

BAR-ILAN UNIVERSITY

**Hands On, Minds On and Virtual Lab
Scientific Inquiry-Based Style:
Effects on High-School Students' Inquiry Skills,
Attitudes, Science Knowledge, and Socially Shared
Regulation of Learning**

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Abstract

Developing inquiry skills alongside understanding the essence of science are major goals in teaching science in Israel and around the world. The purpose of inquiry learning is for students to engage in practices and not just learn about them, which means that they will conduct a scientific inquiry. However, research findings have consistently shown that students experience considerable difficulties in developing scientific research skills and consistently in inquiry-based learning. The main difficulty arises from the student's ability to transfer between one specific scientific research to another and discover the basic scientific research structure and the tools needed in various situations and contexts.

Researchers in science teaching noticed styles of scientific inquiry where different cognitive resources are needed to develop scientific research skills: a) Active research in a science lab called – hands-on: Active research requires practical work alongside thought processes to create new information or discovery, i.e., create procedural knowledge alongside conceptual. Procedural knowledge is formed as a result of procedural-practical processes that were created from collected information. In contrast, conceptual knowledge is formed through cognitive processes that are activated in the process of examining theories following information gathered. b) Theoretical research practice in the classroom, known as minds-on: Theoretical research is the attainment of knowledge through scientific text research that describes procedures and results of laboratory experiments. In other words, minds on research is the acquisition of conceptual knowledge by presenting facts, ideas, principles and theories in the specific field of knowledge. c) With the advancement of technology, the use of a virtual research laboratory performed in a computer lab known as 'virtual lab' can be identified. Virtual research is a computer simulation study that allows you to simulate a real experiment taking place inside a lab. Using computer simulation has become a significant part of teaching and especially in the scientific profession such as physics, chemistry and biology. The visualization enables the student to link the

theoretical-conceptual aspect with the practical, without actual physical and procedural performance in laboratory tools. This allows the user to make scientific inquiries in a way that the learner can process the information more simply.

Another way of promoting research skills is to study scientific research in groups. Learning scientific research in groups, advances inquiry skills by sharing thinking and knowledge processes among group members. However, despite the importance of scientific research work in groups, many studies suggest that gathering students in groups is not enough for effective collaborative learning. Socially shared regulation of learning (SSRL) is required for the success of the task. SSRL is the ability of a group to manage group learning. SSRL has a role in group dynamics and influence on collaborative work outcomes. Further research indicates that there is a high degree of SSRL and high academic achievement. Although there are many studies relating to scientific inquiry-based style and studies dealing with SSRL toward scientific research, the combination of these variables has not yet been considered. In this study, we sought to examine the effect of scientific inquiry-based style: hands-on, minds-on and virtual research effects on high-school students' inquiry skills, attitudes, science knowledge, and SSRL. From the above, the question arises as to what the optimal way of cultivating research skills is. Which scientific inquiry-based style of research: hands-on, minds-on or virtual, has the advantage of developing inquiry skills, scientific knowledge, SSRL and student attitudes?

In this study, participants were students from grades 11 and 12. The students studied 5 points 'Bagrut' biology and were tested for the acquisition of inquiry skills in the laboratory matriculation exam. The students were randomly divided into three study groups, equal in composition, each group numbering 35 students. Each group experimented with a different style of research: hands-on, mind-on and virtual, and in the same content: enzymes, photosynthesis and the transport system. In each study group the students worked in pairs. This study was conducted in an approach that combines both quantitative and qualitative methods to broaden the various

interpretations and to create a broader picture of SSRL and promoting achievements among students.

The results of the study raised several conclusions: Among students who studied minds-on style, improvement in inquiry skills was observed compared to subjects who studied hands-on and virtual research style. On the other hand, regarding SSRL, it was found that the hands-on research group exhibited the best performance, followed by the minds-on research and finally the virtual research. In the present study, no differences were found between the different styles of research in scientific knowledge and change in students' attitudes. When the links between students' attitudes, scientific knowledge and scientific inquiry-based style to inquiry skills were examined, it was found that there was a positive relationship between scientific knowledge and research skills, so that the higher the scientific knowledge, the higher the research skills. In addition, it was found that virtual learning style compared to hands-on and minds-on research style predicts lower levels of scientific inquiry skills.

This study is important in both the theoretical and the practical aspects: In the theoretical aspect, SSRL is a new area that has been explored in the last decade. Considering the changes taking place in the education system in the present age, emphasis is placed on developing skills and designing the learner. One of the main skills is collaborative learning. SSRL was found to be high among students who studied in the traditional style of inquiry, i.e., hands-on research compared to students who studied in the style of virtual and minds-on research. In the practical aspect, we conclude that combining traditional research styles, i.e., hands-on and minds-on research, has been found to be effective in improving both research and scientific knowledge and SSRL. For 21st century learning, virtual learning has many benefits such as low cost, great safety and high availability. However, as far as inquiry skills, scientific knowledge, and SSRL are concerned, this style of research has no advantage over traditional research styles. The present study allows to advance the knowledge of research teaching and SSRL as an integral part of the curriculum. In doing so, the

study completes another slot in the complex fabric of imparting 21st-century skills to the education system graduate.