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DEVELOPMENT OF STUDENT EXPERIMENTAL SKILLS EXPLORING PHYSICAL PHENOMENA

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Abstract
In conditions of formal school education, students come across with physical experiments in the form of teacher demonstration experiment, students experiment and laboratory work. Experiments are carried out according to predetermined procedure, with specified teaching aids, according to pre-selected measuring methods. Our experience shows that students lack the necessary experimental skills for self investigation of physical phenomena.
Based on our four years experience with gifted students` activities we present the procedure for developing of student experimental skills. There are the basic stages of certain physical problem exploring described in details. The exploring procedure of experimental problems is presented with the help of Young Scientists Tournament problem, Air pocket. The described methodology with sample solutions of selected experimental problems can be used as an idea for school laboratory work. To successfully meet the challenges it is necessary to use video measurement, computer-aided measurement, high-speed camera clip and to work with digital data.

1. Introduction
In physics teaching the school physical experiment is used to illustrate and visualize, motivate, demonstrate, verify or investigate a physical phenomenon in order to understand the nature of it. In most cases the experiments are presented by a teacher or carried out by students according to a set of prearranged instructions. However, the limited time spent on experimentation in the class seems not to be adequate to develop the students´ experimental skills. The school physical experiment can be considered a problem, assignment or a challenge that lies ahead of the students. Facing and solving the experimental problem is a process that develops different useful skills.

2. Students´ experimental skills
In solving non-traditional experimental assignments we consider very important to go through the following steps in order to develop students´ experimental skills:
- reading, undestanding and redefinition of the problem,
- prediction of physical factors affecting the process,
- understanding of essential theoretical background
- creation of experimentally verifiable hypotheses,
- design of verification apparatus,
- pilot demonstration and measurement,
- qualitative analysis of measured data,
- appropriate measuring method determination,
- design and setup of measuring apparatus,
- data collection, their processing and evaluation,
- comparison of experimental and theoretical data,
- upgraded design and setup of new improved apparatus,
- collection, processing and evaluation of more-accurate experimental data,
- confirmation of hypotheses and final conclusion of the measurement results.

Students following this procedure should work in groups of 2-3 students having appropriate technical background. To successfully meet the challenges it is inevitable to use up-to–date technologies that help in precise data gathering and processing. The technologies mostly used in the described experimental procedure include video measurement, computer-aided measurement, high-speed camera clip and digital data processing.
During the problem solving teacher acts as an advisor or consultant who gives advice and helps students to achieve the goal. The exploring procedure of experimental problems solving is presented in example of the Young Scientists Tournament problem, Air pocket.

3. Example of the experimental procedure in solving of the Air pocket problem

A vertical air jet from a straw produces a cavity on a water surface. What parameters determine the volume and depth of the cavity?

Reading, understanding and redefinition of the problem

vertical air jet:

- only vertically oriented flow, flow with constant velocity, laminar flow, air flow,

straw:

- straight tube, circular cross-section, diameter much smaller than length,

cavity:

- each deformation of the horizontal water surface,

Prediction of physical factors affecting the process

- speed of the flow, diameter of the straw, straw distance from the water surface.

Understanding of essential theoretical background

Why is the cavity created by air flow?

- the water surface changes the momentum of the air flow,
- the force is needed for momentum change,
- the force deforms the water surface,
- hydrostatic pressure increases with increasing depth,
- the balance occurs in the certain depth,
- the cavity shape is determined by the forces´ balance across the air flow.

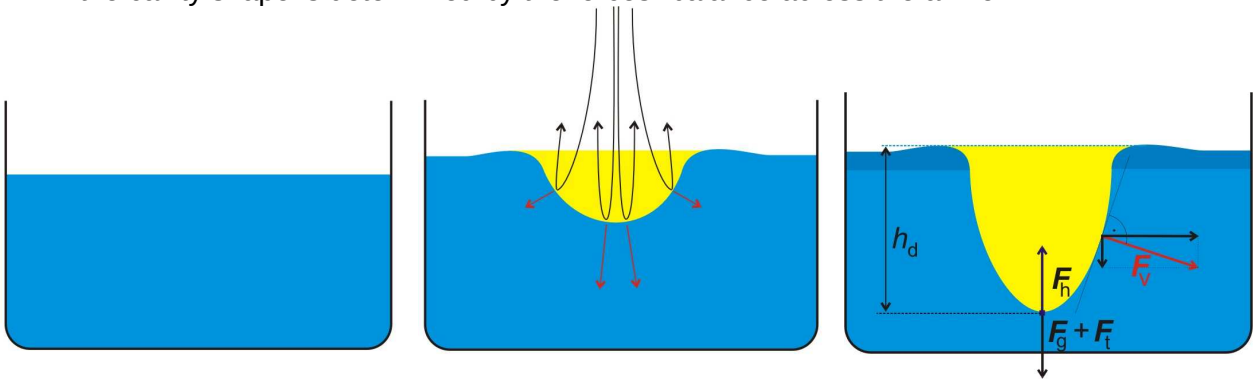

Fig.1a,b,c: The cavity creation.

Design of verification apparatus

The verification apparatus consists of adjustable source of air flow, stand, set of various straws and water tank. For each straw we made the calibration of air flow speed corresponding to levels indicated on source. The ruler was used to determine the scale on the photography for video-analysis.

Fig.2: Verification apparatus and set of straws.

Data collection, their processing and evaluation

We used five different straws. Five various air flow passes through each straw. The each straw was placed by their opening into five rather distances from water surface. After cavity stabilization we have made series of photographs. We selected the best picture for analysis. Video tracker software was used for analysis.

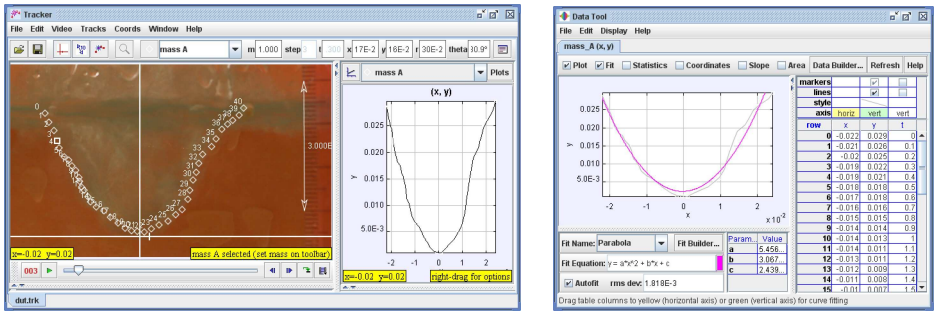

Fig.3: Videotracker.

Processing of experimental data

We process all the experimental data for each straw and each parameter. The final graphs depth (volume) vs. speed, vs. diameter, vs. distance was created.

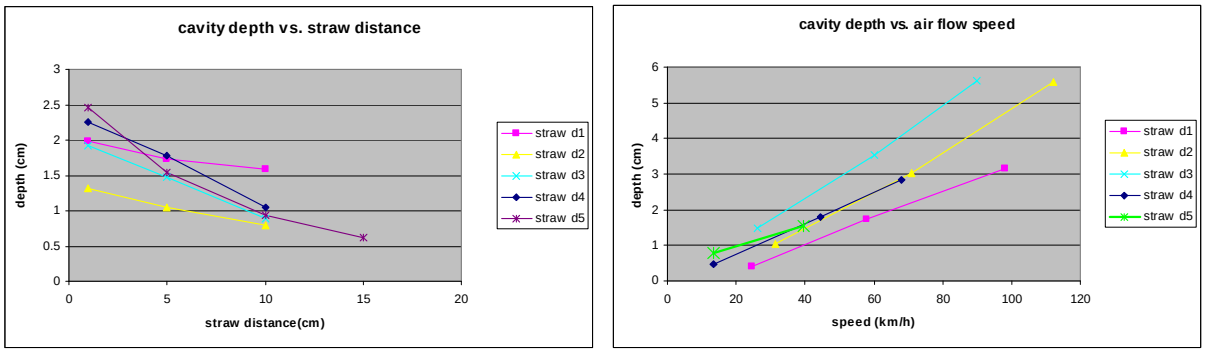

Fig.4: Graphical analysis of experimental data.

Final conclusion

The volume and depth of the cavity:

- decrease with increasing distance of the tube,
- increase with increasing speed of air jet,
- with increasing diameter the depth and volume of the cavity increases until a certain point, then they decrease.

4. Conclusion

The non-traditional experimental assignments can be highly motivating for students´ active investigation and learning. An interesting and attractive problem that lies ahead of the student can attract his attention and motivate him to think up original ideas and come up with original experimental procedure within the problem investigation. This is a good example how to develop students´ competencies in the subject of physics as well as more general key competencies. Moreover, even the quite demanding and challenging problems that have been successfully solved can be later created into school laboratory exercises.

Acknowledgements

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References

Z. Kluiber, T. Stanisic, V. Skocdopole, “The future is influenced by the Gifted”, Prague: Orbis, (2008).

J. Walker, “The Flying Circus of Physics with Answers,” New York: John Wiley &Sons, (1977).

http://www.cabrillo.edu/~dbrown/tracker/