

# New Trend in Engineering Pedagogy Physics at Secondary Vocational schools in Czech and Slovak Republic - state and trends.

*Using innovative methods in teaching PHYSICS at high school.*

Roman Cibulka<sup>1</sup>, Petr Sládek<sup>2</sup>, Jan Válek<sup>3</sup>

## Abstract

Problems in the teaching of physics are the subject of various research. Teaching physics at Secondary Vocational School in non-technical graduate or in study fields means meeting with pupils who have little interest in physics. They look at this subject as unnecessary, often regarded as demanding (even because they must use mathematics). Their knowledge is therefore low. Nevertheless, the inclusion of appropriate teaching methods can attract interest in pupils in this subject, which will certainly improve the results in physical education. In my contribution, I compare the results of physical education at the Secondary School of Gastronomy, Hotel and Forestry Bzenec, the Contribution Organization and the Secondary School of Forestry in Tvrdošín in the Slovak Republic.

## Neuer Trend in der Ingenieurpädagogik Physik an berufsbildenden Sekundarschulen in der Tschechischen und Slowakischen Republik - Zustand und Trends. Subtitle in German.

*Mit innovativen Methoden im PHYSICS-Unterricht an der High School.*

Probleme im Physikunterricht sind Gegenstand verschiedener Forschungen. Physikunterricht an einer Berufsfachschule in einem nicht-technischen Hochschulabschluss oder in einem Studienfach bedeutet Treffen mit Schülern, die sich wenig für Physik interessieren. Sie betrachten dieses Thema als unnötig und werden oft als anspruchsvoll angesehen (auch weil sie Mathematik anwenden müssen). Ihr Wissen ist daher gering. Dennoch kann die Einbeziehung geeigneter Lehrmethoden das Interesse der Schüler an diesem Thema wecken, was die Ergebnisse im Sportunterricht sicherlich verbessern wird. In meinem Beitrag vergleiche ich die Ergebnisse der Sporterziehung an der Sekundarschule für Gastronomie, Hotel- und Forstwirtschaft Bzenec, der Beitragsorganisation und der Sekundarschule für Forstwirtschaft in Tvrdošín in der Slowakische Republik.

### Keywords:

innovative methods  
teaching method  
forms of teaching in subject Physics  
results of education – comparison

### Schlüsselwörter:

Innovative Methoden  
Lehrmethode  
Unterrichtsformen im Fach Physik  
Ergebnisse der Ausbildung - Vergleich

<sup>1</sup> Mgr. Roman Cibulka, MBA, Univerzita Hradec Králové, Rokitsanského 62, 500 03 Hradec Králové III, e-mail: [cibulro1@uhk.cz](mailto:cibulro1@uhk.cz)

<sup>2</sup> doc. RNDr. Petr Sládek, CSc., Pedagogická fakulta Masarykovy univerzity, Poříčí 7, 603 00 Brno, e-mail: [sladek@ped.muni.cz](mailto:sladek@ped.muni.cz)

<sup>3</sup> PhDr. Jan Válek, Ph.D., Pedagogická fakulta Masarykovy univerzity, Poříčí 7, 603 00 Brno, e-mail: [valek@ped.muni.cz](mailto:valek@ped.muni.cz)

## 1. Introduction

### Target:

1. To analyze the results of education before and after the introduction of innovative methods into the subject of physics at secondary technical schools of non-technical orientation.
2. Compare the scores found from available partner school data.

### Selected methods:

1. Quantitative research - simple statistical procedures for categorical data (sums, averages, percentages).
2. Qualitative research - analysis of obtained data, interpretation of acquired data and drawing of own conclusions and recommendations for practice.

In view of the nature of the research, the research is quantitatively oriented. They solve descriptive research problems for which scientific hypotheses can not be formulated (Gavora, 2000) and research problems.

## 2. Data and analysis

The secondary school of gastronomy, hotel and forestry Bzenec, a contributory organization, educates students in two graduate courses and five teaching disciplines.

**Table 1a: Overview of disciplines and time allocation**

| Field of study              | 1st year of study<br>(hourly subsidy) | 2nd year of study<br>(hourly subsidy) | Total<br>(hourly subsidy) |
|-----------------------------|---------------------------------------|---------------------------------------|---------------------------|
| Ecology and the environment | 1                                     | 1                                     | 68                        |
| Hotel servicesí             | 1                                     | -                                     | 34                        |
| Confectioner                | 1                                     | -                                     | 32                        |
| Forest mechanic             | 1                                     | -                                     | 32                        |
| Cook - waiter               | 1                                     | -                                     | 32                        |
| Fisherman                   | 1                                     | -                                     | 32                        |
| Gardener                    | 1                                     | -                                     | 32                        |

**Source: SS GHaF Bzenec, c.o.**

The Tvrdošín Forestry School in the Slovak Republic teaches pupils in three graduate courses and four courses of study.

**Table 1b: Overview of disciplines and time allocation**

| Field of study                                       | 1st year of study<br>(hourly subsidy) | 2nd year of study<br>(hourly subsidy) | Total<br>(hourly subsidy) |
|--|---------------------------------------|---------------------------------------|---------------------------|
| Mechanization of agriculture                         | 1                                     | 1                                     | 68                        |
| Mechanic of machinery and equipment                  | 1                                     | -                                     | 32                        |
| Forest operator                                      | 1                                     | -                                     | 32                        |
| Agromechanizac, Repairer                             | 1                                     | -                                     | 32                        |
| Mechanic of Forest production                        | 1                                     | -                                     | 32                        |
| Mechanic-Repairer – forestry machinery and equipment | 1                                     | -                                     | 32                        |
| Carpenter  | 1                                     | -                                     | 32                        |

**Source: SVSF Tvrdošín, Slovak Republic**

Currently about 120 students are taught in Physics. They are mostly pupils who have some problems with this subject. With such low hourly subsidies and very extensive content of curriculum, classical frontal instruction is no longer satisfactory and difficult for pupils. For these reasons, innovative teaching methods have been introduced in recent years.

Teaching methods are closely related to didactic elements, they do not act in isolation, but only with other factors through which the educator achieves educational goals. In order to achieve any educational goal, in any pedagogical situation and with any class, for any learning topic, to choose one teaching method and to teach it only by this method. In this situation, the teacher chooses a method that is most appropriate for delivering the curriculum and the appropriate age, or combining multiple methods together. The choice of method is always based on the purpose and content of the lesson, the personality of the teacher and the personality of the pupil. While pupils prefer innovative methods, teachers prefer other teaching methods, especially interpretation, explanation and frontal instruction. However, they do not have a negative attitude towards innovative methods, classify them into their classroom lessons, as these methods indicate that the lesson is more fun and pupils are more active and motivated. However, the implementation of Innovative Methods in Teaching is time-consuming to prepare and implement, in some cases also requiring material provision and gradual preparation of pupils for this type of teaching.

Innovative teaching methods are characterized by the ability to apply pupils' activity in formulating goals and planning activities, to enhance personal practical experience, to self-control through self-control, self-confidence and responsibility of pupils. Characteristic is the change in the status of teacher and pupil.

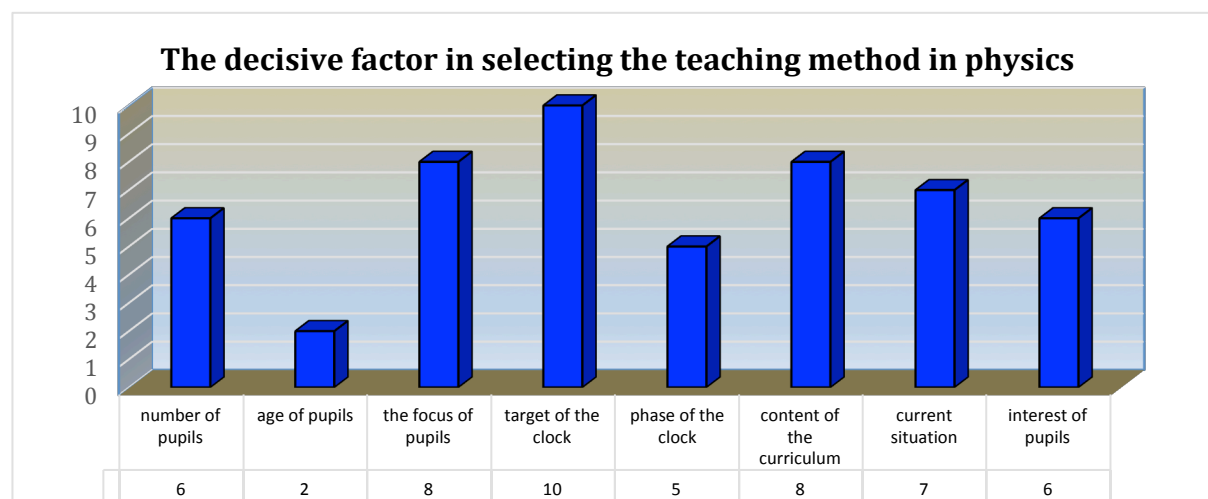
#### Preferred methods in each phase of an hour:

1. motivational phase - explanation, interview,
2. exposure phase - group work, text work
3. fixation phase - interview, thought maps,
4. diagnostic phase - independent work, tests, problem solving
5. application Phase - Project Teaching, Open Teaching, Group Teaching

**Table 2: The decisive factor in teaching**

| The decisive factor in selecting the teaching method in physics |    |
|---|----|
| scale 1 - 10 (10 = the most important)                          |    |
| number of pupils  | 6  |
| age of pupils   | 2  |
| the focus of pupils   | 8  |
| target of the clock   | 10 |
| phase of the clock  | 5  |
| content of the curriculum                                       | 8  |
| current situation   | 7  |
| interest of pupils  | 6  |

Source: SS GHaF Bzenec, c.o.



### Graph no. 1 - a decisive factor in teaching

A decisive factor in selecting a teaching method is the goal and the content of the subject matter for the teacher. The teacher also takes into account the current situation and focus of the class (study / study discipline). Less is taken into account by the age of the pupils and the phase of the lesson.

**Table 3: Predominant forms of teaching - share of hours (in%)**

| Forms of teaching         | study fields (graduation) | teaching branches (vocational certificate) |
|---------------------------|---------------------------|--|
| Frontal education         | 88,2                      | 91,7                                       |
| Group teaching            | 13,3                      | 10,1                                       |
| Cooperative education     | 6,0                       | 4,3  |
| Individual work of pupils | 48,6                      | 38,2                                       |
| Individual lessons        | 4,9                       | 6,3  |

**Source:** Annual Report Czech School Inspection for the school year 2014/2015, Prague, CSI 2015, 236 p. Available from [http://www.csicr.cz/Csicr/media/Prilohy/PDF\\_el\\_publicace/Vyrocní\\_zpráva\\_CSI\\_2014\\_2015.pdf](http://www.csicr.cz/Csicr/media/Prilohy/PDF_el_publicace/Vyrocní_zpráva_CSI_2014_2015.pdf), p. 81

**Table 4: Teaching methods - share of hours (in%)**

| Teaching methods              | study fields (graduation) | teaching branches (vocational certificate) |
|-------------------------------|---------------------------|--|
| Interpretation, lecture       | 41,0                      | 43,6                                       |
| Narration                     | 3,4                       | 2,9  |
| Explaining                    | 51,8                      | 59,1                                       |
| Structured interview          | 45,9                      | 43,8                                       |
| Discussion                    | 9,5                       | 6,6  |
| Problem learning              | 10,8                      | 6,7  |
| Project teaching              | 0,4                       | 0,5  |
| Working with text             | 31,0                      | 26,2                                       |
| Activating methods            | 19,6                      | 17,3                                       |
| Demonstration methods         | 11,2                      | 13,2                                       |
| Practically practical methods | 18,7                      | 13,5                                       |

**Source:** Annual Report Czech School Inspection for the school year 2014/2015, Prague, CSI 2015, 236 p. Available from [http://www.csicr.cz/Csicr/media/Prilohy/PDF\\_el\\_publicace/Vyrocní\\_zpráva\\_CSI\\_2014\\_2015.pdf](http://www.csicr.cz/Csicr/media/Prilohy/PDF_el_publicace/Vyrocní_zpráva_CSI_2014_2015.pdf), p. 81

**Table 5: Predominant forms of teaching in the subject PHYSICS**

| Převažující vyučovací metody | Share in %                |  |
|------------------------------|---------------------------|--|
|                              | study fields (graduation) | teaching branches (vocational certificate) |
| Interpretation, lecture      | 21,3                      | 27,9                                       |
| Narration                    | 0,8                       | 1,6  |
| Explaining                   | 35,7                      | 40,0                                       |
| Structured interview         | 2,5                       | 0,7  |
| Discussion                   | 2,8                       | 1,0  |
| Problem solving method       | 1,5                       | 0,7  |
| Project teaching             | 1,2                       | 0,1  |
| Working with text            | 11,2                      | 5,2  |
| Activating methods           | 20,1                      | 19,8                                       |
| Demonstration methods*       | 2,9                       | 3,0  |
| Skills Practical Methods**   | 0,7 (using ICT)           | 0,0  |

\* demonstration, projection, experiment etc.

\*\* practical, work activities, laboratory exercises, practice, graphic, etc.

Source: SS GHaF Bzenec, c.o.

Table 6: Findings from the course of educational activities in visited secondary schools.

| Monitored indicators |                               | Share in %                |  |
|----------------------|-------------------------------|---------------------------|--|
|                      |                               | study fields (graduation) | teaching branches (vocational certificate) |
| Forms of teaching    | Front education               | 82,8                      | 85,8                                       |
|                      | Group lessons                 | 9,4                       | 10,0                                       |
|                      | Cooperative education         | 9,4                       | 6,9  |
|                      | Individual work of pupils     | 43,4                      | 41,0                                       |
| Methods              | Transmitting lessons          | 57,7                      | 62,6                                       |
|                      | Communicative teaching        | 60,7                      | 63,8                                       |
|                      | Working with text             | 30,2                      | 24,8                                       |
|                      | Project teaching              | 1,3                       | 1,5  |
|                      | Problem learning              | 12,7                      | 7,7  |
|                      | Activating methods            | 24,0                      | 23,0                                       |
|                      | Demonstration methods         | 17,1                      | 23,6                                       |
|                      | Practically practical methods | 15,4                      | 19,5                                       |

Source: Annual Report Czech School Inspection for the school year 2016/2017, Prague, CSI 2015, 236 p. Available from [http://www.csicr.cz/getattachment/cz/Dokumenty/Vyrocní-zpravy/Kvalita-a-efektivita-vzdelavani-a-vzdelavaci-soust/VZ\\_CSI\\_2017\\_web\\_new.pdf](http://www.csicr.cz/getattachment/cz/Dokumenty/Vyrocní-zpravy/Kvalita-a-efektivita-vzdelavani-a-vzdelavaci-soust/VZ_CSI_2017_web_new.pdf), p. 240

Table 7: What form of teaching pupils prefer

| Form of teaching           | Prefer (%) | Both when(%) | I do not like (%) |
|----------------------------|------------|--------------|-------------------|
| Work with computer         | 88         | 12           | 0                 |
| Attempts                   | 40         | 15           | 45                |
| Group work                 | 67         | 30           | 3                 |
| Searching for information  | 70         | 25           | 5                 |
| Laboratory work            | 0          | 10           | 90                |
| Project                    | 50         | 38           | 12                |
| Digital teaching materials | 70         | 28           | 2                 |
| Individual works           | 50         | 30           | 20                |
| Interpretation and lecture | 63         | 27           | 10                |
| Brainstorming              | 65         | 15           | 20                |
| Mind map                   | 20         | 40           | 40                |
| We learn each other/papers | 15         | 38           | 47                |
| 3D animation/internet      | 90         | 10           | 0                 |

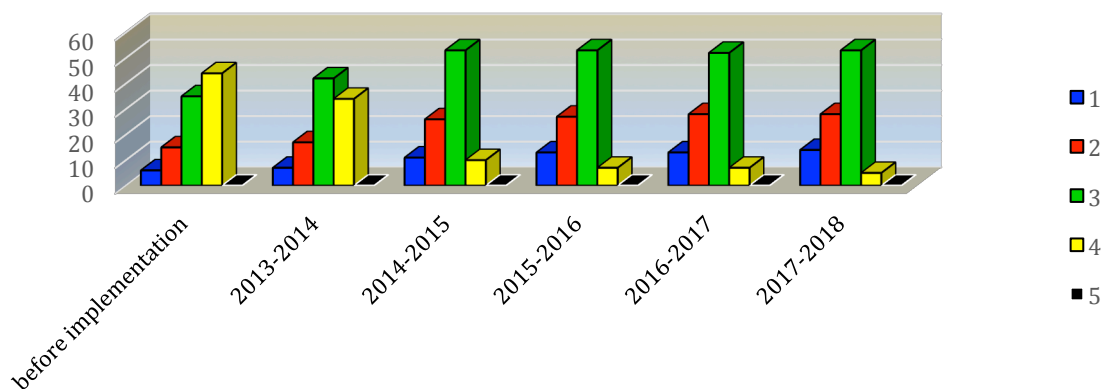
Source: SS GHaF Bzenec, c.o.

Table 8a: Comparing learning outcomes before and after introducing innovative teaching methods

| School year           | Percentage of the classification achieved |             |           |            |           |
|-----------------------|---|-------------|-----------|------------|-----------|
|                       | excellent                                 | commendable | excellent | sufficient | excellent |
| before implementation | 6   | 15          | 6         | 44         | 6         |
| 2013-2014             | 7   | 17          | 7         | 34         | 7         |
| 2014-2015             | 11  | 26          | 11        | 10         | 11        |
| 2015-2016             | 13  | 27          | 13        | 7          | 13        |
| 2016-2017             | 13  | 28          | 13        | 7          | 13        |
| 2017-2018             | 14  | 28          | 14        | 5          | 14        |

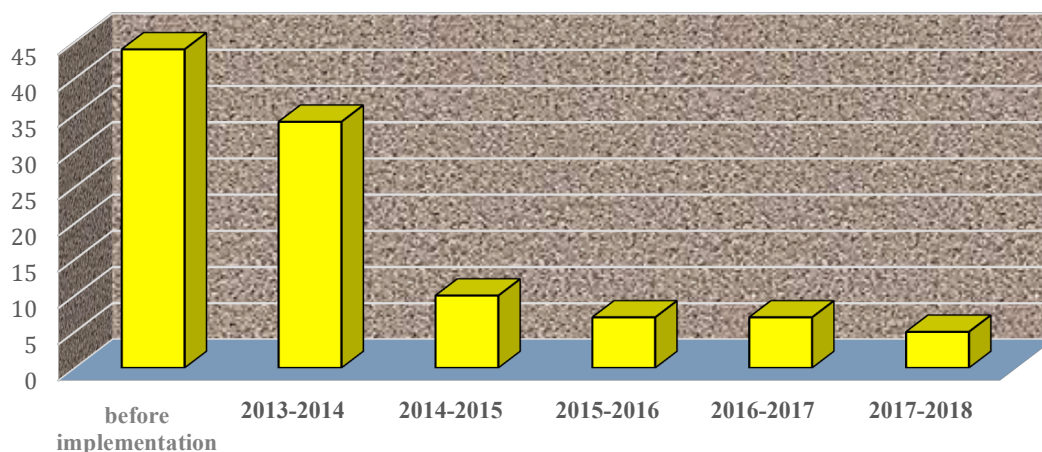
Source: SS GHaF Bzenec, c.o.

### Results of education/Learning outcomes



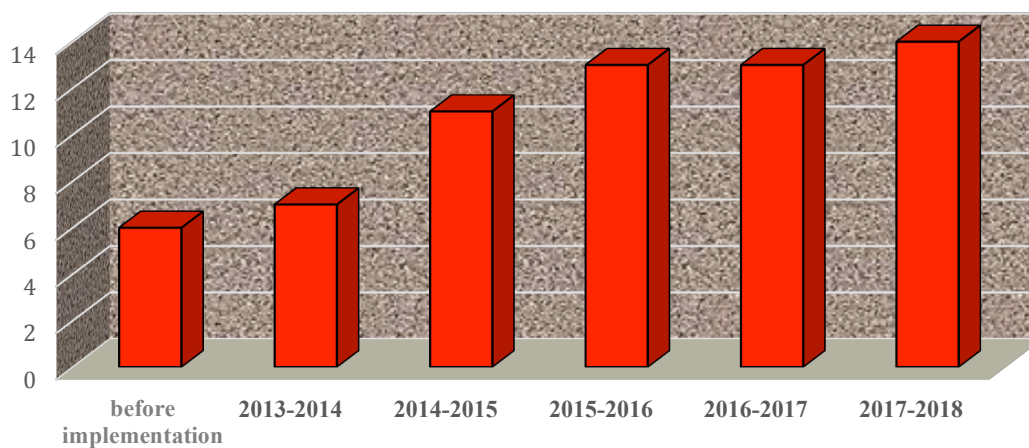
Graph no.2a - learning outcomes

### Evaluation "sufficiently"



Graph no.3a - Evaluation "sufficiently"

### Evaluation "excellent"

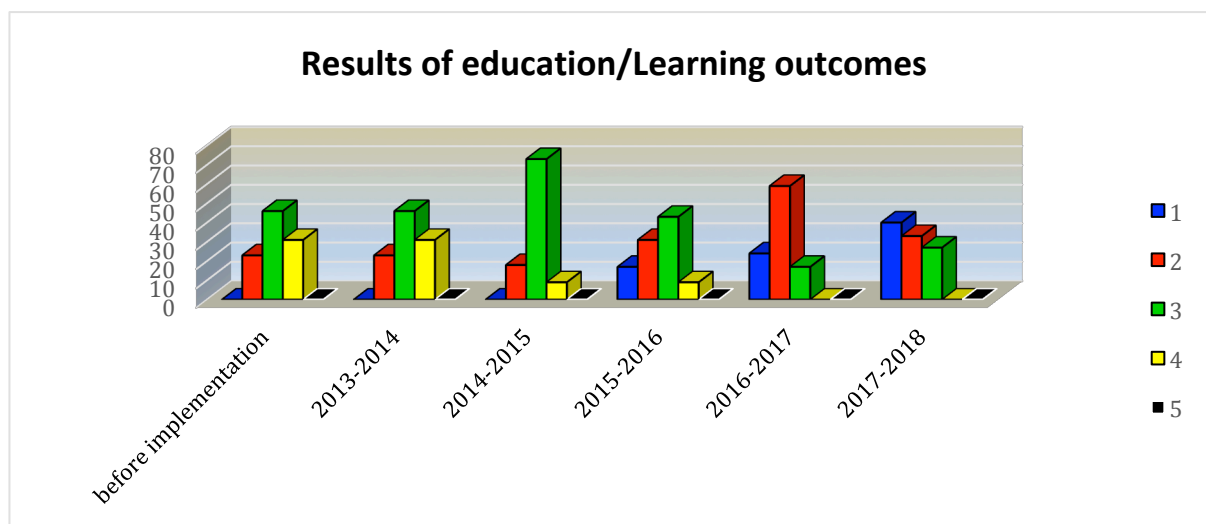


Graph no.4a - Evaluation "excellent"

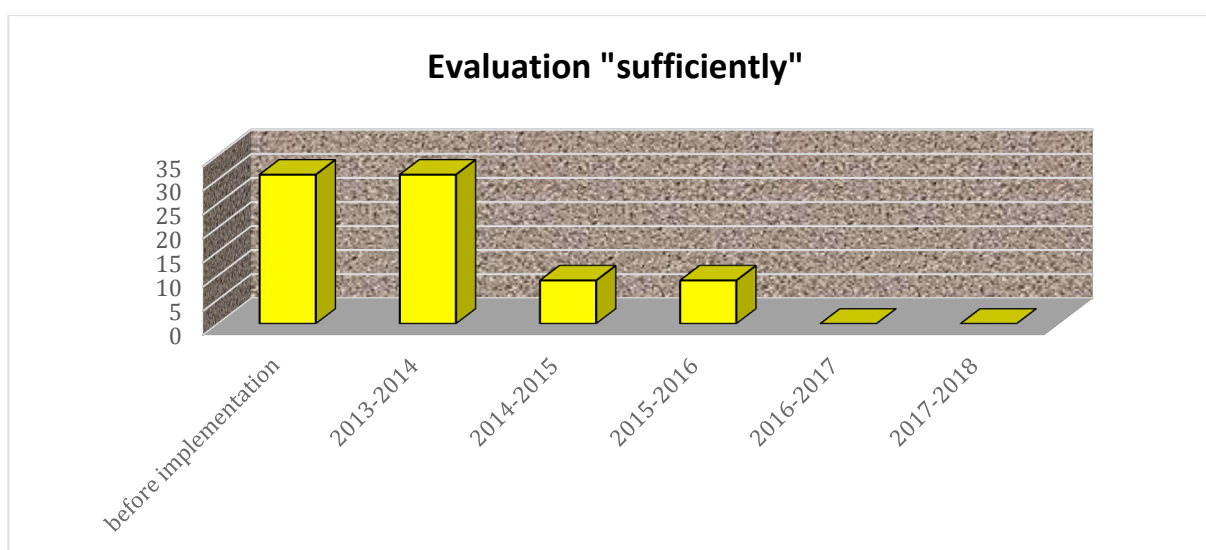
**Table 8b: Comparing learning outcomes before and after introducing innovative teaching methods**

| School year           | Percentage of the classification achieved |             |           |            |           |
|-----------------------|---|-------------|-----------|------------|-----------|
|                       | excellent                                 | commendable | excellent | sufficient | excellent |
| before implementation | 0   | 23          | 46        | 31         | 0         |
| 2013-2014             | 0   | 23          | 46        | 31         | 0         |
| 2014-2015             | 0   | 18          | 73        | 9          | 0         |
| 2015-2016             | 17  | 31          | 43        | 9          | 0         |
| 2016-2017             | 24  | 59          | 17        | 0          | 0         |
| 2017-2018             | 40  | 33          | 27        | 0          | 0         |

Source: SVSF Tvrdošín, Slovak Republic

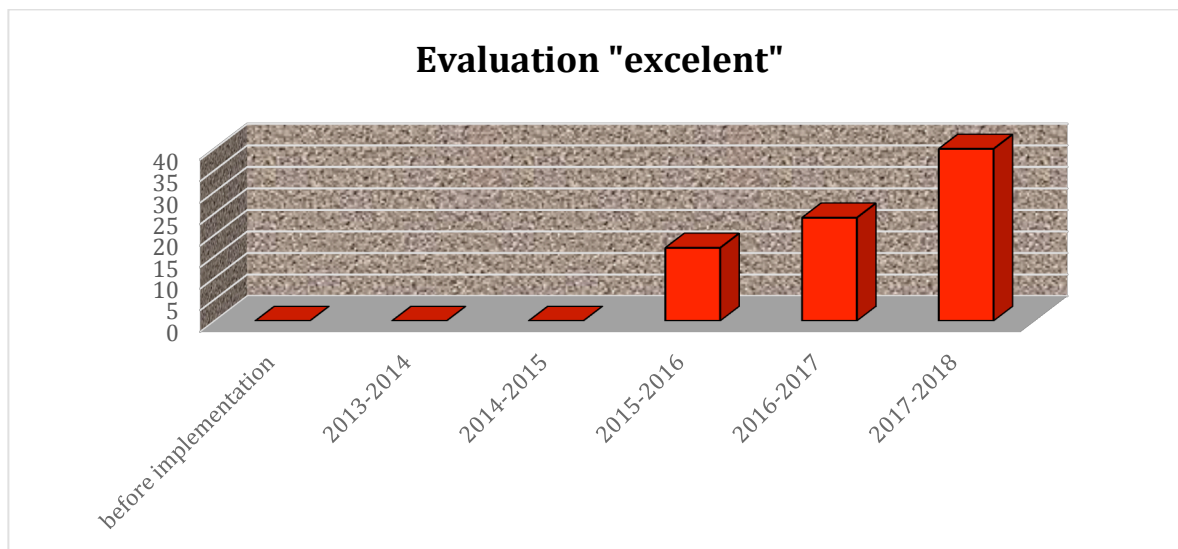


Graph no.2b - learning outcomes



Graph no.3b - Evaluation "sufficiently"





**Graph no.4b - Evaluation "excelent"**

### 3. Recommendation

From the documented results it can be clearly stated that new forms of teaching using information and communication technologies lead to better teaching and better understanding of the subject matter. The new generation of pupils grows on these technologies and is commonly used daily and is very close to them. Progress can not be stopped even in forms of education, but education should be a pioneer of all new technologies.

In high school, where this school is chosen by pupils for the given discipline, we have to assume that we will work with pupils who have had inferior results at the elementary school, and therefore the evaluation from the subject PHYSICS. The problem of the absence of basic knowledge is not due to the transition to secondary school and thus to the higher demands of the subject, but is of a longer term nature. Appropriate motivation and incorporation of innovative methods into teaching even for these pupils will make it possible for pupils to understand the issue and this will improve their physical education.

Appropriate motivation, linking education with practice, introducing and using innovative methods in teaching will not only improve the assessment of pupils but also improve the overall position of PHYSICS on the popularity ranking.

### 4. Discussion

The teacher uses the methods and forms of learning that lead the pupil to work actively. The learner creates an understanding of what he has seen in experiments, verbalizes what he has tried, classifies concepts, classifies information, creates structures, and so on.

A comparison of the evidence suggests that both types of schools are the most widely used teaching methods in physics explanation lessons and e-learning is the least used method. The decisive factor in the selection of the teaching method was given by the teachers of Physics at these schools to the content of the subject matter, the focus of the field and as a negligible factor in both schools the phases are considered by the phases



and the project instruction. The interviewed teachers said they had sufficient access to information where they were looking for tips, advice, and inspiration in terms of teaching methods. (information is mostly sought after on the Internet and usually in book publications)

### **Why?**

- By using innovative methods, learning is much more effective than teaching when the student is passive.
- Other lifelong learning skills (social, communication, cooperative, ...) are being developed in this way.
- By changing methods, the lessons for pupils become more attractive.

### **What is it and how does it work?**

- In physics, we can also use different methods of active learning, such as working with text, discussion activities, problem tasks, group work, brainstorming, thought maps, etc.
- Teaching is varied, alternating between different methods and forms of work. The teacher meets the different learning styles of the pupils.
- Teachers ask open questions for pupils and let pupils respond to them (does not respond by themselves).
- In group work, a teacher assigns assignments to groups in writing, the assignment contains evaluation criteria.
- In formulating the activity, the teacher formulates the meaning and purpose of the activity that pupils understand. (Active learning methods are not perceived by pupils as play and entertainment.) Achieving the goal The pupils evaluate at the end of the lesson. (guiding pupils to self-assessment and evaluation)
- Pupils produce presentations of their work results (use of ICT in physics, thought maps, papers, etc.) on the basis of predefined criteria that respect the learning objectives.

### **What Happens When It Works, Examples:**

- The pupil works with different sources of information (individual experiment, film, internet, text, own observations ...).
- When reading text, the pupil indicates information that is familiar to them and which is new.
- The pupil cooperates with another student VCHD (I know, I want to know, I learned), discussing the pupil's "speech" problem
- The pupil does not understand the wrong answer as his loss, but as a shift to the right solution (learning by mistake)
- Teacher asks for context, own opinion of pupils, discusses and controversies with pupils.
- Before discussing a new thematic unit the teacher leaves the pupils to create a mind map. After discussing the topic you can return to the created map, edit it, and add new findings.
- Project teaching (seminar work can also be done through homework, yearly work, selection tasks, etc.)

## **5. Conclusion**

Comparing the learning outcomes of pupils in the non-technical fields of both secondary and second-tier secondary schools demonstrates that the introduction of exploitation and active methods in teaching physics at high school leads to the improvement of student learning outcomes in these fields. Today's time allows physics teachers to introduce new methods and trends into teaching this subject and using ICT in teaching. If we are not satisfied with the mere removal of the subject matter / topic and we will devote sufficient space to innovative methods in teaching physics, it will certainly help to improve the results in physical education and to improve the overall position of the subject of physics at secondary technical schools of non-technical orientation.

## References

ČESKÁ školní inspekce. [online] Praha. [cit. 2018-06-10] Dostupné z:  
<http://www.csicr.cz/cz/Dokumenty/Inspekcnizpravy>.

Gavora, P. (1996). Výzkumné metody v pedagogice: příručka pro studenty, učitele a výzkumné pracovníky. Brno: Paido.

Grecmanová, H., & Urbanovská, E. (2007). Aktivizační metody ve výuce, prostředek ŠVP. Olomouc: Hanex.

Maňák, J., & Švec, V. (2003). Výukové metody. Brno: Paido.

Mechlová, E., Franková, A., Jedličková, H., , L., Koníček, P., & Smyček. (2009). Metodika výuky fyziky na 2. stupni základních škol a středních školách z pohledu pedagogické praxe - náměty pro začínající učitele. Ostrava: Ostravská univerzita v Ostravě.

GOTTVALD Stanislav. Principy smysluplné výuky, [online] Praha. Dostupné z:  
<http://kdf.mff.cuni.cz/RVP2018/doku.php>

SS GHaF Bzenec, c.o., Czech Republic – data, teaching materia of years 2013/2014 – 2017/2018

SVSF Tvrdošín, Slovak Republic - data, teaching materia of years 2013/2014 – 2017/2018

## A list of tables

Table 1a: Overview of disciplines and time allocation

Table 1b: Overview of disciplines and time allocation

Table 2: The decisive factor in teaching

Table 3: Predominant forms of teaching - share of hours (in%)

Table 4: Teaching methods - share of hours (in%)

Table 5: Predominant forms of teaching in the subject PHYSICS

Table 6: Findings from the course of educational activities in visited secondary schools.

Table 7: What form of teaching pupils prefer

Table 8a: Comparing learning outcomes before and after introducing innovative teaching methods

Table 8b: Comparing learning outcomes before and after introducing innovative teaching methods

## A list of graphs

Graph no. 1 - a decisive factor in teaching

Graph no.2a - learning outcomes

Graph no.3a - Evaluation "sufficiently"

Graph no.4a - Evaluation "excellent"

Graph no.2b - learning outcomes

Graph no.3b - Evaluation "sufficiently"

Graph no.4b - Evaluation "excellent"