Hyper-constructivism in teaching physics: Defining social competences*

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Abstract

Hyper-constructivistic lectures and workshops in physics induce not only notions in science, but also social competences: understanding electrostatic risks, knowledge on subjective effects in colour perception, appreciating harmonic components in hearing voices and music instruments. More than 70 lectures, with 6-12 kids, brought enthusiastic opinions of children (and parents).

Keywords

social competences, hyper-constructivism, electrostatics, colours, acoustics

Introduction

The European Union standardized university teaching by introducing so called European Credits Transfer System, that define clear requirements in curricula: knowledge, abilities and social competences. Universities (and also schools) try to "mimic" these requirements, by fuzzy-expression like "student knows", "student is able". This approach is deleterious: social competence could be a lever to make physics useful and interesting. A change in teaching is needed: from what the *lecturer finds* important to what is necessary for students, as s*ocial competences*. This should increase *usefulness* of Physics as a tool and method for professional lives.

Rationale

Didactics of Physics made recently a significant step forward: in rising the self-consistence of physical concepts [1], in including feedbacks between contents and didactics [2], in relating mathematical formula to the external world [3], and in introducing constructivistic approach into teaching [4]. The recent OECD system for university teaching (AHELO) monitors: critical thinking, analytical reasoning, - problem-solving, - written communication [5]. Physics would be a model science to fulfill these requirements – a kind of *forma mentis*. But pupils say that physics is difficult, not-involving, much formal. Educated persons, appreciating astronomy, mathematics, biology, refrain from physics. How to add, to excellent *input* promises of physics methodology also the *successful* output for professional carriers? Defining possible social competences, gained with learning physics is necessary. These competence must go beyond the banal: "student understands the importance of physics for everyday life".

Implementations

Numerous, and written by acknowledged physicist [3, 6,7], are text-books in which physics is brought "friendly" to broad public, showing presence of physical laws in many every-day phenomena. This is an useful approach, that we implemented in late 90'ies bringing to Poland "Physics and Toys" interactive exhibitions and developing science centers, see [8]. However, that served only to trigger interest in physics, did not change the social perception of Physics. Our approach is on two, blended methodologies: neo-realism and hyper-constructivism [9]. The hyper-constructivistic recipe [10] stays in constructing pupils knowledge by the teacher, but

discussing, not rejecting their previous knowledge. Pupils must be convinced, by the executed line of collective reasoning and by ad-hoc experiments, that their pre-thinking was wrong (if it was wrong, obviously). Secondly, interactive, collective and guided teaching develops a whole series of *social* interactions, both among pupils, with the teacher and with the public – all this can be called a social *apprenticeship*. As writes B. Rogoff [11]: "The notion if apprenticeship as model for children/s cognitive development focuses our attention on the active role of children in organizing development, the active support and use of people in social interaction and arrangement of tasks and activities, and the socioculturally ordered nature of the institutional contexts, technologies, and goals of cognitive activities." Below we give examples of tasks (physical terms and laws to be taught), activities, technologies (didactical instruments), goals (social competences) and social contexts that can be defined while teaching physics at early childhood. Social competences include: - interdisciplinary professional capacities, - assuring pupils in their proper experimental abilities, - teaching how to formulate *important* questions, - indicating *approximate* solutions. We give examples of hyper-constructivistic reasoning on acoustics, optics, electrostatics, in categories listed by B. Rogoff.

Perception of colours

A piece (5 minutes) of an interactive lecture resembles a fashion show, with tow models:
i) task - physical background: light spectra, pure colors, complex colors (magenta, brown), light sources (LED) = those were discussed separately in our previous papers [12]
ii) activity: interactive theatre, in which the public tries to guess colors under LED illumination
iii) technology: two wigs with no-fundamental colors, (see fig. 1b)
iv) social competence: "buying a dress in artificial light can lead to a serious disappointment"
v) social context: the collective astonishment how LED light changes perception of colors.

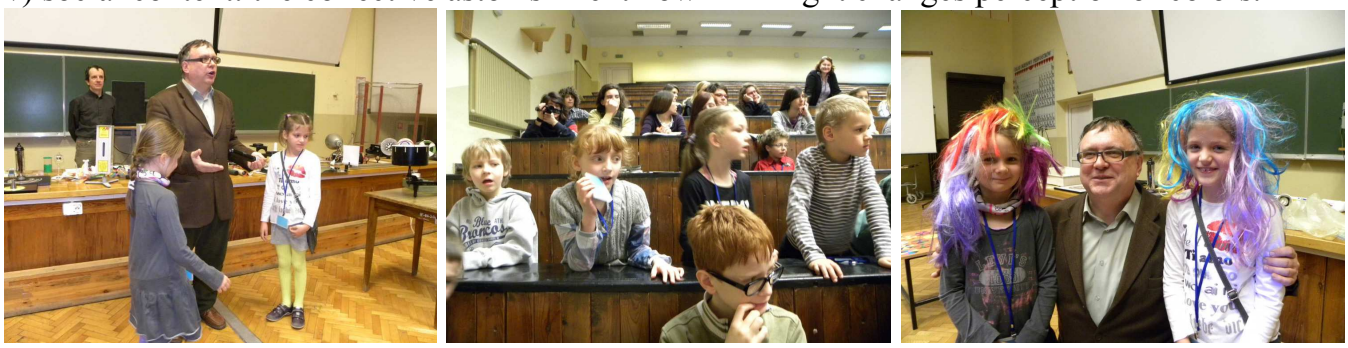

Fig. 1. Interactive teaching of social competences in recognizing colors (UMK, IV 2011): a) inside a standard interactive lecture on optics, a scene is inserted, in which two chosen girls will play models with artificial hair; wearing the wigs must be done in a complete darkness; b) the audience should guess, with a sequence of red, green and blue illumination what are the colors; the astonishment is complete, as they did not predict any single color (front raws are 9-10 olds, in back - students of teachers' Lyceum from Trento, Italy; standing – their teacher of physics); c) in the process of projecting the experiment various colors were chosen, but no fundamental ones (the project, objects, performance – GK, photo M. Karwasz)

Electrostatics: voltages and risks

i) tasks: notions of voltage, current, volts;
ii) activity: workshops, largely self-organized by pupils;
iii) technology: plastic tubes, paper *confetti*, Volta's electroscope, universal meter, old batteries
iv) social competence: use of a universal meter; "electrostatics is extremely dangerous"
v) social context: division of tasks (fig. 2a), written reporting (fog. 2c)

In electricity, concepts of voltage, current and power do not require mathematical definitions, as pupils find them written on batteries of cell phones. They understand that 4 kV is

much more than 220 V and therefore dangerous: let make them check the voltages created by the triboelectric effect, fig. 2b. “If this arrow turns, the voltage is 4 keV! Check it. Remember, never touch inside your phone-cell when I stay in wooden trousers on a plastic chair!”

Lessons and workshops on electricity offer also other social competences: children (girls also, fig.2a) get familiar with electric measurements. We use for this a bag of old batteries; children check them and make *written* rapports, that are one of four educational goals specified by OECD [5], fig. 2c. Workshops allow also to experiment *collaboration* in groups, with a spontaneous defining and division of tasks, see fig. 2a and 2b.

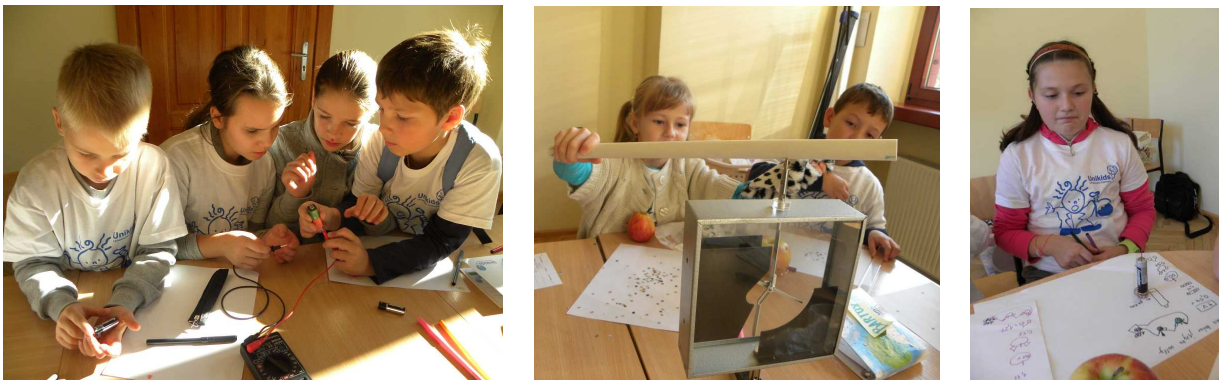

Fig.2. Interactive workshops on electricity (UniKids, Głogów, X 2011): a) spontaneous division of tasks in measuring voltages on old batteries; b) checking that triboloelectricity is dangerous: the arrow on Volta’s electroscope shows 4 keV; c) written rapports are one of added social outcomes of workshops; the girls is sad, because her engine does not turn (photo M. Karwasz)

<u>Acoustics – harmonic analysis</u>
i) tasks: pitch and amplitude of sounds, harmonic components (i.e. Fourier analysis)
ii) activity: workshops, largely self-organized by pupils;
iii) technology: glasses, vacuum cleaner tubes, bottles, ethnographic collections
iv) social competence: everything plays
v) social context: playing in a band requires training, attention, collaboration.

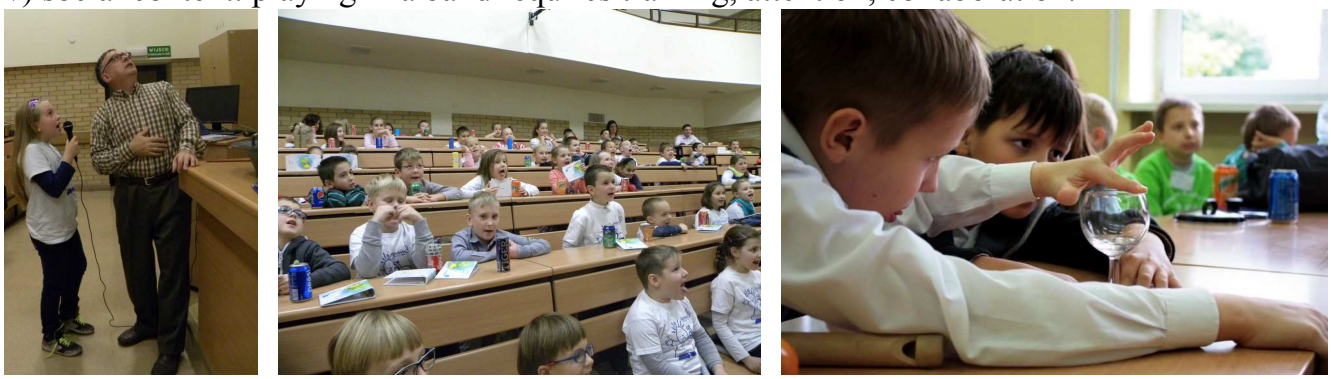

Fig. 3. Interactive acoustics, UniKids Wałbrzych, X 2014 – the educational goal (and tool) is Fourier’s transformation, : a) “Look at the screen! A nice voice is when you see only few vertical signs”; b) “And now everybody – try to make a stupid, sheep-like sound! You will recognize it from a dense “grass” on the screen [i.e. from many non-harmonic components in the spectrum] (photo M. Karwasz) c) playing with wine glasses is not much pedagogical (“Remember! Never do this without your father”) but very educational – it develops attention and manual precision (photo UMCS, Lublin, 25/09/2014).
The harmonic analysis was a difficult task even hundred year ago. Now children know “bars” that appear while listening music. What is needed to be added in a *hyper-constructivistic* way is to associate these harmonic spectra with some sounds: the most simple, single-pitch is the

squeak of a wine glass [14], see fig. 3c. A human voice is multi-harmonic, not saying about drums, wooden African frogs, coca-cola cans filled with rise and so on. Interactive UniKids in Physics in Poland started in 2009. Experiments with simple objects, done with *pedagogical* goals, induce kids' in self-exploring physics, even at early age, and bring much fun!

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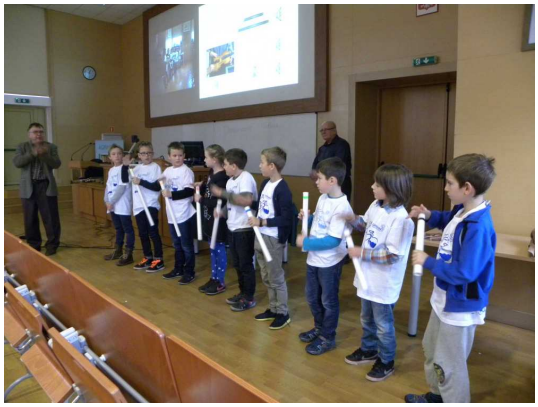

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