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Chemical Laboratory Simulator of  
Qualitative Inorganic Analysis

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# What is LabSim<sup>1</sup>

*LabSim* is a laboratory simulator of qualitative inorganic analysis which was mainly developed with the aim to teach the students in laboratory during the COVID pandemic emergency. Its main features are:

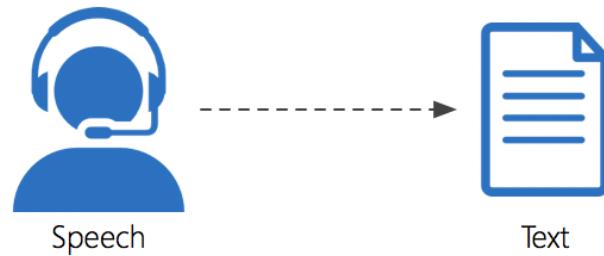
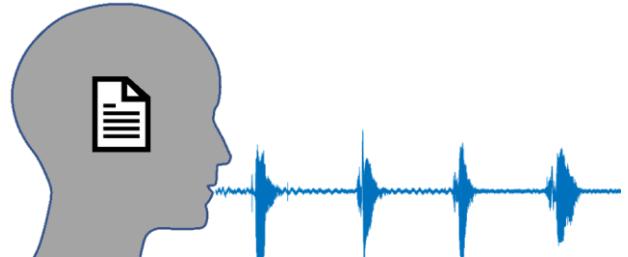
- Complete 3D environment (based on A-Frame/WebGL technology).
- Web-based application:
  - Compatibility with widest range of devices as: VR systems (HTC and Oculus), PCs (Linux, MacOS, and Windows), tablets (Android, iOS and Windows) and smartphones (Android and iOS).
  - Runs inside the web browser (Chromium-based), so no software installation is required.





# What is LabSim<sup>2</sup>

- Support multiple languages (actually *English* and *Italian*).
- Speech synthesis (based on different technologies according to the device).
- Speech recognition for disabled persons.
- Based on a database of more than 3500 reactions that can be used in recognizing 60 analytes.



- 70 video virtual and real tutorials watchable through a TV included in the 3D environment.
- Totally free.



# What you can do

With *LabSim*, you can practice as in a real laboratory of qualitative inorganic analysis and the main activities are:

- **Solubility test** in water of a substance even in the presence of reactants such as strong / weak acids / bases;
- **pH measurement** of a solution with universal indicator paper;
- **Phase separation** by centrifugation;
- **Heating** by plate or water bath;
- Tests for the recognition of **anions** by wet method;
- Tests for the recognition of **cations** by wet method;
- Recognition tests by dry method (non water-soluble substances);
- Flame test;
- Complete analysis of an unknown substance (both water-soluble and non-water-soluble);
- Watching video tutorials on both virtual and real laboratory activities.



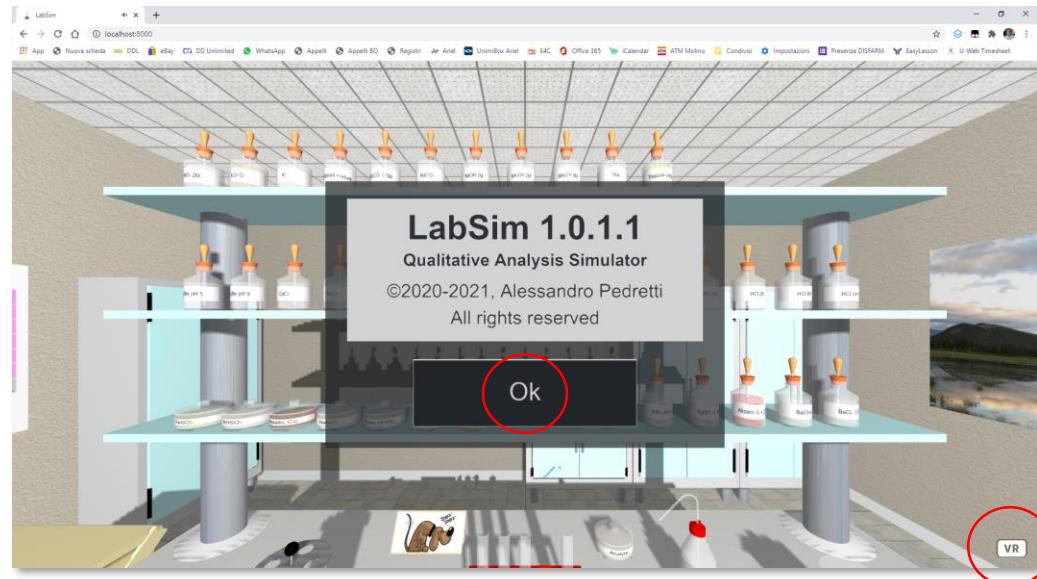


# How to try it

In the address bar of the browser (Chrome or Edge), type:

*<https://nova.disfarm.unimi.it/labsim>*

After the loading screen, it will show the copyright message:



Click the **Ok** button to start the simulation. Clicking the **VR** button, you switch from windowed mode to full-screen or VR mode. Press **Esc** key to return to the standard display mode.



# The mouse

The mouse is the preferred input device for non-VR hardware systems:

**Scroller**

Zoom in/out the scene

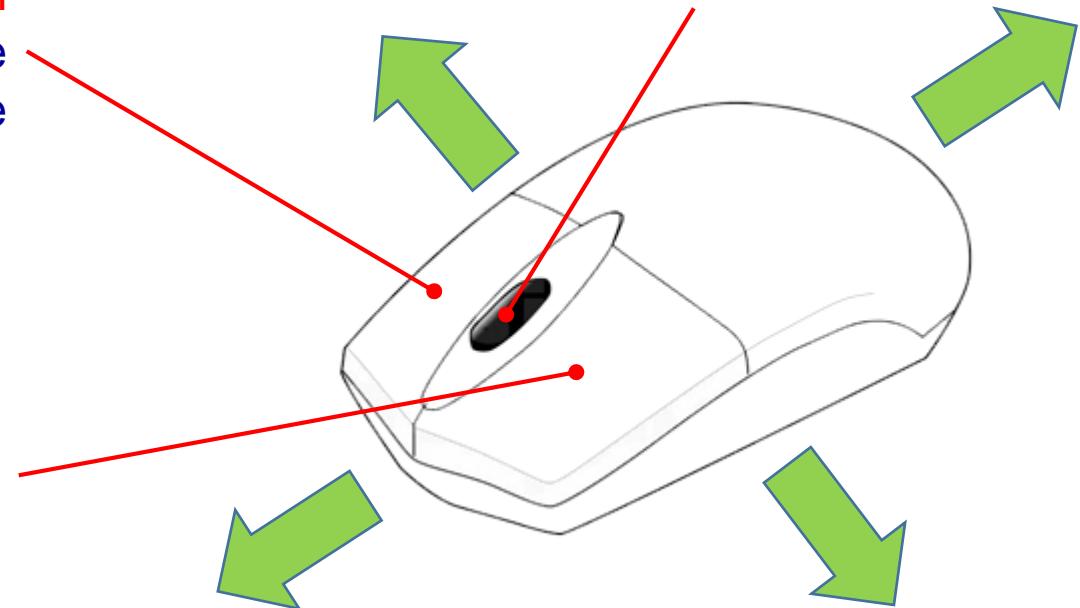
**Right button**

Keep pressed and move the mouse to translate the scene

**Left mouse**

Keep pressed and move the mouse to rotate the scene

Click an object to make an action





# Other input devices

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Some functions are available through the **keyboard**:

- The **cursor key** translate the scene.
- The **space bar** and **m** key show the main menu.
- The **Esc** key closes the menu.

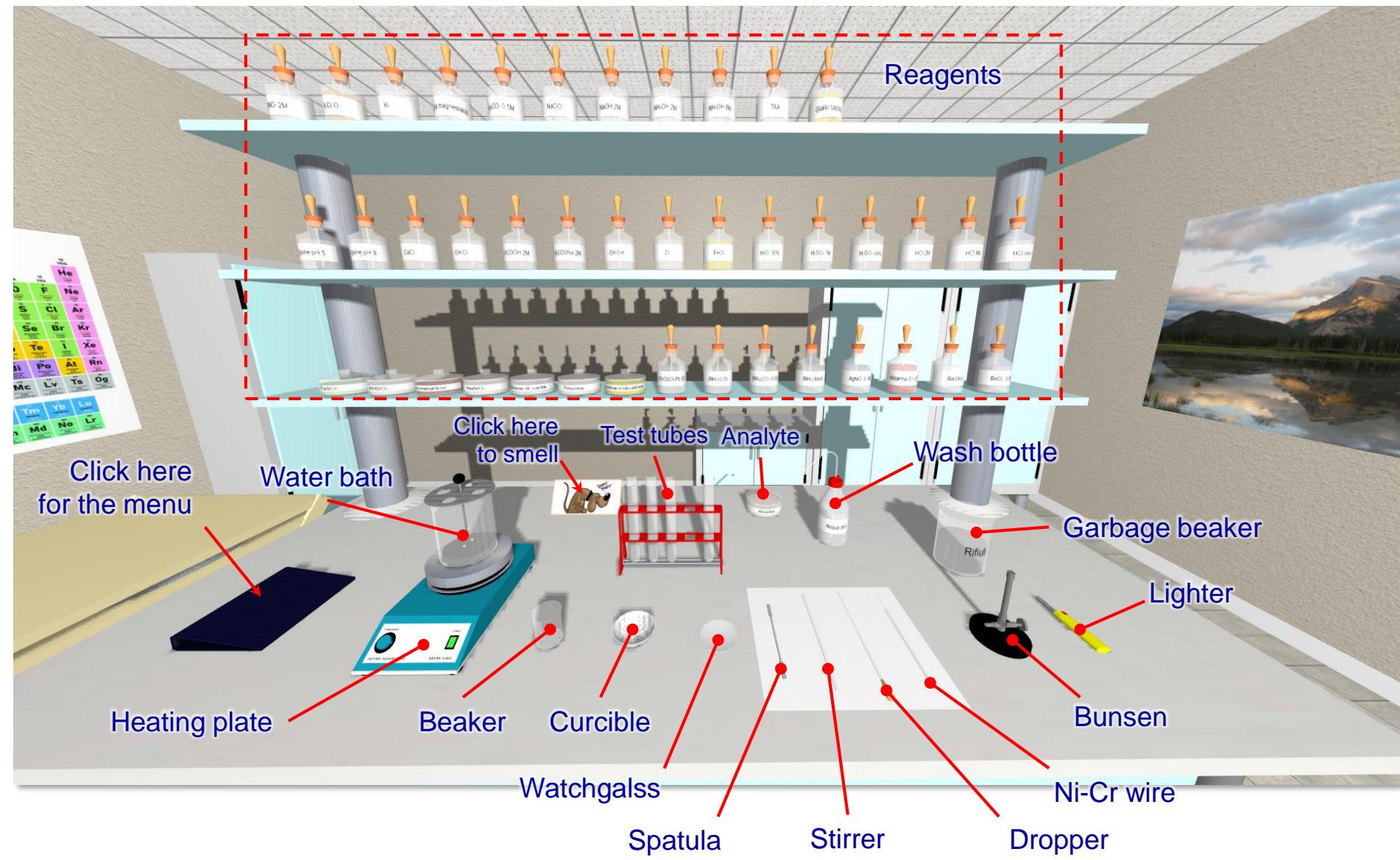


Input devices available only with **tablets** and **smartphones**:

- The **screen touch** (tap) is equivalent to a mouse click.
- The **accelerometer** rotates the scene.

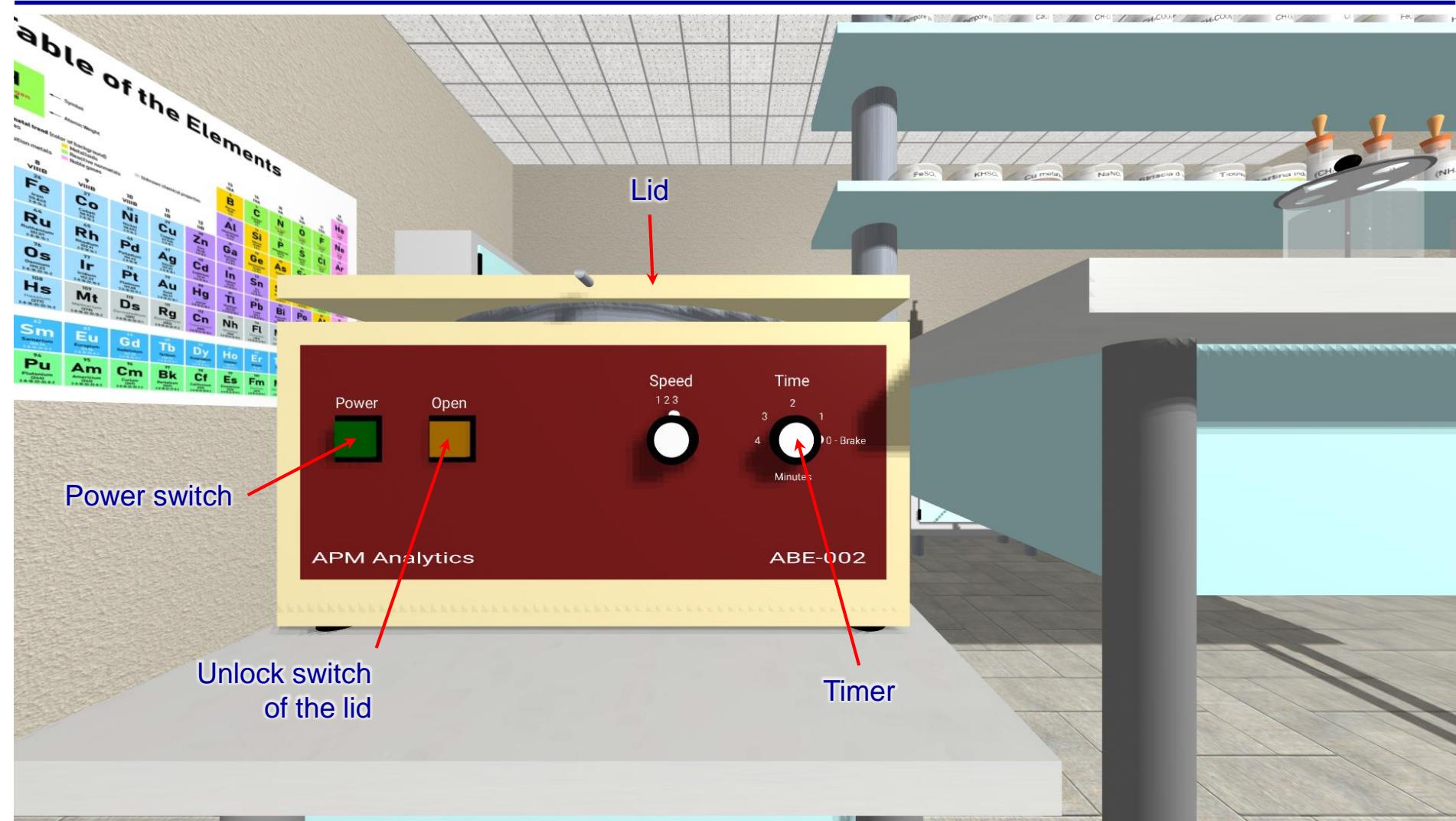


# The workbench





# The centrifuge



To perform a complete phase separation, at least 3 minutes are needed. Watch the video-tutorial for the right use.



# How to watch the video tutorials

When you click the TV, the video *playlist* is shown:

Click one of these  
buttons to play

Click here to  
turn off the TV

## List of the videos

- |   |  |
|---|--|
| 15. LS Riconoscimento $\text{PO}_4^{3-}$              | 16. LS Riconoscimento $\text{CH}_3\text{COO}^-$      |
| 17. LS Riconoscimento $\text{F}^-$                    | 18. LS Riconoscimento $\text{BO}_3^{3-}$             |
| 19. LS Riconoscimento I gruppo ( $\text{Ag}^+$ )      | 20. LS Riconoscimento II gruppo ( $\text{Hg}^{2+}$ ) |
| 21. LS Riconoscimento III gruppo ( $\text{Al}^{3+}$ ) | 22. LS Riconoscimento IV gruppo ( $\text{Zn}^{2+}$ ) |
| 23. LS Riconoscimento V gruppo ( $\text{Ca}^{2+}$ )   | 24. LS Riconoscimento VI gruppo ( $\text{NH}_4^+$ )  |
| 25. LS Riconoscimento VI gruppo ( $\text{Mg}^{2+}$ )  | 26. LS Riconoscimento VI gruppo ( $\text{Li}^+$ )    |
| 27. LS Riconoscimento VI gruppo ( $\text{K}^+$ )      | 28. LS Riconoscimento VI gruppo ( $\text{Na}^+$ )    |

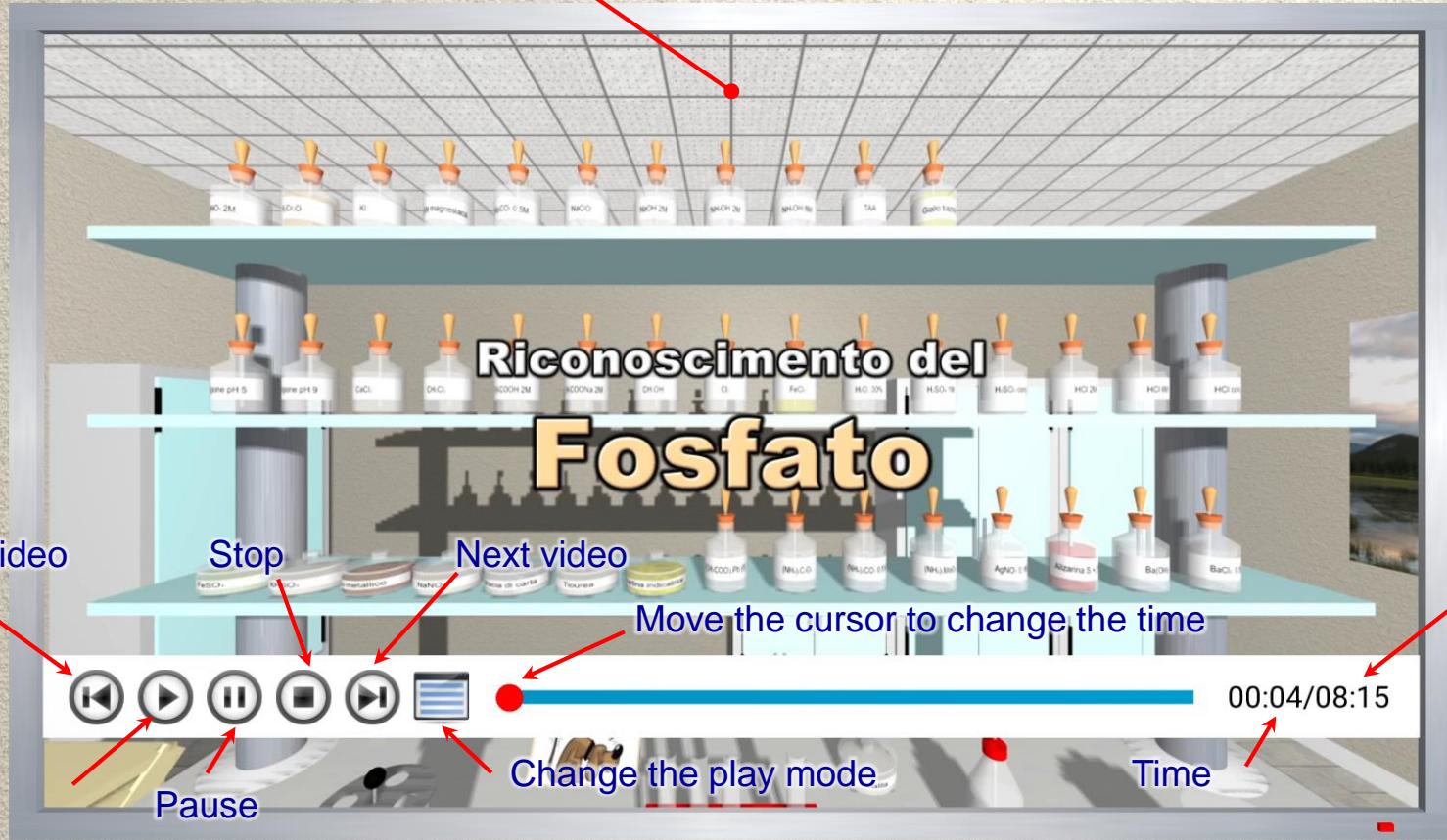


Previous page

Next page



# How to control the player



Clicking Stop, you return to the video playlist.



# Direct access to the videos

You can play the video tutorials outside *LabSim* just with this link:

*<https://nova.disfarm.unimi.it/labsim/video.htm>*

After the loading screen, the following menu is shown:

The screenshot shows a web browser window titled "LabSim Video" with the URL "localhost:8000/video.htm". The page has a light blue header with the text "List of the videos" on the left and the "LABSIM" logo on the right. Below the header is a grid of 14 video thumbnails, each with a blue rounded rectangle overlay containing a number and a brief description. The thumbnails are arranged in four rows of four. At the bottom of the page, there is a copyright notice and a small blue arrow icon.

1. LS Solubilità	2. LS Misura pH
3. LS Uso della centrifuga	4. LS Riconoscimento $\text{Cl}^-$
5. LS Riconoscimento $\text{Br}^-$	6. LS Riconoscimento $\text{I}^-$
7. LS Riconoscimento $\text{IO}_3^-$	8. LS Riconoscimento $\text{SO}_3^{2-}$
9. LS Riconoscimento $\text{S}_2\text{O}_3^{2-}$	10. LS Riconoscimento $\text{S}_2\text{O}_5^{2-}$
11. LS Riconoscimento $\text{SO}_4^{2-}$	12. LS Riconoscimento $\text{NO}_2^-$
13. LS Riconoscimento $\text{NO}_3^-$	14. LS Riconoscimento $\text{CO}_3^{2-}$ e $\text{HCO}_3^-$

This playlist works exactly as in *LabSim*.



# What you can watch

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Tutorials on the virtual lab (LS prefix):

- Base techniques (solubility, pH measurement, centrifuge use).
- Tests for the identifications of the anions.
- Tests for the identifications of the cations.
- Flame test.
- Analysis of water-insoluble molecules.
- Two examples of analysis of unknown molecules.

Tutorials on the real lab:

- Tests for the identifications of the anions.
- Tests for the identifications of the cations.
- Flame test.
- Analysis of some water-insoluble molecules.





# How to change the position

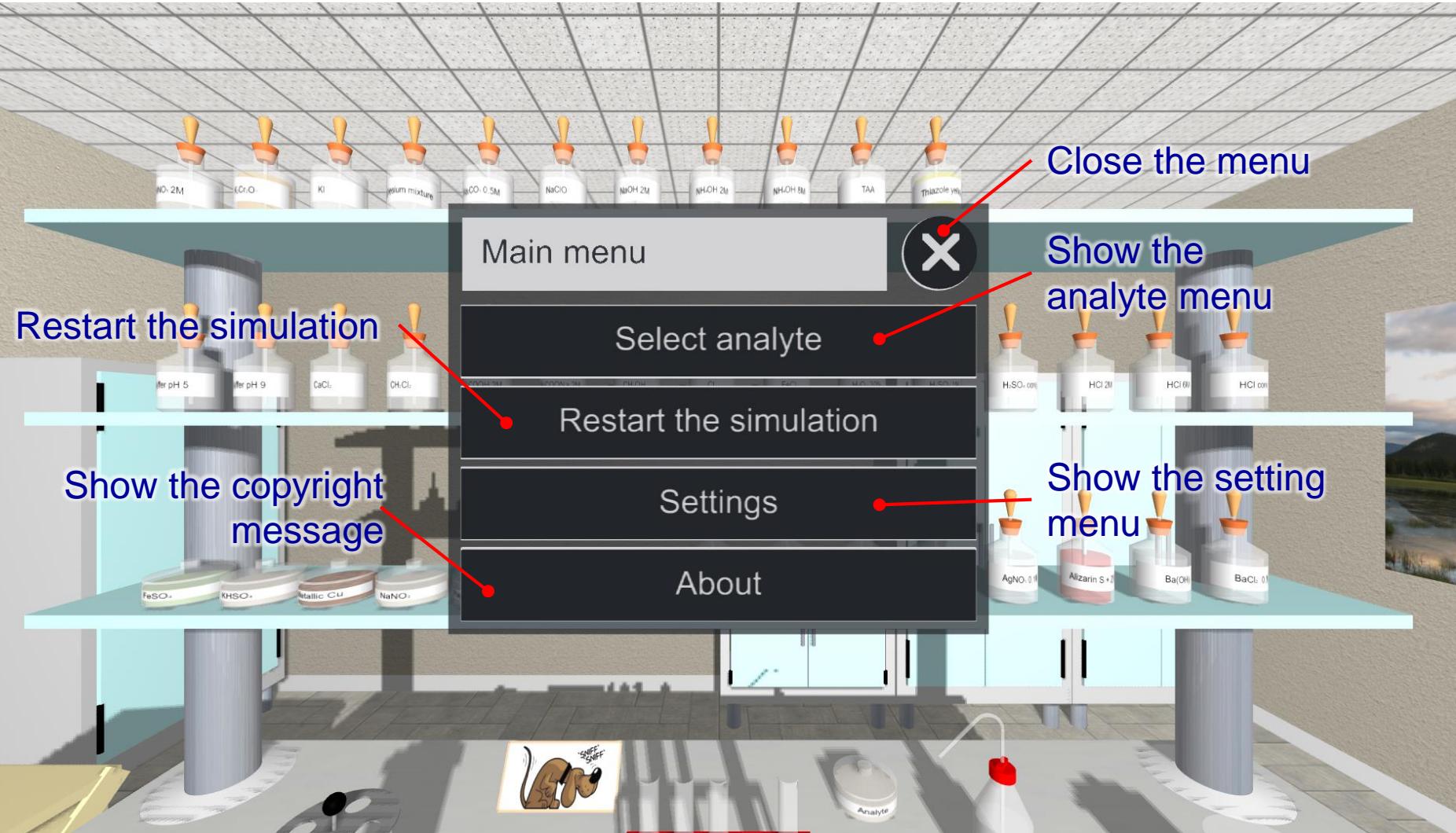
Clicking the footprints, you can change the work position.





# Main menu

To open it, you must click the book or press *m* key.





# Menu analita

In this menu, you can choose the analyte.

Back to the previous menu

Random selection of the analyte

Close the menu

Code	Random	Random soluble	Random insoluble	(CH <sub>3</sub> COO) <sub>2</sub> Ca	(CH <sub>3</sub> COO) <sub>2</sub> Mg
AgNO <sub>3</sub>	Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	AlCl <sub>3</sub>	CaCl <sub>2</sub>	CH <sub>3</sub> COOK	CH <sub>3</sub> COONa
H <sub>3</sub> BO <sub>3</sub>	HgCl <sub>2</sub>	K <sub>2</sub> CO <sub>3</sub>	K <sub>2</sub> HPO <sub>4</sub>	K <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	K <sub>2</sub> S <sub>2</sub> O <sub>5</sub>
K <sub>2</sub> SO <sub>3</sub>	K <sub>2</sub> SO <sub>4</sub>	KAlSO <sub>4</sub>	KBr	KCl	KH <sub>2</sub> PO <sub>4</sub>
KHCO <sub>3</sub>	KI	KIO <sub>3</sub>	KNO <sub>3</sub>	Li <sub>2</sub> CO <sub>3</sub>	MgCl <sub>2</sub>
MgSO <sub>4</sub>	Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	Na <sub>2</sub> CO <sub>3</sub>	Na <sub>2</sub> HPO <sub>4</sub>	Na <sub>2</sub> S <sub>2</sub> O <sub>3</sub>	Na <sub>2</sub> S <sub>2</sub> O <sub>5</sub>
Na <sub>2</sub> SO <sub>3</sub>	Na <sub>2</sub> SO <sub>4</sub>	NaBr	NaCl	NaF	NaH <sub>2</sub> PO <sub>4</sub>
NaHCO <sub>3</sub>	Nal	NaNO <sub>2</sub>	NH <sub>4</sub> Br	NH <sub>4</sub> Cl	NH <sub>4</sub> HCO <sub>3</sub>
ZnCl <sub>2</sub>	ZnSO <sub>4</sub>	(BiO) <sub>2</sub> CO <sub>3</sub>	Al(OH) <sub>3</sub>	AlPO <sub>4</sub>	BaSO <sub>4</sub>
Ca(OH) <sub>2</sub>	Ca <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub>	CaCO <sub>3</sub>	CaSO <sub>4</sub>	Mg(OH) <sub>2</sub>	MgCO <sub>3</sub>
TiO <sub>2</sub>	ZnO				

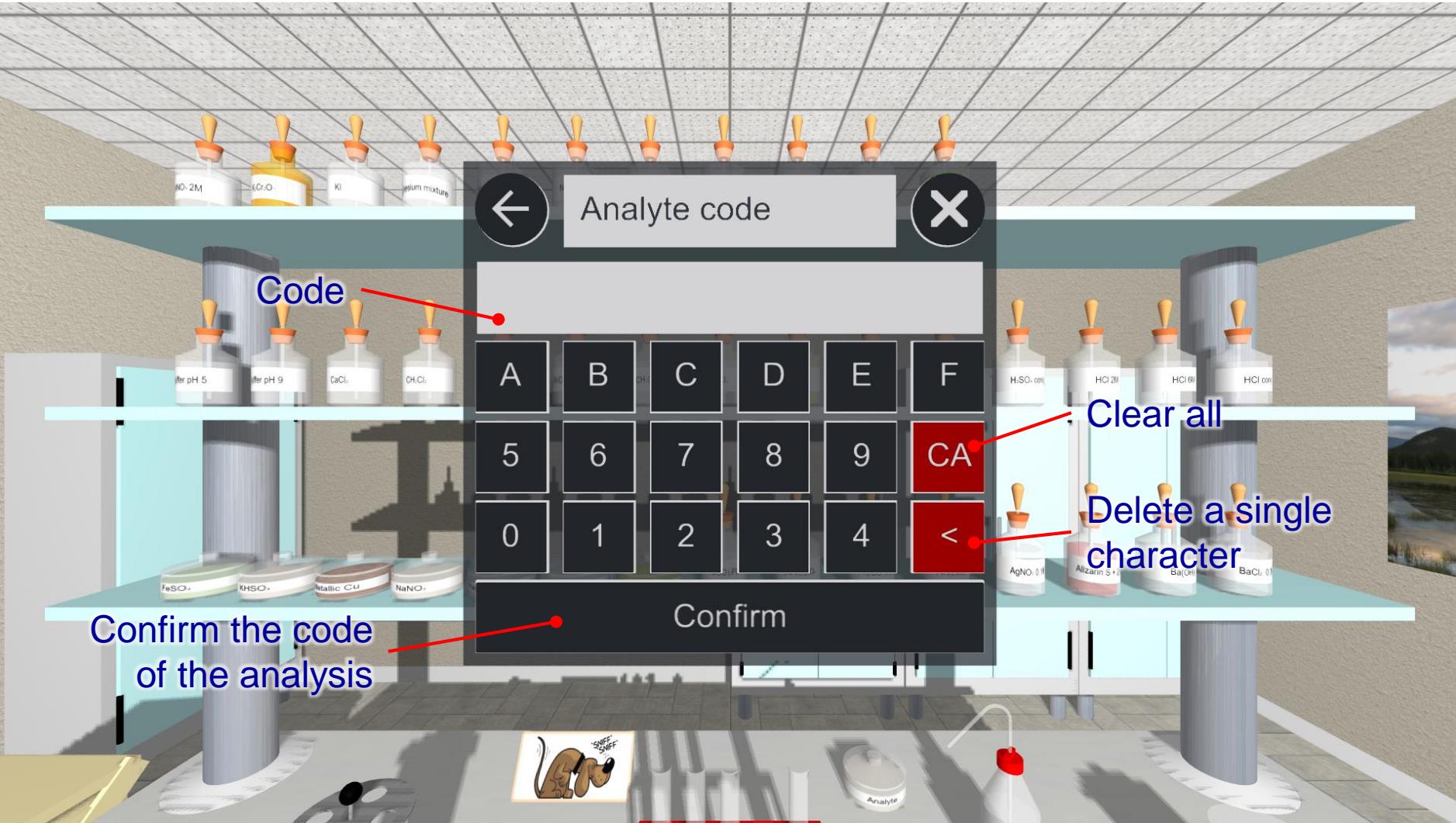
Water soluble

Water insoluble



# Code for the unknown analysis

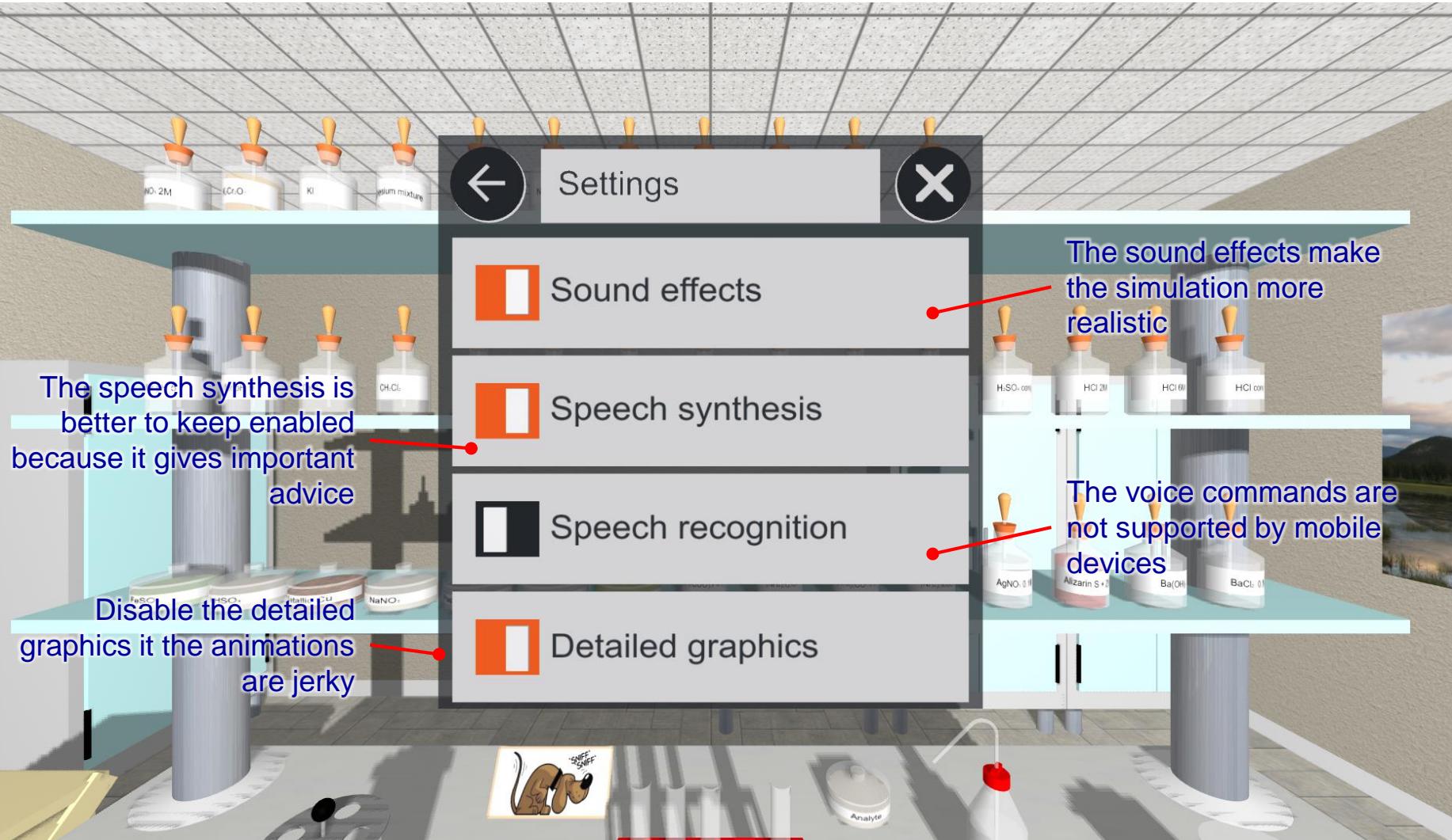
Clicking the keys, you can type the six-character code of the analysis.





# Settings menu

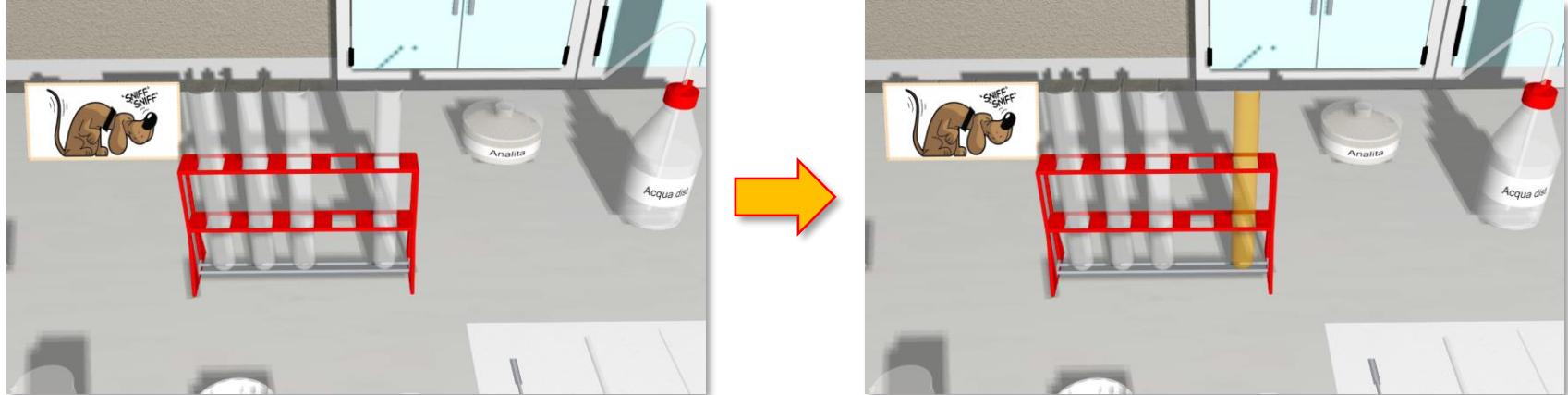
Here you can change some settings of the simulator.





# Interaction with the objects<sup>1</sup>

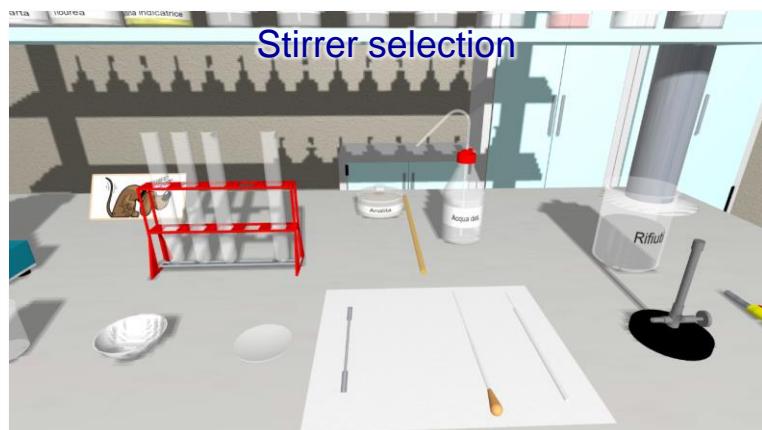
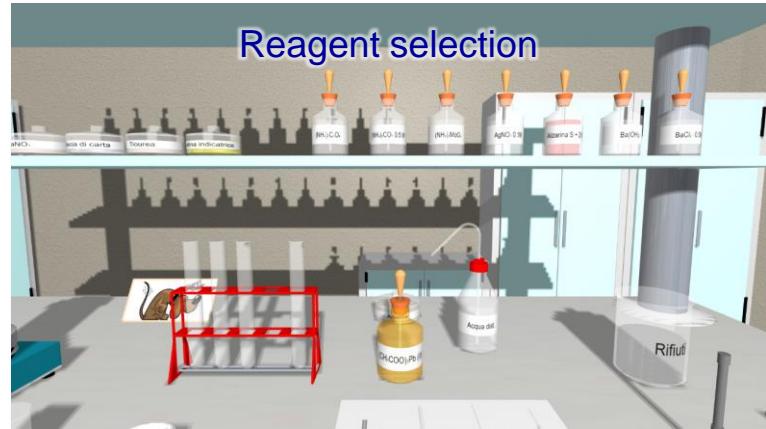
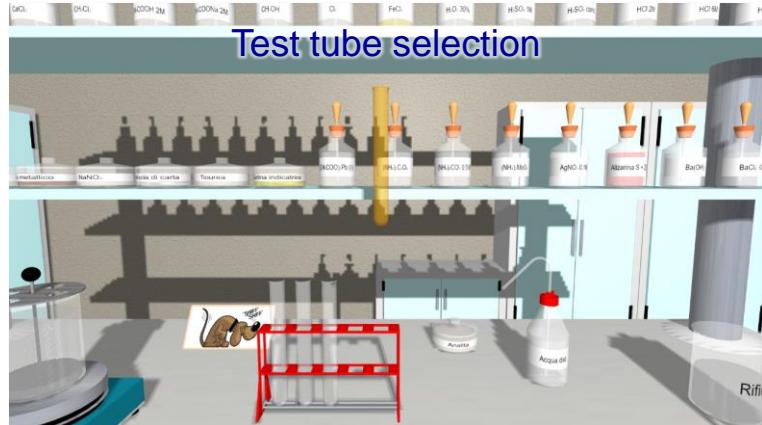
- The objects with which you can interact are highlighted on hover changing their color (**orange** or **red**) or **size** (like the book and the TV).



- You can interact with the objects only by **clicking with the mouse** or **touching the screen (tap)**.
- The **single click** (tap) selects the object or starts an action.
- In the case of the trash beaker, **double click** (double tap) empties automatically all glassware containing something. Several video tutorials show this useful action.

# Interaction with the objects<sup>2</sup>

- To use an object, it must be selected by a mouse click (tap). The selection is highlighted by lifting or moving of the object in the foreground (see reagents and analyte).





# Interaction with the objects<sup>3</sup>

The objects can interact each other through actions given by:

- Selecting the object 1 and clicking the object 2 (e.g. selection of the stirrer and click the test tube to stir the content).
- Selecting the object, selecting the liquid reagent and clicking the reagent dropper (e.g. Selection of the test tube, selection of HCl 2M and click the reagent dropper).
- Selecting the object, selecting the solid reagent or the analyte and clicking the spatula (e.g. selection of the test tube, selection of NaNO<sub>2</sub> and click the spatula).



## **WARNING:**

When an action is not permitted, the speech synthesis warn you and, if it is disabled, the action is just not completed without notice.



# The glassware<sup>1</sup>

The **glassware** is always dirty and needs to be rinsed with deionized water before the use. The simulator prevents the use of dirty glassware, avoiding the student from making mistakes in the analysis.

## Generic cleaning procedure:

- Click the **glassware to clean** (e.g. a test tube) which will be then selected.
- Click the **wash bottle**. Some water will be transferred to the glassware.
- Click the **trash beaker**. The glassware content will be emptied.

## Dropper cleaning procedure:

- Click an **empty test tube**. If you are not sure on its content, empty and wash it. The tube will be selected.
- Click the **wash bottle**. About 1 mL of water will be transferred to the tube.
- Click the **dropper** to select it.
- Click the **test tube with the water**. The dropper will suck up the tube content.





# The glassware<sup>2</sup>

- Click the **trash beaker**. The content will be released.

## Ni-Cr wire cleaning procedure:

1. Turn on the **bunsen** setting the flame as oxidizing.
2. Put some concentrated hydrochloric acid in a test tube.
3. Click the **Ni-Cr wire** selecting it.
4. Click the **test tube with HCl**. The wire will be soaked in HCl.
5. Click the **bunsen**. The wire will be placed into the flame.
6. Repeat the steps from 3 to 5 until the flame does not change more the color (usually this operation must be repeated 3 times).





# Transfer of substances

The simulator approximates the liquid and solid quantities according to the action and the size of the glassware on which you act:

Glassware	Liquid	Solid
Test tube	1 mL	One spatula tip
Beaker	5 mL	One spatula tip
Watch glass	1 mL	One spatula
Curcible	5 mL	One spatula
Paper	One drop	-

Therefore, if you want to add 2 mL of water to a test tube, you need to repeat the action twice because 1 mL is transferred at time.

There are some reactions in which the quantities play an important role for their occurrence as:

- **Borate test** (you must add methanol at least twice so that it is more than sulfuric acid and can ignite).
- **Nitrate test** (you must add  $\text{FeSO}_4$  at least twice so that the solution is enough concentrated to permit the formation of the brown ring).



# Chemical reactions

*LabSim* is based on a database of about 3700 reactions that can occur between:

- Analyte + one reagent
- Analyte + two reagents
- Two reagents
- Reaction product + one reagent
- Reagent product + two reagents



The physical aspects influencing the result of a reaction are:

- Heat given by:
  - water bath (e.g. phosphate test, tests with TAA, dichromate paper, etc.);
  - electric heater (e.g. calcination with con KHSO<sub>4</sub>).
- Time.



## **WARNING:**

In order to occur correctly a reaction, the solution must be homogeneous after the addition of each reagent stirring the mixture.



is a web application developed in 2020-2021  
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