out, and, consequently, the production of the videos, present the same configuration, which can be seen in the image illustrated below.

Uma imagem com texto, captura de ecrã, diagrama, design

Descrição gerada automaticamente

Figure 1. Room Caption

In the table below, it is possible to observe the characteristics of each element present in classroom 3.\*

|  |  |  |  |
| --- | --- | --- | --- |
| **Surface** | **Surface Temperature []** | **Power [W]** | **Air Flow** |
| North Wall (+X) | 24,9 | - | - |
| South Wall (-X) | 25,0 | - | - |
| East Wall (+Z) | 25,5 | - | - |
| West Wall (-Z) | 25,3 | - | - |
| Ceiling (+Y) | 25,7 | - | - |
| Floor (-Y) | 24,0 | - | - |
| Lamps (Individual) | - | 64 | - |
| People (Individual) | 31,6 | 100 | - |
| Diffuser (+X) | 20,4 | - | 0,0472 |
| Diffuser (-X) | 19,9 | - | 0,0472 |
| Extractor (+Y) | - | - | 0,0944 |
| **Dimension** | **Axle X [m]** | **Axle Y (height) [m]** | **Axle Z [m]** |
| Room | 4.8 | 2.4 | 4.2 |
| **Element Dimension** | **Axle X [m]** | **Axle Y (height) [m]** | **Axle Z [m]** |
| Diffusers | 0,3 | - | 0,3 |
| Extractor | 0,3 | - | 0,3 |
| Lamps | 1,2 | - | 0,2 |
| Occupants | 0,4 | 1,1 | 0,35 |



This table is also present in the “Characteristics\_Simulation” sheet, in section “Characteristics of the Initial Study Case”.

## **Videos Setup**

As mentioned, for class 3, three breathing regimes were simulated: a situation in which one of the occupants spoke, another in which the person coughed, and a last one in which one of the occupants sneezed.

In all situations, only occupant 1 emitted particles. All simulations were conducted for a situation where the ventilation system (2 diffusers + extractor) was present in the room. A situation was also simulated in which one of the occupants spoke, but the room did not have a ventilation system, so that the students could understand the advantage of using a ventilation system.

Each simulation was conducted for a time of 60 minutes, visible in the upper left corner of each video.

In the lower right corner will be contained a color caption, which represents, in meters, the size of each particle emitted by the emitting occupant. The scale goes from m (blue) to m (red). In the image below it is possible to observe these two highlighted elements.

Uma imagem com texto, captura de ecrã, diagrama, Software gráfico

Descrição gerada automaticamente

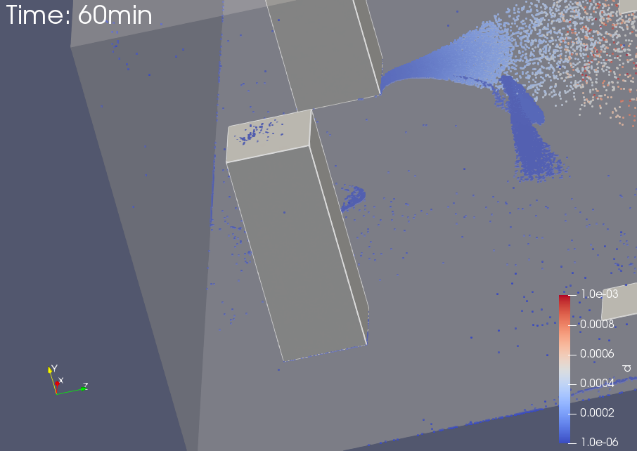
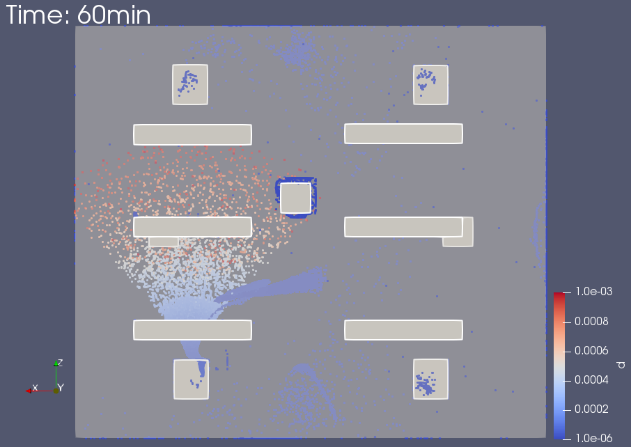
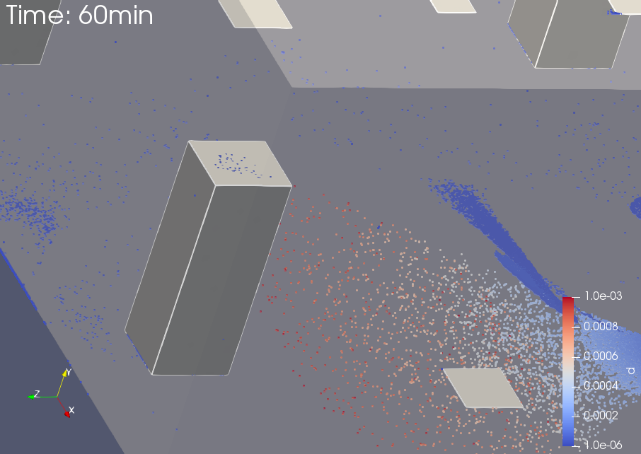
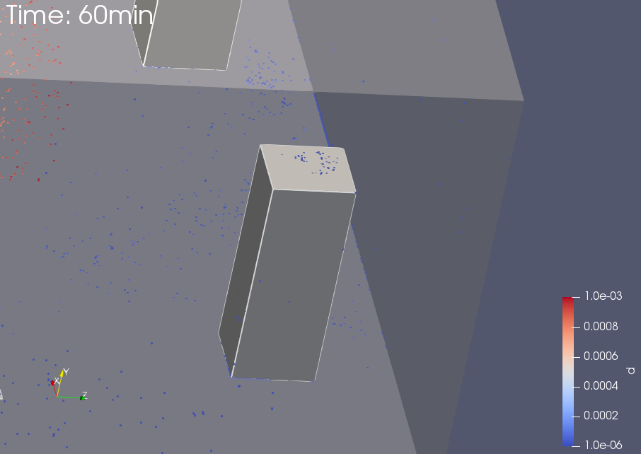
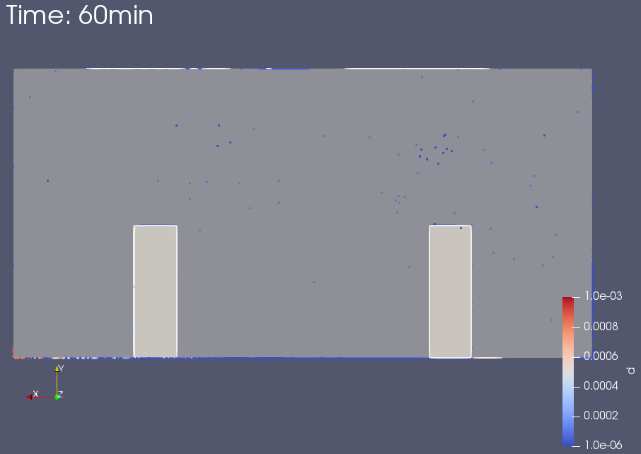
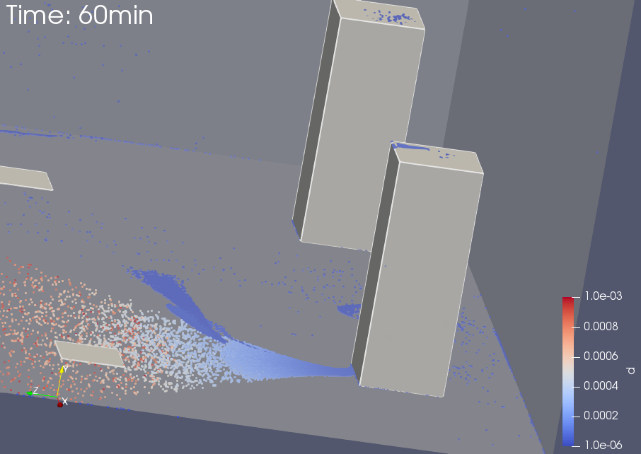
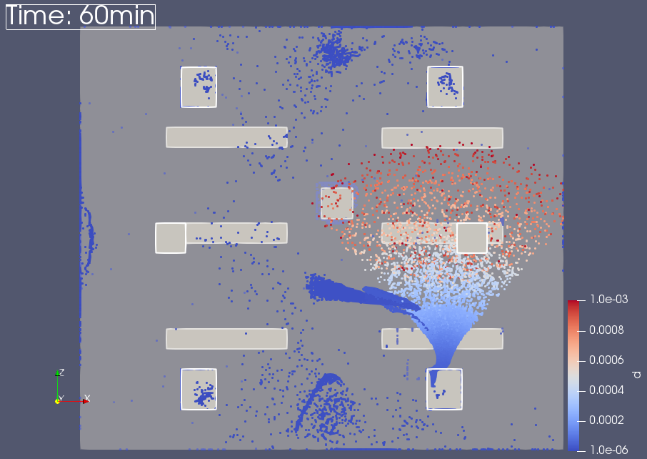
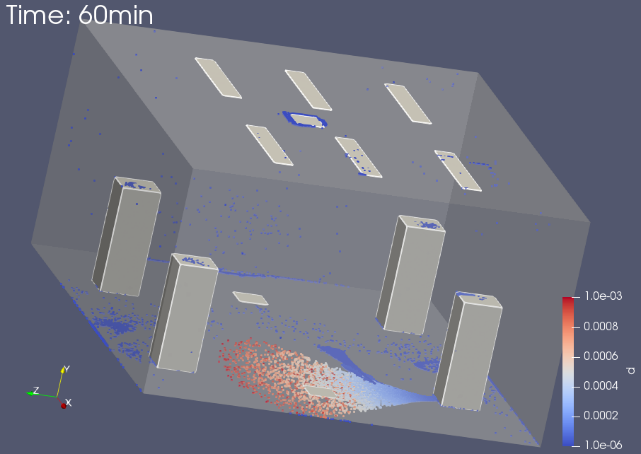
For each simulation, two video typologies were produced: one in which it is possible to analyze, in detail, what happens only during the 1st minute of the simulation, and another in which the 1st minute is analyzed in detail, followed by the complete simulation up to 60 minutes.

The typology of videos of the 1st minute of the simulation was produced since this is the time interval in which is possible to better visualize the path that the particles travel.

## **Complementary Elements of Video Analysis (Images)**

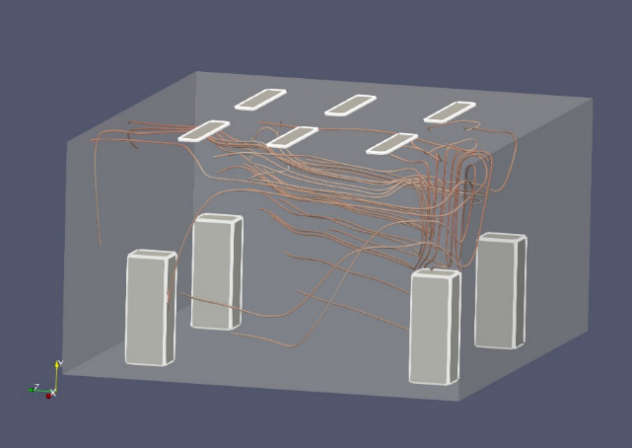
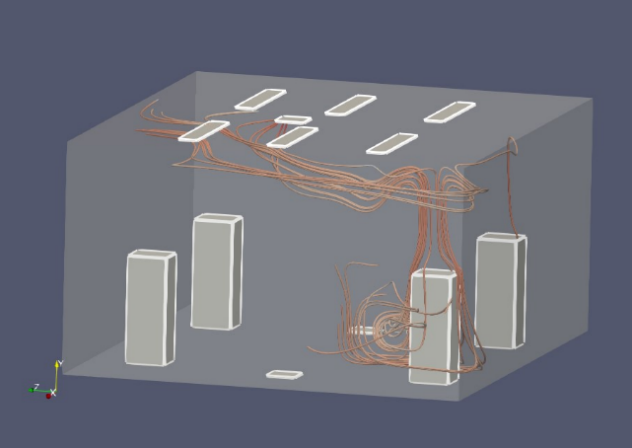
Sometimes the results at the end of the simulations may not be very noticeable to the students, so a set of images was created at the end of each simulation (at 60 minutes), from different perspectives of the room, so that the students can visualize what happened during the simulation. In the images illustrated below, as an example, there are various perspectives at the end of the simulation for the situation in which the occupant spoke.





The analysis of these images by the students is not mandatory, but it can help in the interpretation of the results of the simulations, and in the subsequent resolution of the worksheet proposed for this activity.

Students will also have available an image regarding the air streamlines developed inside the room, for both cases, with and without ventilation. The images of the flow lines are marked below. \*



**\***  The explanation of what chain lines are is present in the PowerPoint introduction explanatory guide for class 1.

# **Explanation of Phenomena Observed in Each Video**

The explanation of each phenomenon observed in the videos is present in the PowerPoint “Video analysis guide of lessons 3 and 4”.

# **Videos Analysis Sequence**

As mentioned above, students in class 3 will have to analyze the two video typologies (only 1st minute of the simulation + total simulation) for the following four situations:

* Occupant 1 speaks;
* Occupant 1 speaks in the room without ventilation;
* Occupant 1 sneezes;
* Occupant 1 coughs;

The sequence of analysis of the videos should be as follows:

1. Students analyze the videos from the 1st minute to the four situations, in which, preferably, the situation with and without ventilation should be analyzed next to one another, that is, if they analyze the video in which the occupant speaks with ventilation first, the next video to be analyzed should be the one in which occupant 1 speaks without ventilation;
2. Subsequently, students analyze the four videos of the total simulation;
3. If necessary, students regard the images from different perspectives of the room at the end of each simulation;

**Note:**

**It is** **of utmost importance that students have next to them (either printed, or on their devices), the image of Figure 1**, so that, when analyzing the videos, they can clearly identify each element inside the room.

In order for this analysis activity to be conducted efficiently, the teacher asks the students in advance (e.g. in the class prior to the analysis of the videos), to analyze the learning script “study method class 3”, so that, when students arrive in class 3, they already have a sense of what will be done during the class and the activities.

To reinforce this last point, it is also suggested that, at the beginning of the class, the teacher tells the students how the sequence of analysis of the videos should be done, also mentioning that video typologies exist, or even the existence of the images.

# **Completing the Lesson 3 Worksheet**

The lesson 3 worksheet is available on the Dropbox link for scenario 1 in the “Worksheets” folder. The form is accompanied by a solution that contains the answers to each of the questions. This last one can be obtained in the folder “Solucoes\_Fichas”. The name of the form is “Worksheet\_PT\_Aula\_3” and the solution in the “Solucoes\_Fichas” folder is “Worksheet\_PT\_Aula\_3\_Solucao”. An abbreviated version of the responses to the forms can also be found in the Word document with the description of the educational scenario.

# **Final Note**

In order for the activity to run efficiently, here are some suggestions for the logistics of implementing this specific class:

* It is **fundamental** that students, before entering the classroom, **have read the script "study method class 3"** to already have a little preparation of what they will find in the activities proposed for class 3.
* If possible, before starting the class, the room must already be prepared to carry out the activity, that is, the tables must already be divided so that the groups can work (it is assumed that before this class, the work groups are already known), and the computers (if the school has them) must already be in the room before the students enter, so that these moments of organization do not occupy the precious time of the class;
* If students do not have access to school computers, it is imperative that before class all students have available, at least on their mobile phones, the videos and images related to class 3. This aspect is crucial for the activity to be successfully developed in the stipulated time.

# **Additional literature**

[1] **Additional information about DesignBuilder software:** Available at: <https://designbuilder.co.uk/>

[2] **Additional OpenFOAM Software Information:** Available at: <https://openfoam.org/>

[3] **Additional information about ParaView software:** Available at: <https://www.paraview.org/about/>