EVALUATION OF ENGINEERING KNOWLEDGE THROUGH AN INTERACTIVE ESCAPE ROOM GAME

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Abstract

- Education as a concept includes every effort to train and develop people and their skills by applying the appropriate tools. One type of education is the formal, which includes a logically built and organized curriculum that is under the jurisdiction of state mechanisms.

- However, there is also a non-formal education which, unlike the formal one, refers to all organized educational programs that take place outside the institutional framework of formal education and are usually voluntary and short in duration.

- It is mainly addressed to adults and does not have to provide a document certifying education in this field. In this context, the present work, adopting the research methodology based on design, aims to develop and formulate a mobile augmented reality game in the form of escape room/s targeting to train engineers.

Aim of the paper

"Escape Rooms" is the name of an interesting trend of modern times that has flourished in the last decade in many countries around the world. These are puzzle and composition games, in which participants are asked to work together and solve problems using the information that exists in the room/s in order to unlock the door and escape.

The purpose of this paper is the evaluation of advanced students, through a series of high level and content of polytechnic questions, in the context of group collaborations that are formed during the coexistence of students in escape rooms, where an augmented reality is incorporated.

Finally, the aim of this work is the implementation and evaluation of one or more thematic escape rooms regarding the mobilization, satisfaction and involvement of polytechnic students in puzzles and problems that require significant engineering knowledge.

Methodology

- Compared to the traditional lecture, the "active learning" of an escape room will not only arise students' interest, but may offer a way out for further occupation beyond the escape game.

- Escape training rooms can be extremely effective in universities because of their ability to adapt to any subject. Some teachers have noticed that students' desire to learn has increased significantly, allowing many of them to thrive in this natural problem-solving environment, even those who do not normally interact in the classroom.

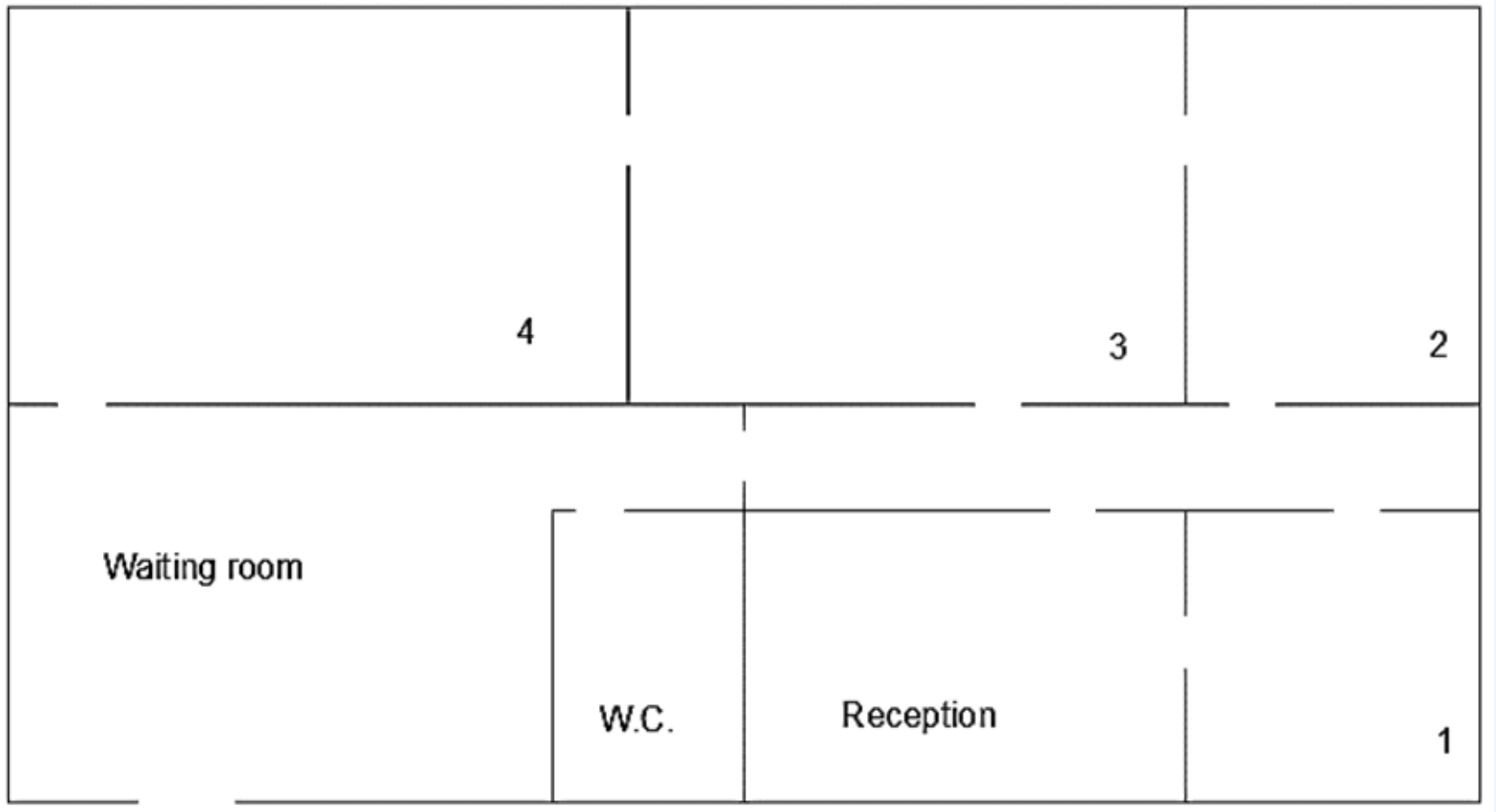
- From the beginning, the escape rooms manage to quickly charm the participants and make them work with their teammates in an effort to achieve their overall goal. In the classroom environment, students are more likely to retain the object material through active learning and apply what they have learned in different situations, rather than memorizing events

Rules of the game

Initially the group of students to be put to the test enters the reception area and after registration, through the inner door is guided in the first room. Following is the process of solving the 1st complex puzzle. After removing the difficulties presented and the correct answers, the team proceeds to the 2nd room. The entrance is achieved by unlocking the inner door between the first two rooms.

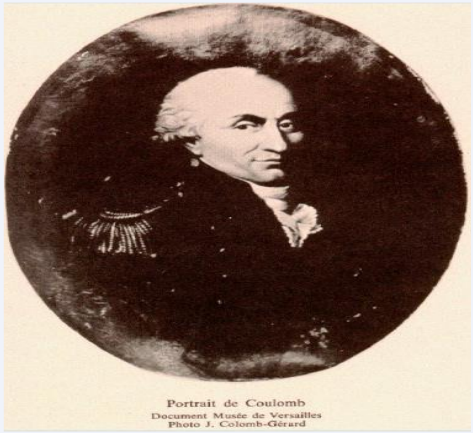
It should be noted that in each room there is an emergency exit that facilitates the escape in case a member of the team is not able to continue. The process proceeds for the total of four rooms but the puzzles and questions concerning engineering issues are considered to be of equivalent difficulty in each escape room. After solving the puzzles of the 4th room, the players are led to the terminal exit.

Rules of the game



Description of puzzles

Indicative game application for Engineers - Soil Mechanics Room



- Initially, the group of students - players is led by the teacher - game master in the 1st room where there is the appropriate logistics infrastructure. The group is invited to start the game, without any information available in advance. A number of possible applications to be used by the students are provided by the computer on the room desk.

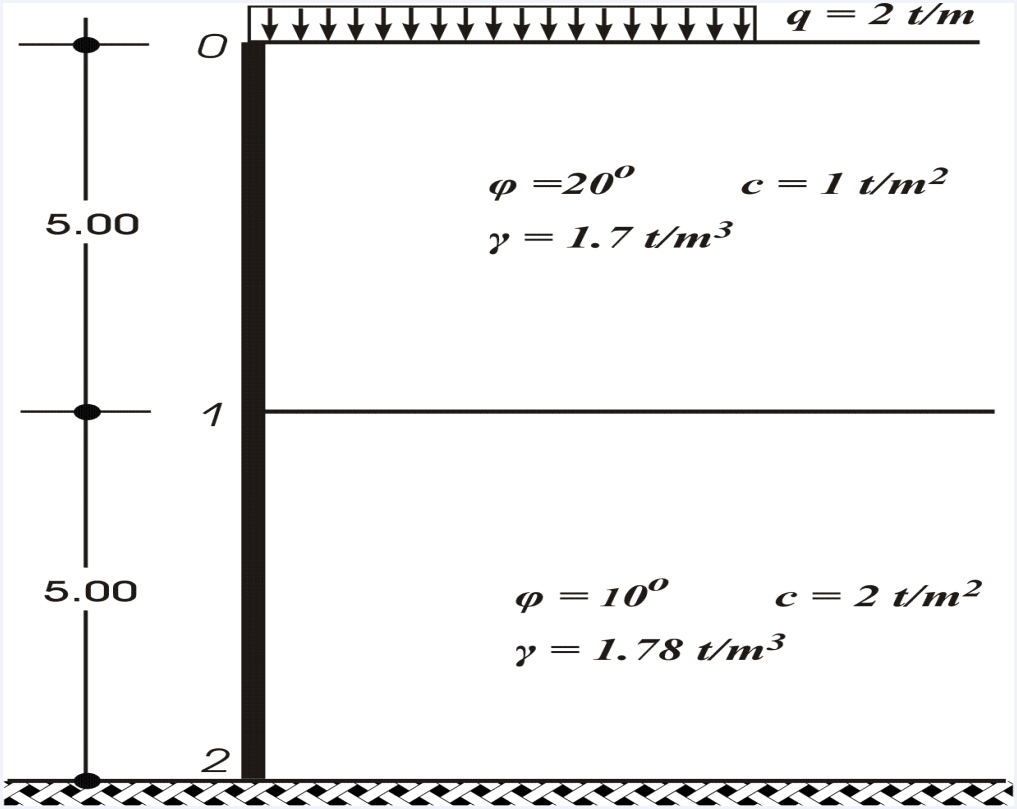
- To begin with, the students are provided with a manual describing the steps to be followed in order to solve the riddles and move on to the next room. This manual informs them that they must first select one of the two photos that are placed on a bench in the corner of the room. Relatively easily, students can distinguish in the portraits the famous French engineer Charles Augustin Coulomb as well as the Austrian engineer Karl Terzaghi who went down in history as the "Father of Soil Engineering".

Description of puzzles

Indicative game application for Engineers - Soil Mechanics Room

When they browse the 1st portrait an arrow shows them in the back the 2nd portrait and when they turn the 2nd an arrow shows them the only drawer of this room.

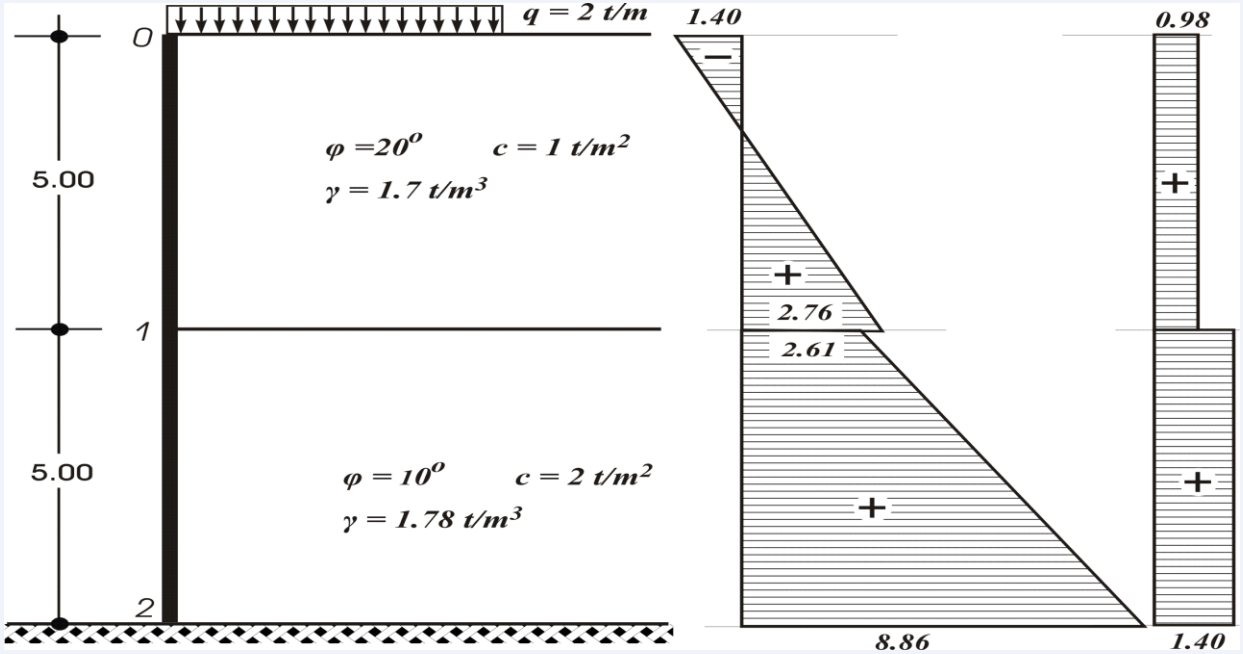
Of course they open the drawer, in which they find a page where the loading of a pile board with the required soil mechanical characteristics is illustrated. They are asked to calculate the diagrams of the thrusts that develop at the height of the structure that supports the soil.



Description of puzzles

Indicative game application for Engineers - Soil Mechanics Room

The next page says: "Show the correct solution to the computer". The students try each and every one of them to solve the issue of soil-mechanics and when they finish their thinking they formulate it in a notebook that they had with them before the start of the game. When they scan the solution on the multifunction machine next to the computer the monitor shows: "Correct answer, you can move on to the next room". At the same time, the inner door obviously unlocks and the students pass to the next room.



Description of puzzles

Indicative game application for Engineers – Statics' Room

Welcome to Static's room! Here you will need to use basic knowledge of Statics combined with Algebra. On the table of the room there is a piece of paper where a statically determinate beam is depicted.

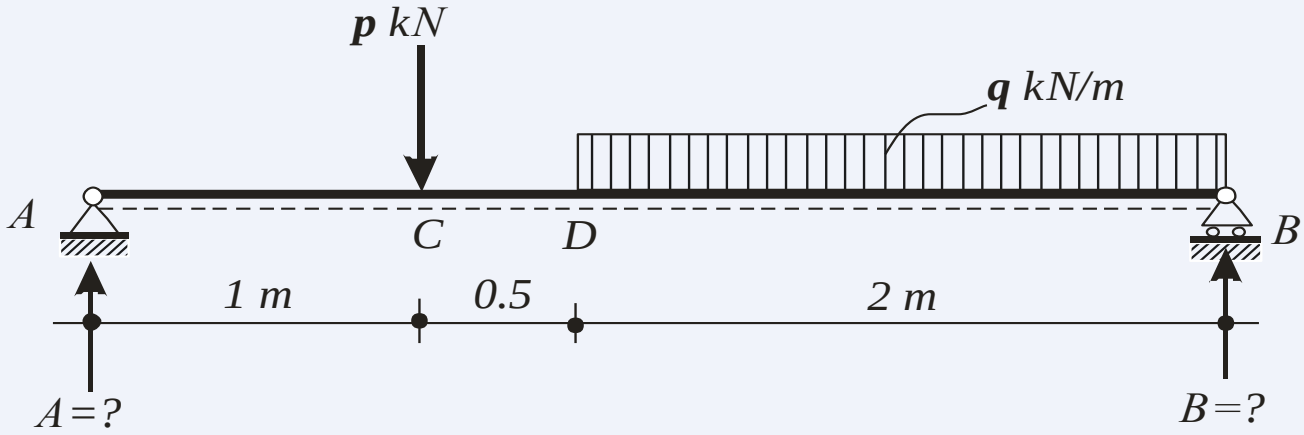


***Fig. a** Simply supported beam*

Caution! To calculate the reactions correctly you should use the correct values for the parameters p and q, i.e.:

p is 1/5 of the positive root of equation $x^2 - 5x - 24 = 0$ and

q is 1/5 of the number of members that exist in a statically determinate simply supported truss with 7 joints.

Description of puzzles

Indicative game application for Engineers – Statics' Room

Then, after locating the point where the shear force is zero, you have to calculate the maximum bending moment, which you will use as a key code to enter the next room! The correct answers that lead to the key value are shown in next Figure.

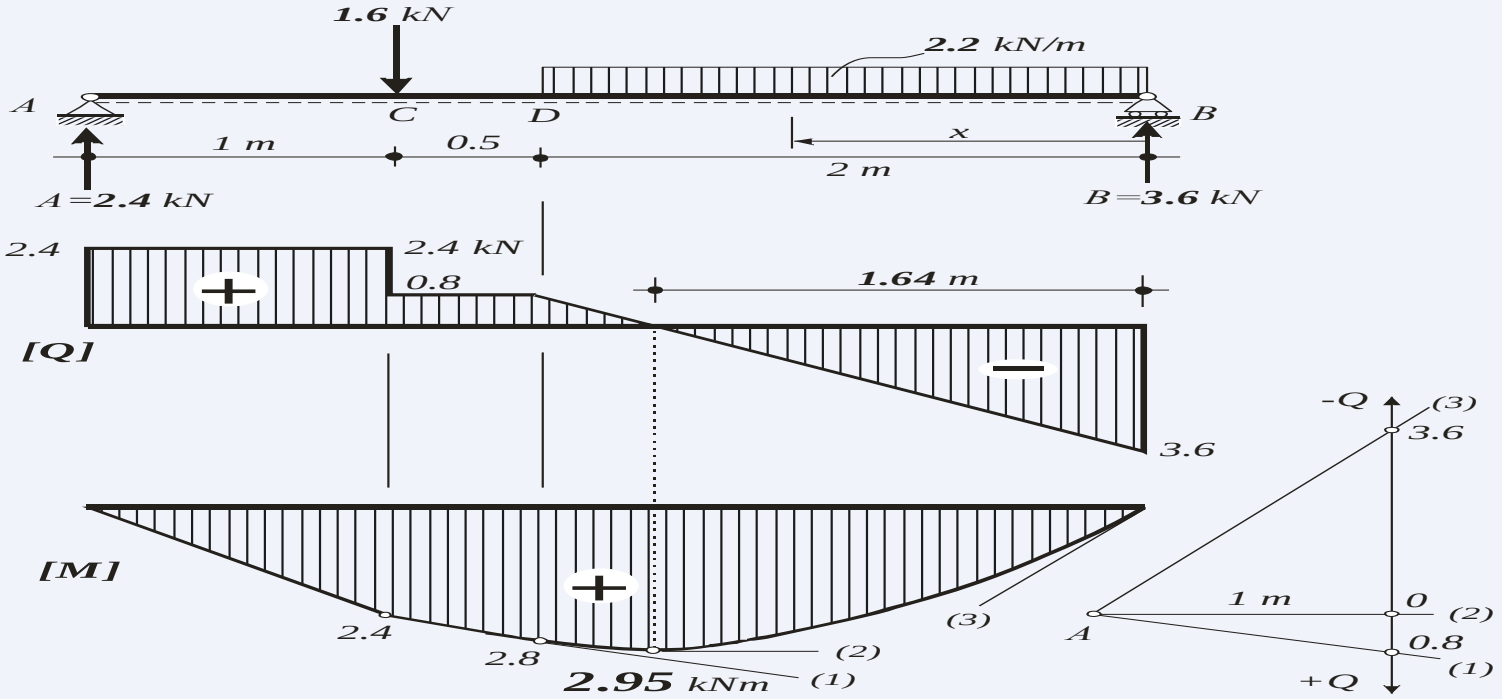


Fig. b Shear forces and Bending moments diagrams

Description of puzzles

Indicative game application for Engineers – Strength of materials' Room

Welcome to the Strength of materials' room! Making use of the maximum bending moment that was found in the previous room, you have to determine the dimensions of the beam's cross-section, applying the corresponding knowledge of Mechanics.

It is assumed that the material is steel, the cross-section is rectangle and the plane of bending contains the section's vertical axis of symmetry. Given are also:

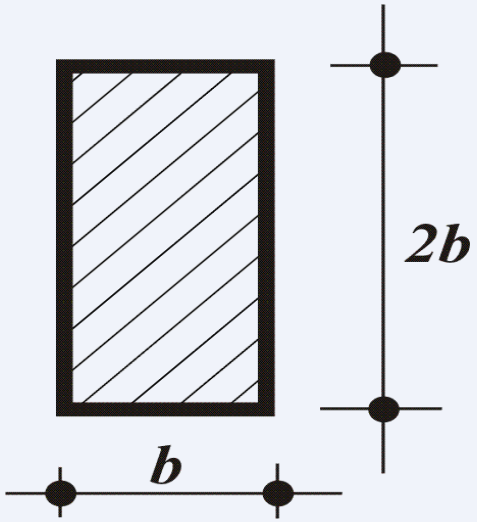
- the allowable stress for the steel, which, in bending is 160 MPa and in shear is 90 MPa
- the height of the cross-section is double its base.

The strength of the beam will be checked both in bending and shear.

The number of the cross-sectional height, expressed in mm, should be integer and will be the key code to enter the next room.

Description of puzzles

Indicative game application for Engineers – Strength of materials' Room



The strength of the beam will be checked both in bending and shear.

The number b of the cross-sectional base, expressing the minimum integer in mm, should be the key code to enter the next room.

The necessary cross-section's moment of resistance, W_{nec}, due to the height / base relation, is

$$W_{nec} = \frac{bh^2}{6} = \frac{2b^3}{3} .$$

Therefore the relation which expresses the bending strength control,

$$\sigma_{max} = \frac{M_{max}}{W_{nec}} \leq \sigma_{allow} ,$$

becomes

Description of puzzles

Indicative game application for Engineers – Strength of materials' Room

$$\frac{2b^3}{3} \geq \frac{M_{max}}{\sigma_{allow}} \quad \text{or}$$

$$b \geq \sqrt[3]{\frac{3 \cdot 2.95 \cdot 1000\ Nm}{2 \cdot 140 \cdot 10^6 \frac{N}{m^2}}} = 0.0302\ m\ .$$

The final choice is therefore **b** = 0.0302 m = **31 mm**.

The corresponding shear-strength stress-control,

$$\tau_{max} = \frac{1.5 \cdot Q_{max}}{A_{nec}} \leq \tau_{allow}\ ,$$

since $A_{nec} = 2b^2$, becomes

$$b^2 \geq \sqrt{\frac{1.5 \cdot Q_{max}}{2\tau_{allow}}} \quad \text{or}$$

$$b \geq \sqrt{\frac{0.75 \cdot 3.60 \cdot 1000\ N}{90 \cdot 10^6 \frac{N}{m^2}}} = 0.00548\ m\ .$$

The final choice is therefore b = 0.0302 m = 31 mm .

Description of puzzles

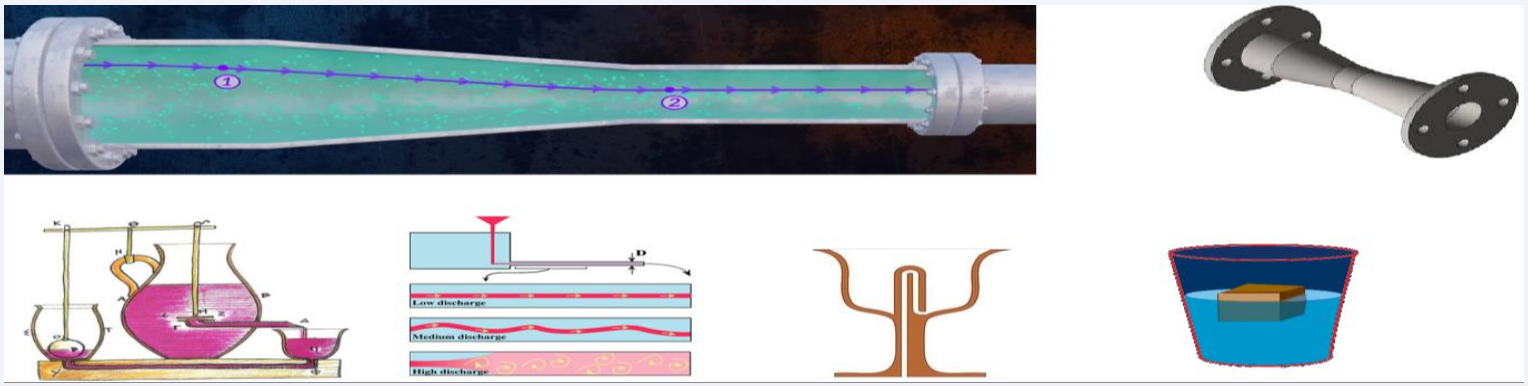
Indicative game application for Engineers – Fluid Mechanics' – Hydraulics Room

In the last room, the students are asked to solve a complex puzzle involving Fluid Mechanics' problems. As soon as they enter the room the students can see a tablet, a locked box and a faucet.

To unlock the box and see its contents, they must "match" names of scientists to their inventions on the tablet.

- The given names are: **Pythagoras, Heron, Archimedes, Bernoulli, Reynolds, Ventouri,**

followed by the images

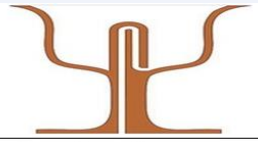


Description of puzzles

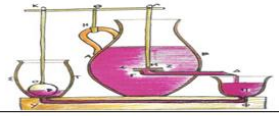
Indicative game application for Engineers – Fluid Mechanics' – Hydraulics Room

Following the correct matching of students

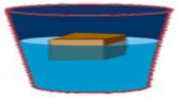
Pythagoras



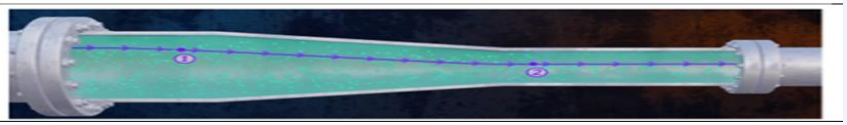
Heron



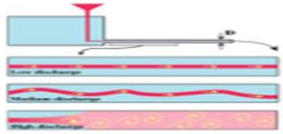
Archimedes



Bernoulli



Reynolds



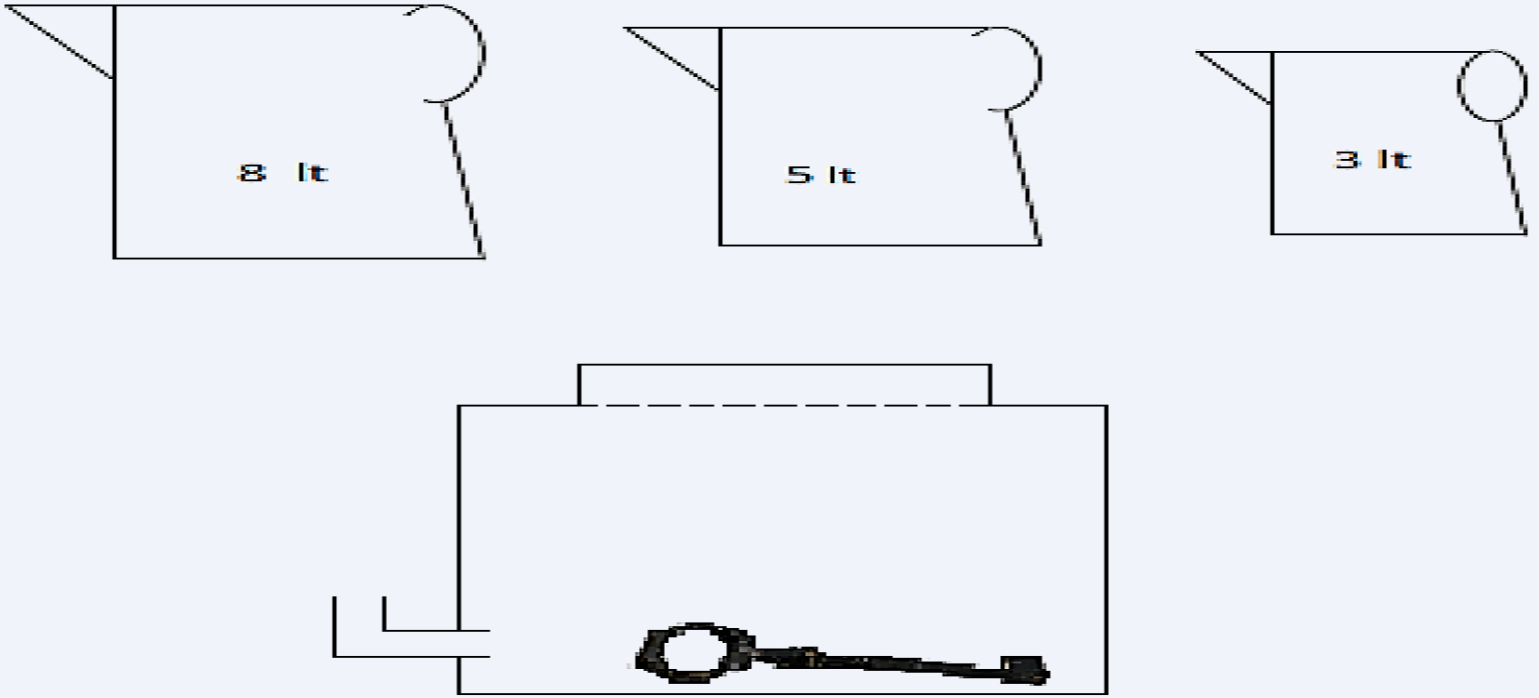
Ventouri

the box is automatically unlocked while the voice "EUREKA!!" is heard.

Description of puzzles

Indicative game application for Engineers – Fluid Mechanics' – Hydraulics Room

Inside the box there are 3 containers with a capacity of 8 lt, 3 lt and 5 lt together with a closed small tank of 4 lt, having a hole in its upper part. Both the containers and the tank do not have any indication for their water capacity. At the bottom of the small tank there is a key which unlocks the door leading to the exit.



Description of puzzles

Indicative game application for Engineers – Fluid Mechanics' – Hydraulics Room

In order to get the key, the students have to fill the tank with 4 lt of water so that the key goes up and out of the hole. They have to follow just one basic rule which is announced to them by the game expert at the entrance:

"The faucet can be used to fill, up to 2 times the 8 lt container. The transferring of water from one container to another takes place either until the first one is empty or until the second one is full. It is not allowed to use the water of 8 lt container to fill the tank".

To get the key, the students should follow the following steps:

1. Fill the 8 lt container.

2. Decant 5 out of the 8 lt into the medium container.

3. From the medium container of 5 lt, pour 3 lt into the small one.

The situation in this phase is 3 lt in the large container, 2 lt in the medium and 3 lt in the small one.

Description of puzzles

Indicative game application for Engineers – Fluid Mechanics' – Hydraulics Room

4. Completely empty the small container in the faucet sink and pour the 2 lt of the middle into the small container that is now empty.

5. Refill the large container for a second time.

At this stage we have 8 lt in the large container, 0 lt in the medium and 2 lt in the small one.

6. From the large container having 8 lt, fill the middle one with 5 lt.

7. Pour the necessary water to fill the small container (which already has 2 lt).

In this phase we have 3 lt in the large container, 4 lt in the medium (5–1) and 3 lt in the small one (2+1).

8. Pour all the water (4 lt) of middle container to fill the tank completely so that the key rises, thus enabling the escape and the end of the game.

Conclusions

- ✓ Through the escape rooms the student acquires the feeling of cooperation, teamwork, strategy, skill, problem solving and knowledge acquisition.
- ✓ In conclusion, the process of solving puzzles in an escape room is essentially a collaborative problem-solving process in which players exchange information, access different elements at the same time, use a variety of skills and knowledge due to the variety of puzzles found in the room. Escape rooms display characteristics that enhance learning teaching through problem solving.
- ✓ ……

Thank you for your attendance

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