Third Misconceptions Seminar Proceedings (1993)

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Keywords: E. Tech, computer assisted instruction, multimedia,E. Methods, empowering students,concept mapping,Computer assisted instruction,multimedia instruction,concept mapping,empowering students,learning strategies ,
General School Subject: biology
Specific School Subject: microbiology
Students: two year college students

Macintosh File Name: De Groot - Microbiology
Release Date: 12-15-1993 C, 11-5-1994 I

Publisher: Misconceptions Trust
Publisher Location: Ithaca, NY
Volume Name: The Proceedings of the Third International Seminar on Misconceptions and Educational Strategies in Science and Mathematics
Publication Year: 1993
Conference Date: August 1-4, 1993
Contact Information (correct as of 12-23-2010):
Web: www.mlrg.org
Email: info@mlrg.org

A Correct Reference Format: Author, Paper Title in The Proceedings of the Third International Seminar on Misconceptions and Educational Strategies in Science and Mathematics, Misconceptions Trust: Ithaca, NY (1993).

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Concept Mapping with computer support, laser disc and graphics applied to Microbiology

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This presentation demonstrates and discusses a computer based instructional tool to teach various types of biology. in particular microbiology, that incorporates principles of concept mapping with electronic access to graphics, text and laser video disc material. The HyperCard application presents the learning strategy of concept mapping in detail, provides a bibliography, shows examples of maps, teaches the user how to identify key components of concept mapping, and lets the user design his own concept map from a list of selected concepts arranged about several general topics of microbiology.

The purpose is to train users, instructors and students, to identify a concept, recognize the relationships between several concepts with links and propositions, and depict them in a visualized form as a map. Concept mapping de-emphasizes memorization and supplants rote learning with a knowledge base that emphasizes relationships by connecting new knowledge in the form of a concept to existing knowledge. (Novak, and Gowin, l986) Learning of this type supports problem solving and critical thinking activity in contrast to rote memorization of concepts as words.

An example of classroom technique is producing a map showing relationships of microorganisms. Concepts include microorganisms, molds, bacteria, protozoa, antibiotics, cheese and spoilage. Concepts, represented by words, are moved on the computer screen to make a map. (See figure 1 & 2) The computer permits further examination of concepts by linking to a compendium of information that may include text, graphics, animation, quiz questions, textbook reference and laser disc pictures of specific organisms. (See figure 3)

The technology of computerizing concept mapping with links to visual and detailed material greatly increases the potential of existing knowledge, introduces immediate visualization, and provides mapping activity that can be saved, reviewed for changes, and easily critiqued. A classroom equipped with a computer for classroom assisted instruction (CAI) lets the instructor use concept mapping as a framework for non linear learning that expands to include material they write, textbook provided graphics scanned into the program, original drawings, quiz challenges, as well as laser disc films and slide presentations. The interactive capability encourages the student to become involved by exploring learning opportunities provided by the computer and hardware in a computer lab. Cooperative learning is introduced by creating teams to develop concept maps that represent team thinking. Access to student computer labs provides an ideal situation for team interaction.

- WHAT KIND OF STUDENTS ?

Researchers (Arnaudin et al, 1984, Ault, l985, Cliburn, 1990) have applied concept mapping to a wide range of students, especially college and adult learners, from different social classes and racial background. Students at St. Petersburg Jr College range from 16-65 years old, represent a wide range of social class and racial backgrounds with a majority experiencing ineffectual learning in high school or previous college, especially in science. Women with a weak science background, studying to enter vocational type programs in the allied health programs, represent over half of the students. Most classes meet twice a week with 50-60 students. Use of computerized concept mapping in an interactive, multimedia manner is ideally suited for community college science students and presumably for high school science student as well.

- CONCEPT MAPPING DEVELOPED FOR COMPUTER

Concept mapping was introduced to SPJC microbiology students in September of l987. The instructor selected the 6-9 concepts for a central topic, with four topics included in unit. Four units comprise the course. Concept selection was based on course objectives, curriculum designation and was frequently expanded with student suggested concepts. Computer access supplied by the college in l988 supported the development of a HyperCard application to present the methodology of concept mapping in a repeatable electronic mode, and provide the experience of making maps on the computer by moving concepts about the screen, labeling and printing. 1989 saw the installation of hardware that projected the computer screen via a Kodak data show, a laser disc player, and a monitor with laser material display capability. This application was used for classroom assisted instruction (CAI).

During this time students worked as teams creating paper and pencil maps as part of the course structure. As students learned concept mapping and progressed in microbiology a need for more information about concepts before mapping was apparent. A separate HyperCard stack was developed that included text about the concept, graphics, animation and possible electronic links to the Laser disc video. This stack provides opportunities to identify prior knowledge for selected concepts and additional comprehension of concept relationships. Quiz questions, notes and textbook references were added to this stack as the developer found time. Concept mapping and critical thinking are emphasized in an effort to help students develop their cognitive thinking and apply concepts to problem solving ability. Class discussions helped students understand how to relate concepts to critical thinking and inclusion of test questions challenged students to integrate concepts selected from two or more topic areas into one map for credit.

- WAYS TO USE COMPUTERIZED CONCEPT MAPPING

There are four levels of use with computerized concept mapping.

<u>Level 1</u> A Macintosh computer with HyperCard, and a printer are minimal requirements. Users, teachers, student teachers, and graduate assistants, can learn how to map, review terms like super ordinate, subordinate, proposition, links, and create their own maps. A group of learners can create maps, file them, and review and discuss maps in a non confrontational manner. It is possible to critique maps with an invisible field overlay. If maps are designed for classroom use they can be printed as overhead acetates. The user is in control, can practice and produce maps, change or add concepts, develop text support, and insert graphics, there is, however, no computer interactive ability that involves and interests students. That interaction requires additional hardware.

<u>Level 2</u> A classroom equipped with a computer and data display for screen projecting demonstrates the interactive ability of the application, (making maps on the screen and viewing graphics, and text). The instructor has several pedagogical opportunities or classroom techniques available:

- Students can be verbally involved in developing a map from listed concepts with questions about super ordinate concept, arrangement and propositions.
- Students can suggest concepts.
- Maps can easily be rearranged, propositions changed, and copies made for comparison. Class discussion of maps reveals students' misconceptions in a nonconfrontational manner. "Oh, I see!" is an often heard remark.

- Concept graphics and text material viewing frequently suggest changing the placement of a concept or a proposition to students. This provides the opportunity to ask "why?". Students reveal their thought patterns and involve other students as they follow the explanation. How to think is a new experience for many students!

Assistance in the form of support personnel may be needed to help users not familiar with the Macintosh computer and HyperCard, especially to integrate graphics and animation into the application.

Level 3 The addition of a laser disk player and monitor to level 2 CAI hardware provides the opportunity to show color illustrations and video film of concepts in conjunction with the computerized framework and data display. This reinforces the concept-symbol with a picture in color or a time lapse video that shows how or where, i. e. cell division, phagacytosis, types of organisms. While this multimedia approach is classroom based, and can be repeated or reviewed at another class meeting, student involvement is limited to class response and discussion.

Level 4 A student computer lab available for individual and group use is a separate entity. It must include the computer, software and space for several students to view the screen at one time. Students are empowered to learn individually or together as a team. Computer technology lets them explore the information and make their map. Experience with teams to develop maps and hopefully study together provides an excellent opportunity for cooperative learning. Team members work together at one computer, suggest concepts placement, ask questions, explain why they chose such an arrangement, and propose propositions which expands their vocabulary. Students can print their maps, store them electronically and bring them to class on a computer disc. When the map is projected in class each member of the team must be able, if called upon, to explain the arrangement of the map. This verbalization, keeping in mind the idea that "there is no correct map", insures cooperative learning versus one person 'doing' the entire map. Student verbalization on a team or one on one with the instructor is a valuable activity in expression, explaining and defending the thinking in map making.map evolved.

If laser capability is present in the lab, the student can view disc pictures and video. This is presently limited due to expense of the disc and projecting hardware which is controled by one computer. Many publishers are marketing science textbooks with a laser disc which will expand accessibility. Student labs should have capable assistance, a person with an understanding of HyperCard, to help students with the application.

- HOW TO FINANCE

Various grant programs may provide help to instructors who wish to adapt the application for their subject and class. Apple Computers and NSF grants to improve secondary science education, two-year college science education and non-science majors education are available for application. It is possible to borrow laser discs on a variety of subjects from public libraries, resource pools at school district and state level. Adoption of a textbook with accompanying laser disc could be a priority for getting material. Budgeting for direct purchase of hardware and disc is most satisfactory. The possibility of instruction of a large number of students in one classroom supports the expenditure. Repeatability of material is a benefit that insures students can review to be more successful in the course.

- WHAT IS THE VALUE?

Currently the need to change the way science is taught in public schools as well as in post secondary educational institutions is supported by several studies. In 1988, the Second International Science Study (SISS) reported that American students were among the lowest achievers of the seventeen participating countries. Specific conclusions reported by the SISS interpretive panel were as follows:

- At grade 5, the U.S. ranked in the middle in science achievement relative to 14 other participating countries.
- At grade 8, U.S. Students ranked next to last (13 of 14).
- In the upper grades of secondary school, the advanced science students ranked last in biology and performed behind students from most countries in chemistry and physics.

The National Assessment of Educational Progress (NAEP) has analyzed middle and high school student performance in several subject areas. The analysis included student grasp of information as well as student ability to demonstrate higher order thinking within the subject area. In 1988, NAEP published a report, *Science Learning Matters*, which concluded that only 7% of the U.S. students are prepared to succeed in college-level science courses, and that more than half of the 17-year-olds can neither perform jobs requiring technical skills nor benefit from on-the-job training. Almost half of the 13-year-olds were seen as unprepared for high school science and unable to apply basic scientific information.

The need to teach the processes of science, in biology especially, is supported by Luther Williams of NSF in his article "The Undergraduate Science Curriculum--Bridging Biology to Human Resources" (1990) when he suggests that if the undergraduate science curriculum were to "connect units of knowledge in a newly coordinated instructional process," then science would become more appealing to more students. To meet these needs, a learning strategy, such as concept mapping is ideal.

Interactive computerized concept mapping incorporates flexibility in this learning strategy to meet curriculum and instructor requirements yet provides an overall recorded structure for a course

that incorporates active student participation in their learning. The computerized approach solves many of the acknowledged shortcomings of pencil, paper, and chalk concept mapping. It allows direct choice of concepts and participation of students in developing maps and applying them to critical thinking. Indeed, because concept mapping stresses linking new knowledge to existing knowledge and demonstrates the relationship of the concepts, it empowers the student to succeed in problem solving activity. The application can be expanded by a creative instructor who wishes to challenge students to expand their knowledge base.

SPJC students who have participated in concept mapping have demonstrated greater understanding verbally and in written answers, and recounted the ongoing usefulness of concept mapping for science and other courses. Comparison of grades pre and post introduction of concept mapping in 1987 indicates an increase in numerical grades and a decrease in number of students who drop the course for academic reasons. Introduction of computerized concept mapping saves time over chalkboard maps, provided creativity of making a map that can easily be viewed and changed, provided repeatability, encouraged students to participate and try mapping. In science courses the learning strategy is particularly helpful to minority and women students who have weak backgrounds in study techniques and are unaware of non rote, i.e. flash card memorization, methods of learning. The availability of student computer labs in 1993 created the opportunity for groups of students to work together on the computer. A sense of tremendous accomplishment in bringing a disc with a map to class is obvious and develops student confidence. The advantage of cooperative learning, using concept maps, and empowering students with additional information should be recognized.

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For 22 years I have taught BIOLOGY and MICROBIOLOGY to community college students. I studied with Joseph Novak, PhD, Professor of Science Education at Cornell University, in July,1987 and

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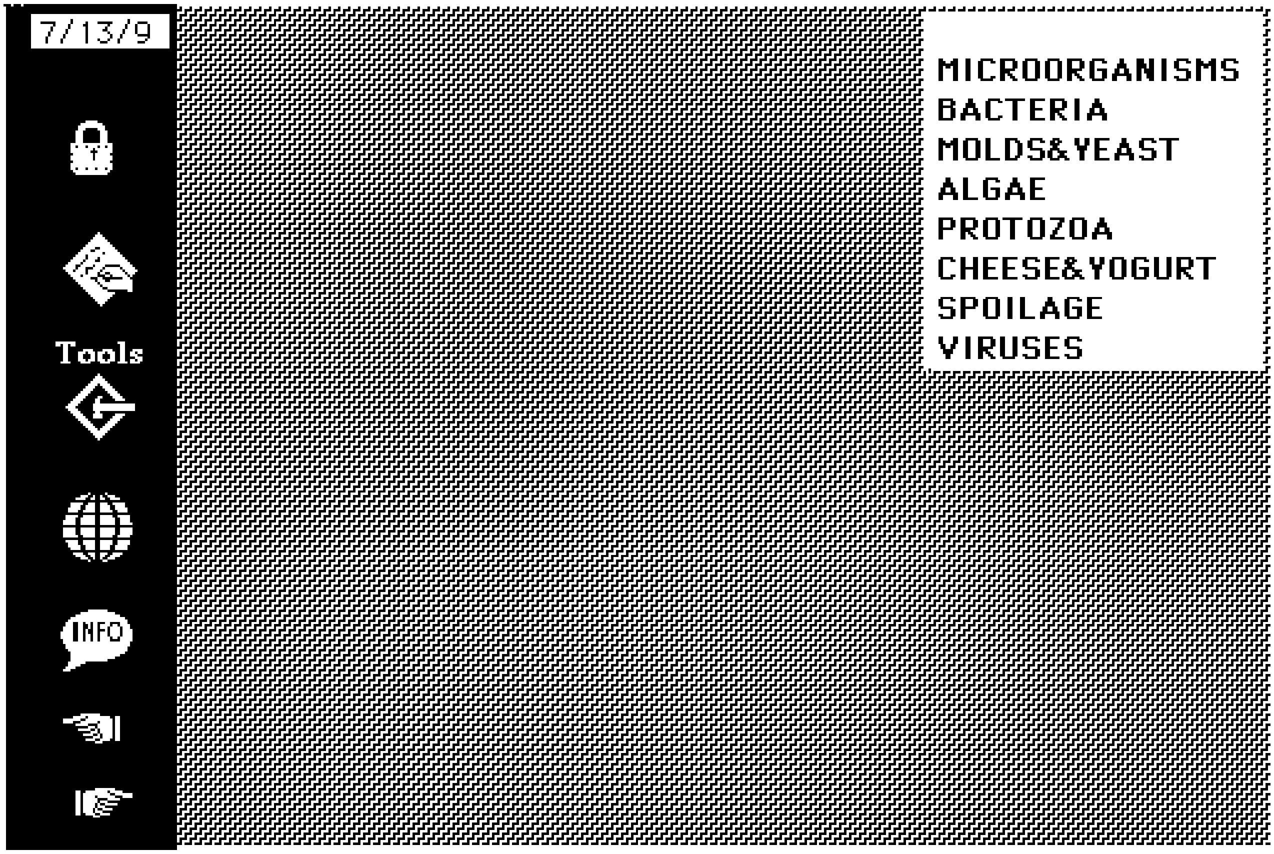

Fig 1. Computer Screen of Concepts for Microorganisms

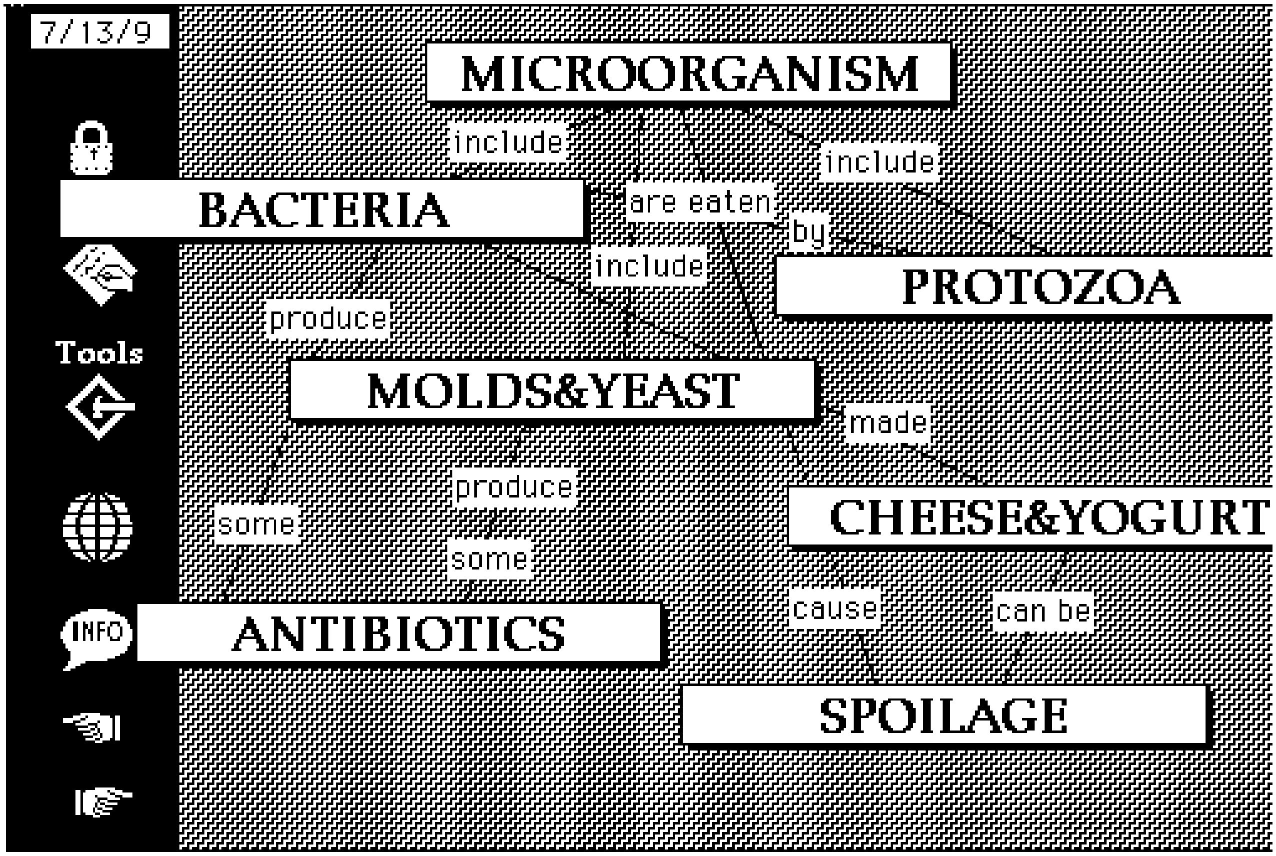

Fig. 2. Student created Computerized Map.

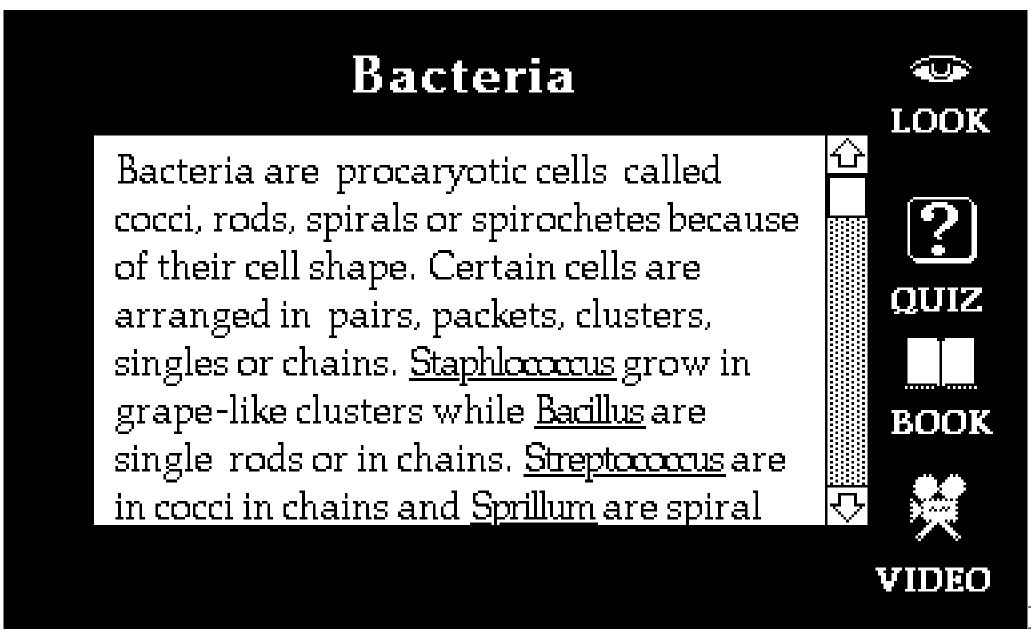

Fig 3. Information for Concept Bacteria.