Advanced Physical Research
Vol.2, No.2, 2020, pp.113-117

SYNERGISM IN THE PROCESS OF TEACHING PHYSICS AND ITS USING METHODS

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Abstract. Presented article shows the necessary conditions for the implementation of synergy in the learning process. It has been established that synergy occurs when two or more sources are used together, in a coherent manner in order to achieve a certain result. The use of synergy in the teaching process has been investigated and applied to the teaching of physics. Examples are given in accordance with the teaching of various subjects of physics.

Keywords: *Synergy, synergy in the teaching process, teaching physics.*

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Received: *25 July 2020;* ***Accepted:*** *15 September 2020;* ***Published:*** *30 September 2020.*

1. Introduction

It is known that science and new technologies are developing rapidly. Both the development of new methods and the emergence of new directions at the intersection of sciences accelerate these processes. It is very important to bring scientific innovations into the teaching process and develop their teaching methods. Recently, the development of interactive teaching methods plays an important role in the acquisition of knowledge (Andrews & Nikolopoulos, 2018; Colletti, 2017; Kristak *et al.*, 2014; Coudhary *et al.*, 2013; Holubova, 2008).

Therefore, modern teaching methods are developed using smart phones and robots (Souza & Duarte, 2015; Oprea & Miron, 2014) in order for pupils and students to study physics in depth.

In this work, methods for the implementation of synergy in the teaching of physics in secondary schools were developed and the conditions for synergy were indicated. Different examples are given according to the teaching of several subjects of physics. One of the characteristic conditions of synergetics is that the development of the system takes place by nonlinear law. If there was a linear development, it would be based on the principle of superposition. However, the development of the system takes place by nonlinear law. One of the important conditions in synergetics is that the system is unbalanced. In order one system to be able to influence another system, it must be unbalanced. It must have an uneven distribution of the gradient of the property being traded, depending on the coordinate. This is the essence of the system's imbalance in synergetics.

2. Conditions of synergy

Several conditions must be met for synergism in the training process, which are as follows:

a) there must be two or more sources of knowledge that serve the same purpose;

b) knowledge systems derived from those sources of knowledge should be formed as successors to each other; knowledge systems that successor to each other are analogous to each other; the inherited knowledge system has the same elements of knowledge as the inherited knowledge system;

c)It is necessary to integrate analog knowledge systems in order to form them as a new knowledge system, prepared them for use together.This integration creates an environment of synergy (this is like the preparation of two drugs that will be used simultaneously in medicine);

d) the combined use of analog knowledge systems is synergistic; these knowledge systems help each other in the formation of a intended knowledge system (this is like the combined use of prescribed drugs, the other drug helps each drug to perform its function during the simultaneous use of drugs);

e) The result of synergy depends on the order of cooperation of analog knowledge systems. If they are not used in a certain sequence, the result of synergy is minimal, in other words, there must be coherence and agreement in the joint use of knowledge;

f) the teacher's guiding activity, the student's activity has a special role in ensuring the coherence of the knowledge system (such as the correct role of the doctor, the patient's correct adherence to this appointment, has the special role in the treatment of the disease).

We will call these requirements "synergistic conditions". It is clear from the conditions of synergism we have defined above that synergy occurs when two or more sources work together in a co-operative, coherent manner, in order to achieve a certain result. For synergism to occur, at least two systems must interact. Let's call these interacting systems subsystems. A new system is formed due to the synergy of subsystems. Namely, the intensity of that system is Y. This phenomenon is analogous to the phenomenon of interference of coherent light sources with intensities I1 and I2 (Table 1). This analogy is clearly seen in the table below.

Table 1. Analogy of light sources with knowledge sources

Light sources	Sources of knowledge
Intensity of light source I.	Quantitative characteristics or intensity I of the source of knowledge.
Coherence of light sources: *a*) the frequencies of the sources are the same; *b*) stability of phase difference.	Coherence of knowledge sources (coordinated operation): *a*) the source knowledge meets the requirements of the same standard; *b*) simultaneous application of knowledge.
Maximum intensity of light sources when the phase difference is zero.	Maximum knowledge gained when two sources of knowledge are applied together to solve the same problem.

In order for synergism between subsystems to occur, they must be analogous. The analogy of knowledge systems is determined by their succession. If one knowledge system is formed as the successor of another, these knowledge systems are analogous.

Synergism (cooperation) is possible between them. In other words, there is a synergistic environment for the formation of a new knowledge system from sub-knowledge systems.

A new system formed by the synergy of subsystems is a complex system because it is composed of subsystems.This is the meaning of the complexity of the system in synergetics.

Successive subsystems are analog or analog systems. If a new system (its intensity is Y) resulting from the synergy of the first two analog subsystems interacts with the third subsystem, "gain knowledge" is still obtained through synegism. This means that the more analog subsystems that enter the synergistic environment, the more the system will develop. For example, if a student conducts a simple experiment on the interaction of an electric field, he will gain knowledge of intensity I3. The I3 knowledge system is analogous to the Y knowledge system. As a result of the synergy of I3 and Y, a system of knowledge about the electric field of intensity Y1 is formed. The "gain knowledge" gained through synergism is up to Y1 - (Y + I3).

The greater the number of sources of knowledge that contribute to the knowledge system about the electric field (multiplicity), the more "gain knowledge" that knowledge system will gain through synergy. This is the essence of the condition of system multiplicity in synergetics. They work with open systems in synergetics. Indeed, if the systems are not open, it is impossible for the two systems to be synergistic, that is, for them to work together and trade between them.

3. Results and discussion

Diversity in synergetics allows the identification of several cases of synergy in the teaching of physics in secondary schools.

• Synergism between classroom teaching materials. It is known that the training material for each class was chosen to balance the requirements of several content standards. Content standards are the same in grades VI, VII, VIII, IX:

Pupil:

1.1. Demonstrates knowledge and skills on physical phenomena.

2.1. Demonstrates knowledge and skills on the forms of matter.

2.2. Demonstrates mastery of interactions in related systems in nature. 3.1. Conducts experiments, presents results.

3.2. Demonstrates mastery of the role of physics in the development of modern life

The similarity of the standards means that the training materials subject to their requirements are each other's successors and analogues. Such analogues create an environment of synergy, ie the upper class material that meets any standard is studied as the successor of the lower class material that meets that standard. Due to the synergy of knowledge systems obtained from the training of lower and upper class materials that meet the same standard, the knowledge system that balances the requirements of that standard expands and deepens (enriches).

• Synergism between subject topics that balance the requirements of the same sub-standard and between them and other subject topics.

Knowledge gained from different topics in order to meet the requirements of the same sub-standard is analogous to each other. These analogues create an environment of synergy. The knowledge system that balances the requirements of that sub-standard is

enriched due to the synergy of knowledge systems obtained from the training of different topics that meet the requirements of any sub-standard. Interdisciplinary communication provides synergies between subject topics. Interdisciplinary communication provides synergies between one subject and another. So, interdisciplinary and interdisciplinary communication was created for the purpose of synergy.

• Synergism between training stages within the topic.

The training of each topic is carried out in the following stages. (A) Motivation. At this stage, previously acquired knowledge is restored and repeated. For this purpose, various situations and events are described, guiding questions are answered. In fact, at this stage, a basic knowledge base is created to understand the topic. (B) Research. At this stage, experience, laboratory work and various tasks are given and performed as new sources of knowledge. The knowledge gained from these works is formed as the successor of the knowledge gained at the stage of interest. Since the knowledge systems derived from (B) and (A) are analogous, a synergistic environment emerges between them. As a result, due to synergy, the system of knowledge about the studied topic is enriched.

(C) Explanations. At this stage, explanations are given of the knowledge gained from (A) and (B), more general opinions, definitions and rules are given. Here synergy has the opportunity to make more money. The knowledge gained from (A) and (B) is applied in a collaborative environment.

(D) Creative application. The aim is to reinforce and apply what has been learned in (A), (B), (C). To apply it, you need new knowledge over the previous ones. In our case, the new is achieved due to the synergy of the previous ones.

(E) What did you learn? (F) Check what you have learned. The project. Don't work. Practical work. Generalization tasks. At these stages, the development of knowledge on the subject through new sources and their synergies, in other words, the acquisition of more gainful knowledge. Due to the large number of sources of knowledge at the stage of generalization tasks, the knowledge gained from them is also large. This is why the generalization phase is so important in training.

There is no doubt that there is a "synergy between the stages of training within the topic." This state of synergy serves to enrich the knowledge of the studied topic. It should be noted that in the essence of 5E, 7E technologies used in the teaching of physics in the international arena, there is a state of synergy between the stages of learning. These stages serve to create an environment of synergy. This, of course, is based on the natural-scientific basis of the process of logical cognition.

• Synergism between substandards.

Let's explain with an example. Class IX has the following standards:

Pupil:

1.1. Demonstrates knowledge and skills on physical phenomena: 1.1.1. Explains electromagnetic (magnet, light), atomic and nuclear phenomena, their causes.

1.1.2. Prepared and solves problems related to electromagnetic (magnet, light), atomic and nuclear phenomena.

1.1.3. Explains the motion of charged particles, atomic and nuclear particles.

1.1.4. Interprets data collected on the laws of electromagnetic (magnetism, light), atomic and nuclear phenomena.

Knowledge that meets the sub-standards 1.1.1., 1.1.2., 1.1.3., 1.1.4 is formed as a successor to each other. There is a synergistic environment between these knowledge

systems. The application of these knowledge systems in a collaborative environment ensures the expansion and deepening of knowledge that meets standard 1.1. The same can be said about standards 2.1., 2.2., 3.1., 3.2. What we have said is an indication of the existence of a "synergism between substandards."

• Synergism between students' knowledge when solving a problem by a group of students. An example of the synergy of knowledge systems is that in an intellectual game on television, a group of students think together and find the right answer to the same question in a short period of time.

4. Conclusion

The principle of multivariate in synergetics was used in the teaching of physics. Several cases of synergy have been identified: Synergism between classroom teaching materials. Synergism between subject topics and their other subject topics that balance the requirements of the same sub-standard. Synergism between training stages within the topic. Synergism between substandards. Synergism between students' knowledge when solving a problem by a group of students.

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