

## Introduction

Although general biology students may think of science as a body of facts, there are many biological controversies of academic and general interest. Argumentation is a fundamental intellectual skill with pedagogical significance, and research has found correlations between students' argumentation skills and their critical thinking process, which is central to higher education. Evidence shows that students often lack good argumentation skills, but these skills can be taught.

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An argumentation visualization tool, the Dialectical Map (DM), facilitates the teaching of argumentation skills. The DM is a hybrid of argument maps and argument vee diagrams. Students create DMs by identifying and composing arguments and evidence in written assignments or in a computer-supported environment. They then draw an integrated conclusion by evaluating arguments, counterarguments, and supporting evidence in a visually hierarchical structure.

## Preliminary Findings

Preliminary findings show improvements in students' argumentation skills over time and possible transfer of such skills. Students were better able to summarize arguments and present relevant evidence in support of these arguments following training with the DM argumentation tool. Students' improved argumentation skills also showed transfer, with matching improvements in writing styles, organization of information, and reasoning skills.

Students responded very positively to the DM. One student said, "It challenged us to learn how to argue effectively." Another said, "The DM challenged my ability to argue a topic. I thought I had skills [in argumentation] before, but I don't think I was actually very skilled."

## Case Studies

**BISC 316:** In an upper division vertebrate biology course, 32 students used the online DM to complete three assignments in which they weighed evidence and made arguments in support and opposition to hypotheses drawn from three current biological controversies. Students were assessed on the quality of their reasoning and their use of relevant evidence to support arguments for specific hypothesis for each assignment. They were also provided with detailed feedback on the quality of their arguments and evidence. Students were later asked to present arguments and evidence relevant to these controversies on lecture examinations.

**BISC 100:** In an introductory-level biology course, 20 students used the DM to complete three writing assignments similar to those in BISC 316. In the initial writing task, students wrote a summary of a brief text that presented arguments and counterarguments on a biological topic. Later in the course, students were again presented with the same brief text and asked to write a brief essay on the topic addressed in the text.

## Discussion

Students were enthusiastic about using the DM due to the support it provided for their learning.

The use of the DM appeared to facilitate more organization and coherence in students' subsequent writing about the ideas in the source text.

The use of the DM also appeared to facilitate greater synthesis and integration in students' writing. This may be due to the way the layout of the DM requires paraphrasing and integration of ideas.

Argumentation training alone (absent the DM) did not induce changes in students' writing in comparison to the control group. This suggests that the DM may provide guided practice in argumentation of a kind that is a necessary complement to merely telling students how to use argumentation.

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## DM Assignments (BISC 316)

Students developed a set of arguments and evidence to address the following questions:

1. Did the jaws of early gnathostomes originate to allow efficient gill ventilation?
  - **Pro** reasons argue that efficient gill ventilation was the original function of the jaws of early gnathostomes.
  - **Con** reasons argue that predation and food handling (not gill ventilation) was the original function of the jaws of early gnathostomes.
2. Did tetrapods arise after 375 million years ago?
  - **Pro** reasons argue that tetrapods after 375 million years ago, as the synapomorphies of the 'fishapod' *Tiktaalik* and tetrapods suggest.
  - **Con** reasons argue that tetrapods arose before 397 million years ago, as suggested by tetrapod tracks found in Zachelmie, Poland.
3. Did bird flight arise in cursorial dinosaurs that used their wings for lift?
  - **Pro** reasons argue that bird flight arose in cursorial dinosaurs that used their wings for lift.
  - **Con** reasons argue that bird flight arose in arboreal dinosaurs that used their wings to glide from trees to the ground.

## Two Dialectical Maps (BISC 100)

The top screenshot shows a Dialectical Map titled "Wolves should be killed to protect endangered woodland caribou in northern British Columbia and Alberta." The map is divided into "Pro Reasons" (green) and "Con Reasons" (red). The central thesis is "Wolves should be killed to protect endangered woodland caribou in northern British Columbia and Alberta." The Pro Reasons include: "The caribou population is unable to recover under natural circumstances any more due to habitat loss. Wolves are causing significant decline of caribou populations and need to be controlled if there is any hope of giving the caribou population a chance to recover." The Con Reasons include: "Just killing wolves is not enough to completely recover the dwindling caribou populations; other factors like habitat conservation need to be taken into consideration." The bottom screenshot shows a Dialectical Map titled "Genetically modified organisms (GMOs) are dangerous to human health." The map is divided into "Pro Reasons" (green) and "Con Reasons" (red). The central thesis is "Genetically modified organisms (GMOs) are dangerous to human health." The Pro Reasons include: "Popular methods of transferring DNA into developing plant cells create the possibility of mutations to genes surrounding the splicing site. The 'gene gun' and bacteria used to insert genes both create the potential for mutation." The Con Reasons include: "Malnutrition is arguably more dangerous to human health than the consumption of GM food."