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**Slide 1**

**The Didactics of Science through Polymorphic Self-Made Experimental Apparatus of Quantitative Determinations**

An alternative proposal for the teaching of Natural Sciences

The undertaking of teachers' training on Natural Sciences is very difficult. This difficulty is related with the implementation of the two classic models "learn how you learn" and "active exploratory approach of knowledge". That's because we have to use for our students, the same teaching style, as we propose them to teach in their classrooms. During their basic and probably the Academic studies, they had the theoretical model of the knowledge, as a unique model of learning Science. The disengagement from that requires an experience from a suitable model of teaching, through which the knowledge is approached experientially, through a scientific – inquiring way.
This model has to follow a route, between teacher and student, out of which, the student leads to an authentically active participation of in an exploratory process during which proposals immerge, processed, tested, rejected or are being accepted through peer collaboration. During this collaboration the teacher 'fatefully' banish his 'authority' and premises the handling of knowledge and his experience in an inquiring course, in which the student becomes participant straightforward. The experience of this type of research, is useful and essential, for the activation of the inquiring interest, ın their classroom in the future.
More generally, teachers are expected to behave as students with the same way as they are proposed to use as teachers in their classroom.

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This model has:

- To evoke student's interest and spontaneous attendance,
- To control the acquisition of knowledge, by themselves.
- To acquire training and psychomotor skills,
- To help them to collaborate.

In experiments, the use of sophisticated equipment may give accurate measurements. However, it removes the authentic creative activity and converts the experiment to a demonstration process, in which the student observes the results of an apparatus that he does not understand. This, combined with the general attitude to get the results of the experiments instead of inquiring a situation of a Natural phenomenon, eliminates the personal participation.

The use of Polymorphic Self-Made Experimental Apparatus for Quantitative Determinations could be an alterative way.

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A self made experimental apparatus has the following advantages.

- It is an authentic creative activity.
- It is an inquiring approach of natural phenomena.
- The construction, totally or partially, of the apparatus to be used in classroom, is associated with the development of cognitive and psycho motive skills and facilitates the logical process of induction.
- It makes clear the discrimination between observations' data and their interpretation.
- In a group work construction, the development of social skills is also facilitated while the "pleasure of creation" covers the sentimental sector.
- It connects the classroom lab with the activities outside the school and gives the opportunity to observe everyday's activities in a scientific inquiring way.

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Why it has to be quantitative?
The estimation of the accuracy, the manipulation of the errors and their treatment, helps for a deep understanding of phenomena.
Additionally:

- It combines science with mathematics especially statistics.
- It admits personal control of knowledge and personal evaluation.
- It gives the sense of the monad, through the calibration step.

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Why it has to be polymorphic?
"Polymorphic experiment" is a term used first from Prof. Michaelides. It refers to experiments that are designed to run on at least two different levels. So the teacher learns a phenomenon at a higher, university level for himself, and at the same time the way of how he will teach it at a lower level in the classroom.

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I will present you now, a project for a self made battery, out of which we expect the following Educational Goals:
To connect the electromagnetism with chemistry
To familiarize students with the classical prototype of the atom.
To study reduction-oxidization reactions, as a process of electrons transmission.
To study the conductivity of an electrolytic conductor and the factors affecting it.
To study the internal resistance of a battery and the factors affecting it.
To study the transformation of the chemical energy to electric

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We place a piece of Zinc in a cooper sulphate solution. We observe a layer of metallic Cooper on the Zinc surface and the change in the color of the solution. We concentrate

on the transmission of electrons from Zinc to Cooper kations. We connect it with the classic prototype of atom.

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In order to make a battery we have to drive these electrons through an external wire.
We place a piece of Zinc in a Zinc sulphate solution and a piece of Cooper in a Cooper sulphate solution. We connect the two solutions initially with a metal conductor.
We observe a voltage. It is 0.93volts. The electrical current is 0.
Voltage proves the transfer of the electrons from zinc to cooper
The absence of electric current shows a solution's polarization.

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We use a paper salt bridge, as a way to transfer sulfuric anions from cooper to the zinc sulphate solution. We observe the voltage and a very small current of microamperes.

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We discuss on the Ohms low. The external resistance is almost zero.
The internal resistance of the system is high.
In order to find a way to reduce the internal resistance, we run a side experiment.
We prepare a sodium chloride solution. We place into it, two cooper plates. We connect the electrodes with a battery through a lamp. We observe the lightness in comparison to:

- the distance of the electrodes, by moving the electrodes
- the surface of the electrodes by the addition of sodium chloride solution
- and the concentration of sodium chloride by the addition of solid sodium chloride

We summarize, that conductivity increases as we increase, the electrode surface, the concentration of the solution, and decrease the distance of the electrodes.

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We apply all our observations for the battery construction.
We use as a salt bridge a paper cylinder. The paper cylinder of a toilette paper is appropriate.
We place the two electrodes inside and outside. So we solve the problem of the short distance and the big surface.
We fix that with glue or silicone on the bottom of a glass.

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We have a limit on dilution of zinc and cooper sulfate, we make both solutions saturated in sodium sulfate. So we have a lot of sulfuric anions, which is the electric current carrier.
This battery is able to light a small lamp for a long time.
Now we are able to give an explanation of how a lemon or fruits work as a battery.
It is the same pair of metals, the chemical reaction form salts of zinc citrate and cooper citrate around the electrodes and the tissue of the lemon works as a salt bridge.