INTERNATIONAL JOURNAL
FOR INNOVATION
EDUCATION AND RESEARCH
ISSN: 2411-2933

Journal URL: https://scholarsjournal.net/index.php/ijier

DOI: https://doi.org/10.31686/ijier.vol13.iss2.4261

Learning through Active Participation and Collaborative Thinking – The Sokoloff Method in Practice

Fekete – Nagy Tamara - Jedlik Ányos Secondary School/ Doctoral School of Physics, Eötvös Loránd University

Dr. Schramek Anikó – Fazekas Mihály Secondary School

Dr. Baranyai Klára Dorka – Berzsenyi Dániel Secondary School

1. Introduction

The aim of our paper is to present and promote David Sokoloff's method through a selection of specific experiments.

Students from Generation Z and Generation Alpha, through their daily use of screens, have become accustomed to rapidly changing, high-intensity stimuli. As a result, the duration of their effective concentration has decreased. It is essential that education adapts to students' needs and that teaching processes are designed with these needs in mind. With interactive and varied task ideas, students' attention can be repeatedly captured during lessons. Actively involving students in physics lessons contributes to the development of a solid and in-depth understanding of physics, while also fostering a more positive attitude toward the subject. In our view, David Sokoloff's method is an effective tool for maintaining students' attention throughout a 45-minute lesson and supports the development of scientific thinking as well.

2. Introduction of Sokoloff method

Since 1978, David Sokoloff has been teaching physics at the University of Oregon, where he developed his experiment-based method involving the active participation of students. His goal is to facilitate a deeper understanding of physical phenomena and laws. The foundation of his method in every topic is a teacher-led demonstration experiment, which is carried out following the same set of eight steps. Each step has a specific purpose and rationale. He often selects experiments that challenge students' preconceptions or misconceptions (Nagy – Czirok & Horváth, 2019, p. 64), confronting them with the actual outcomes. This element of surprise helps students remember both the experiment and its conclusions over the long term. His worksheets and the questions related to the experiments further support this process and help students form accurate conceptual understandings.

For each experiment, he prepares a worksheet that students receive in two copies. One serves as a draft where they can freely write, correct their answers, and explore ideas; the other is submitted at the end of the lesson. This practice reduces anxiety and the fear of failure. Students understand that making mistakes is part of the learning process, and they will have the opportunity to revise their thinking. The method also promotes students' emotional engagement for several reasons, which in turn enhances the effectiveness of long-term memory retention. (Hannaford, 1995, p. 45)

The eight instructional steps applied in his method:

1. The teacher describes and sets up the experimental apparatus, explains what will be demonstrated or measured, but does not yet perform the experiment.
2. The teacher asks students to individually complete a worksheet labeled with their names, based on their assumptions or predictions. Students are reassured that the worksheet will not be graded. (At the university level, submitting the worksheet can earn extra credit, as it also serves as proof of attendance.)
3. Students may discuss their predictions with their immediate neighbors.
4. The teacher collects responses or predictions from the whole group.
5. Students record their final answers on the worksheet.
6. The teacher performs the experiment, including any measurements, ensuring that all aspects are clearly visible to the students (possibly by projecting the demonstration).
7. Students discuss their observations and underlying causes, then record their findings on the results sheet.
8. Students (or the teacher) discuss similar phenomena that are based on the same physical principles but differ in appearance or context.

In Step 2, students are transformed from passive recipients into active participants in the experiment or measurement, as they are required to predict the outcome. This naturally raises their curiosity about what will happen and whether their reasoning was correct. They are free to make guesses, since there are no real consequences attached to their responses.

In Step 3, students discuss their answers with their neighbors, reflect on what they have written, and may revise their predictions. At this stage, they are essentially formulating hypotheses, which is a fundamental aspect of scientific inquiry (Radnóti, 2016, p. 138).

In Step 4, the class shares and discusses their predictions collectively, allowing students to confront differing opinions and—if persuaded by a compelling argument—revise their answers once again.

Afterward, students observe the experiment and compare the results with their initial predictions. If the observed outcomes contradict their earlier assumptions, they discuss the reasons behind this discrepancy. (Bloom – Understanding level)

In Step 8, they identify similar phenomena, which reflects a higher level of comprehension. (Bloom – Analysis level)

Students are active participants in the learning process; they construct knowledge themselves based on their own experiences. Throughout the steps, they repeatedly “retrieve” what they know or believe about the given phenomenon. This recall is a critical component of learning and of encoding information into memory.

The level at which understanding is “tested” or recalled also plays an important role in the learning process (Ramcsány, 2015). During the eight steps, there are multiple opportunities for such retrieval, and in the case of a given phenomenon, students may reach the analysis level. Individual differences may arise here, as participants engage in the process at their own pace and according to their abilities.As a result, the method is also suitable for differentiation. The learning process is guided by the teacher, but the teacher is not the sole source of knowledge. The experiment is not used to illustrate previously learned material, but rather to introduce and teach new content. This requires the teacher to take on a supportive rather than an exclusively directive role, which can foster a more motivating relationship with students compared to a traditional, lecture-based approach.

Most of the steps (3, 4, 7, 8) facilitate student collaboration, providing space for learning from one another. Students first exchange opinions in pairs, and then in larger groups. One of the most significant benefits of this exchange of views is the development of communication skills. Students learn to express their thoughts and arguments clearly, understandably, and persuasively. Additionally, they practice active listening, as they not only have to speak but also carefully listen to their peers' opinions and respond appropriately. This fosters the development of a culture of dialogue and enhances argumentative techniques.

When students have to compare their views with those of their peers, they also develop critical thinking skills (Walsch at al., 2022). They need to examine how well-supported their position is, what arguments back it up, and how these can be defended against others' arguments. At the same time, they must assess how valid others' arguments are and whether any of them could potentially influence their own position. This promotes flexible, open, and self-reflective thinking.

During these exchanges, students encounter multiple perspectives, which provides an opportunity to realize that there may not be just one correct solution. Experiencing this helps develop tolerance and empathy. Opinion exchanges do not always occur without conflict, and in such cases, students learn how to conduct a debate in a civilized manner, ensuring it is constructive for both parties. By confronting a different perspective, students' self-reflection abilities and self-awareness develop over time.

3. Worksheets and Teacher's Guides

Sokoloff's experiments and the accompanying worksheets are available online (Sokoloff & Thornton, 2004). In this article, we briefly describe five experiments that can be demonstrated in domestic schools. We will make their detailed descriptions, related worksheets, and teacher's guides available (Fekete, 2025). The experiments and their worksheets comply with curriculum requirements and can confidently be used in high school and middle school physics lessons.

Overall, it can be said that the exchange of opinions in pairs and groups triggers a complex learning process in students, which not only involves exploring the content but also touches on every aspect of communication, thinking, and self-awareness (Horváth, 1991, p. 229).

- **Investigation of Thermal Equilibrium**

The aim of the measurement is for students to become familiar with the concept of thermal equilibrium and to understand the phenomenon. In the experiment, the temperature change of two bodies of water at different temperatures is examined. The worksheet suggests the use of an Arduino-controlled sensor for temperature measurement, but the experiment can also be perfectly carried out using a traditional thermometer.

- **Worksheet for Investigating Melting Times**

In this experiment, we investigate the melting times of ice cubes in saltwater and freshwater. The experiment may come as a surprise to those who predict that the ice cube will melt faster in saltwater, as in winter, roads are salted to melt the thin layer of ice that forms on them. Students will come to the explanation of the experiment themselves, using a colored ice cube as a visual aid.

- **Worksheet for Top-Down Heating**

In this experiment, we heat water using a submersible heater, keeping the heater just below the water's surface. By using food coloring, we can track the changes in the water temperature. The graph included in the worksheet helps students carefully consider and analyze the phenomenon.

- **Worksheet for Horizontal Projectile Motion**

In this experiment, we compare the fall times of balls that are freely dropped and those launched with a horizontal initial velocity. The separation of the two directions of motion is not always intuitive, and some students find it challenging to interpret compound motions. A good example of this is the question of where an object will land if thrown inside a moving vehicle. Many believe the object will land "behind" its original position because, while it was in the air, the vehicle moved forward.

- **Worksheet for the "Two Bubbles" Experiment**

In this experiment, we investigate a phenomenon based on the pressure of two individually inflated, differently sized bubbles or balloons that are initially separated by a valve. We ask the students to predict how the sizes of the bubbles will change once the valve between them is opened.

Supported by the eköp-kdp-24 university excellence scholarship program cooperative doctoral program of the ministry for culture and innovation from the source of the national research, development and innovation fund.

References:

1) Baranyai, Klára. “Melting Icebergs, Warming Seas” *Fizikai Szemle*, 2013/7–8, pp. 267–269. [in Hungarian]. Accessed: May 9, 2025. https://fizikaiszemle.elft.hu/archivum/fsz130708/BaranyaiK.pdf

2) Fekete Nagy, Tamara. *Personal academic website*. [in Hungarian]. Accessed: May 9, 2025. https://feketenagytamara.elte.hu/

3) Hannaford, Carla. *Smart Moves: Why Learning Is Not All in Your Head*. Arlington, VA: Great Ocean Publishers, 1995.

4) Horváth, Imréné. “Group Work in the Classroom” *Módszertani Közlemények*, 1991, 31(4), pp. 227–231. [in Hungarian]. Accessed: May 1, 2025. https://acta.bibl.u-szeged.hu/27751/1/modszertani_031_004_227-231.pdf

5) Nagy-Czirok, Lászlóné Kiszi Magdolna, and Horváth, Gábor. “Misconceptions of Students about Physics – Is the Earth Not Moving After All?” *Fizikai Szemle*, 2019/2, pp. 63–70. [in Hungarian]. Accessed:

April 12, 2025.
https://epa.oszk.hu/00300/00342/00336/pdf/EPA00342_fizikai-szemle-2019-02_63-70.pdf

6) Radnóti, Katalin. "The Role of Hypothesis Formation in Physics Education" *Fizikai Szemle*, 2016/4, pp. 136–142. [in Hungarian]. Accessed: April 12, 2025.
http://epa.niif.hu/00300/00342/00305/pdf/EPA00342_fizikai_szemle_2016_04_136-142.pdf

7) Racsmány, Mihály. "Teaching Quizzes That Will Change Education Forever" *Official YouTube channel of the University of Szeged*. [Video, in Hungarian]. Accessed: April 12, 2025.
https://www.youtube.com/watch?v=57Xa-BIMpyo

8) Sokoloff, David R., and Thornton, Ronald K. *Interactive Lecture Demonstrations – Active Learning in Introductory Physics*. Accessed: May 9, 2025.
https://pages.uoregon.edu/sokoloff/ILDbook0116.pdf

9) Walsch, C., Lewandowski, H. J., & Holmes, N. G. "Skills-Focused Lab Instruction Improves Critical Thinking Skills and Experimentation Views for All Students." *Physical Review Physics Education Research*, 18(1), 2022.
https://doi.org/10.1103/PhysRevPhysEducRes.18.010128