ACTA DIDACTICA NAPOCENSIA

Volume 8, Number 3, 2015

METHODS OF STIMULATING THE STUDENTS` CREATIVITY IN THE STUDY OF GEOMETRICAL OPTICS

Gabriel Florian, Sorin Trocaru, Aurelia-Daniela Florian, Alexandru-Dumitru Bână

Abstract: The aim of the present article is to focus on the operational aspects referring to the actions – strategies and on the defined modalities of establishing educational objectives/competences. In the achievement of our work a special attention has been paid to the operational aspects of the learning process of the optical phenomena. There were carried out representative and functional experiments concerning optical phenomena like: reflection of light, refraction of light, dispersion of light, using accessible and/or recyclable materials to run our experiments. The education of creativity implies both an explicit approach from the cognitive perspective and also all the dimensions of the personality and intellectual, psychomotor, affective and motivational potential of the students, together with the environmental factors.

Key words: optical phenomena, creativity, experiments, environment

1. Introduction

A new approach of the pedagogy of creativity targets mainly the educational activities which promote collaborative relationships [1] of the educational dyad, which encourage students and promote the heuristic educational system.

Recent studies on the stimulation and development of the Romanian students` creativity in the field of the optical phenomena are particularly completed for the secondary school students [2-3].

In order to confirm or refute the achievement of specific skills in the school curriculum [4] – for example, knowledge and skills acquired by the students working with theoretical and practical concepts of "Geometrical Optics" [4] - we used certain evaluation items whose aim was not only to incite the ninth graders in the study of the optical phenomena (reflection of light, refraction of light, dispersion of light) but also to educate their creativity. Therefore, we considered a careful and accurate planning of the teaching process in accordance with the enforced educational provisions [5]. A particular emphasis has been given to the process of creative teaching-learning-assessment since the creative approach represents the expression of the synergy between the two cerebral hemispheres, one resorting to reason, the other to synthesis [3].

We proposed to approach the optical phenomena which are based on the concept of the beam of light from a perspective that can significantly contribute to the students` development of a concrete and coherent creative spirit by [6]:

- Creating a permissive, stress free, open to innovation environment;
- Permanent stimulation of the students` critical thinking;
- Encouraging the students` personal reflection;
- Encouraging the students to ask questions/to ask themselves questions;
- Encouraging the students to make predictions;
- Encouraging the students to achieve ideal/material models;
- Encouraging the students to work with the models they have created/to change models/to use the models;
- Involving the students in doing various types of exercises;
- Encouraging the students to formulate problems and to to problematize;
- Involving the students in developing syntheses;

Received September 2015.

- Determining the students to develop various intellectual and material products;
- Stimulating the students to solve problems in several variants;
- Involving the students in curricular and extracurricular activities;
- Rewarding the students` ideas and actions.

2. Methods of stimulating creativity by group working

The following part of our study focuses on the main methods of stimulating the students` creativity by group working, which we consider relevant to teaching and learning the optical phenomena.

Our major concern was the exploitation of the students` basic knowledge, which contributed significantly to their acquisition of new information. The instructional methods we used to stimulate and activate the group work activity and the students` generative thinking were: Brainstorming, Brainwriting, Philips 6-6 and Synetics.

In planning and designing the lessons and activities for the study of the optical phenomena we took into consideration both the notional content specific to this approach and the recent studies in the field [7].

To reflect the paradigm shift, we selected and presented some representative problems / situations and experiments / laboratory activities for each of the methods listed above, which were formulated and adapted for the level of the secondary school study of the optical phenomena [8-14].

We also took into account the didactic component, reflected by the studies on heuristic strategies, which can be successfully applied to teaching physics [15, 16]. According to [6] we pointed out the following:

- Acquisition of new theoretical and practical knowledge at each student's own pace.
- Sparkling the students` interest and discovering their abilities, strengthening their self-confidence and developing their cooperation skills.
- Developing the students` critical thinking and creativity.
- Highlighting the knowledge acquired in a given teaching activity and consolidating the knowledge acquired following the study of the chapter "Geometrical Optics".

2.1 Brainstorming

Brainstorming is the most commonly used method to optimize creativity [3]. Essentially, this method consists in the intentional splitting of imagination from critical, rational thinking. The basic principles of this method are as follows: any person can generate ideas and quantity breeds quality. This method is particularly used to generate ideas in a group situation. Brainstorming favors imagination and its free expression, stimulates a rich flow of ideas and the processing of the ideas generated by the other members of the group [1].

The teacher can intervene to encourage the students to find solutions and make associations [6].

Examples:

- *Characterize the optical phenomena that can be explained using the concept of the light beam.*
- *Why is the cloudless sky blue?*
- *The images shown in Figure 1 illustrate several optical phenomena conducted under experimental works.*
  a) *Identify as many of these phenomena as possible.*
  b) *List the materials used in the experiments presented.*
  c) *Represent the way of the light beams for two of the phenomena identified on a sheet of graph paper.*

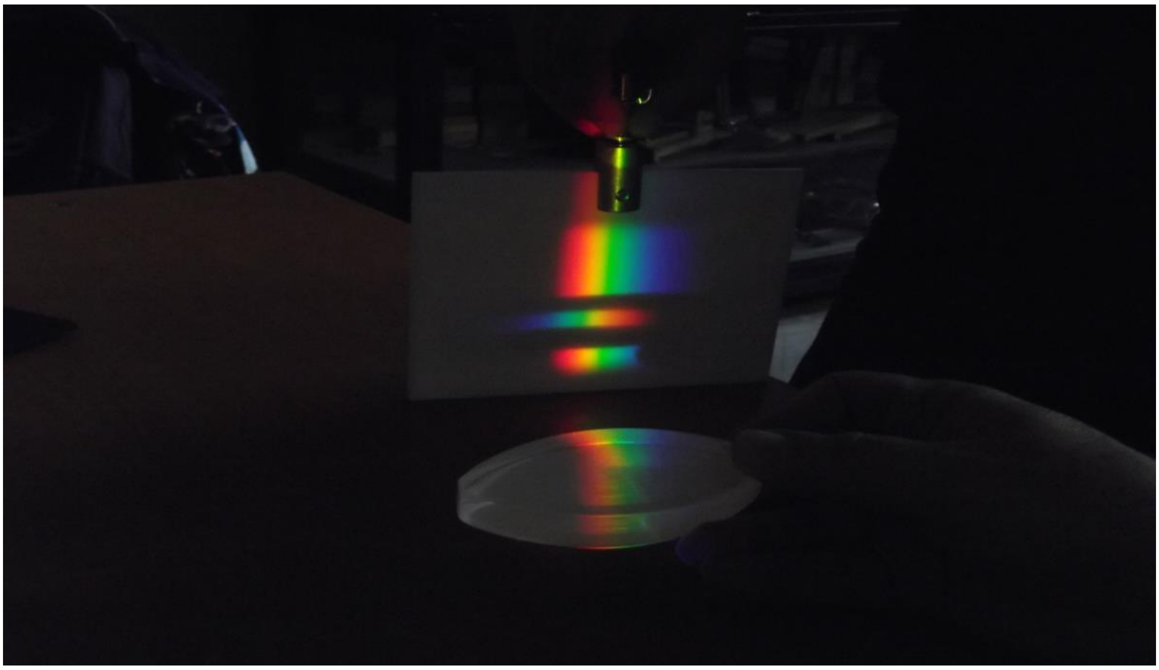

Figure 1. *Optical Phenomena carried out under experimental work*

2.2 Brainwriting

Brainwriting, also called the method 6-3-5, is often used to solve problems [3]. This method is similar to brainstorming, but the new generated original ideas are written. The students are divided into 6 groups, arranged around a table [1]. Within 5 minutes they have to write 3 solutions / ideas on a sheet of paper to solve a certain problem. Then, the sheets of paper move from one group to another in a well-defined sense. Finally, all the ideas are shared with all the participants to generate new ideas.

Examples:

- *How can we explain the whiteness of milk and the blackness of coal?*
- *How can we explain that the shadows of the bodies are blue in the snow when the sky is clear?*
- *In an experiment we use a laser pointer, a protractor and an optic fiber, which is long enough and has the refractive indices* $n_1 = \sqrt{2}$ *for the outer layer and* $n_2 = 1{,}5$ *for the core. What is the maximum angle of incidence which a laser ray can have on the input cross section in the air (*$n_{\mathrm{aer}} = 1$*) to propagate through the optic fiber?*
- *We have some rings of the same diameter, made of copper wires of different sections (2 pcs.), a nail and millimeter graph paper (A4 size). With the help of the rings of the same diameter, made of copper wires of different sections, and of a bowl with water, we can make water lens.*
    - *a) Identify the type of the water lenses obtained.*
    - *b) Using the millimeter graph paper, measure the focal length of the water lens, which is thinner at the ends and thicker in the middle.*
    - *c) Determine the course of the light beams for each type of the water lens, if an object is placed between the lens focus and its optical center.*
- *Describe the process of measuring the focal length for the lens models shown in the photos in Figure 2 and Figure 3. Build the image focus for each lens model.*

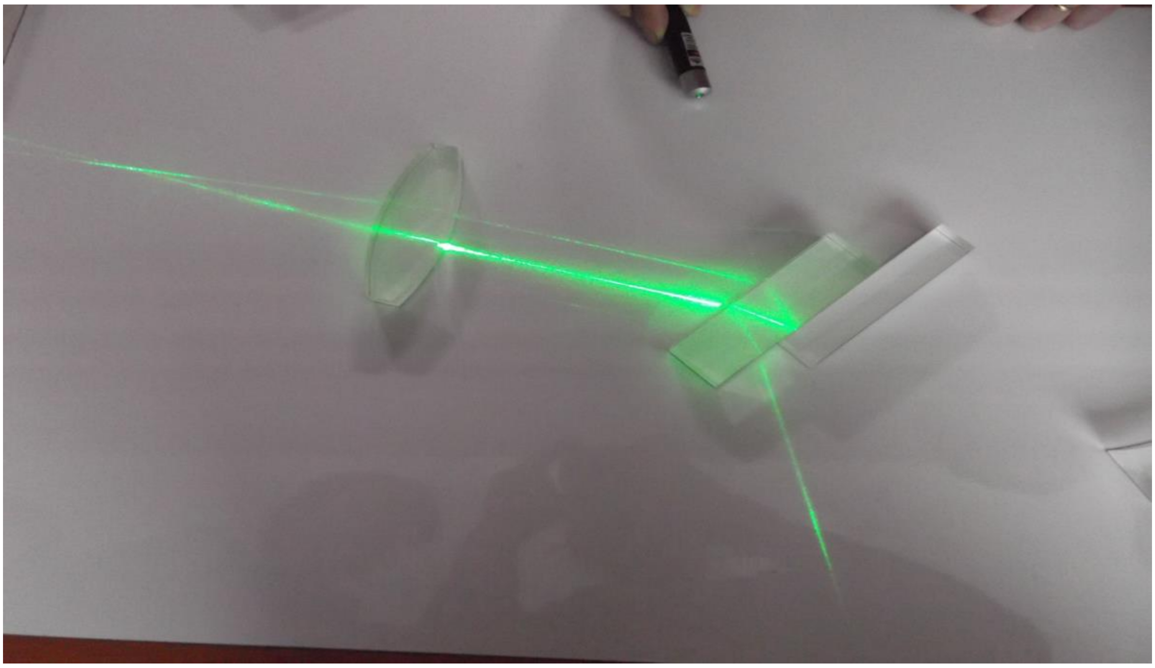

Figure 2. *Method of measuring the focal length of a converging lens model*

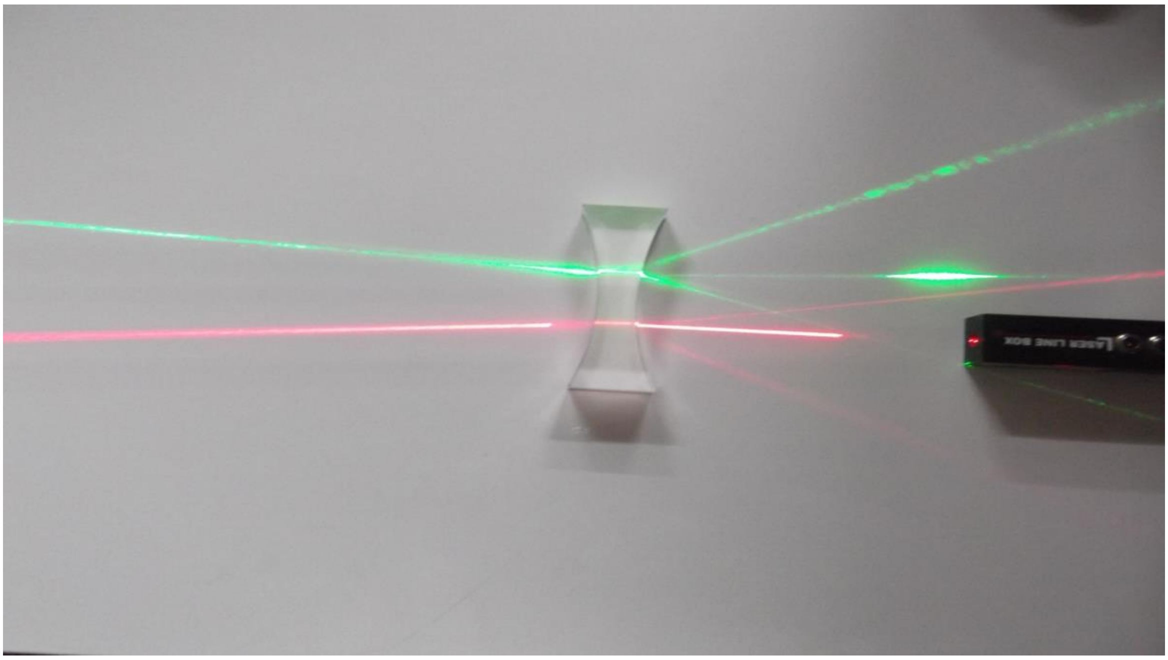

Figure 3. *Method of measuring the focal length of a diverging lens model*

2.3 The method Philips 6-6

This method facilitates the consultation of large groups of students. It incites the students` involvement and action. A large group of students is divided into 6 sub-groups and within each group there is chosen a mediator [3]. Then, the teacher proposes a problem and all the students are asked to offer solutions and put them down. There is a 6-minute debate in each sub-group. Finally, the group mediators discuss the ideas [1], and all the students validate the optimal solutions.

Examples:

- *Give examples of practical use of the spherical mirrors.*

- *Place two plane mirrors vertically, on a sheet of millimeter graph paper, to form a dihedral angle of 90º. A slotted disc is placed between the two mirrors, without touching them, and its images obtained with the optical system are in the same plane, on the circumference of a circle with the center at the intersection of the mirrors.*
  - a) *Build the images of the slotted disc reflected in each mirror images.*
  - b) *Calculate the radius of the circle for the two positions of the ratchet.*

2.4 Synetics

Synetics, or Gordon Method, is based on analogies and associations of ideas. This method consists of combining various components, seemingly irrelevant and unrelated one to the other [3]. Synectics aims to escape from template, cold thinking to generate original ideas. It is a highly qualitative method since it develops one idea, which is then molded in a rich flow of ideas. In the specialty literature [1] we can find the following types of analogies: the *direct analogy* or *the example-analogy* (to solve a problem there are mentioned similar situations from various life field), *the fantastic analogy* (there are mentioned imaginary or legendary situations and then the solutions appear as a successful result of imagination), *personal analogy* (we place ourselves in the examined person`s shoes and describe our emotions, feelings, thoughts in an attempt to solve or improve the situation) and *the symbolic analogy* (the problem is analyzed in relation to images and symbols).

Examples of direct analogy:

- *Build up some mirrors by the type and characteristics of a laddle.*
- *You have a converging lens model and two laser pointers. Run the experiment shown in the photo in Figure 4. Identify the principles of geometrical optics in this case.*

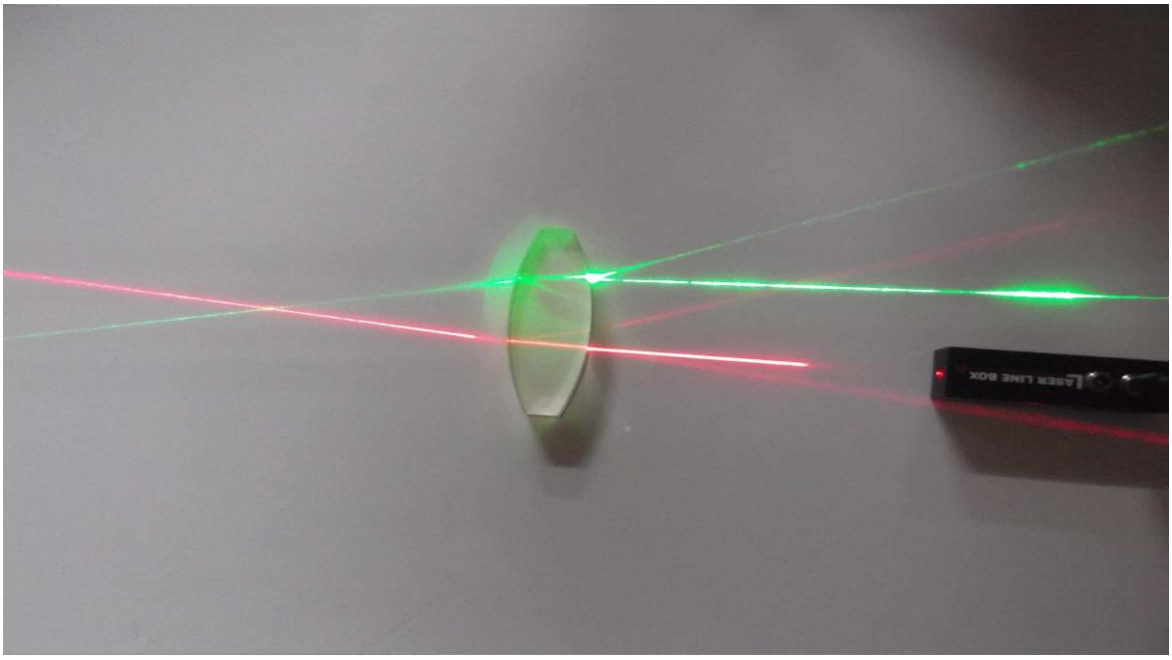

Figure 4. *Optical phenomena made with a converging lens model and two laser pointers*

Examples of fantastic analogy:

- *Imagine a trip inside the atom.*
- *Imagine a trip into space on a beam of light.*

Examples of personal analogy:

- *The students in a group identify themselves with a flat or spherical mirror.*
- *The students in a group identify themselves with a beam of light.*

Examples of symbolic analogies:

- *Compare the rainbow with natural fading of light after crossing an optical prism.*
- *Compare the plane mirror with the surface of a lake at night.*

3. Method

In the present study, run within the first semester of the school year 2014-2015, there were involved 75 students (51 studying in the scientific profile and 24 students belonging to the humanistic profile) in the 9 th grade. Students come from two prestigious high schools from our country: the National College "Carol I" and the The National College "Nicolae Titulescu".

According to the National Physics Syllabus [4] and the National Curriculum there are 3 hours of physics per week for the IXth grade students (aged between 14-15 years old) belonging to the scientific profile and 2 hours per week for the students from the humanistic profile.

Our teaching approach took into consideration the general methodological suggestions and recommendations to effectively support the educational process of learning [1] in terms of creativity in education.

We insisted on the students` interpretation, redefinition and reformulation of the specific notions of physics through their own words, respecting the scientific correctness.

We also took into account the finding and maintenance of favorable conditions to create intrinsic motivation because it is the most effective way to stimulate the students` creative spirit, to spark their interest in science and even to arouse their moral convictions.

4. Findings

The students were encouraged to build material and ideal models and they used both their imagination and judgment, with functional and, definitely, very original results. Due to the strategies applied in the experiment, 84% of the total number of students succeeded in creating ideal and material models of the given representations. Promotion of the pedagogy of creativity is justified by the results of the students in the case of formative and informative valences when solving new different problem situations. Out of the total number of the students participating at the study, over 72% of them proposed new issues / problem situations.

Moreover, 60% of the students involved in the study ran original experiments based on the acquired knowledge of optical phenomena because it was essentially different from anything they had done or heard before the study.

5. Conclusion

Creativity and the pedagogy of creativity represent the most complex challenge of the contemporary educational system [17], [18]. Creative behavior involves a wide range of creative activities [1] that contribute both to the formation of new models with varying degrees of complexity and to the development of human knowledge.

The didactic approach we developed and proposed analyzed 75 students who were involved in specific learning situations. These learning situations aimed, primarily, at the education of the students` creativity in the study of optical phenomena from the chapter "Geometrical Optics", studied in the IXth grade.

The methods we used in this study contributed significantly to the development of the students` creative spirit and also to the rationalization and adequacy of the notions underlined in the chapter of "Geometrical Optics" to the individual characteristics of students.

Furthermore, these methods contributed to the development of the students` personality (their motivation, level of education, knowledge and learning style), which led to the creation of new premises for optimal expression of interactions between the other components of the learning process.

Therefore, our study showed the paradigm shift in the education of the students` creativity because we valued their creative spirit not only in terms of educational activity, but also as a result of it; we succeeded in having an explicit approach from the cognitive perspective since we took into account the students' personality dimensions, their intellectual, psychological, affective and motivational potential and, last but not least, the environmental factors.

References

[1] Ionescu, M. (2005). *Training and Education*, Editura Universităţii Vasile Goldis, Arad.

[2] Ciascai, L. (2003). *An Exercise to Develop Students`Creativity (vol. II)*, Editura Casa Cărţii de ştiinţă, Cluj-Napoca.

[3] Ciascai, L., Opre, A., Secara, R.R. (2003). *Educating Students' Creativity*, Editura Casa Cărţii de ştiinţă, Cluj-Napoca.

[4] The Ministry of Education and Research (2004). *Physics Curriculum for IX^th^*, issued by Ministerial Order No. 3458, Bucharest.

[5] Singer M., (coord.), (2002). *Guidelines – Mathematics and Science Curriculum Area – High School,* Editura Aramis, Bucharest.

[6] Bocos, M. (2002). *Interactive Learning: Guidelines for Reflection and Action*, Editura Presa Universitară Clujeană, Cluj-Napoca.

[7] Ciascai, L. (2001). *Teaching Physics*, Editura Corint, Bucureşti.

[8] Young, H.D. (2014). *College Physics: 9th edition*, Pearson Education Limited, Edinburgh Gate.

[9] Popescu, I.I., Uliu, F. (2006). *Geometrical Optics*, Editura Universitaria, Craiova.

[10] Uliu, F. (2008). *Fundamentals of Classical Physics*, Editura Universitaria, Craiova.

[11] Giambattista, A., Mc Carthy Tichardson, B., Richardson, R. (2010). *College Physics: with an integrated approach to forces and kinematics (3rd edition)*, Mc Graw-Hill Companies, New-York.

[12] Popovici, M.M. (1999). *Optical Phenomena*, Editura Teora, Bucharest.

[13] Uliu, F. Macesanu, F. (2012). *Geometrical Optics ... Intriguing Problems*, Editura EMIA, Deva.

[14] Popescu, S., Narboiu, R. (1998). *Lessons of Geometric Optics*, Editura Moldogroup, Iaşi.

[15] Ciascai, L. (1999). *Teaching and Learning Physics in Secondary School*, Editura Albastră, Cluj-Napoca.

[16] Stoenescu, G., Constantinescu, R. (1999). *Teaching Physics*, Editura SITECH, Craiova, 1999.

[17] Fautley, M., Savage, J. (2007). *Creativity in Secondary Education*. Learning Matters Ltd.

[18] Craft, A. (2005). *Creativity in Schools. Tensions and Dilemmas*. Routledge, New York.

Authors

Gabriel Florian, University of Craiova, Department of Physics and The National College "Carol I", Craiova, Romania, e-mail: gabiflorian@yahoo.com

Sorin Trocaru, The Ministry Of National Education, Bucuresti, Romania, e-mail: sorin.trocaru@gmail.com

Aurelia-Daniela Florian, The National College "Nicolae Titulescu", Craiova, Romania, e-mail: aureliaflorian@yahoo.com

Alexandru-Dumitru Bână, The National College "Nicolae Titulescu", Craiova, Romania, e-mail: banaalex54@yahoo.com