DENSITY OF MATERIALS IN FLOATING & SINKING PHENOMENA

TEACHERS' MANUAL

ADAPTED VERSION

MATERIALS SCIENCE PROJECT

UNIVERSITY-SCHOOL PARTNERSHIPS FOR THE DESIGN AND IMPLEMENTATION OF RESEARCH-BASED ICT-ENHANCED MODULES ON MATERIAL PROPERTIES

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DENSITY OF MATERIALS IN FLOATING & SINKING PHENOMENA

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1. THE STRUCTURE OF THE TRANSFER MODULE

The aim of the module is to teach pupils the concept of density with the help of floating and sinking. Density does not usually belong to the curriculum of primary schools in Finland but it can be taught with the physics and chemistry subtheme “Substances around us” or to teach making observations about materials around us. It also suits the cross-curricular themes “Technology and the individual” and “Safety and traffic”. See Finnish national core curriculum for basic education 2004.

The skill goals set for the module are:

- following the instructions of the worksheet
- making a hypothesis
- conducting a natural science experiment
- problem solving based on learned knowledge
- presenting the results
- making conclusions
- conversation using the correct concepts

FIRST LESSON: INTRODUCTION TO THE SUBJECT (45 MIN)

1. TEACHING OBJECTIVES FOR THE LESSON

- awaken interest into the subject
- connecting pupils’ own experiences of floating/sinking into the subject
- mapping the preconceptions of the pupils (what makes some objects float and some sink)

2. COURSE OF THE LESSON

The teacher begins the lesson by telling the pupils that: *In the next episode we familiarize ourselves with the phenomena floating and sinking and learn a new concept – density.*

The teacher continues with asking the pupils: *What do you think floating is? In what situations have you observed floating?*

After short discussion the teacher shows life-belts to the pupils and asks about experiences in using them: *How do life-belts work? Why do they float? What other life-saving aids a boat/ship has?*

The teacher leads the discussion to ships with the following questions:

- *Who has on occasion travelled on a ship?*
- *What important parts or objects there are in a ship?*
- *What different materials are the different parts of the ship made of?*

After short discussion the teacher tells the pupils the following: Soon we will see a series of pictures about the sinking of a Greek cruise ship at the Aegean Sea in April 2007. Does anyone remember the incident? The ship was built in Finland and it had sailed the Baltic Sea with its old name the Birka Princess.

The ship run aground April 5th 2007 in the Aegean Sea only a few minutes after it left Santorini. It was reported that there were over 1200 passengers and 390 crew members on board. Most of the passengers were from the United States and Germany. Apart from two missing French passengers all aboard the ship were evacuated. The ship sank in front of Santorini in the depth of approximately 140 meters early in the morning of April 6th 2007 approximately 15 hours after the ship had hit the rocks and started to leak.

According to the crew the rock was incorrectly marked to the nautical chart, according to the chart it was supposed to be 57 meters from shore but new mappings have shown that it is in fact lying 131 meters from the shore.

The teacher presents a multimedia-show about the sinking of the Sea Diamond.

After the presentation discussion can be encouraged with asking: *What other cruise ship singings do you know?*

After this the teacher will show two clips about the accident of Estonia that are available on the internet in the YLE Public broadcasting company's website. First TV-news around 6:30 and a report telling that the main reason for the accident was the failure of the bow visor around 2:20.

Pupils are encouraged to discuss the happenings and after short discussion the pupils are told to start working on Worksheet 1. Teacher moves around the classroom. The pupils' answers are checked together. The teacher will aim to find out which variables the students think that affect floating/sinking.

SECOND LESSON: DOES IT FLOAT OR SINK - EXPERIMENTS (90 MIN)

1. TEACHING OBJECTIVES FOR THE LESSON

- to learn which variables affect floating/sinking
- to learn how to use concept of DENSITY in explanations
- to learn that the nature of the liquid affects floating

2. COURSE OF THE LESSON

The lesson starts with recapping the previous lesson: *Why do some materials float and others do not?*

After short discussion the students are directed to working with worksheet 2. Before engaging with worksheet 2 the teacher and the pupils will go through the materials which are about to be examined: *Where do we get cork? What is polyurethane?*

The pupils do the experiments in the Worksheet 2 in pairs or in small groups. Materials available for the experiments include: *wood (two different-sized blocks), rubber, steel, cork and polyurethane foam. Also other materials are possible but only observations of the above-mentioned will be written down.*

The teacher will move around the classroom helping pupils. When the experimenting is finished, the pupils' answers will be checked together. Teacher will direct the discussion towards using the concept of density: *Is floating affected by only one variable, for example size, material and weight, or more together? Does the material have a property which tells us if it floats or not?*

The teacher will write on the blackboard:

- *If the density of the object is bigger than the density of water, it sinks.*
- *If the density of the object is smaller than the density of water, it floats.*

Possibly already in the discussion so far the problem of surface tension has arisen. The teacher will help pupils to discover that the floating of a flat metal plate is due to the surface tension and that is why it is a different thing than floating due to the density of the material.

Next the teacher will start directing the lesson towards a new topic: *A minute ago you did floating tests in the water, tell what other fluids you know. What fluids can be found at home?*

Teacher writes a list on the blackboard and asks: *What do you think; does the fluid affect the floating?*

After short discussion the teacher shows how the potato sinks in water but floats in saltwater.

The teacher asks students to move to the computers and go to the room "Test liquids" in the simulation-software. Teacher tells what mercury is and also asks about pupils' experiences and previous knowledge about mercury.

Pupils start working from task 2 of the Worksheet 3 with the help of the computer simulation. Teacher moves around the classroom and helps when needed. When it seems appropriate, the answers are checked together. The teacher will ask: *What do you think; why does the iron cube sink in water and oil, but floats in mercury?*

Teacher then writes on the blackboard:

- Iron has bigger density than oil and that is why the iron cube sinks in oil.
- Iron has smaller density than mercury and that is why the iron cube floats in mercury.

THIRD LESSON: THE DOT MODEL AS A REPRESENTATION OF DENSITY (90 MIN)

1. TEACHING OBJECTIVES FOR THE LESSON

- to learn that by weighing same-sized objects one can compare their density
- to learn how to use the dot model as a representation of density
- to learn that by shaping the material it is possible to make it float
- to learn that the overall density of the object affects its floating
- use the learned topic in hands-on application (salvaging of a model ship)

2. COURSE OF THE LESSON

The teacher starts the lesson with asking: *What variables affect floating? When the expected answer arises he continues with: Apart from the floating test, how else one could find out if one material has a higher density than the other?*

Teacher shows two cubes of the same size which are made of a different material: *What is the same in these cubes?* (Size.) *And how do we find out which has the bigger density?* (By weighing.)

The teacher instructs pupils to make the tasks 1, 2, 3 from the Worksheet 4 with a computer. Teacher walks around and looks at the pupils' achievements and gives permission to go forward to the next task.

When appropriate, teacher moves to the blackboard. Teacher draws seven cubes on the blackboard and asks the pupils in which order the materials they have weighed go to: *So what material is the lightest and what is the heaviest? Are all the cubes of the same size?*

Teacher shows the cubes again in his hands and asks: *From which of the materials in the task one can actually make a cube? The other cubes are imaginary cubes of the same size but possible on the computer.*

Teacher underlines the use of the concept density: *Because the cubes are of the same size but not of the same weight, they have also a different density. So it can be said that the former always floats in the latter.*

Teacher goes through the whole list of materials on the blackboard and says that oil floats in water, water in rubber etc.

Teacher directs discussion towards one model of density: *What do the dots tell about the material?*

Then the teacher will draw the right amount of dots in every cube of material on the blackboard: *What does it mean that one material has more dots than the other? What is the reason for floating or sinking?*

After this the teacher will write on the blackboard: *The more dots the material has, the bigger is its density.*

Next the teacher will move on to a demonstration where the model may be applied. The teacher makes an experiment where he drops a piece of rubber to the glycerol. Before the experiment he shows the rubber and asks: *How many dots does rubber have? How many dots does glycerol have?*

The teacher tells what glycerol is and then moves on to next demonstration. He does an experiment where he demonstrates the differences between the densities of different liquids. He pours glycerol, coloured water and vegetable oil into the glass. Then the teacher and pupils will observe how the fluids settle. The glycerol and water mix a little bit but the layers can be clearly seen. The phenomenon is made clearer when the teacher drops different objects into the glass. They will float in different layers.

After short discussion the teacher does one more demonstration. He sets a piece of glass in the water: *Does the glass have bigger density than water?*

Teach sets a water glass into the water: *Why does the water glass float even though the density of the glass is bigger?*

Discussion should follow.

Teacher then puts a cork in the mouth of a small glass bottle: *What different materials do we have here now?* (Glass, air and cork.) The teacher puts the bottle in water and states that: *The bottle floats in the water so the overall density of it is smaller than water's.*

Pupils are instructed to do tasks 5 and 6 of the Worksheet 5. After the experiments are finished the teacher asks: *How did you get the Blu-tack to float?*

Teacher shows the ship the visitors brought and asks what material the ship is made of. After this he initiates a discussion about why ships float.
Does iron have more density than water? Why does the ship float despite the fact? How do you get a ship to sink?

Teacher then demonstrates the sinking of the ship in a vessel. The teacher then instructs the pupils to start working on a problem-solving task: *Find out a way with which you can get the ship raised up from the bottom. You have in your disposal thread, balloons, styrofoam, cork etc.*

Pupils will then plan the salvage operation in pairs or small groups and then try it in practice taking turns.

B: EVALUATION TASKS

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1. RATIONALE

The implementation of the developed material differed from the original material in many ways and some topics such as understanding models were left out. The emphasis of the module was now on teaching the concept of density through floating and sinking. The questionnaire items and the worksheet exercises thus could be used to a) sketch pupils' explanations of floating and sinking in different stages and b) sketch the development of these ideas.

The data collected included a pre-questionnaire before the teaching period and a post-questionnaire after it with similar tasks. In the post-questionnaire there was one more task. Also the worksheets that the students worked on in the classroom were collected at the end of the teaching period. The last worksheet was left out of the analysis due to very little answers.

Emergence of students' ideas on:	Pre-questionnaire	Worksheet 1	Worksheet 2	Worksheet 3	Worksheet 4	Post-questionnaire
Motivation for floating/ sinking	1a, 1b, 1c, 1d	1a, 1b, 1c	1a, 1b, 1c, 5a, 5b, 5c, 5f, 5g, 5h	5a, 5h, 5i	6a, 6b, 6c, 6d	1a, 1b, 1c, 1d
DCV-method	3aa, 3ba, 3bb, 3bc, 3ca, 3cb, 3cc, 3d					3aa, 3ab, 3ba, 3bb, 3bc, 3bd, 3ca, 3cb, 3cc, 3d

2. QUESTIONNAIRE TASK ANALYSIS

Responses appearing in the table are from pre-questionnaire / post-questionnaire. The model answers are translations from pupils' answers in Finnish and some of them have been shortened or simplified.

TASK 1: FLOATING/SINKING – FLOATING/SINKING EXPLANATIONS

This pre- and post-questionnaire task examines the explanations that the students give concerning (a) floating (of the life buoy) and (b) sinking (of the anchor) phenomena.

	CATEGORY OF RESPONSE	TYPICAL STUDENT RESPONSE
1a	Causal relational reasoning (Desired Knowledge), Student compares object's density to liquid's density	"They contain a substance that is lighter than the water and they are meant to stop people from drowning." "(Because) the material is more heavy and dense than the water." / "Because they contain some substance which is not denser than water." "They are of a heavy material. And denser than water which is why they sink."
1b	Causal linear reasoning (Intuitive towards desired knowledge), Student refers to the material as a reason for floating or sinking or refers to the existence of air in the object	"Because they fill with air." "Iron sinks." / "Life vests are light and life vests are made to float so that they are of a floating material." "Because they are made of a material that floats."
1c	Causal linear reasoning (Intuitive towards Alternative), Student refers to the weight, volume, or the shape of the object	"Life-vests are light and they are made to float." "Because anchors are so heavy because they are made of iron." / No response for floating was coded 1c. "Because it is so heavy because the material is iron."
1d	Irrelevant answers	"I don't know how to explain." / "Not (air) tight."

TASK 2: ALTERNATIVE IDEAS ABOUT FLOATING/SINKING

This pre- and post-questionnaire task examines to which extent the students use causal relational or causal linear reasoning. Students should decide which factor to change in order that the plasticine ball floats.

	CATEGORY OF RESPONSE	TYPICAL STUDENT RESPONSE
3aa	Focusing on one variable (Desired Knowledge), Student changes only one relevant variable	"One has to make it hollow." / "I can make it float if I take plasticine off the object."
3ab	Focusing on two or more variables (Alternative view), Student changes two or more relevant variables simultaneously	No answers were coded 3ab in this task in the pre-questionnaire. / "It's possible. The plasticine has to be made into a boat where there are as high borders as possible and the boat also has to be light."
3d	Irrelevant answers	"No comment...." / "I have to place it on the water surface very gently."

TASK 3: ALTERNATIVE IDEAS ABOUT FLOATING/SINKING PHENOMENA – WEIGHT OR SIZE

This pre- and post-questionnaire task examines if the students have the alternative idea about floating and sinking that a big object will sink and a small will float. The 2nd icon gives the opportunity to the students to choose the swinging of an object as another situation except from the floating or sinking. It plays the role that the answer "I do not know" has in other tasks.

	CATEGORY OF RESPONSE	TYPICAL STUDENT RESPONSE
1a	Causal relational reasoning (Desired Knowledge), Student compares object's density to liquid's density	"The cubes are made of wood and wood floats because it is lighter than water." / "If the cubes are wooden they float, size doesn't matter as long as the material has less dots than water." "The density of the cube that Irene dropped is the same as the one that Kalle dropped despite of the size so it stays afloat."
1b	Causal linear reasoning (Intuitive towards desired knowledge), Student refers to the material as a reason for floating or sinking or refers to the existence of air in the object	"I would think that it would have to be 1 because the cube is made of the same material even though the other one is larger and thus they both have to float then." / "Size doesn't matter because only if the cubes were of different material could the result be different."
1c	Causal linear reasoning (Intuitive towards Alternative), Student refers to the weight, volume, or the shape of the object	"Because the cube is larger, it usually sinks unlike the smaller. It also depends on the material." / "A larger cube weights more, that's why it sinks."
1d	Irrelevant answers	"Because the water condenses in the vessel and it produces such a high pressure in the water that both of the cubes will stay afloat because the water is so densely in the vessel." "Because this choice floats." / "Size doesn't affect floating."

TASK 4: ALTERNATIVE IDEAS ABOUT FLOATING/SINKING PHENOMENA – WIDTH OF THE TANK

This pre- and post-questionnaire task examines if the students have the alternative idea about floating and sinking that the width of the vessel influences the phenomenon. The 3rd icon gives the opportunity to the students to choose the swinging of an object as another situation except from the floating or sinking. It plays the role that the answer "I do not know" has in other tasks.

	CATEGORY OF RESPONSE	TYPICAL STUDENT RESPONSE
1a	Causal relational reasoning (Desired Knowledge), Student compares object's density to liquid's density	No responses were coded 1a in the pre-questionnaire. / "Because it is not denser than water it will jump to the surface."
1b	Causal linear reasoning (Intuitive towards desired knowledge), Student refers to the material as a reason for floating or sinking or refers to the existence of air in the object	"If the cube floated in a large vessel then it will float in a smaller one as well because water and the cube are still made of the same materials." / "Because the size of the vessel doesn't matter to how a thing floats but it matters what material the things is (to determining) whether it floats or not floats."
1c	Causal linear reasoning (Intuitive towards Alternative), Student refers to the weight, volume, or the shape of the object	"Probably because they are so heavy." / No responses were coded 1c in the post-questionnaire.
1d	Irrelevant answers	"In a narrower vessel there is less space and the cube sinks but can also come back up to the surface." "Nothing happens except for that the room for floating becomes less." / "The size of the vessel doesn't affect floating."

TASKS 5 AND 6: CONTROL OF VARIABLES STRATEGY, CVS, SAME PROBLEM, A VARIABLE NEGOTIATED DURING THE IMPLEMENTATION

The task 5 in pre- and post-questionnaire and task 6 in post-questionnaire examine to which extent the students learn the control of variables strategy – same problem, a variable negotiated during the implementation. Students should describe (a) the procedure to control a variable and (b) the procedure to draw a conclusion taking under consideration the results of the experiment, in other words their observations).

	CATEGORY OF RESPONSE	TYPICAL STUDENT RESPONSE
3ba	Attempting two trials on the focal variable and observing (Desired Knowledge), Student makes two trials changing the focal variable, keeps all other variables constant, makes observations	"By trying out whether some particular object floats in different liquids or not." "I would take for example water and some thick liquid for example sour milk and try with the same equipment that would they float." / "I would find out which one is right so that I would put two bowls on the table. One with water and the other one with mercury. I would put a piece of iron to both bowls and see how it goes." "I would try to the same liquid with a rough and smooth object that whether it has effect on it."
3bb	Attempting two trials on the focal variable (Partially desired knowledge), Student makes two trials changing the focal variable, keeps all other variables constant	"First I will drop some small object into some bad quality liquid and then some exactly similar or the same object to a better quality liquid." / "I would take to same kind of cubes, a bowl of water and e.g. a bowl of oil. I would drop the other cube to water and the other to oil. I could also check the dots of the cube first and if the other would have fewer dots than water it would float." "I would try with some material e.g. wood whether the surface has effect on it or not."
3bc	Changing two variables simultaneously (Alternative view 1), Student controls two or more variables simultaneously including the focal variable, or do not change the focal variable changing other variable/es	"I would try putting cubes into different liquids and then I would see the answer." / "I would put cubes to different kinds of liquids and see what happens." "By putting e.g. one big, rough surfaced iron cube and a small and smooth surfaced cube into water and see what happens."
3bd	Confusing own expectations with evidence (Alternative view 2), Student refers his /her opinion instead of the process to control the variable	"Maria is right because naturally it depends on the object (and) what material it is made of. It is either heavy and sinks or if it is light, it will float." /"Yrjö. (One) should put glycerol in to a bowl and drop a piece of rubber into it. In glycerol it would float but not in water." "It doesn't affect it because it is the same material so either one doesn't sink."
3d	Irrelevant answers	"I would look it up in a book." / "I would put a cube or ball of the same weight to both." "No."

	CATEGORY OF RESPONSE	TYPICAL STUDENT RESPONSE
3ca	Using evidence to conclude (Desired Knowledge), Student makes comparison of the results of the experiment	"If the cube would have sunk or floated in all liquids, the liquid would not have an effect. If the cube would have sunk in some liquids and not-floated in some liquids, the liquid would have an effect on sinking/floating." / "If the cube would float/sink in all liquids, the liquid wouldn't have an effect on floating/sinking but otherwise it would affect." "Well, when I would drop a smooth surfaced object to the liquid and observe it for a while so that would it stay afloat or would it sink. I would do the same with a rough surfaced object."
3cb	Referring to the evidence (Rough view), Student mentions the evaluation of the results of the experiment	"I would come to the conclusion based on what I've seen and concluded myself." / "When I would see what happens." "One would have to see whether both cubes would stay on the surface or whether one would try to sink."
3cc	Confusing own expectations with evidence (Alternative view), Student mentions his / her conclusion or the procedure of control the variable instead of the procedure to conclude	"At first I would out into water a piece of wood that would be so heavy that it would sink. Then I would add plenty of salt to the water. Then the piece of wood would come up to the surface. The conclusion: The quality of the liquid can affect floating. For example: sea water makes things float better than water from a lake." / "Different objects float in different materials. If for example the liquid would be denser than the object, the object would float, but is the object would be denser than the liquid, it would sink." "Both pieces of rubber would sink because the roughness doesn't affect sinking."
3d	Irrelevant answers	"I don't know." "By testing." / "Because water and oil have different weights so in that way." "I would just think."

3. WORKSHEET TASK ANALYSIS

Responses given in the table are sometimes divided with "/" to signify answers to different questions in one task e.g. explanations for floating/explanations for sinking.

WORKSHEET 1: EXPLANATIONS FOR FLOATING AND SINKING

When the students engaged the first worksheet they had just seen motivational material to the module. They had not yet learned anything new about the subject yet. In the first exercises they color objects in a picture to signify either sinking or floating in water. Their explanations for sinking or floating are classified using the same coding key as with questionnaire items 1, 3 and 4.

	CATEGORY OF RESPONSE	TYPICAL STUDENT RESPONSE
1a	Causal relational reasoning (Desired Knowledge), Student compares object's density to liquid's density	"Life vests float because they have air in them and air is lighter than water." / "The ship will sink because it is made of iron which is heavier than water."
1b	Causal linear reasoning (Intuitive towards desired knowledge), Student refers to the material as a reason for floating or sinking or refers to the existence of air in the object	"The ladder will float if it is made of wood." / "Because they are made of a material that doesn't float."
1c	Causal linear reasoning (Intuitive towards Alternative), Student refers to the weight, volume, or the shape of the object	"The flags, lifeboat, barrel and lifeboat float because they are light and they have floating parts in them." / "Because they are made of a heavy material that weights a lot so they will sink."
1d	Irrelevant answers	No responses were coded 1d.

WORKSHEET 2: EXPLANATIONS FOR FLOATING AND SINKING, DRAWING CONCLUSIONS ABOUT FLOATING AND SINKING

In worksheet 2 there are two activities that have written answers that were classified. Task 3 includes explanations for the floating or sinking of objects that were used in practical work in tasks 1 and 2. In task 4 the pupils attempt to draw conclusions of their results. They are trying to create a model or rule for floating and sinking. These answers have been classified using a coding protocol that is based on the data and theory of usual alternative conceptions about floating and sinking.

	CATEGORY OF RESPONSE	TYPICAL STUDENT RESPONSE
1a	Causal relational reasoning (Desired Knowledge), Student compares object's density to liquid's density	"Weight affects (the phenomenon) so that if a thing weights more than water it will sink but if less, it will float." "If a materials density is smaller than waters, it will float."
1b	Causal linear reasoning (Intuitive towards desired knowledge), Student refers to the material as a reason for floating or sinking or refers to the existence of air in the object	"The weight didn't have an effect. The size didn't have an effect. The material has an effect."
1c	Causal linear reasoning (Intuitive towards Alternative), Student refers to the weight, volume, or the shape of the object	"A steel nut is heavy iron and it is (water tight/air tight)."
1d	Irrelevant answers	No responses were coded 1d.

	CATEGORY OF RESPONSE	TYPICAL STUDENT RESPONSE
5a	Desired knowledge, Student compares object's density to liquid's density	"If a material's density is smaller than water's it will float."
5b	Possibly not relational conclusions but has to do with density, Student understands that density affects f/s	"Dense sinks. Porous floats."
5c	Intuitive towards alternative: Weight, F/s is due to weight of the object	"Iron doesn't float, but wood floats, because wood is light and iron doesn't float because it is so heavy. Rubber doesn't float because it's dense but Styrofoam floats because it's light."
5d	Intuitive towards alternative: size, F/s is due to size of the object.	No responses were coded 5d.
5e	Intuitive towards alternative: shape, F/s depends on the shape of the object.	No responses were coded 5e.
5f	Intuitive towards alternative: air, F/s is due to air in the object	"When things are full of air, they float. It it's heavy and it hasn't got air, it sinks."
5g	Intuitive towards alternative: material, F/s is due to material of the object	"The material (affects sinking/floating). And also the weight."
5h	Unable to draw conclusions, lists observations, Student lists observations.	"Wood floats and metal doesn't."
5i	Student draws a simple conclusion, Student states that liquid has an effect on f/s.	No responses were coded 5i.

WORKSHEET 3: DRAWING CONCLUSIONS ABOUT FLOATING AND SINKING

In worksheet 3 the pupils are asked to work with the computer simulation and then to draw conclusions of their observations. These conclusions are classified according to the same coding protocol as in worksheet 2.

	CATEGORY OF RESPONSE	TYPICAL STUDENT RESPONSE
5a	Desired knowledge, Student compares object's density to liquid's density	"Iron is more dense than oil and in the mercury vessel the mercury is denser than iron."
5b	Possibly not relational conclusions but has to do with density, Student understands that density affects f/s	No responses were coded 5b.
5c	Intuitive towards alternative: Weight, F/s is due to weight of the object	No responses were coded 5c.
5d	Intuitive towards alternative: size, F/s is due to size of the object.	No responses were coded 5d.
5e	Intuitive towards alternative: shape, F/s depends on the shape of the object.	No responses were coded 5e.
5f	Intuitive towards alternative: air, F/s is due to air in the object	No responses were coded 5f
5g	Intuitive towards alternative: material, F/s is due to material of the object	No responses were coded 5g.
5h	Unable to draw conclusions, lists observations, Student lists observations.	"Mercury will keep a cube of iron on the surface and in oil it will sink."
5i	Student draws a simple conclusion, Student states that liquid has an effect on f/s.	"I can make such a conclusion that the quality of the liquid will affect floating."

WORKSHEET 4: A RULE FOR EXPLAINING FLOATING AND SINKING WITH A MODEL OF DENSITY

Task 5 in worksheet 4 asks the students to come up with a rule that allows them to explain floating with the help of dot model of density. These rules have been classified using a coding protocol that has arisen from the data

	CATEGORY OF RESPONSE	TYPICAL STUDENT RESPONSE
6a	Causal relational reasoning (Desired Knowledge)	"The density of water is 4 dots. So all substances that have their density more than 4 dots will sink and those which have fewer dots float. The more points, the denser the substance."
6b	F/s and density have a connection but the explanation is unclear	"The more dots, the better it sinks. The dots also tell how heavy the objects are."
6c	No real conclusion made, student states that dots mean density	"The more dots the denser the substance is!"
6d	A wrong conclusion made where the dot model is interpreted as a way of representing weight of the object	"The more dots, the better it sinks. The dots also tell how heavy the objects are."

4. QUESTIONNAIRES

QUESTIONNAIRE TASKS

Task 1

On a big ship, among others, you can find: life-buoy and anchor. Which of them do you think that float and which sink if we drop them on the sea? Justify your answer.

The life-buoy: ☐ floats ☐ sinks ☐ I do not know

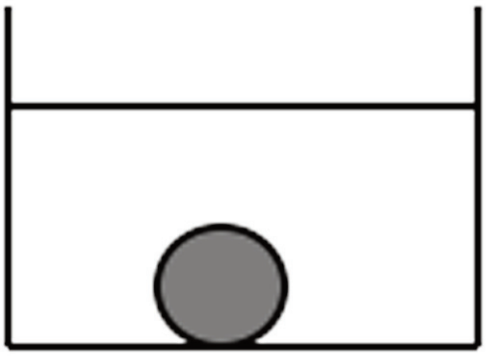
Why: .....

The anchor: ☐ floats ☐ sinks ☐ I do not know

Why: .....

Task 2

In the water vessel we see a sunken ball made of plasticine. Could you change a feature (factor) so that the ball floats? Describe which feature you would change and in which way.



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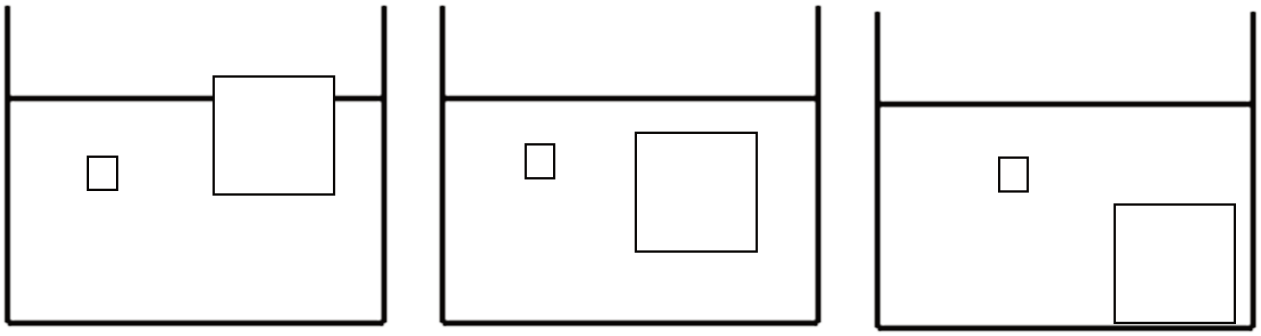
Task 3

Costas drops a small piece of a material in a vessel filled with water and he observes that it floats. Afterwards, Irene drops a big piece of the same material in the same vessel. In your opinion, where will the big piece stop moving? Check the number 1, 2 or 3 of the picture that you think it represents the final position of the two bodies that Costas and Irene dropped in the vessel.



1 2 3

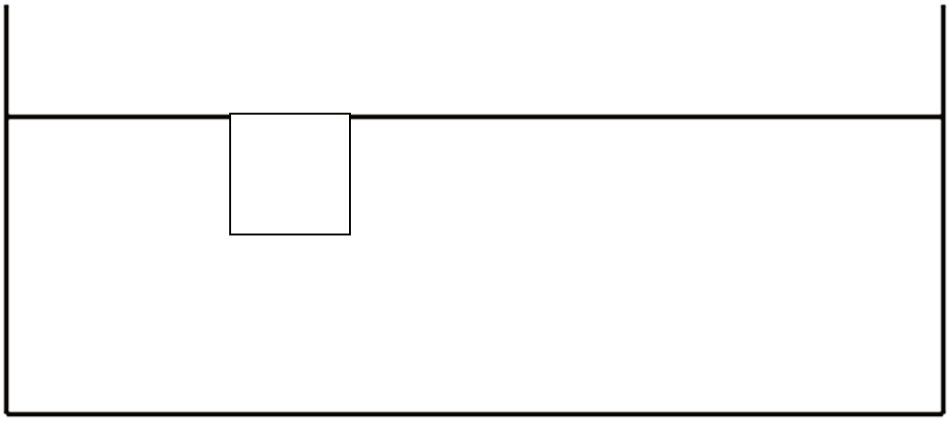
Justify your choice:

.....

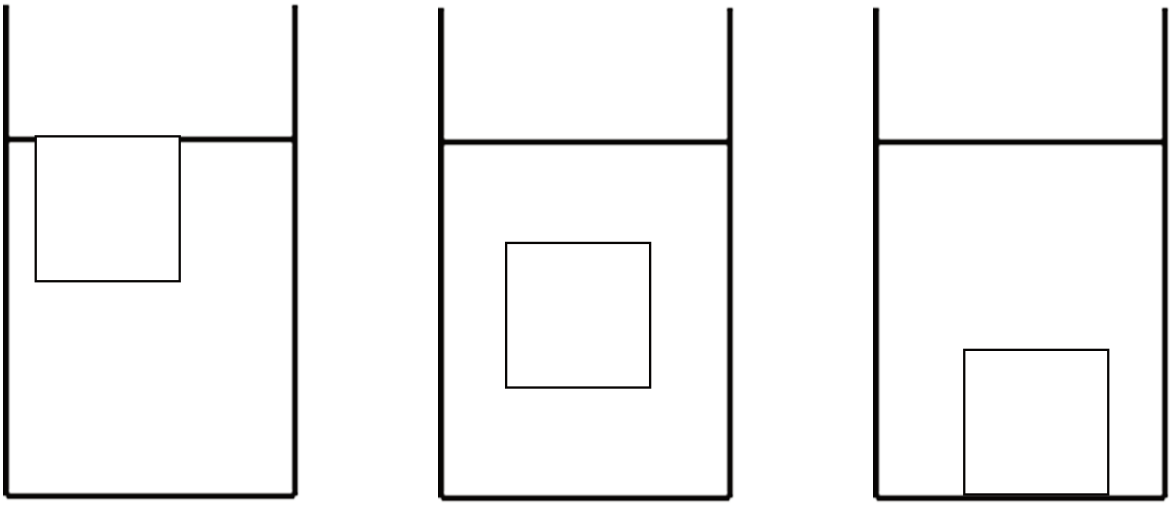
.....

Task 4

Costas dropped the cube in the liquid which is in the wide vessel shown below and the cube floats. Irene dropped the same cube in a narrow vessel, containing the same liquid. In your opinion, where will the cube stop moving in the narrow vessel? Check the number 1, 2 or 3 of the picture that you think it represents the final position of the cube that Irene dropped in the narrow vessel.



WIDE VESSEL



1 2 3

NARROW VESSEL

Justify your choice:

.....

.....

Task 5

George said that *«…the kind of the liquid in a vessel affects the floating or sinking of a body in this liquid…», whereas Maria said the opposite, that is «…the floating or sinking of a body in this liquid is independent of the kind of the liquid in the vessel…»*. If you want to find out which of the two students is right, what would you do to check their opinions.

If you were to make any of your above suggestions you would draw some conclusion. Describe how you would come to this conclusion.

Task 6

A group of children discuss about the factors that can influence the floating and sinking of an object in a liquid that was placed inside a vessel. Someone from them says that probably it is influenced by the kind of surface of the object: rough or smooth. This means whether the object has or not protrusions. Can you describe what you would do to check it?

If you realized the above proposals you would have come to a conclusion. Describe the steps that your thought would follow in order to reach a safe conclusion.

MATERIALS SCIENCE PROJECT

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