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WHERE DID WE LOSE THE "WHYS"?

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WHY
As soon as my little son climbs
In the morning in my lap, he already
Starts with his why? Why?
So, why, why, why?

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A b s t r a c t

It is in the early childhood that we get the first ideas about the world and its events. Children do not stop asking "why?" where this 'why' most often means that the child would like to know what happened or what will happen if we do something or not. Once in school this curiosity somehow disappears. The late physics professor in the Faculty of Mathematics and Physics I. Kuščer used to say "School messes children up." He of course meant that the school system was not geared towards curious children and that inquisitive children yielded to the majority and usually stopped asking questions or became the disturbing element in the classroom. Why is school no longer interesting for a majority of young people? Where is the content that would have the learning youth ask "why?" and would have them want to learn more? Is there a way that one could use education technology for more active learning of sciences, especially physics? We discuss this in what follows.

Key words: *questions, teaching, educational technology, oscillation, optics, physics*

Introduction

On the arrival of the first child comes the relief realizing that everything is OK. When the child starts walking and gains some independence you look forward to the first questions, commentaries, and "explanations". At age five a child can tell a "life truth" and you have a hard time keeping with him/her. Then the child starts going to school. In the beginning with great joy and enthusiasm, but with years that disappears. When asked what they learned in school he/she barely answers with a typical "Well, just something" or when in a bad mood "We sat and listened." In high school one has no right to control him/her after the age of eighteen (or maybe we do?). Besides, according to young people, parents are "too old" (out of touch) and cannot understand them anyway. How can one conduct lectures and labs to get a positive reaction from young people? So that they will want to be heard? So that it will be clear that they are interested in the material and that they will attend classes with curiosity.

Preparation for classes

I am faculty at the Faculty of Education. I lecture and conduct labs for future K-12 teachers and daycare specialists. Learning science matter is particularly important to them, since they will be role models that will either attract children to science subjects or discourage them.

Lately we cannot imagine teaching without technology. Handouts are available online ahead of time and can be printed. This way, students know the content ahead of time and get ready for classes. At least this is the hope of the professor. But the truth is different. Class attendance has been dropping significantly. This is of particular worry in science subjects. Students think that they can learn the material on their own, watching videos of experiments and reading short descriptions included in the study materials. Lab experiments that students are required to prepare and conduct on their own are less and less popular and are causing more and more problems. It is very hard to have students describe an experiment after completing it, to make illustrations, and to write down conclusions. Even though we try to foster independent thinking and problem solving through elementary and high school, majority of students prefer the classical system: tell us what to do and how. In short, give us a recipe.

How to teach in order to stimulate more interest and more active participation?

Without technology

For the last five years I have been teaching lab sections in pedagogy of natural sciences. There we are supposed to cover some topics from the curriculum of elementary schools, discuss teaching methods, perform some experiments, and explain which concepts and in what order should be separately treated in specific grades. Since labs are mandatory, students' attendance is pretty much steady and they do what is required.

This year I changed the way I conduct labs. I would no longer turn on the computer. I would bring abandoned newspapers found in the university hallways and start to construct, together with students, simple devices that would be used to talk about motion in the air and in water, about the position of the Earth in the universe, heating and cooling, and to measure temperature, electric current and voltage. Finally I experienced the moment when the expression that we are all eagerly waiting for, appeared on their faces. The conversation in the hallways was "Physics was really fun today!"

Still the greatest difficulty for them was to tell *why* a specific experiment was done and what it showed and explained.

What can one learn from such an experiment? Pocket experiments can still be of value if we know how to use them at the right moment and in the right place.

Performance at exams

A short questionnaire was given to students, regarding reasons for poor outcome of an exam. Already the meaning of the expression "poor outcome" caused some problems. Majority of students were satisfied with a positive grade (63% or above). 64% stated that they studied one to two days for the exam and felt that they studied a lot. Students blamed "poor preparation" as the main reason for poor success (52%). Success of the schematic presentations of experiments was not good either (28% correct answers).

Even though there is not much material to be covered and we often tell students "this is a frequent question on exams" it does not appear that this helps student perform better, because in the last two years the success of the first exam term was significantly below 30%.

What can be done to arouse more interest and active participation of those who have pretty good knowledge, as well as of those how still need to acquire the basic concepts?

Start early

It is too late to start arousing enthusiasm at the college level, even though we still try, since only the person who enjoys the material, has solid theoretical and practical knowledge, good understanding of child's psychology, and likes working with children, can be a good teacher?

Future teachers should enjoy teaching. But do they? Since there is high interest in this major (due to a restricted registration volume, less than 50% of applicants are accepted yearly), we assume that those who get accepted would enjoy teaching. This means that we should show them how to get children excited about science.

Use of technology

One solution is a combination of independent lab work with computer animations, where materials can be partly prepared by the teacher, and partly or completely by students. This means that students become creators of animations. We will limit ourselves to GeoGebra, a geometry freeware, which can be used to create simulations and animations of examples in physics. We will show examples of oscillations in optics that can be adapted to the teaching in elementary or high school.

Oscillations

The treatment of oscillations in elementary school can be tied to children's experiences at sea, even though this is quite a bit more complicated than oscillations that are later studied in class.

First we prepare experiments (Razpet, 2009) used to introduce the necessary concepts. Amplitude and frequency are introduced using the movement of hands between to wooden logs, while the rhythm is maintained by a metronome. By increasing the distance between the logs while maintaining the same rhythm we introduce the notion of amplitude. On the other hand, the change of rhythm is used to introduce the notion of frequency. Pulling on a tight rope helps introduce the speed of propagation of a wave pulse and later of an oscillation, and then, with either a fixed or a free end, the wave reflection. We play with stationary waves on a rope and repeat it with a spring that allows both transverse and longitudinal oscillations. We also observe the oscillation of a marked rope or spring end, and draw pictures (*important*). We tend to forget that everything is prepared on worksheets. Drawing pictures takes extra effort, therefore students pay more attention during experiments if they know that they will have to do it. An analysis of school work has shown that students are less successful when pictures are required than when they only have to write answers (Tegelj, 2010).

More skillful students are able to measure the wavelength already during experiments, or they take pictures and use a graphics editing on a computer to calculate (measure) wavelength, frequency, and speed of wave propagation.

Here we notice differentiation. Those students who are skillful in the use of computer graphics will enjoy this kind of work.

Animations produced with GeoGebra can be used to complement reviews and practice. We can animate the travel of a wave pulse, reflection at a fixed or free end, and the birth of stationary waves. GeoGebra allows us to slow down the process and emphasize those characteristics that we either do not notice during the observation of the oscillation of a rope or a string, or the ones that occur so rapidly that we are not able to see the details. These animations can be produced by students themselves. At the Faculty of Education in Ljubljana students are required to produce animations for given topics in the course Pedagogy of Physics. At first they have some difficulties with the application but later they see that they have learned a lot and some produce more animations than required.

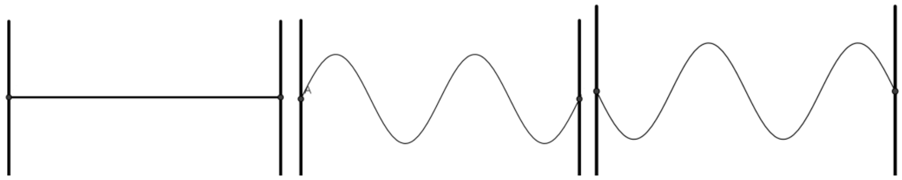

Figure 1: Three pictures of stationary waves on a string.

Looking at the pictures in Figure 1 the important question is Do the three pictures represent stationary waves on a string? If yes, WHY? Is it possible to determine the wavelength? WHY? Where are the nodes of this oscillation? WHY?

This is the type of questions that students are the most afraid of. In the beginning they think that they should know a certain FORMULA. Only towards the end of the semester they relax enough to realize that the answer is probably simple and that it can be seen from the picture.

Consider the frame of an animation that shows the forming of stationary waves.

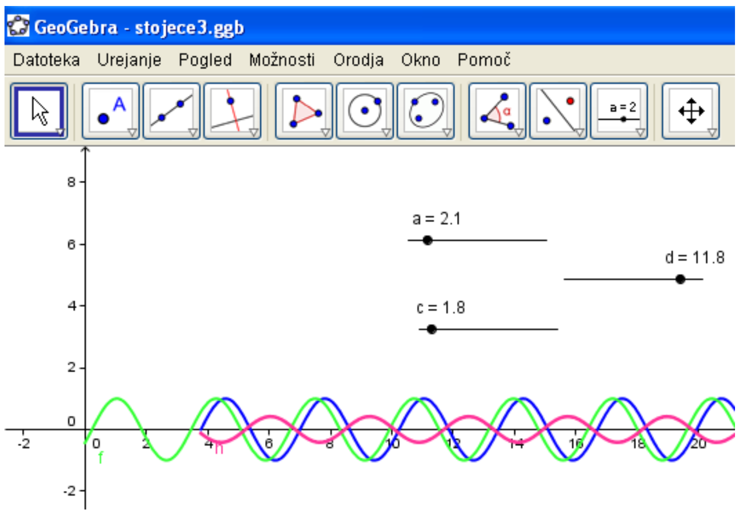

Figure 2: The forming of stationary waves from two propagating oscillations. Sliders a, c, and d influence the amplitude, the frequency, and the speed of wave propagation

Since the animation can be "frozen", it can be used in such a way that students need to complement it, correct it, or simply measure something.

In high school we can also write relevant equations and see how different quantities influence the oscillation.

Several segments of such instruction have been tested and therefore we believe that it can be recommended.

Optics

The treatment of optics in schools used to be limited in scope, but now it has gained importance because of the development of digital cameras and other optical instruments.

Explanations can be tied to the phenomena observed in nature. First we pour a little bit of milk in a cup and on the milk's surface we notice what is called the caustic curve. We ask WHY such a curve appears on the surface of the milk? Can we discern it? Can we draw it? How?

We follow up with experiments using a smoothly polished metal band rolled into a cylinder. If we put it on a table we also see such a curve inside the cylinder. Again we ask Why? Or, why we don't see the curve?

This helps us explain why, during the treatment of curved mirrors it was important to know which rays were to be drawn and why they had to be in a narrow band along the optical axis.

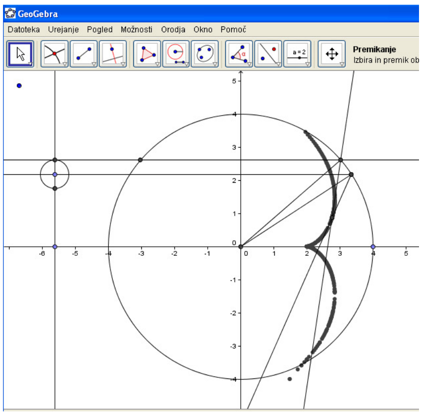

Figure 3: The caustic curve

Look at rays passing through a lens and draw a graph showing the dependence between the distance of the subject from the lens and the distance of the image from the lens.

We start with familiar experiments, the image of a candle flame on a screen. This kind of experiments has been avoided lately, due to strict fire safety regulations, and in some classrooms also due to very sensitive smoke detectors. Moving the candle (or an object) students see the location of the image. Later they also move the lens. They quickly observe that some pictures cannot be captured on the screen but can still be seen. It is important to emphasize the difference between a real and a virtual image of an object. Textbooks state (and we say the same in the classroom) that the real image is visible on the screen (it exists where the refracted rays intersect after passing through the lens), while the virtual is not (it exists at the intersection of the extensions of reflected rays). Is it also possible to see the real image when there is no screen? What does it look like? When we have completed all the experiments, including the case where the object is slanted towards the optical axis, students draw rays and construct pictures.

Using GeoGebra we construct the image of an object positioned in front of the focal point and is perpendicular to the optical axis. Using the intersections of appropriately chosen rays students find the image of the object. Changing the position of the object we determine the image's position and shape.

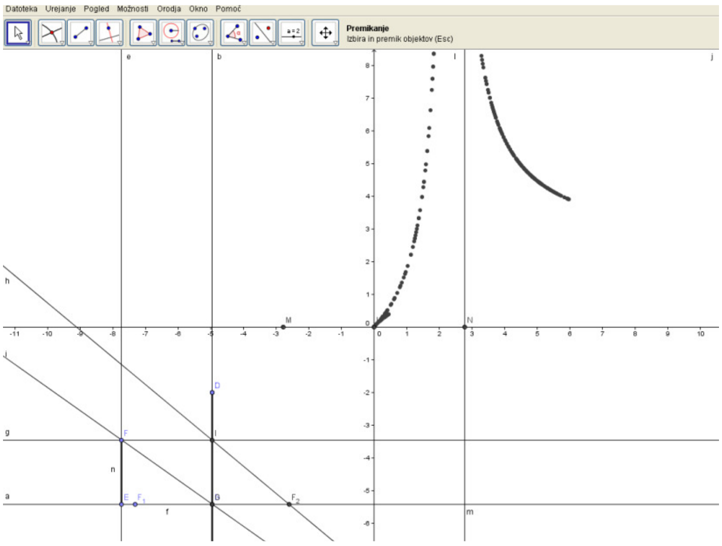

Figure 4: The relationship between the distance of an object and its image, from the lens

Later we can ask what can be concluded from the right part of the graph and what from the left part. Why is the graph not continuous? Where is the vertical asymptote? How can we see this from the equation of the lens? Can we determine the focal length of the lens from the graph? What is such a curve called? Since it is possible to draw algebraic curves using GeoGebra, students can see that points used during the drawing lie on a curve, familiar to them from mathematics.

Better students can construct a picture using the Law of Refraction. They determine when the lens can be assumed to be thin and when not.

In short, there are many possibilities.

Conclusion

In a static text, not all the advantages of animation can be shown. We only discussed two topics where such an approach makes sense. There are many animations on the Web. One could therefore say that there is no need to bother with them in the classroom. However, we want to emphasize again that it is essential for a student to construct animations on his/her own. This is the only way that he/she will really review those physical principles that need to be used for the animation to function correctly. Besides, it is important that future teachers be able to carry out simple constructions on their own, not the least to show their students that they are skillful creating animations themselves, and competent in the use of modern technology.

Despite good computer applications one still has to start with experiments where all (or as many as possible) senses are used. Students quickly discover that not all experiments succeed and that some skill is needed even for the seemingly simple experiments.

After each experiment we require paper trail, which should consist of a narrative, a picture, measurements, and a commentary. Otherwise the independent experimental work can degenerate into entertainment, which is of particular interest to students when computers connected to the Internet are used.

This method changes what questions are being asked. First we ask about causes and consequences, we look for dependent and independent variables and constants, write connections using symbols, discuss magnitudes and the validity of physical laws. All this requires mental alertness. This is why, in the beginning, there is resistance not only from children, but also from parents. They often say "The child does not know how he/she is supposed to answer your question," while students complain "We do not know what is the correct answer".

During my classroom visits I discovered that students have a hard time writing what they saw or what they found out during an experiment. If the teacher does not tell them right away what the correct answer is students go to their teacher and ask what they should write down. This shows that we got students used, with all the regulations regarding exams and grading, to have everything "served on a plate". Therefore those who understand the material faster have enough time for mischief, or they tell the result so quickly that the others cannot follow, in which case the teacher asks the others to be "quiet" which of course is far from the right method.

Simple experiments that we can "pull out of the pocket" during a class, and in a casual way demonstrate or ask students to think how they could demonstrate something, can be a good motivation for those who could generate questions, i.e., WHY's.

We hope that at the end of a class students will still know how to say "Wow, this was something!"

Have you noticed anything else? I have only a few references. Lately references have become a particular phenomenon. If an article doesn't have at least

20 references then it is not a real article. I would think that it is OK to write something relating our own experience, right?

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KJE SMO IZGUBILI »ZAKAJE«?

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ZAKAJ

Komaj sinek skobaca se
zjutraj k meni, že začne se
ta njegov: zakaj? zakaj?
no, zakaj, zakaj, zakaj?

Avtor: *Frane Milčinski Ježek*

P o v z e t e k

Prve predstave o svetu in dogajanju v njem dobimo že v rani mladosti. Otroci nenehno sprašujejo »zakaj?« pri tem ta zakaj največkrat pomeni, da otroka zanima, kaj se je zgodilo, ali kaj se bo zgodilo, če to ali ono naredimo ali ne. Ob vstopu v šolo se radovednost nekako izgubi. Pokojni profesor fizike na Fakulteti za matematiko in fiziko v Ljubljani, dr. Ivan Kuščer, je pogosto rekel: »Šola pokvari otroke«. Pri tem je seveda mislil na to, da šolski sistem ni pisan na kožo radovednih otrok in da se zvedavi otroci uklonijo večini in navadno nehajo spraševati ali pa postanejo moteči elementi v razredu.

Zakaj šola za večino mladih ni več zanimiva? Kje so ostale vsebine, pri katerih bi se učeča se mladina spraševala »zakaj?« in želela o tem izvedeti kaj več? Kako torej izrabiti izobraževalno tehnologijo za aktivnejši pouk naravoslovja, predvsem fizike? O tem bo tekla beseda.

Ključne besede: *vprašanje, poučevanje, izobraževalna tehnologija, valovanje, optika, fizika*