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**Biology majors' ability to connect topics at different
levels of organization: Using an online learning
environment.**

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Abstract

Current biological research deals with solving complex problems, problems whose solution requires understanding and linking between several levels of organization. This link between multiple levels of organization is one of the components of "systems thinking". Scientists, who think systematically, are able to "move" in their minds between organizational levels - up and down. On the other hand, novices tend to think linearly - only at a certain organizational level. In this way novices often think that there is one central factor that governs a variety of processes, while the experts are able to see a picture in which there are multiple processes, each with a certain contribution. Today's biological research, which emphasizes the interaction and logical and continuous relationship between different levels of organization in biology, requires the formation of links between different levels of organization, and requires the understanding that cell-level processes, for example, affect other levels of organization within the organism.

Examination of the high school biology curriculum reveals that subjects of study at different organizational levels are separated in the curriculum at intervals of months or even years. This form of learning can make it difficult to create connections between different organizational levels and can result in the preservation of information as disconnected pieces, which can create a non-coherent repertoire of ideas on a given topic.

From the understanding the importance of the systems thinking approach, I decided to develop a learning environment, which aims to facilitate the creation of connections between pieces of information - between the core subjects in biology and the elective topic "bacteria and viruses in the human body". For example, in an attempt to understand the interaction between intestinal bacteria and humans, it is necessary to create connections between the micro level and the macro level, so that students may succeed in creating the necessary connections between the levels of the organization in the system.

In order to test students' ability to make connections and whether there was an improvement in this ability after learning the sequence of activities proposed in the e-learning environment, the following research questions were asked in this study:

1. What are the difficulties of biology teachers in teaching the elective topic "bacteria and viruses in the human body"?

2. What is the ability of high school biology students to link different subjects in the biology curriculum at different organizational levels?
3. How do students deal with questions that require connections between different organizational levels while learning using the learning environment that was developed in the course of this study?
4. Does the use of learning activities in the learning environment allow students to explain biological phenomena using several levels of organization?

In order to examine the students' ability to make links, a group of 21 12th graders from a high school in the center of the country was asked to answer questions requiring the integration of different core subjects. The students' answers were analyzed, and the students' use of the concepts from the various core subjects was examined when answering the questions. A year later, a group of 51 12th graders from the same school in the center of the country answered three different questions, which also required integration, and then experimented with two activities that were built in an e-learning environment. After this experiment, the students answered the three questions which was previously answered by the first group of students.

The ability of most of the students who have learned using the environment to integrate topics from several different core subjects when answering questions requiring integration between different core subjects has improved. The ability of one of the students, who used more concepts in his answers, to integrate concepts in his responses to questions in the learning environment improved, compared to a student who used a few concepts in his answers and was unable to improve his ability to integrate concepts. In addition, the difficulties faced by the biology teachers in teaching the elective topic "bacteria and viruses in the human body" was examined. The study population consisted of 171 biology teachers with a seniority between 1 and 41 years. The teachers teach in a variety of sectors: state, state-religious, settlement, Arab, Bedouin, Druze, etc. It was important to examine whether the teachers themselves found it difficult to relate issues from the elective topic and the core subjects. If the teacher finds it difficult to create the necessary connections between the different organizational levels and the core curriculum, it is likely that his students will find it difficult to make these connections themselves. However, an examination of the responses of the 171 teachers who chose to teach the elective topic "bacteria and viruses in the human body" in the previous school year, showed that the teachers actually see this as a topic that is easy to connect to the other core subjects, and this was one of the reasons they chose to teach

it. This is an important factor, because if teachers have difficulty in creating connections between the core subjects, they are unlikely to teach how subjects from different organizational levels and different core correlations are interconnected, and if students are not exposed to this system view, they may have difficulty identifying and matching concepts to the level of organization, and so perhaps they will be able to link subjects that belong to the same level of organization (horizontal coherence), but may have difficulty in creating vertical coherence, and the acquisition of these two capabilities is part of the model of the development of systemic thinking.

The results of this study show that students' ability to use terms from a number of core subjects that were greater than those used prior to the experiment was improved among those who learned using the sequence of activities proposed in the e-learning environment. In addition, since the core subjects are defined at specific levels of organization (the cell: molecules, organelles and cells; the human body: cell to organism levels; ecology: organism to biosphere levels), the more students use terms in their answers, the more likely they will use concepts that belong to different organizational levels, which will increase the use of concepts of more core subjects when answering questions that require integration of topics.

In summary, the use of the teaching sequence offered in the learning environment can contribute to improving students' ability to create connections between the various core subjects at different levels of organization, when questions that require integration of these topics are asked.