

# **Physics lessons taught by pre-service teachers and in-service teachers – didactic case report and comparison**

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## **Abstract**

*The aim of this paper is to present the outcomes of the project that is solved at the Faculty of Science in Olomouc, Czech Republic. One of the key activities of the project is to interconnect more closely the pre-graduate teacher training with the practice at schools and the cooperation with teachers of various secondary schools. Video hospitalizations of lessons are provided. Lessons realized by experienced teachers are compared with lessons realized by university students (pre-service teachers). The lessons are analyzed and reflected. Particular examples of the comparison of various physics lessons will be presented, crucial problems in these two types of lessons will be discussed.*

**Keywords:** Teaching Physics, Didactic Case Report

## **1. Introduction**

Secondary school physics teachers in the Czech Republic are educated at universities in a five year program and they have to get a magister degree.

Science teachers have to get knowledge of physics as a science subject; they have to study all parts of general physics – the same topics that are taught at schools (mechanics, thermodynamics, optics, electricity and magnetism, nuclear physics, astrophysics). Each course incorporates experimental laboratory exercises. Pedagogical disciplines and didactics of physics are taught in the 6<sup>th</sup> to 9<sup>th</sup> term. (<https://www.prf.upol.cz/studenti/studium/#c1547>)

Teaching practice is a crucial part of the teacher training program. The practice lasts two times 3 weeks (during the 8<sup>th</sup> and 9<sup>th</sup> term of study). For the majority of students it is the first contact with the real school environment. Pedagogical knowledge and pedagogical content knowledge is applied in practice. Because a lot of problems during the practice of pre-service teachers were identified, it was necessary to concentrate on main difficulties and evaluate the training program. It is possible to take advantage of the community of practice and show “good practice” presented by in – service teachers.

A lot of studies were presented about problems that pre-graduate and novice teachers have. ( Beichner 2009, Berliner 1995, Kirschner et al. 2006, Ruthven 2009, Šimoník 1995) It is stated that pre-graduate and novice teachers make the same mistakes. They focus on short-term planning, mostly they copy the way of teaching of teachers, they taught them in the past school years. A lot of time they spent with the preparation for the lessons – one teaching hour requires about four hours previous work. Often they are not able to

answer students' questions. Novice teachers have little ability to anticipate reactions of learners in different situations in the class environment. They cling in detecting and bullying, handling of learners with specific needs, solution of disciplinary offenses etc.

Within the framework of our research, videoconferencing was carried out in teaching lessons led by experienced teachers (in – service teachers) and students in the undergraduate stage of study as a part of their pedagogical practice (pre – graduate teachers). A didactic case report was conducted for these lessons. The lessons were analyzed and compared.

## **2. Didactic case report based on the curriculum depth model (Methodology AAA)**

During the research, video hospitations were realized, both for experienced teachers and for beginning teachers (students in the undergraduate stage of study). The aim was, basing on the analysis of these lessons, to design methods suitable for teaching subjects, which are considered critical in the secondary school curriculum. Each case contains suggestions for improving the course of teaching. Based on a wide-ranging discussion within the community of practice (with all the teachers involved in the project) the best practices for teaching the subject will be proposed. This methodology will then be verified in the next part of the research in real learning situations. The case studies are based on the model of the depth structure proposed by Janík et al. (Janík et al. 2016, Slavik 2014) The model contains three basic layers, which represent the state of the content of teaching and two transitions, expressing the process of the content transformation during the mutual activity of the teacher and the student (abstraction and generalization). Characteristics of the individual layers are as follows:

Thematic layer - captures those components of teaching content that can be directly observed and described in the activity and communication of pupils in solving problems and interacting with the teacher. In this layer we combine: (1) the professional concepts of the relevant field with (2) common terms close to the everyday pupil experience, as well as (3) the phenomena corresponding to these terms. The thematic layer, for example, includes common types of snail, salt, water, together with a professional term or symbol of garden snail, sodium chloride, H<sub>2</sub>O. And, of course, there are real objects of that name, which are used in the teaching as illustrative aids. The content of the thematic layer, as a rule, the pupils are at least partially familiar with from their own experience, so they have already developed a certain preconception or idea and somehow manage them. Without this layer, learning cannot go without because it would lack all the content. Teaching thinking moves into the thematic layer, especially when the teacher constructs tasks for pupils.

Conceptual layer includes concepts of a given branch or a thematic unit. The concept layer captures expert concepts with a relatively high level of generality. However, these concepts may appear and be named in the tasks for the pupils, so they fall into the thematic layer. Competence layer - represents the key competencies contained in the Framework Educational Program.

The course of realization of the hospice video study consists of three components (steps), which are: annotation, analysis, alteration (AAA method, 3A)

1. *Annotation* - definition of the context of the learning situation - aim, theme, continuity of content and didactic grasping of content - activities of teacher and pupils (layout of the lesson, used

methodical methods, definite activities of students during the class.

2. *Analysis* - Content Structure - analysis of the learning situation using the concept diagram, benefit of learning for students.
3. *Alteration* - Overall assessment of the learning situation, its quality and the suggestion of improvement.

Processing in the form of didactic (video) case is developed for the purposes of communication and sharing in the professional community, it is appropriate to process the disassembled teaching situations in the form of didactic case reports, to the form of didactic videotapes that include video recording. By studying didactic case reports we can learn about the nature of certain phenomena in a particular field, how certain processes occur, how certain practices work, etc.

Didactic case reports act as bridges between practice and theory of teaching - in the situations of teaching illustrate theoretical constructs, and through analysis help to understand and use them in our efforts to improve learning.(Janik 2018)

As an example, we present two didactic case reports in the subject physics (8<sup>th</sup> grade) – university student of physics teaching (4<sup>th</sup> grade, first pedagogical practice) and experienced physics teacher working at the eight-year grammar school.

### ***2.1 Didactic case report - Student, Teaching Physics - Critical Site Electromagnet***

**Teacher and pupil activities:** In the first part of the lesson, the group work method was used as an example of activating method. The teacher controlled the work of the pupils in such a way that the representatives of the individual groups presented the solution of the task to the teacher. There was a lot of noise in the classroom. A demonstration experiment was included into the next part of the lesson. The schematic model of the presented circuit was created by use of the schematic marks of the individual elements in the circuit, drawing of the circuit diagram - the generalization (from the specific to the general one). In addition, pupils work with the diagrams of the device (electromagnet, electromagnetic relay). The teacher tries to motivate pupils to cooperate by the follow-up questions - pupils should understand the function of electromagnet and electromagnetic relay. Pupils are less active at this time; often do not answer the questions. In this case, the teacher completes the interpretation and explains the device's function by means of the image projected on the chart. The teacher often uses vague formulations, is uncertain in the interpretation, has mistaken in the preparation that the pupils draw attention to. The teacher tries to communicate with the class; the conclusions of interpretation often melt in class noise.

**Thematic layer:** It is possible to include components of teaching contents that can be immediately observed and described in the activity and communication of pupils during the educational activity - professional terms, common terms from everyday pupils' experience, phenomena that correspond to terms. In our case these are the terms electromagnet, electromagnetic relay, bell, electric circuit, coil, core, soft steel, nail attraction, anchor, coil poles, wires, electric current, and switch. The analogy with everyday pupils' experiences is used - cooking tea, tea bag, and kettle.

**Concept layer:** It summarizes expert concepts with a relatively high level of generality. At the given lesson we include into the concept layer a circuit diagram of electromagnet circuit, an electric bell, an electric

circuit diagram and electromagnetic relay circuit diagram. It also includes an explanation of the principle of the equipment operation and the function of the individual elements. Superior concepts are: electromagnetic field, electricity, magnetism.

**Competence layer:** Communication skills, problem solving, learning competencies

The pupils observe the experiment, describe the scheme, derive the bell function, and apply the knowledge to explain the function of the bell and the electromagnetic relay

Alteration: Complex evaluation of the learning situation has not been developed. It includes basic skills and concepts, but requires alteration in the field of content analysis and comprehension, generalization, application, and metacognition.

Scientific component is the use of electromagnet concept, electromagnet inclusion into electric circuit, operation of electromagnet devices. The concepts are presented quite correctly; schema-based device interpretations have been presented.

Technical Component - students have received worksheets. The real experiment was conducted only at the beginning of the class as a demonstration experiment.

Methodological component is the organization of lessons - group work of pupils in the first part of the lesson; it follows by individual activities of pupils - elaboration of tasks from the worksheet, writing to the workbook. Teacher's communication with pupils - an attempt to clarify the activity of the device, based on active involvement of pupils through the teacher's questions.

**Summary of the learning situation:** The teacher tried to use activating teaching methods - group work, communication with pupils. As a result, it was very noisy in the class; the teacher could not exploit the potential of these methods, lacking a strong appreciation of the group's activities, evaluation of the work.

There have been some deficiencies in explaining a new material: It was not emphasized: the effects of the magnetic field of the coil can be amplified by using a coil with a core of magnetically mild steel or a coil with a larger number of threads, or allowing a higher current to pass through the coil. The force effect of the coil with the core also depends on the material and the cross-section of the core. There is always a magnetic field around the permanent magnet. In the vicinity of the solenoid there is a magnetic field only when the electric current is passing through the circuit. The effects of the solenoid can be changed by increasing the current size. The two coils are used in the solenoid to increase the magnitude of the force that attracts the anchor to the coil core. The poles of both coils that are closer to the anchor must be consistent (bell). This has led to a limitation of learning situations in the area of content analysis and comprehension.

**Alteration:** The discussed learning situation points to the inexperience of the teaching student. The student tried to use activating methods of teaching, realized a demonstration experiment, tried to use modern technical means - projection of images through a data projector.

Remarks - The experiment was demonstrated at the teacher's desk, so it was poorly observable for the students from the back benches. When using projection over a data projector - it could be used the intent of interactivity or the appropriate animation of the bell. The bell could also be presented as a real physical aid. During the learning situation a number of "deaf" places appeared, where the teacher was waiting for too long to stop the pupils' activity, for example, drawing the parts of the perimeter in the worksheet with colored pencils. Thus the given instruction - you have 2 minutes - was not followed, the activity lasted

more than 5 minutes. The teacher often used incomplete sentences during her interpretation and explanation, helped with eech insertions, used unscriptural Czech.

**Recommendations:**

1. If a group teaching method is used - clearly formulate conclusions; evaluate the work of the groups.
2. Better prepare the lesson on a professional side - to have the correct solution to the given task, to present the pupils with complete information about the given learning situation. Have the thoughtful curriculum; study the subject so that during the interpretation and explanation there is no need for correction of the communicated knowledge. This will create the conditions for generalizing and developing the level of competency layer.
3. Make better use of co-operation with pupils in explaining the new curriculum - using students' mistakes, making sure that questions are properly formulated (questions about the type of 'circuit closure' are not appropriate)
4. Better organize the time schedule worthy, do not waste time on handing out worksheets, other "papers".
5. Make better use of the possibilities of modern computer technology and a real experiment.
6. Clearly, distinctly and accurately formulate physical concepts and dependencies.

**2.2 Didactic case report - an experienced teacher**

This lesson was preceded by an interpretive lesson on serial connection of resistors. The lesson consisted of two parts. In the first part the teacher repeated with students the serial connection of two, three, and more resistors and controlled the home work - the solution of the numerical task. In the second part there was an experimental activity of pupils. Their task was to assemble two parallel resistors and determine their properties. The mathematization of the relationship for the parallel connection of the resistors was not the subject of this lesson; the teacher advises the derivation for the next hour.

**Teacher and pupil activities:** In general, a friendly atmosphere between pupils and teachers takes place over teaching hour. The teacher may too often praise pupils even for quite common knowledge (e.g. the term node), for an hour she used the word "supr, super", which can be perceived as parasitic, a total of 32 times, that is, almost once per minute. In some parts of the lesson she even used this "praise" up to three times in a row. In the classroom, there was a lot of noise during the whole class, which often disrupted the perception of pupils in communicating essential information from the teacher towards the pupils. In spite of this deficiency, however, pupils were able to master the task. Also inappropriate can be considered the placement of the demonstration panel with the parallel connection of two resistors, which often shielded the writing of information on the board. The panel was not used by the teacher for direct demonstration of the magnitude of the current in the branched and unbranched parts of the circuit and other features of this connection.

In the first part of the lesson, the teacher discussed the way how the homework was solved and also drew attention to the possibility of "mathematical way of solving" over the ratio of resistor values, thus strengthening the mutual relation of mathematics and physics in a context of this particular situation. In the second part, the teacher discussed with the pupil the parallel connection of two resistors, only this time

using the demonstration panel to allow the pupils to integrate their components from the Boffin kit according to the panel. The derivation of mathematical relationship for the resulting resistance of the parallel connection was no longer mentioned.

**Analysis:** The thematic layer contains the objects with which pupils make measurements: resistor, ammeter, voltmeter, voltage source, and current and voltage measurement on individual resistors. The concept layer can include abstract concepts, such as wiring, node, and circuit branch that pupils use to implement a particular resistor connection. The concept of pupils' knowledge obtained by observation is then revealed that the magnitude of the current in the unbranched portion of the circuit is the same as the sum of the currents in the individual branches. Competence layer consists mainly of communication competencies and competence to solve the problem. In this case, this layer is closely related to the concept layer, the pupils cooperate in pairs, but they also interact with one another. Up to a few pairs, all others successfully solved the problem at the given time. A negative phenomenon can be seen as the aforementioned noise and restlessness in a teaching hour that the teacher does not solve in any way. As a result, for example, a situation where the teacher wants to draw a diagram on the board, but most pupils no longer perceive his / her instructions and devote themselves to the connection of resistors. Writing of a topic on a blackboard, plotting the location of voltmeters and ammeters is basically in parallel with the activity of pupils, who do not devote any attention, with some exception, to the writing on the blackboard. This situation is also repeated in the second part of the teaching hour, when measuring the voltage on individual resistors (the teacher comments with the words: "So, some fools are already spinning."). Transcript of the learning situation: in an external file.

The scientific component of the experiment is almost always limited in the school environment, in particular by the mathematical knowledge of pupils, so the teacher must strike a balance between the comprehensibility and the professional concepts he uses. In common school practice, the resistor and resistor terms, which are used both for a real electronic component, are usually not distinguished in this situation, although the resistance is physical magnitude and property of the resistor. In the first part of the lesson the teacher in the first part confuses these concepts, for example, when discussing "resistor ratios" with pupils, even though the pupils are surprisingly correct to speak of resistance ratios themselves. In the next part of the teaching hour the teacher indicates it correctly "... parallel connection of two resistors, current by the first resistor", etc. However, the learning situation shows that pupils perceive the term resistivity as a physical quantity and the resistor as an electronic component, that is, in the correct way. The technical component was managed without any problems, the pupils had their kits, and spare parts were available if something was missing. The method component offers the greatest potential for change. For example, the repetition could be shortened, and it would be possible to devote more time for derivation the resulting relationship for the resulting resistance of parallel resistors, which would be desirable. Teacher's heuristic questions at the end of the lesson, when pupils correctly derive and write the relationship between the total current in the circuit and the currents by the individual branches are excellent on the didactic side. Equally positive is the question of how to apply the ammeter and the voltmeter, which often causes a big problem for the pupils. It is also right to praise the pupil Bára for the initial choice of the largest scale, if

the student is not sure how high current is passing through the circuit.

**Alteration:** Despite the above mentioned shortcomings, the lesson was basically an example of a functioning teaching, where a lot of heuristic and constructivist elements were used. Pupils, according to the teacher's instructions, went to the right conclusions, mostly used the correct terminology and the mathematical apparatus to derive the relevant relationships. Teacher does not play a central role here; he/she is more a mentor and a guide, or a counselor to solve pupils' problems.

**Recommendations:**

1. Better plotting the timeline of a given teaching hour, not relying on "how it comes out, so it goes out and we'll discuss the rest again."
2. Too much noise disturbs the concentration of the weaker pupils.
3. Prepare for pupils a worksheet with a diagram, the values of the currents and voltages on the individual resistors, adding the sign (+) in the relation for the total current, adding some parts of the derivation of the relationship for the resulting resistance (due to lack of time).
4. Devote more time to discover the relationship between the currents and especially to derive the relationship for the resulting resistance of the parallel-connected resistors during the same teaching hour in which pupils experimentation takes place.
5. Consistently take care of terminology - distinguish resistance and resistor.

**3. Conclusion**

Based on the analysis of the teaching lessons of the university student and the experienced teacher, it can be said that both the student and the experienced teacher are making mistakes during teaching. The student has encountered major problems - inadequate mastering of the methodology of group work, insufficient acquisition of specialized physical topics resulting in poor and imprecise formulation. The student also did not have pre-solved the tasks applied during the lesson. The method used in both lessons was group work. Only the experienced teacher was able to exploit deeper the potential of this method. Pupils actively worked and formulated their conclusions; the teacher immediately gave them response. The main disturbing element in both lessons was noise.

Although the university students are trained in didactics for their pedagogical practice, there is a big difference between the university seminar with presentations of physics lessons (only in front of schoolmates) and a real school environment. The method used in both lessons was group work as an example of learner centered methods. From the teachers' point of view learner centered methods are very difficult. The classes are made up of mostly 30 pupils, that are differently motivated or active, differently interested in the subject, with differences in knowledge. The outcome of our research goes to the improvement of the study program of the teaching profession. The direct pedagogical practice at schools is too short, therefore other subjects were included into the curriculum – "listening" practice, and "continuous" practice. These subjects will allow students to stay longer and more often in contact with the real school environment and take part in various teaching activities at schools. On the basis of these

findings, methodical materials for critical topics in physics are modified too. Within the subject “reflection of practice” a deep analysis and evaluation of the teaching lessons is carried out.

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