Educational Games in Physics

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Introduction

Educational games are an illustration of the in-formal educational SCHOLA LUDUS approach in school education. The general basis of the SCHOLA LUDUS approach is [1]:

- complexity and complex approach to real physical experiments;
- parallel method of learning and teaching;
- authentic learning through play and active experimentation.

In order to prepare an educational game we specify basic requirements:

- theme, content of the game should be familiar to children's experience;
- questions asked in the game should be challenging;
- the game should enable the teacher to assess the actual state of pupils' knowledge;
- the game should alert both - students and teachers on discrepancies and misconceptions;
- playing the game should encourage cognitive progress.

The challenge and stimulus for learning is in SCHOLA LUDUS games realised by the key case. Parallel cases – each task or question is presented by several situations – awake similarities and differences and encourage generation of students' own ideas. The run of the game, the manner of questioning and looking for answers support development of cognitive skills (questioning, formulating hypothesis, verifying them, evaluate the observed phenomena).

Structure of the labyrinth-like game

One of the structures fulfilled above mentioned requirements is inspired by cross-country games. There are several stations in the play-area (e.g. schoolyard). Each station consists of a written question and several alternative answers. The player should choose the answer which she/he considers as the best. Alternative answers fit the most frequent of the pupils' alternative conceptions. The player is routed to next station according to her/his answer. In the case of the correct answer the player is routed closer towards the finish. In other cases the player is routed to a station with a simple verification experiment that helps to awake the pupils to the invalidity of their alternative conceptions (figure 1).

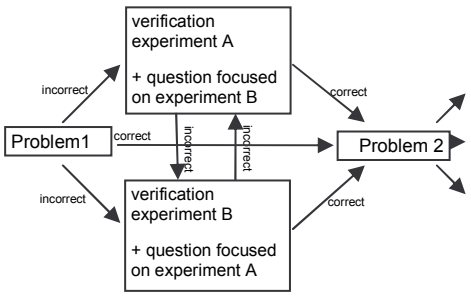


Figure 1: Structure of the labyrinth-like game

To play the game and complete it is not the end

Common discussion follows immediately after the play. All participants discus:

- nuances of alternative answers;
- arguments for choosing the best of alternatives;
- the meaning of presented experiments, with respect to the particular questions and answers;
- other possible experiments to verify particular hypothesis;
- particular conditions and their influence on presented phenomena.

"The Diver"

The game named "The Diver" is focused on mechanics of fluids at the secondary school level (pupils aged about 12 years). The aim of the game is to assess pupils' conceptions about pressure and pressure force, its' dependence on depth and density of liquid and independence on contact surface orientation. The context (diving) is attractive to children and allows us to capitalise on the pupils' spontaneous interest and common experience.
The game is intended to be played in a larger area such as schoolyard. Each player has a map of the stations as arranged in the yard. The player should choose one answer on each station (which he consider as most credible), continue to next station (in accordance with the chosen answer) and record the path from the beginning to the finish. Pupils play the game either individually (the teacher assesses the conceptions of each individual) or in teams (team members can discuss presented problems, with ample opportunity to develop communication skills, mutual learning is possible among team members).
Preparation of the stations takes approximately 30-40 minutes (according to the area). To play the complete game (from beginning to the finish) takes approximately 30-40 minutes. The best team can usually finish in about 15 minutes. Pupils who complete the game early should visit the originally skipped stations and do all the experiments.

References

[1] Teplanova, K.: Comenius SCHOLA LUDUS in the 21st Century, In: Proceedings of the International Seminar Inter-Academia, Bratislava: Comenius University 2002, ISBN: 80-968253-6-4, pp.61-70

APPENDIX – The Diver - assignment

Introduction

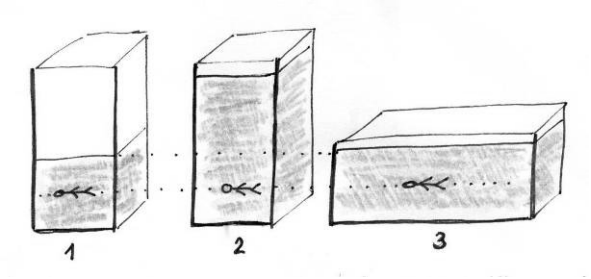
Novice diver, Adam Careful, has decided that he will prepare himself seriously before he dives into the unknown depths of the deep. He wants to know what awaits him there.

Instructions

Thirteen workstations are positioned in the "school yard". Each one has a question with alternative answers. Select the best answer
Go to the station indicated by that answer.
Keep a record of the sequence in which you visit the stations.
The beginning is at the station R.

Station R

The first situation, which Adam conceived:
Each aquarium, indicated by numbers, 1, 2, 3, contains a diver.

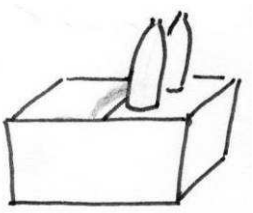


Which of Adam's hypotheses do you consider correct?

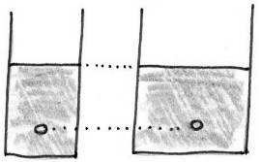
a) The divers feel the same pressure in each case. Go to B
b) Divers 1 and 3 feel the same pressure. Go to E
c) Divers 2 and 3 feel the same pressure. Go to Y

Station B

Experiment: Place the bottles on the platform. Note the water flowing out. (If there are more of you at the same time, put all the bottles on the platform. If there is only one person, he may investigate the bottles two by two.)



Question: Does the flow rate depend on the height of the hole from the bottom? Try the experiment!

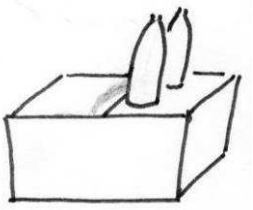


Question: Imagine situation as in the figure. At the beginning of the flow, is the flow rate of the two bottles equal?

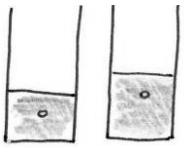
a) Yes (Go to E)
b) No. (Go to Y)

Station Y

Experiment: Place the bottles on the platform. Note the water flowing out. (If there are more of you at the same time, put all the bottles on the platform. If there is only one person, he/she may investigate the bottles two by two.)



Question: At the beginning of the flow, is the flow rate from the wider bottle larger? Try the experiment!

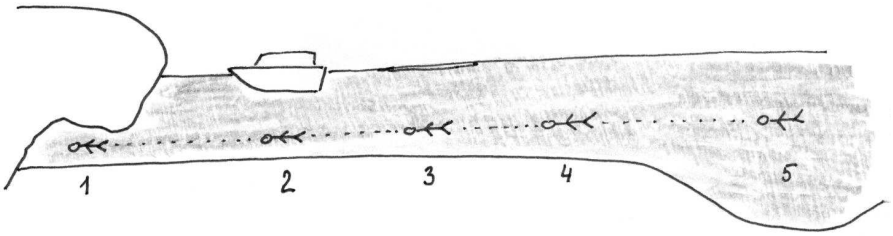


Question: Imagine situation as in the figure. At the beginning of the flow, is the flow rate of the two bottles equal?

a) Yes (Go to E)
b) No. (Go to B)

Station I

Adam would like to know what he can expect if during his underwater travels he gets himself under a stone overhang, a boat, or an oil slick.



Which one of Adam's hypotheses is correct?

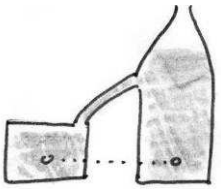
a) In positions 1, 2, 3 and 4 the diver feels the same pressure and in position 5, stronger pressure (Go to R)

b) In position 1 the diver feels the most pressure, and in positions 4, 5 the least pressure (Go to U)

c) In positions 4,5 the diver feels the most pressure, and in 1 the least pressure (go to S)

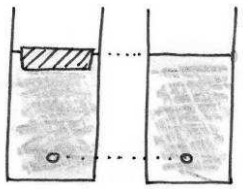
d) The diver feels the same pressure at all the positions. (Go to V)

Station S



Experiment: Place the arrangement of the bottles on the platform. Observe the outflow.

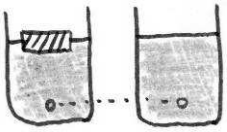
Question: Is the flow rate from the smaller vessel smaller (as long as the connecting tube is full of water)? Try the experiment!



Question: Imagine the situation as in the figure. At the beginning of the flow, is the flow rate of the two bottles equal?

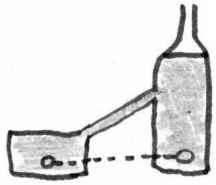
Yes. (Go to V)
No. (Go to U)

Station U



Experiment: Place the bottles on the platform. Observe the flow rate out of the bottles.

Question: At the beginning, is the flow rate the same for both containers? Try the experiment!

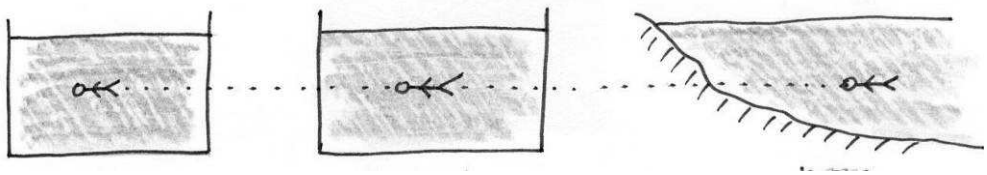


Question: Imagine the situation as in the figure. At the beginning of the flow, is the flow rate of the two bottles equal?

Yes. (Go to V)
No. (Go to S)

Station V

Adam would like to know what to expect when he dives in,
(1) the "Big Basin Swimming Pool" (filled with rather cold water),
(2) the "Hot Thermal Swimming Spot" (quite warm water),
(3) the pleasantly warm sea water.

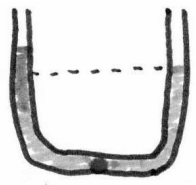


Which one of Adam's hypotheses is correct?

a) The diver will not register any difference except for the scenery. (Go to O)
b) The diver will feel the same pressure in cases 1 and 2, but less pressure than in case 3 (Go to P)
c) The diver feels the same pressure in cases 2 and 3, and less pressure in case 1. (Go to I)

Station O

Note: In the U-tube there is water and oil with a bead at their interface as shown in the figure. (Oil has a lower density than water). For the bead to be at the lowest position of the U-tube, the pressure from the waterside must equal the pressure from the oil side, and thus the level of the oil must be higher than the level of the water.



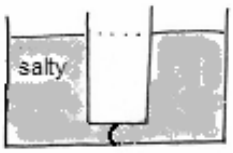
Question: Imagine that the U-tube is divided in the middle with an elastic membrane (e.g., a balloon). To one side we pour hot water, and to the other side we pour cold water so that their levels are equal. To which side will the elastic membrane bulge?

a) towards the cold water (Go to P)
b) towards the hot water (Go to I)

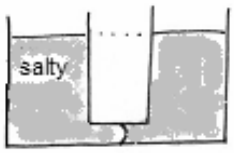
Station P

Experiment: Compare the mass of equal volumes of hot and cold water.

Question: Imagine the situation illustrated in the figure – two containers, (1) one for salty water and (2) one for pure water, are separated by a balloon-like membrane. The water levels are equal. Which figure best describes the resulting shape of the membrane?



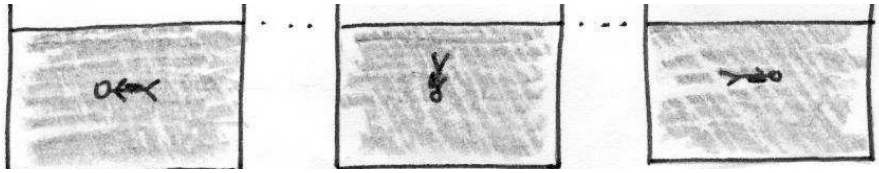
a) Go to I



b) Go to O

Station I

Adam would like to know what a diver feels when he makes a somersault in the water.



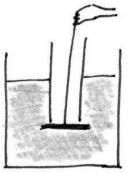
phase 1 phase 2 phase 3

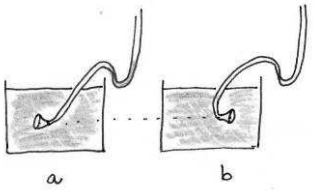
Which of Adam's hypotheses is the right one?

a) The diver feels the most pressure in phase 2 (Go to A)
b) The diver does not feel any pressure in phase 2 (go to T)
c) The diver feels the same pressure in all cases (Go to D)

Station A

Experiment: With the help of a thread pull a thin disk to be the bottom of a glass cylinder. Submerge the lower end of the cylinder without loosening the thread. What happens when you now let go?



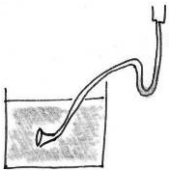


Question: Imagine the situation illustrated in the figures.
The thin end of a funnel is attached to a tube. The wide end of the funnel is closed-off with a balloon-like membrane. The tube is filled with water.
Is the water level in the tube the same when the orientation of the funnel goes from that in figure a) to that in figure b)?

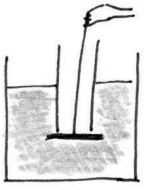
a) Yes (Go to D)
b) No (Go to T)

Station T

Experiment: Immerse the membrane end of the funnel into the water. Note the water level in the tube. Now rotate the mouth of the funnel without changing its depth. Does the water level in the tube change? What happens to the water column in the tube?



Question: Imagine the situation illustrated in the figures.
A thin metal disk is held by a thread to be the bottom of a glass cylinder. What happens when the thread is cut?



a) The disk falls to the bottom (Go to A)
b) The disk remains at cylinder (Go to D)

Station D

Congratulations! You managed the challenges of today's game.
Maybe you were lucky. Maybe you are persistent.

If this is exactly the fifth station that you are visiting (in the order **R°E V I D**) you have the thinking to dive into the deep depths of physics.
We wish you lots of luck and happiness searching for discoveries.