Research on students concepts using SCHOLA LUDUS tests

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Abstract

The paper presents SCHOLA LUDUS approach to testing pupils' and student's concepts in physics on the base of simple experiments. Testing is primarily treated not as an instrument for classification of knowledge but for finding out the state of pupils understanding as an effective instrument for further authentic learning and teaching. A series of tests with parallel cases is presented related to the key case of the inverted covered water glass. The particular tests stimulate students' thinking, support understanding of process development and of basic physical concepts. The tests were proved with a sample of 80 high-school students ages 15-17.

Introduction

SCHOLA LUDUS is a project focused on development of own alternative educational methodology, procedures and materials. The essential strategy of SCHOLA LUDUS is authentic learning. The strategy is based on playing with simple experiments while the final educational goal is to build up students' awareness of complexity [1]. In order to gain this goal, a series of special tests are being developed that should enable teachers to find out current pupils' conceptions. They also help students gain complex insight into the undergoing process, basic knowledge of physics and into science approaches in general.

1 Structure of SCHOLA LUDUS tests

Each SCHOLA LUDUS series contains 1. a *key case* – surprising attractive experiment/problem with two functions: to motivate students, and to determine the context of learning and teaching; 2. a test consisting of a set of parallel cases considered as a *generator of students ideas* with respect to different parameters of the problem; 3. tests consisting of sets of parallel cases supporting *understanding of the development of the whole process* with recognition of the respective phases of the process and finding out their physical boundaries [2]; 4. tests consisting of sets of parallel cases focused *to basic science concepts*, and a 5. *a top case* that is considered to be the end of the series in order to check the actual understanding of the problem after teaching and learning procedure and evaluate the knowledge shift and abilities of students to apply the gained knowledge to another challenging problems (usually a new key case that introduces additional physical concepts).

For parallel tests there are typical 1. always the same question for all considered parallel cases and 2. that after testing students are curious about correct answers and encouraged to investigate and search for their discoveries.

2 Example series

2.1 The key case

The sample series is represented by the following key case: *When a glass filled partially with water and covered with paper is turned upside down the cover remains on the glass also after the hand is put away.*

Students ideas obtained from this series relate to 1. the concepts of atmospheric and hydrostatic pressure and their changes with respect to open and closed system; 2. the equation of state for ideal gases; 3. the role of different forces and the state of its balance and unbalance; 4. The relation between force and pressure; 5. basic properties of fluids (density, viscosity, adhesion, surface tension) 6. non-linearity, 7. development of the system, 8. phases of the process and their boundary conditions.

2.2 The test for stimulation of students ideas

This test (Table 1) is used after a teacher's demonstration of the key case. The parallel cases are chosen in order to stimulate students to find out similarities and differences of the respective cases and propose appropriate new cases. At this key case the question relates a prediction of the system development: *Will the cover remain on the vessel?* Mutual comparisons of the respective students' answers enable teachers to deduce preconceptions and misconceptions: For examples: 1. in the last two cases we can conclude: The relatively high percentage of YES answers in the nearly full bottle is probably the consequence of usual school introduction of the case with a bottle full of water (e.g. no air inside), while the NO answer reflects the misconception: *The more water the larger the water pressure while the "lighter" air contribution is negligible.* 2. Comparing the percentage answers in the second and third cases they reflect controversial ideas: *"Gauze is full of the holes." "Wet glass is enough to glow the cover."* as

both cases relate the forces between molecules and surface phenomena, etc. And the tests could give also a side result: From 62 students who explained at least one answer, 23 used the term "pressure", and only three used the term "acting forces"!

Table 1 "W*ill the cover remain on the vessel? Explain."*					
	Glass, water, paper	glass, water, mull	vet glass, metal	bottle, water, paper	bottle, water, paper
yes / certain time	75 %	24 %	54 %	64 %	45 %
No	25 %	76 %	46 %	36 %	55 %

2.3 The test related to process development

In this test two questions were built up. The first relates to the same cases as are in Table 1 and is supposed as a starting point for students' ideas to understand the dynamics of the process development.: *The cover remains in all cases on the vessel.*[1] *What holds it there, the balance of forces, the unbalance of forces or something else?* For good understanding, students own experience with experiments and observations plays a significant role. Only then students could recognise small, sometimes permanent water flow out of the vessel and deformation of the shape of the paper or gauze cover. The second question of this test (Table 2) hints the student to different phases of the process. The students' answers showed evident absence of complex dynamic thinking. Only five students from 80 chose two of offered cases but with wrong time sequence. One student thought that in certain conditions all situations could be possible (without thinking about sequences. (Students, who chose the first case, explained this most often by push of hydrostatic pressure force. Students, who chose the second case added the force due to air outside the vessel but did not consider the air inside. Students, who chose the third case assumed vacuum inside the glass.)

2.4 The test related to basic physical concepts

This test is aimed to support students' understanding of air pressure and concepts of pressure in general (Table 3). The answers showed serious problems of students with the pressure concept. Only two students wrote that in all cases the pressure of closed air is the same and nine students thought that in first and second cases the air pressure is the same while in the third case it is a bit lower because *water flowed out.*

The test was completed by the question: *Is there any difference between the pressure and the pressure force? If yes, what is it?* 90% of students wrote that there is some difference. Some explained with one of the following: pressure is anywhere, but pressure force push; pressure is a consequence of pressure force; pressure force is a consequence of pressure; pressure acts in all directions, pressure force only in one; pressure and pressure force have different units.

Table 2 *"Which of the pictures are relevant to the case of glass covered by paper? Why?"*			
	20	50	18

Table 3 *"What is the pressure of air in the glasses? Explain."*			

2.5 The top case

As a top case of this series, questions: *What is the maximum of the water column at which the cover would yet remain on the glass?* could be used with the expected answer: *10 meter*, and *What would be the minimum amount of water?* with an expected answer: *A continuous layer between glass and cover in the state of balance.* Another possibility would be a new simple experiment. (An egg that gets into a bottle through a narrow opening when the temperature of air in the bottle will fall down or others). For advanced students the computer modelling [3] is recommended as the top case.

Conclusions

The number of students who assumed the influence of air inside the vessel during the work with these tests increased. Understanding of the difference between pressure and its forces became more clear after discussion over questions from Tables 2 and 3. Also a shift of originally static viewing towards a process was significant. Hence we can conclude that tests get teachers a relatively complex picture of students' views – not only what kind of phenomena they take (at least intuitively) into consideration but also in which way they understand them. And students get effective hints for their work and cognitive progress.

A new series of tests is being developed to cover basic physics. It is expected that teaching and learning by use of SCHOLA LUDUS parallel tests and authentic strategies could be a perspective way to find out students preconceptions and misconceptions and, on these bases, to support development of physical concepts and dynamic thinking relevant to the complexity of natural processes.

References

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[2] MARENCAKOVA, A.: Simple Experiments at Extreme Parameters. GIREP. Ostrava, 2004, pp. ...
[3] BIZNAROVA, V.: Simple Hands-on Experiments and the Computer Modeling for better understanding. GIREP. Ostrava, 2004, pp. ...

[1] Student already have got their own experience.