COMMON MISCONCEPTIONS ABOUT ECOLOGY AND PEDAGOGY TO OVERCOME MISCONCEPTIONS

THE ECOSYSTEM

Misconception	Reference*
Varying the population size of a species will only affect the others that are directly connected through a food chain.	Griffiths & Grant 1985, Munson 1991
Varying the population size of a species may not affect an ecosystem, because some organisms are not important.	Munson 1991
Varying the population size of a species will affect all other organisms to the same degree.	Griffiths & Grant 1985
Organisms higher in a food web eat everything that is lower in the food web.	Griffiths & Grant 1985
The top of the food chain has the most energy because it accumulates up the chain.	Adeniyi 1985
Populations higher on a food web increase in number because they deplete those lower in the web.	Munson 1991
Total biomass for a trophic level is greatest at the top of the food web because the organisms are larger.	Brehm et al. 1986
Ecosystems are not a functioning whole, but simply a collection of organisms.	Brehm et al. 1986
Communities change little over time.	D'Avanzo 2003
More herbivores than carnivores because people keep and breed herbivores.	Leach et al. 1996
Decomposers release some energy that is cycled back to plants.	Lavoie 1997
The nitrogen cycle is used to provide energy for the carbon cycle.	Lavoie 1997
The carbon cycle consists of photosynthesis and respiration.	Lavoie 1997
The number of producers is high to satisfy consumers.	Leach et al. 1996
Plants do not live in water.	Adeniyi 1985
Plants are dependent on people, not vice versa.	Eisen and Stavy 1992
Energy is not lost in trophic transfer.	D'Avanzo 2003
An organism cannot change trophic levels.	Lavoie 1997
Humans provide food for other organisms.	Leach et al. 1996

PLANT-HERBIVORE INTERACTIONS

Misconception	Reference*
Plants cannot defend themselves against herbivores.	Stamp 2004
Spices don't have any particular function in plants.	Stamp 2004
Some plants produce caffeine because they need it for their own metabolism.	Stamp 2004
Plants cannot defend themselves against pathogens.	Stamp 2004
Except for plant toxins, the quality of food for herbivores is the same as that for carnivores.	Stamp 2004
Most insect herbivores will eat a variety of plant species.	Stamp 2004

PREDATORY-PREY INTERACTION

Misconception	Reference*
The relative sizes of prey and predator populations have no bearing on the size of the other.	Gallegos et al. 1994

In a food web, a change in size in one population will only affect another population if the two populations are directly related as predator and prey.	Gallegos et al. 1994
Organisms higher in a food web eat everything that is lower in the food web.	Griffiths & Grant 1985
Populations higher on a food web increase in number, because they deplete those lower in the web.	Munson 1991, 1994
The number of producers is high to satisfy consumers.	Leach et al. 1996
"Balance of nature" refers to populations of predators and prey being similar in size.	Brehm et al. 1986
Food chains involve predator and prey, but not producers.	Gallegos et al. 1994
Carnivores are big and/or ferocious. Herbivores are passive and/or smaller.	Gallegos et al. 1994
Carnivores have more energy or power than herbivores do.	Adeniyi 1985
Plants are weak and cannot defend themselves.	

ENERGY FLOW

Misconception	Reference*
Plants take in food from the outside environment, and/or plants get their food from the soil via roots.	Bell 1985, Smith & Anderson 1984
Organisms higher in a food web eat everything that is lower in the food web.	Griffiths & Grant 1985
The top of the food chain has the most energy because it accumulates up the chain.	Adeniyi 1985
Populations higher on a food web increase in size because they deplete those lower in the web.	Munson 1991, 1994
More herbivores than carnivores because people keep and breed herbivores.	Leach et al. 1996
Decomposers release some energy that is cycled back to plants.	Lavoie 1997
The number of producers is high to satisfy consumers.	Leach et al. 1996
Plants do not live in water.	Adeniyi 1985
Plants are dependent on humans, not vice versa.	Eisen and Stavy 1992
Carbon dioxide is a source of energy for plants.	Lavoie 1997
Energy is not lost in trophic transfer.	

SUCCESSION

Misconception	Reference*
Succession involves separate stages leading ultimately to a deterministic climax.	Gibson 1996, Lavoie 1997
Communities change little over time.	D'Avanzo 2003
Without human intervention, old fields either remain largely barren or in a perpetual state of weedy growth.	Brehm et al. 1986
Soil decreases in fertility over time.	Brehm et al. 1986
Soil is fertile only if humans intervene.	Brehm et al. 1986

As succession progresses, community is characterized by bigger plants and bigger animals.	Brehm et al. 1986
The climax community is usually the final stage, long-lasting, and self-perpetuating.	Gibson 1996

HOW TO OVERCOME MISCONCEPTIONS

OVERVIEW

Teachers may find it difficult to overcome student misconceptions, since students often try to fit new ideas into the faulty framework they possess, which is caused by the persistence of misconceptions. In order to effectively teach students, educators must help students to overcome their misconceptions by diagnosing the misconceptions, creating dissatisfaction with the misconceptions, and providing opportunities to practice the goal conceptions [5]. Traditional methods of instruction (eg. class-long lecturing) are not sufficient in overcoming student misconceptions [19,21,23].

Most science faculty take their teaching seriously but have little or no background in the pedagogical issues of science education at the university level. This problem is compounded by the limited time that most faculty can devote to exploration of the science education literature for new approaches to teaching. In addition, faculty often do not have time to ferret out the misconceptions of students and develop ways to challenge those, both of which are quite time-consuming tasks. Consequently, few faculty deliberately identify and challenge such misconceptions, even though there is a proven framework for that. That framework is the 5E teaching cycle [6].

5E Method of instruction:

In 1989 the Biological Science Curriculum Study (BSCS) group developed the 5E Model of instruction. The 5E cycle 1) focuses on major misconceptions, 2) begins with an ‘engage’ phase that requires active participation by students, 3) moves to additional phases that develop and expand the information and ideas, 4) but with much of the articulation done by the students, and 5) ends with an ‘evaluate’ phase that emphasizes student synthesis and/or application, plus self-assessment, more than grade reports.

The 5E learning/teaching cycle is based on the interactive exploration of a concept. During this investigation, students build on former concepts in order to place the new ideas into their working framework of knowledge. The cycle part of this method refers to the need to revisit misconceptions and reinforce conceptions within a course and across courses (or grade levels), which is necessitated by the difficulty in displacing misconceptions. Once the new concept is in place, it can then be used as the foundation for learning new concepts. Given this continual building of the knowledge framework, the problem of persisting misconceptions becomes very clear. If a student’s knowledge and future learning is based on the validity of their previous learned concepts, and one (or more) of those concepts is faulty, then the student may have difficulty learning new information.

The 5 E’s of the model are: Engage, Explore, Explain, Elaborate, and Evaluate.

ENGAGE:

During this stage, the instructor piques the student’s interest in the subject matter by asking questions, providing an interesting or unusual event, and/or providing discrepant events. This is not the time to explain or define concepts, provide answers, or lecture. The point of this stage is to generate enough interest in the subject at hand to propel the student into the learning process, which follows with the remaining stages. A key to successful 5E cycles is the ‘engage’ phase, which whenever possible makes use of ‘discrepant events’. For large enrollment lecture courses, it is much easier to conduct classroom demonstrations that provide challenges to misconceptions in physics and chemistry than it is in biology, especially in ecology and evolution. However, discrepant events can be done via analogies that make use of simple, inexpensive manipulative [12,22], or analogies or real events that can be shown in 2-5 minute video-clips.

EXPLORE:

In the explore stage, students have an opportunity to work through the problem to become familiar with it by using some hands-on model, discussion, or logical thought processes. Instructors here can ask directing questions, provide minimal consultation, and observe and listen to student interactions.

Instructors should not provide answers, critique students, or lecture extensively. The focus of this component is for the student to become familiar with the workings of the problem and generate further interest in the subject.

EXPLAIN:

During the explaining stage, students will begin to use and understand the correct terminology surrounding the subject. Students are formally provided with definitions, explanations, and relationships as they pertain to the concept. Students may still be encouraged to work with hands-on materials, and participate in group work and class discussions. Instructors should not introduce unrelated material, but should correct misconceptions (alternative conceptions).

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ELABORATE:
In this stage, students use what they have learned to solve the initial question, as well as others that are similar in nature. During this stage, students should be able to use the concepts introduced during the Explain stage to solve new problems. Instructors should listen for the correct concept and vocabulary usage, and provide directive questions.

EVALUATE:
During this stage, instructors can assess their students' ability to use the concepts correctly. This may be done through a variety of processes (e.g. tests, interviews, observations, capstone projects, etc.). Alternatively, students can assess their own progress via a self-evaluation. Teachers should avoid testing for isolated facts, but rather they should ask questions that determine if students can discuss and apply the concepts covered.

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