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Professional paper

SEA[a]- TEACHING METHODOLOGY IN NATURAL SCIENCES AND MATHEMATICS

Fadil AJREDINI[1], Naim SYLA[2]

[1*]*Department of Physics, Faculty of NSM, University of Tetovo. Republic of North Macedonia.*
[2] *Department of Physics, Faculty of NSM, University of Prishtina. Kosovo.*
[*]*Corresponding author e-mail: naim.syla@uni-pr.edu*

Abstract

Teaching science based on student experience is not a new idea. SEA is based on the teaching/learning strategy of the German pedagogue Martin Wagenschein. Some other well-known names (predecessors of thought) were: Jean Piaget, Neil Bruner Dieter Nachtigall, and more recently Jürgen Schönherr and Ingo Mueller. Jürgen Schönherr is regarded as the man who introduced SEA and practiced it in many countries of the world, and for this reason, he is also known as Papa SEA. Through Starter Experiment, a comprehensive approach to teaching science and mathematics is provided. According to this approach, special attention is paid to the internal motivation of more students, especially girls who usually suffer from the "natural dominance" of boys during natural sciences and mathematics learning.
The constituent elements of the SEA are:

- At the beginning of each chapter of the course, the lesson begins with observations of the environment or with an experiment which is called initial or starter.
- Individualization of important steps such as: observations, construction of hypotheses, and formulation of concepts.
- Working in groups for planning and carrying out verification experiments.
- Communicating to the whole class about the idea, strategy, concept, and their application.
- Elaboration of the new knowledge anticipated to be understood.
- Redefining the role of the teacher as a stimulator and organizer of the learning process.
- Motivation of students and teachers for natural sciences and mathematics.

Keywords: teaching, natural sciences, mathematics, starter experiment, hypothesis, verification experiment.
[a] SEA - Starter Experiment Approach.

1. Introduction

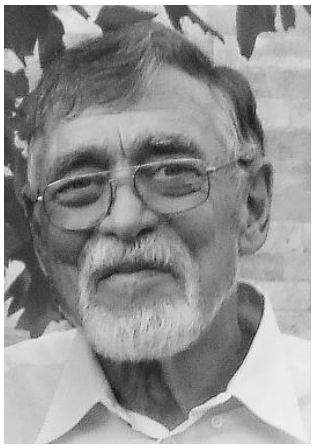

Photo 1. Jürgen Schönherr (1942-2020)

Natural sciences and mathematics play a decisive role in the technical and technological development of human society. The knowledge of natural sciences depends on the laboratory capacities and the preparation of the teaching staff. In different stages of society, laboratory capacities were at different levels, therefore the methods of teaching and learning were different. Simply the methodology of teaching natural sciences and mathematics subjects evolved depending on the development of society. In recent times, the methodology has also been influenced by the rapid development of artificial intelligence and computer science. In transition and developing countries, teaching methods are more specific, because laboratory support is not always satisfactory. For this reason, various methods have been developed [1-6] which have significantly influenced the learning of these sciences by primary and secondary school students. Among these methods, the one first

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applied by the German physicist Jürgen Schönherr (Photo 1) occupies a worthy place. Based on the concept and structure of the method, Mr. Shönherr named this method SEA, which means Starter Experiment Approach. The application of this method begins in Germany, to continues in the Philippines, Malaysia, Indonesia, Tanzania, Kyrgyzstan, Tajikistan, Kosovo, and Bosnia and Herzegovina.

2. The idea, basic concepts and structure of sea

The name "Starter Experiment" was chosen to indicate two things [1]:

1. The process of teaching/learning in science has to **start off** from the observation of phenomena, either obtained from the environment or from an experiment (Martin Wagenschein).
2. **Starting** a new chapter of the syllabus or in the textbook shall be based on students' observations of phenomena in nature or derived from a "Starter-Experiment". For their explanations they are using their pre-concepts / pre-knowledge which –in the course of the 'SEA-lesson'- will be confronted with the science concepts. These concepts will be developed by the students as the result of their investigations to test their hypotheses for correctness. Thus, new concepts are developed as the result of the teaching/learning process, the new concepts replacing incorrect pre-concepts (Jean Piaget: Restructuring). This way, students will avoid developing two unconnected sets of knowledge, one they use for getting along in their environment in daily life in the family and community and the other one to cope with the demands in school. For this purpose, each chapter of the syllabus should be started if possible by this approach.

"Re-uniting" students' worlds -their environment and the school- makes learning meaningful and motivating for them. Both, are the precondition of the improvement of the teaching / learning process esp. in science subjects.

The Starter Experiment Approach follows the "Scientific Cycle" (Fig.1) [7]:

1. **Observing** phenomena either directly in the environment or through an experiment;
2. **Attempting to Explain** why certain things were observed, students using their pre-concepts;
3. **Verifying/Falsifying** the attempted explanations (hypotheses) using experiments, preferably designed by the students themselves;
4. **Assessing** the attempted explanations by means of the results of the verification experiments;
5. a) **Formulating a Concept** in case of a positive assessment of the hypothesis. Or b) **Formulating a New Hypothesis** in case of a negative assessment of the original hypothesis followed by a new verification process;
6. **Linking the Concept** to students' environment and its applications in technology and science;
7. **Evaluating** students' degree of **comprehension** of the newly found concept.

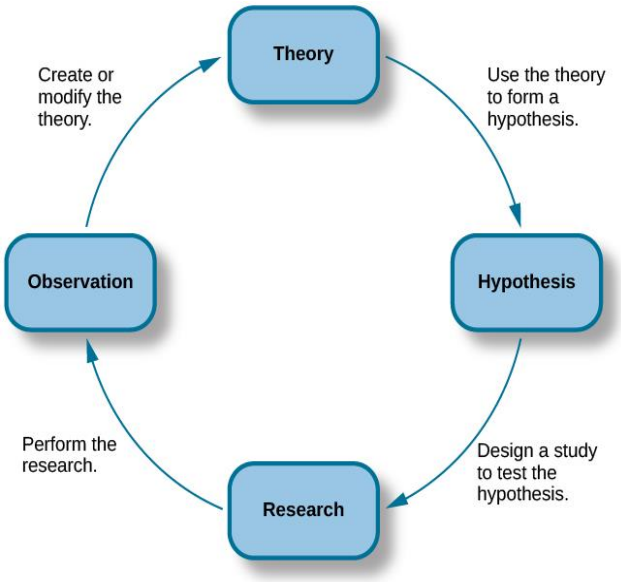

Figure 1. Structure of Scientific cycle.

In the following, we will present the teaching steps according to this approach, as well as the carrier/s of the activity.

Table 1. SEA steps and their realization in one lesson (90 min).

1. Starter experiment	**Teacher (T) demonstrates, students (S) observe individually**
2. Observations	**S individually record their observations on labels, one observation on a label**
- Collection of observations	*For each observation, a label will be placed on the table. (similar observations are collected on the table)*
- Repeating of starter experiment	*One student reads the observations, while another demonstrates the experiment, while the whole class verifies the accuracy of the observations through the experiment. Incorrect observations are marked with a minus sign*
3. Selection of observations for hypotheses	**T selects observations for hypotheses, while students sketch and record d students simultaneously sketch the initial experiment**
- Writing questions	*T formulates questions from selected observations*
- Writing hypotheses	*S individually write the hypotheses answering the questions posed*
- Collection of hypotheses	*Collect the hypotheses and weight them according to the selected observations*
- Determination of relevant parameters from the hypotheses	*T together with all the students, they determine the parameters from the received hypotheses*
4. The division of students into groups	**T made the best division of students into groups. He also distributed observations, hypotheses and corresponding parameters for each group**
-Planning the verification experiment	*Each group plans the verification experiment, while T advises the groups*
-Construction and realization of the verification experiment	*S work in groups, T advises the groups*
-Preparation of group reports	*S work in working groups*
5. Presentation of reports of groups	**One S from the group presents the report while another S from the group demonstrates the experiment**
- Evaluation of hypotheses	*Based on the results, i.e. verification experiments, the class evaluates whether the hypotheses are correct or not*
- Writing new knowledge	*One S from the group presents the report while another S from the group demonstrates the experiment*
-The formulation of concepts	*Based on verified hypotheses and new knowledge S individually formulate concepts*
- Building the final concept and naming it	*S with the support of T elaborate the general formulation – formulated concepts and name it*
6. Discussions on the application of concepts	**Discussion S – T, for application in daily life, industry, science, ..., eventually reports or research in the library or internet.)**

3. Realization of a lesson according to the sea method

In advance, it should be considered that the lesson according to the SEA method can be completed in two block lessons, i.e. 45min+45min. In the initial phase of applying this method,

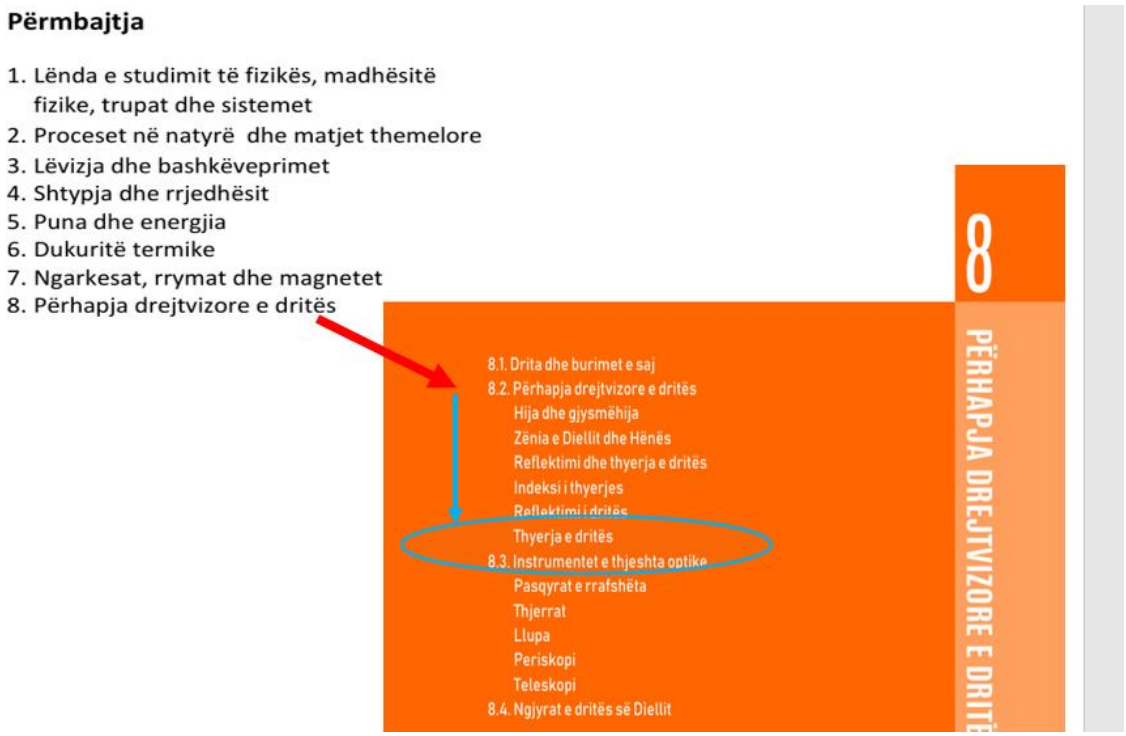

Figure 2. Program content of Physics 6 in Kosovo

Figure 3. Starter experiment.

it is preferable that another teacher participates in the class as a class monitor. Simply, at the beginning of the course chapter, a star experiment is designed by the course teacher, through which any of the basic concepts of the chapter is explained. The materials used for the Starter Experiment should, whenever possible, be obtained from the students' environment. Special laboratory equipment can be used later in the course of the lesson, when students plan and carry out their verification experiments. As far as possible, the design of the experiment should be clear and simple. The teacher must be careful, so that each student has the opportunity to observe the experiment in detail. This means that large classes can be divided into smaller groups, so that one after the other, the groups observe (observe) the experiment. A Starter experiment is particularly good if and only if it produces the effect of surprise and not to be complicated and time consuming, because most of the time should be reserved for students.

An example of how the lesson is carried out according to the SEA method, we will take the sixth-grade physics teaching program in Kosovo (Figure 2). From this content, we will choose chapter 8 respectively the teaching unit on refraction of light. To carry out the starter experiment, we need a glass, water and a pencil. The middle schooler fills the glass with water and then puts the pencil in an inclined position (Figure 3). The equipment with which the experiment was built are known to the students, therefore they will mainly focus on "breaking the pencil" on the surface of the water. After the realism of the experiment, the teacher continues

the lesson according to Table 1. The activity and flow of the lesson is reflected in the lesson table as in Figure 4.

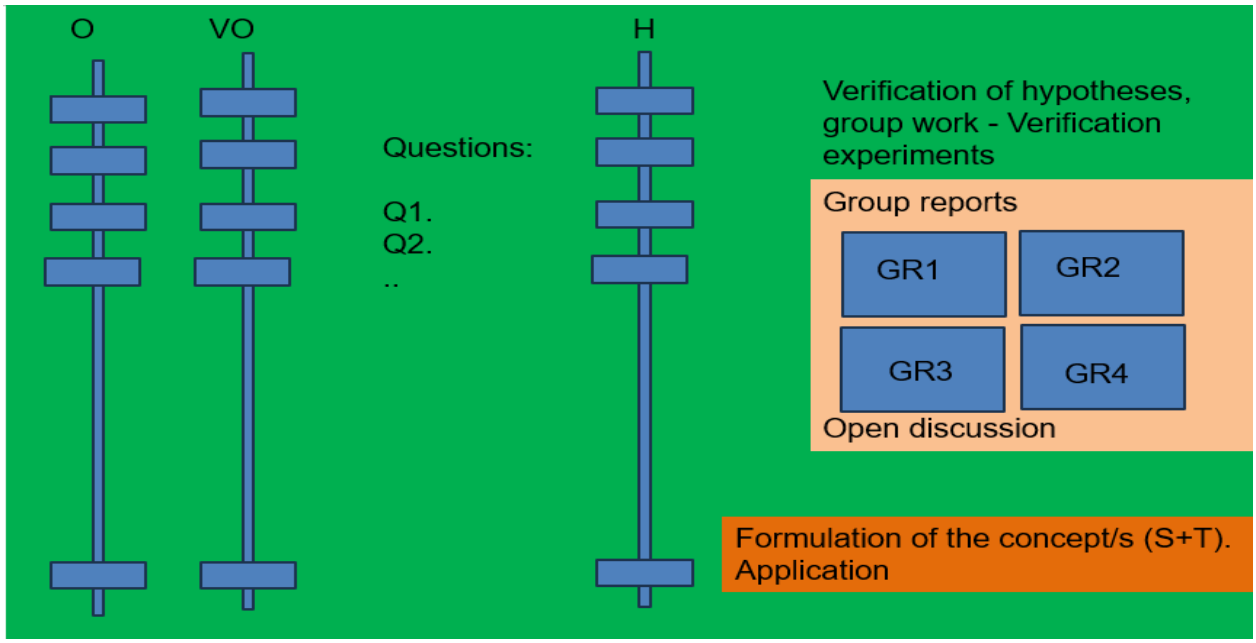

Figure 4. The flow of the lesson according to the SEA method

The lesson ends with constructive discussions between the teacher and the students. Students need to reflect on what they have learned. While, after the end of the lesson, the monitoring teacher talks with the teacher who held the lesson to improve the teaching and achieve the goals in the realization of the educational program. The results of the application of this method are measured in several countries [5,7, 8]. The research shows that the application of the method has had positive effects on its goals and objectives.

4. Conclusions

- The SEA method can be applied to the subjects of natural sciences and mathematics by teachers who have prior knowledge of this method, so they are trained.
- The teacher must know well the subject he teaches. So he must be professionally prepared, because only such a teacher can manage the lesson during which different observations and hypotheses can come from the students.
- Planning and building the starter experiment is very important for the lesson. Therefore, it takes time and requires commitment.
- In the initial phase of the application of this method, it is very important to monitor the lesson by any colleague who applies this method.
- The teacher must be careful even in the part of the class where they work in groups. Students with different successes and different genders should be equally distributed in the groups.
- Discussions at the end of the hour should be open. It is very important to formulate the concept/s.
- The students must show what are the new knowledge they have learned in this lesson and show their application together with the teachers. Additional homework can even

be given to research on the Internet and the library or to talk with families at home about the application of new knowledge.

- Research proves that, in the countries where this method has been applied, it has had positive impacts.

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