DIDACTIC MODEL FOR THE DEVELOPMENT OF STUDENTS' COGNITIVE SKILLS IN STUDYING OF ELECTROMAGNETIC PHENOMENA

Georgi Malchev,
Department of Physics, South-West University "Neofit Rilski", Blagoevgrad, Bulgaria
gmalchev@abv.bg,
Radost Vassileva, PhD
Department of Physics, South-West University "Neofit Rilski", Blagoevgrad, Bulgaria
radostiv@abv.bg

Abstract: The paper views opportunities for the development of some cognitive skills of students in the 9th grade while studying electromagnetism in their mandatory training in physics. It presents an author's didactic model based on four pedagogical approaches – activity-oriented, intrapersonal, interactive and interdisciplinary. The correlation between them finds expression in a particularly developed methodological system. Technologically the model is implemented by using the information-communicative technologies (ICT), the academic essay, the project method and the portfolio technology. The point is for the teacher to contribute the best way possible to the creation of active educational environment by applying various methodological combinations and carefully chosen cognitive assignments. Such active educational environment stimulates students to research, analyze, summarize and be creative in their physics classes. The tangible result is a different quality of education, which involves cognitive interest in the studied school material. The model has been implemented in school. The experimental data have been summarized with the application of appropriate statistics methods and the results unambiguously prove the model's efficiency.
Keywords: physics education, cognitive skills, electromagnetic phenomena, pedagogical approaches, motivation

1. INTRODUCTION

It is well known that contemporary students' motivation to study is somewhat decreasing these days, which is why physics teachers have to start searching for new approaches to transform their students from mere learners to knowledgeable researchers in pursuit of new opportunities to take advantage of. Combining traditional methodology with contemporary educational and IT innovation, some of which is already utilized by the present generation of young learners, makes the field of physics easier, a bit more luring and does away with the routine of studying the subject. This, in turn, stimulates students to study, boosts their urge to explore, analyze, summarize and create in their physics classes.

The "Electromagnetic Interaction" part of the school curriculum is most definitely practice-oriented. It views the various applications of electromagnetism in contemporary technology, nature and life. The teacher should skillfully act upon this favourable premise and by applying various methodological combinations and carefully selecting different cognitive tasks he/she should be able to create the most active educational ambience.

The object of the current research is the educational process of physics education in high school.

The object of the research is the process of developing students' cognitive skills in the course of studying "Electromagnetic Interaction" in the 9th grade.

The aim of the research is to reveal new pedagogical opportunities for developing and mastering student's cognitive skills while studying electromagnetism.

Activities to do:

- work out a didactic model aiming at developing and mastering students' cognitive skills in the study of electromagnetic phenomena;
- work out and apply methodological system for the practical implementation of the aforementioned didactic model;
- come up with and apply a set of tools to control and evaluate students' achievements in accordance with the suggested methodology;
- conduct a didactic experiment to check the model's efficiency;
- analyze and sort out the didactic model's advantages and shortcomings.

2. PEDAGOGICAL APROACHES AND TEACHING METHODS

In order to achieve the research goals, elements of the four pedagogical approaches are successfully combined with each other – activity-oriented, intrapersonal, interactive and interdisciplinary. They are the foundation of a didactic model developed for the purpose of promoting the studying of electromagnetic interaction in the mandatory training in physics (Fig.1). The model has to do with the pedagogical and control activity of the teacher. The selected pedagogical approaches are combined in the most optimal and relevant way and aim at developing the cognitive skills of the students through a specially designed for this purpose methodical system. Technologically speaking, the model is put into practice by utilizing the information-communication technologies (ICT), the academic essay, the project method and the so-called training portfolio technology.

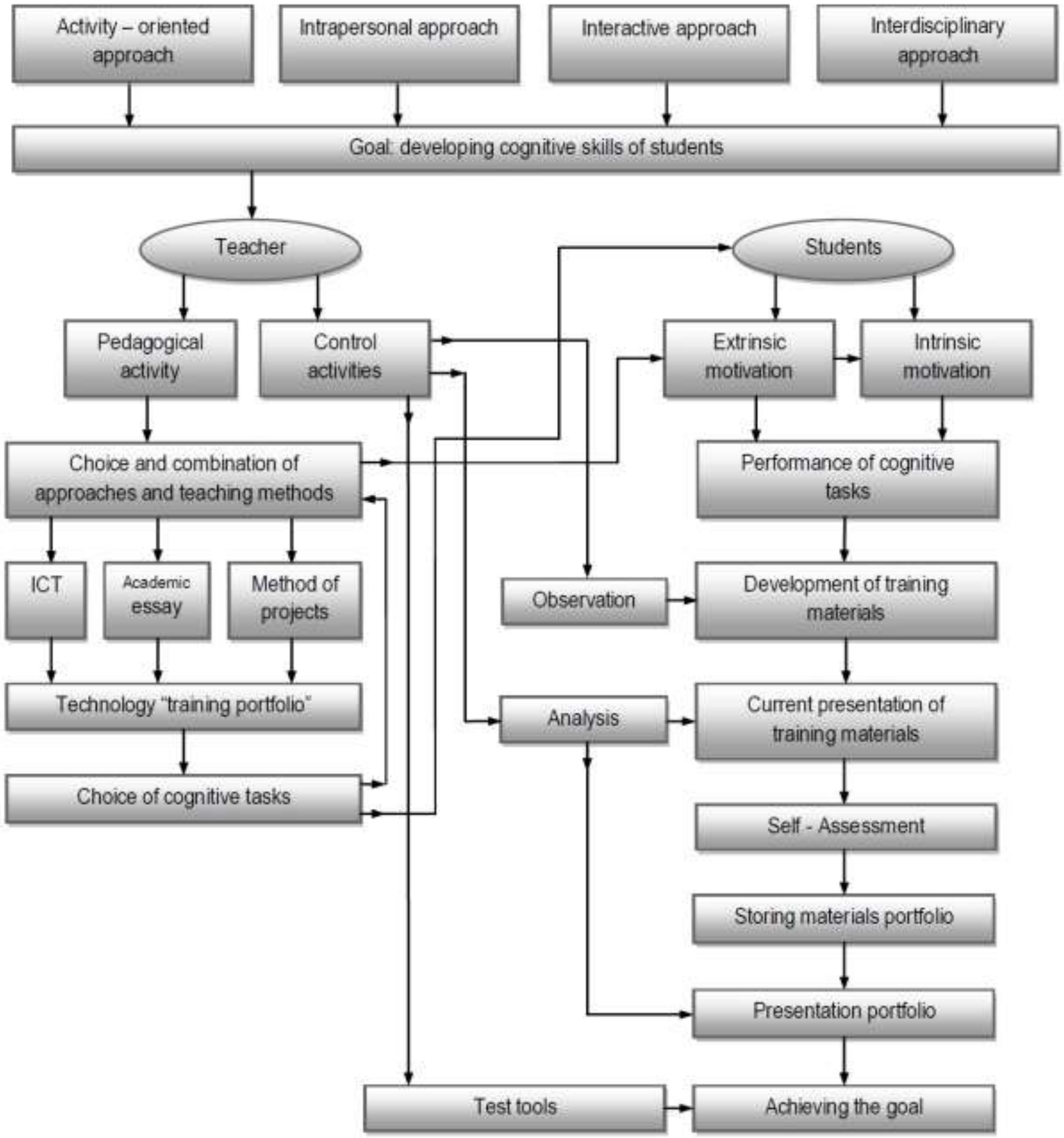

Fig. 1. *Didactic model for the development of cognitive skills of students studying electromagnetism*

The use of the ICT in the study of the electromagnetic phenomena helps students handle the scientific information in an electronic form. Thus enriched, the content of the "Electromagnetic interaction" part is better understood and rationalized, which also lead to a positive effect on the motivation to study. When students study the electromagnetism with the help of ICT, they can also use information resources on the Internet, to develop original products, to shape the experimental results, and in general - to facilitate their learning process and self-preparation.

The writing of academic essays, associated with the application of electromagnetic phenomena in the fields of engineering, energetics, in the nature and in life, allows students to comprehend the study material in an independent and critical manner. Relying on the knowledge and skills acquired in the Bulgarian language and literature classes, they can further develop their interest, broaden their horizon through interpretation of scientific evidence and support their personal position with well-founded arguments.

The project-based study of electromagnetism allows students to develop themselves as explorers and to accumulate knowledge in the process of learning, thus forming new competencies. The method of projects facilitates the independent cognitive activity through solving personally significant problems, studied in the particular section of the book. The students learn to plan, observe, experiment, analyze and create. All of this gets them motivated and has a beneficial effect on their individual fulfillment and development.

A distinctive feature of the suggested model is the fact that the methodical combination of ICT, the academic essay, and project-based approach find its documental application in the "training portfolio" technology. It helps students to better comprehend the learning process and attach personal meaning to the scientific information about the electromagnetic phenomena. The portfolio documents the academic activities of the students in their entirety, measures the development of their competencies and represents a modern tool for a more inclusive and comprehensible grasp of the studied material. It is an efficient instrument for stimulating the learning process as well as for the development of specific skills. All this leads to a qualitatively different learning level, which indicates the presence of a cognitive interest in the electromagnetic phenomena.

The full utilization and integration of the model has an important advantage over the traditional form of instruction: the learners are not passive observers in the process of acquiring the educational material [1]. The teacher presents the educational material as a system of cognitive tasks, tailored to the approaches and particular methods. Each of these tasks reveals the specifics of the object, its properties, the laws it abides to, as well as its relations with other objects [2]. The cognitive tasks in the model are divided into three groups (Table 1). The students complete the tasks using educational materials. In every class, a student selected via lottery, is chosen to present his study product in front of his or her classmates. He self-evaluates himself and receives a mark from the teacher. Students keep all the materials in their portfolio, which they give to the teacher for evaluation twice in the framework of the section. The final grade is formed after the summary lesson, and is the average of the two current marks [3]. According to the model, the educational activity represents a unity of tasks, activities, self-control and self-evaluation. It not only fosters the cognitive abilities of the students, but also instills positive educational motivation in their minds [4].

Tabl. 1. *Cognitive tasks in the course of studying electromagnetism*

Cognitive tasks	Training materials from the performance of tasks
Creating:	● computer presentation of: — Earth's magnetic field — electromagnetic induction — structure and operation of the dynamo — electricity transmission — electric and magnetic field comparison
	● graphics of induction lines of different magnetic fields
	● clips using internet images of the aurora
	● an info board on magnetic field of direct current and electromagnetic interaction; an info board on alternating current characteristics
	● newsletter "Motors - yesterday, today and tomorrow"
	● website for electromagnetic phenomena
Writing:	● academic essays: — "Application of motors in engineering and their importance for the people" — "The magnetic recording of information and its application in audiovisual and computer technology" — "Transformers and their importance for technology and energetics"
	● report on the life and scientific way of Andre-Marie Ampere

	• their own physics problems on the following topics: — "Interaction between magnetic fields and moving charges" — "Electromagnetic induction" — "Alternating current"
	• laboratory reports on the topic: — "Defining of magnetic induction" — "Studying the work of transformer"
Search the Internet for:	• photos of magnetic storms • graphs of magnetic storms • videos of magnetic storms

3. RESULTS AND DISCUSSION

1. General description of the research

The didactic model was launched in Peyo Yavorov High School in Petrich, in 2014/2015 school year. 72 students in the 9th grade (experimental group) studied electromagnetic phenomena following the new methodology whereas 22 other students (control group) studied in accordance with the old one.

The ascertaining experiment was carried out before the beginning of the chapter with entry test 1 whose aim was to show the initial level of students' knowledge and skills.

The experimental verification of the efficiency of the suggested methodology was carried out in 3 stages with 3 tests covering:

- *stage 1* (test 2) – 4 lessons for acquiring new knowledge and 1 hour lab practice;
- *stage 2* (test 3) – 4 lessons for acquiring new knowledge, 3 lessons for solving physics problems and 1 hour lab practice;
- *stage 3* (concluding experiment, test 4) – all the lessons in the chapter.

2. Experimental Results

Moses' non-parametric statistical test was applied on the data from Entry test 1. The verification showed that the initial results of the control group and the experimental group were comparable. The lack of statistically significant differences between the two groups was also noted (level of significance p=0,741), which ensured the reliability of the experiment.

The Mann-Whitney non-parametric statistical test was used to indicate the differences in the success rate of the two groups in the educational experiment. The parallel presentation of the results from the experiment is reflected in Fig. 2. The following conclusions can be drawn:

- Test 2 – The data shows presence of statistically significant difference (indicator of Mann-Whitney U=516,5; level of significance p=0,009). As can be seen from Fig. 2, the average rank MR of the experimental group ($MR_{experimental}$=51,33) was noted to significantly exceed that of the control group ($MR_{control}$=34,98). The indicators demonstrate that even in its initial phase the experimental influence has a positive effect over the success rate of the students.
- Test 3 – There are clearly detectable statistically significant difference (U=186,5; p<0,001). The average rank of the experimental group ($MR_{experimental}$=55,91) significantly exceeds that of the control group ($MR_{control}$=19,98), which confirms the effectiveness of the experimental influence at this stage as well.
- Test 4 (final) – The data shows presence of categorical statistically significant differences (U=166,5; p<0,001). The average rank of the experimental group ($MR_{experimental}$=56,19) significantly exceeds that of the control group ($MR_{control}$=19,07).
- In spite of the initially similar results, the experimental group demonstrated a significant increase of the success rate immediately after the first stage of the experiment when compared to the control group. This tendency was preserved throughout the second stage and after the third stage the differences in the results of the control and the experimental group were clearly in favor of the latter.

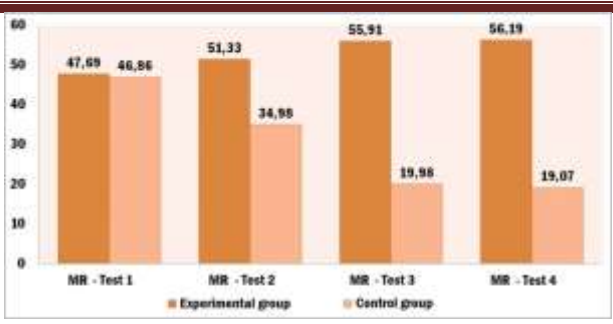

Fig. 2. *Parallel presentation of the results of the experiment*

The experimental data, irrespective of the separate phases and as a whole, confirmed the effectiveness of the developed model.

3. Advantages of the model:

The model:

- has proved to develop students' cognitive skills;
- objectively reflects young learners's achievements through the application of the developed test tools;
- enhances students' scope of knowledge through performing some particular cognitive activities;
- helps solve some scientific problems through research, experimental and creative work;
- generates new ideas as regards further school activities and projects.

4. Disadvantages of the model:

- the new method of teaching and self-study is considered harder by the students at the beginning because of the habits they have developed in traditional schooling;
- young learners often experience exhaustion due to performing the cognitive tasks;
- having physics classes in a computerized room is not always a feasible option at school, which limits the use of computer technology in the classes for acquiring new information.

4. CONCLUSIONS

The experiment shows that the creative mixture of various pedagogical methods in physics education is a major factor for increasing its efficiency. In this particular didactic model traditional methodology is made the most of by using ICT, the academic essay, the method of project work and the school portfolio. This boosts students' motivation to study and most definitely brings their cognitive skills closer to perfection.

Similar model can be applied to other parts of the physics and astronomy syllabus. However, achieving the main goal of the model mostly depends on the creative approach of the teacher. This approach is also instrumental in achieving enhanced students' motivation and provoking their interest in studying physics and other natural sciences.

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