Implications for teaching college physics in the development of creativity

Juan Carlos Ruiz Mendoza[1], César Mora[2], Nivia Álvarez Aguilar[3]
[1]*Facultad de Ciencias Físico Matemáticas de la Universidad Autónoma de Nuevo León México, Cd. Universitaria San Nicolás de los Garza Nuevo León C.P. 66451.*
[2]*Centro de Investigación en Ciencia Aplicada y Tecnología Avanzada del Instituto Politécnico Nacional, Av. Legaria 694, Col. Irrigación, C.P. 11500, México D. F.*
[3]*Centro de Estudios de Ciencias de la Educación Superior "Enrique José Varona" Universidad de Camagüey, Cuba. Carretera Circunvalación km. 5½ C.P. 74650 Cuba.*

E-mail: juancr1@yahoo.com.mx

(Received 9 August 2011; accepted 18 February 2012)

Abstract

In this research the current requirements to higher education, which should be in line with the scientific-technological development while encouraging the development potential of each student, are considered. A summary of the essential relationships between the epistemological nature of physics since its connotation for teaching and learning process in college is shown. Furthermore, the epistemological characteristics of this science, which have a direct and relationship with their didactic process oriented to the development of the creativity in students, is valued. Also the significance that may have the study of physics for students when linked to other sciences and life in general is taken into account. For this objective the experimental - practical activities play an important role.

Keywords: Creativity, methodological approach, integral training, educational teaching process.

Resumen

En esta investigación las necesidades actuales de la educación superior, que debe estar en consonancia con el desarrollo científico-tecnológico así como fomentar el potencial de desarrollo de cada estudiante, se considera. Un resumen de las relaciones esenciales entre la naturaleza epistemológica de la física desde su connotación para la enseñanza y aprendizaje en la universidad se muestra. Además, las características epistemológicas de esta ciencia, que tienen una relación directa y con su proceso didáctico orientado al desarrollo de la creatividad en los alumnos, se valora. También la importancia que puede tener el estudio de la física para los estudiantes cuando se vincula con otras ciencias y la vida en general se tiene en cuenta. Para este objetivo, el experimental - actividades prácticas juegan un papel importante.

Palabras clave: Creatividad, enfoque metodológico, la formación integral, proceso de enseñanza educativa.

PACS: I01.40gb, 01.40.Ha, 01.40.-d. **ISSN 1870-9095**

I. INTRODUCTION

One of the challenges posed by society to the education system and teachers today is the development of creative potential, like done by the memory or other human faculties. "This imperative arises from the social and educational scene of the late twentieth century, in which uncertainty, complexity, unpredictability and changing paradigms in many areas of knowledge demanding new, original and creative solutions" [1].

With respect to last paragraph, in present time, which is characterized by rapid change, the education is behind in relation to social reality and the advancement of knowledge and action; thus this reality tends to be more dynamic in comparison with the relatively static nature of educational scenarios. This insufficient transformation and adaptation includes the creative field in a broad sense, a problem in which teachers are not trained; this limits its implementation in practice with the same level as others areas such as computer sciences.

However, ".... the university can no longer anchored in parameters that a few years ago seemed valid. The prototype of the University outside the social changes and new needs of society, is outdated and is necessary to launch an education system more in tune with the times, more practical and participatory" [2].

There are numerous articles, papers, research, associations and websites which address the creativity from almost all areas of human activity. It is well known that although different approaches are reported, they are identified with a particular product. We must not underestimate the real fact is not always behind a creative product, there is a way of thinking and acting partial, stereotyped, non-creative, this position to identify creativity with a tangible product, shows the evaluation of it by a recognition external, resonance field in the epistemological,

pedagogical and social development that is relevant to the teaching and learning of physics but not sufficient.

Numerous academic publications stress on the need to continue deepen on issues related to creativity at this level, particularly in the teaching of physics in this sense, like Martinez states: ".... These realities and their educational needs, particularly in the field of scientific, humanistic and technological research, pose the challenge of increasing a variety of strategies to achieve greater attention with the approach that has been outlined, in the training for the creativity in physics classes, through participatory education incorporated to the overall university education and forging this way the generations that will take over the country from this century XXI on" [3].

Based on mentioned this work is directed towards the main objective of exposing some aspects of physics and its teaching that would foster the development of creativity in students.

II. DEVELOPMENT

Physics for its characteristics as a natural science, allows the analysis of the phenomena that occur in nature. Because we live in a physical world, initially physics was concerned with the study of all physical phenomena perceptible to humans; throughout the course of time it was divided into areas depending on the features that present the phenomenon to study, as a consequence Astronomy, Biology, Chemistry, Geophysics, etc., are now considered independent sciences. However, this does not detract from this branch of knowledge dominance in respect to other sciences, as in much of the scientific - technological development occurred throughout history, this science has been based on the advantage of the causes and effects of different natural phenomena.

In general, any scientific knowledge and in particular physics, according to Bunge, is a knowledge that is characterized as: rational, descriptive, explanatory, predictive, methodical, systematic, testable, clear, precise, objective provisory and critical [4].

These features, punctuated by the same author, are of great value in terms of student background, since the understanding of the nature of science must have a direct implication on its teaching and logically on the development of creativity, taking on account that the basis of that nature, in its own manifestation of certain laws and regularities, is essentially creative.

Moreover, according to Ramirez "For many people, physics is a science completely unknown and for some, it's only a bad memory of laboratory experiments in their schools, where they used outdated instruments that should rather be on a museum. For others, it is a series of digressions that have nothing to do with practical problems such as engineering and they located it as a branch of philosophy" [5].

From the educational aspect, the learning of physics has endless possibilities to enhance the integral formation of the student, as its understanding requires the student to develop a series of mental processes which would later be useful in the study of some other discipline or activity in general, also all physical concepts learned, provide the opportunity to be applied to other phenomena that occur in the surroundings, although this depends on the treatment given to the training classes of features such as: flexibility, imagination, among others.

The teaching-learning process of physics must be consistent with the epistemological nature of this science, which requires taking into account:

- Planning intentional understanding of its nature.
- The agreement and coherence of the nature of physics with the phenomena that is learned, the concepts being taught and the scientific procedures used.
- The level of knowledge by the teachers of different epistemological paradigms and their characteristics.
- The coherence between the activities and learning resources used in the classroom and the possibility of being transferred to different contexts.
- The ability of teachers to understand that physics, like science in general and from its merits, can be used as a source for cultural and axiological development of the student.

From above it is important that the syllabi of Physics contain current issues in philosophy and history of science, an issue that usually does not occur. The teacher's domain of the philosophical and historical aspects related to this science and the methods of scientific work, although they are not the considered in the teaching programs, could be an important condition for students to gain a better understanding of its conceptual system and the methods for its knowledge.

However, the domain of the teachers of the theoretical aspects does not always guarantee the achievement of the student understanding of its meaning and significance. One of the peculiarities of the study of physics, as fundamental science, is the fact that it is not sufficient to acquire a wealth of knowledge. It is necessary to use teaching´s alternatives to enable their introduction in the classroom [6]. If these alternatives are not applied, knowledge does not transcend, neither in the student's personal life nor on society.

Another feature to consider in the didactic treatment is that, due to its nature, the fundamental knowledge is acquired prior to its application, having as a result that the accumulation of knowledge is greater than the applied knowledge. For this reason, the first ones comes then to be an auxiliary for students with regard to its scientific world view but know-how knowledge is required. On the other hand, often the inverse process of mention above is underestimated, from practice to theory and from there back to a more conscious and systematic practice to study a concept, a category, a physical phenomenon not previously conceptualized.

Another epistemological trait of Physics which impacts substantially on its teaching is its relationship to other sciences; a fact that provides students with conditions to acquire a broad, multilateral development, a complex vision

of the world and its uniqueness. It is indispensable to address it in class.

The predominant site of experimental practice for the development of creativity is frequently highlighted, foundation that is obvious but not exclusive, do that creativity as a human potential can be developed by any physical or mental activity. Creativity may be present in any act of our lives whether cognitive, instrumental, axiological, etc. From the simple and utilitarian use of fire, invention of the wheel and the lever, as far as the broad technological development today, are all the fruits of human creativity.

On the other hand, experimentation as a key method of teaching and learning physics can be used not only for instructional purposes but also as an enhancing agent for the education in positive values such as discipline, diligence, honesty and in qualities as valuable as the will and the perseverance.

The link between theory and practice through experimentation provides students the opportunity to relate the abstract to the concrete, the objective with the subjective, the internal and external; leading to a better understanding of reality. These are issues closely related to creativity, in particular - the abstraction. The connection between theory and real life is something that is usually difficult to achieve, it reveals this thought, “Teachers and students have difficulty connecting theory to real life. Teachers receive training about the different theories on the teaching - learning or physics courses, but have difficulty applying these ideas in their classrooms” [7].

Moreover, if the possibilities of experimental activity are used then the ability in the student’s to generate problems and to solve them is stimulated; being done under different and varying conditions are aspects that also stimulate creativity. Moreover, taking into account the relationship with society, the environment, creativity is energized and its transformation makes possible.

The relationship of science with other facets of human activity may be an important point for its teaching. Several years ago Erwin Schrödinger very clearly pointed out the relationship of science and culture. In this regard he said: "the tendency to forget that science is linked to human culture in general and that scientific results, like those that in a moment appear the most advanced, esoteric and difficult to grasp, lose their sense out of cultural context" [8].

Trough the learning of physics students expressed more or less creative qualities, most importantly, is the fact that they are taught. This real and optimistic understanding about creativity has become important in academic circles in different areas of knowledge, as manifested by Rogers to ask the following questions:

"Being a professor, ¿how can I be creative with students, putting them in touch with the people, experiences, books and all kinds of resources that encourage curiosity and nurture their interests?. ¿Can I accept and promote abnormal and unusual thinking, and impulses and absurd expressions, taking them as learning scouts and creative activity as attempts? ¿Can I accept original and different personalities? "[9].

The study of physics, by its natural characteristics, represents a real alternative to foster the creative development of the student. Among its potential to develop creativity, we can highlight among other things, the following:

1. Logic skills such as: observation, description, analysis, comparison, evaluation and testing which can be developed through the study of physics are essential to form creative students.
2. The use of theoretical models in different branches to predict the behavior of natural phenomena is impossible without the knowledge of physics, and these models are an important ways for students to use analogies, change their views, reflect, question, contribute, etc.
3. The study and understanding of the essence of physical phenomena as well as its interaction allows students a creative transforming attitude and position to reality and to themselves.
4. The analysis of the physical aspects that affect environment can develop greater human sensitivity by detecting and proposing improvements to assess harmful conditions to the environment and man as part of it.
5. The study of physics allows the understanding of its main concepts in coordination with the laws, theories and models; and also allows the evaluation of their role in the development of society.
6. Knowledge of processes and physical phenomena allows students to obtain and evaluate information from different sources which enables the development of critical thinking and the development of their own opinions on current world related issues.
7. Understanding of physics as a science with dynamic features, without dogma or absolute truths, enables the development of a flexible and open attitude and also a divergent thinking in front of the diverse and contradictory opinions.
8. The ability to apply physical knowledge is a source of autonomy to use, in different contexts, the acquired learning; in addition is useful to assessing the importance of responsible participation and collaborative work teams.
9. On the discovery of the wonderful possibilities of physical phenomena and their wide application, the study of physics can produce an emotional effect ranging from the explanation of the collapse of a fruit, to the understanding of how the domain of physics and its application, together with other sciences, has contributed to the amazing scientific and technological development today.
10. The conceptual system of physics as a science, as manifested in the content of teaching programs, can be an effective way not only for conceptual and methodological training of the student but also for their ownership on the methods for "learning to learn" in a creative way.

Epistemological logic of physics is characterized by a theoretical foundation, which is related to the peculiarities of this science, pointing the way to how they should study and systematize the natural phenomena on the basis of

principles and laws that govern them. For this, the physics is supported on the application of a set of actions methods and processes such as: Observation, analysis, modeling, testing, among others.

Thus, for example, through observation, the student interest surges in the analysis of natural phenomena and their interaction with their environment; it can also help enhance his concentration and induce the application of a logic which integrates interpretive discrimination elements and their relationships and functions from a complexity approach. The development of complex thinking in the student, as claimed by Morin goes beyond the search for structure of science, its aimed to link the order and disorder, beyond the need for separation of subject and object, it uses a logic that links the separable and inseparable away from the omnipotence of reason [10].

As rightly pointed out by Erwin Schrödinger (Nobel Prize in Physics) in 1947, "Life is neither unaware nor opposed to the laws of thermodynamics but biological systems retain or expand their exporting complexity entropy-producing processes" [11].

When teaching and learning follows the logic referred above, besides helping the logical development thinking skills of the students, it may also affect their future actions to transcend on personal and social development while leading to an interpretive ability to help socio-cultural formation.

III. CONCLUSIONS

The analysis developed in this work indicates that the didactic logic for teaching and learning of physics is applicable to other contexts. However, Mexico still applies the traditional approach, focusing on oral transmission of knowledge by the teacher, deprived of interaction between teacher and students, with emphasis on learning basic facts and definitions, neglecting the interaction with other sciences and aspects of reality that surrounds us.

REFERENCES

[1] Rubio, L., *Creatividad y capacitación docente*, Disponible en: http://www.umce.cl/~cipumce/educacion/ciencias/creatividad_y_capacitacion_docente.html [Retrieved: Nov. 2007].
[2] López, C. J., Revista Física y Sociedad, Colegio oficial de físicos **14**, 40-45 (2003).
[3] Martínez, F., *La investigación en la educación integral universitaria*, Ciencia UANL **71**, 168-171 (2005).
[4] Bunge, M., *La investigación científica*, (Ed. Ariel, Barcelona, España, 1985).
[5] Ramírez, R., Conferencia invitada, Jornada, *La Física en la Enseñanza Media*, organizada por la Sociedad Chilena de Física, Santiago, (1982).
[6] Vázquez, M., *Apuntes sobre creatividad: origen del término*, Facultad de Ciencias sociales, Universidad de Vigo, España (2000). Disponible en: http://www.salacolibri.com/_creatividad_vazquez_gestal articulo164_enesp.htm [Consulta: Enero 2010].
[7] Riveros, H.G., V11 *Congreso Nacional de Ciencias Exploraciones fuera y dentro del aula*, "El placer como Herramienta Didáctica en la enseñanza de la Física" Costa Rica, (2005).
[8] Stuewer, R., *Historia y Física*, En: Resultados de Investigaciones en Didáctica de la Física en la Formación de Docentes Libro de "I.C.P.E." © International Commission on Physics Education I.S.B.N. 0-9507510-3-0 (English Edition) Publicado por la Comisión Internacional de la Enseñanza de la Física (ICPE) (1998).
[9] Rogers, C., *Libertad y creatividad en la Educación*, (Ed. Paidos, Buenos Aires, Argentina, 1987).
[10] Morín, E., *Ciencia con consciencia. Barcelona*, (Editorial del hombre, España, 1984).
[11] Schrödinger, E., *¿Qué es la vida?*, Trad. de Greta Mayena (Espasa Calpe, Buenos Aires, Argentina, 1947).