DOCUMENT RESUME

ED 465 628	SE 066 350
AUTHOR	Bleicher, Robert E.; Romance, Nancy; Haky, Jerome
TITLE	Curriculum by Design: Improving Student Learning in College Chemistry and Biology.
PUB DATE	2002-01-00
NOTE	11p.; In: Proceedings of the Annual International Conference of the Association for the Education of Teachers in Science (Charlotte, NC, January 10-13, 2002); see SE 066 324.
AVAILABLE FROM	For full text: http://aets.chem.pitt.edu.
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Academic Achievement; Biology; Chemistry; *Curriculum Design; Higher Education; Program Effectiveness; *Science Instruction; Success

ABSTRACT

It is well documented that college students arrive poorly prepared to succeed in science and mathematics courses. Reasons for this include: (1) lack of student conceptual understanding in science; (2) inability to think critically; (3) little interest in science; and (4) a lack of self-discipline and study skills. The purpose of this paper is to demonstrate that if a Curriculum Design Model (CDM) is applied to course curriculum and instruction, then college students will be able to understand the basic concepts underlying important science topics. Further, the effectiveness of the CDM can be tested in the form of improved student conceptual understanding, achievement and course retention. It is postulated that when students are given the opportunity to construct their own conceptual understanding, there is an increase in their motivation and interest in science. (Contains 26 references.) (MVL)

Reproductions supplied by EDRS are the best that can be made from the original document.

ED 465 628

Curriculum By Design: Improving Student Learning in College Chemistry and Biology

Robert E. Bleicher
Nancy Romance
Jerome Haky

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

- This document has been reproduced as received from the person or organization originating it.
- Minor changes have been made to improve reproduction quality
- Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY

P. Rubba

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

1

SE066350

BEST COPY AVAILABLE

CURRICULUM BY DESIGN: IMPROVING STUDENT LEARNING IN COLLEGE CHEMISTRY AND BIOLOGY

Robert E. Bleicher, Florida Atlantic University
Nancy Romance, Florida Atlantic University
Jerome Haky, Florida Atlantic University

It is well documented that college students arrive poorly prepared to succeed in science and mathematics courses (Kean & Middlecamp, 1994). Reasons for this include: (a) lack of student conceptual understanding in science; (b) inability to think critically; (c) little interest in science; and (d) a lack of self-discipline and study skills. National attrition rates are high among first-year college students, particularly in underrepresented groups. Finally, college teaching is still heavily didactic in approach with little opportunities for active engagement necessary for students to construct their own conceptual understanding.

Purpose

The purpose of this paper is to demonstrate that if a Curriculum Design Model (CDM) is applied to course curriculum and instruction, then college students will be able to understand the basic concepts underlying important science topics. Further, the effectiveness of the Model can be tested in the form of improved student conceptual understanding, achievement and course retention. It is postulated that when students are given the opportunity to construct their own conceptual understanding, there is an increase in their motivation and interest in science.

Theoretical Background

Figure 1 illustrates the three tenets that underpin the Curriculum Design Model. These three tenets (less is more, scaffolding learning, scientific literacy) were derived from the professional experience of the faculty as well as a substantial research literature base.

934

ERIC
SE066350

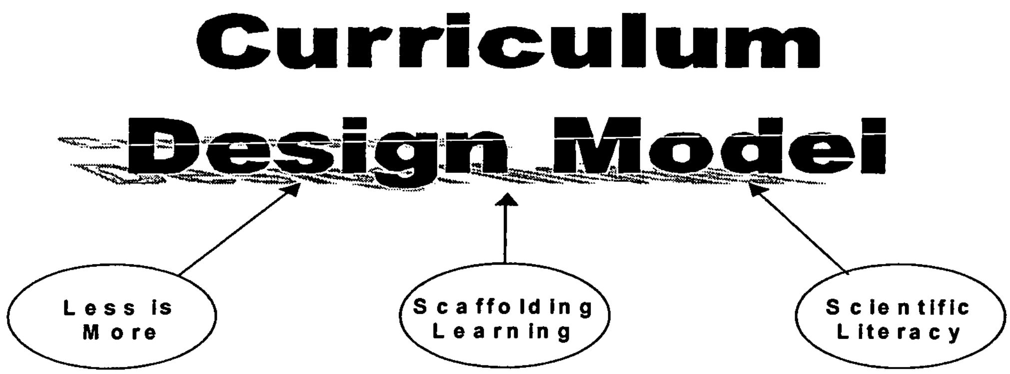

Figure 1. Three Tenets of the Curriculum Design Model.

Less is More: First Tenet of the Curriculum Design Model (CDM)

Recent research in college physics learning indicates that success in undergraduate courses depends heavily upon students following cookbook-like solutions to problem solving tasks (Maloney & Siegler, 1993). Further, success in these courses was not a valid indicator of student conceptual understanding (McDermott & Shaffer, 1992). Interviews with 'A' and 'B' students from these courses showed that many held naïve and incomplete views of basic science concepts. Findings from other studies concur that success in traditional undergraduate science courses is not a valid measure of the depth of their conceptual understanding (Maloney, 1994). Vosniadou (1996) suggested that core concepts within a discipline have a relational structure that directly affects conceptual understanding. The relatedness among these core concepts must be reflected in course curriculum and text-based materials. Similarly, Romance and Vitale (1997, 1999) suggested that instructional activities should be designed to require learners to demonstrate how they would represent their understanding of core concept relationships. Finally, the TIMSS study (Schmidt, McKnight & Raizen, 1996) found that instructional materials used in the United States typically consisted of many diffusely arranged concepts that inhibited meaningful learning. Further, the amount of information presented is so vast that it results in the mere "mentioning" of concepts rather than developing student understanding of core concepts and their relationships. This research base underpins the "less is more" tenet of the CDM. Instead of covering more topics, it is based on covering the most important topics in greater depth, and emphasizing relationships between core concepts.

Scaffolding Learning: Second Tenet of the CDM

Experts, unlike novices, are characterized by the degree to which they have developed and organized their conceptual understanding (e.g., Andersen, 1993; Carey, 1985; Chi, Glaser & Rees, 1982). Within this framework, the goal of meaningful learning is considered to be the continued organizational development of the conceptual understanding necessary for deep thought processing associated with abstractions and generalizations (Glaser, 1991; Glaser & Bassok, 1989; Royer, Cisero & Carlo, 1993). Reif and Heller (1982), in addressing problem-solving in physics, found that deep understanding involves hierarchical organization of conceptual knowledge into easily accessible schema. Carnine (1992), DeJong and Ferguson-Hessler (1996), & Grossen, et al., (1998), suggest that curriculum and instruction designed around 'big ideas' as core concepts promote active student conceptual understanding. Finally, Kozma et al., (1996), in studying learning in chemistry, have shown that novice learners cannot be expected to direct their attention to core concepts in a discipline. Rather, novices require extensive guidance from experts (teachers) to develop deep thought processing and conceptual understanding.

Supporting Scientific Literacy for All: Third Tenet of the CDM

Another fundamental issue associated with effective teaching and learning is the need for students to engage in meaningful discourse in order to construct their own conceptual understanding (Bleicher, 1998). Such discourse is promoted through collaborative learning environments where students feel comfortable to take risks, ask questions and share ideas. This is in keeping with the National Science Education Standard, "to advance learning and increase the scientific literacy of all students" (National Research Council, 1996).

Methodology

The research followed a mixed-method design (Frechtling & Sharp, 1997), involving both quantitative and qualitative research methodologies. It examined project activities and correlated these to changes in student learning, achievement, and interest in science. It also assessed changes in faculty understandings and practices in curriculum and instruction.

Student achievement data (exam scores, laboratory grades, final course grades) were collected. Survey data were collected from students, gathering feedback about all course components, but particularly the non-traditional recitations. The Reformed Teaching Observation Protocol (ACEPT, 2000), a cooperative learning classroom teaching rubric, was used to measure the effectiveness of the implementation of cooperative learning strategies by the undergraduate peer leaders who facilitate the
non traditional recitations.

Data were analyzed using a strategy developed by Miles & Huberman (1994). This methodology provides a framework for a collaborative group of researchers to perform three research functions: (a) reduce the data to a subset of information (categories) without losing essential data; (b) display (matrices, maps, summaries) this information in a manner that facilitates group discussion and notation of consensus upon emerging patterns (narrative documents); and (c) draw conclusions that help explain observed participant actions and consequences.

Results

Example of A Module: Structure and Function of Cells

Most introductory biology students do not appreciate the significance of studying the cell because they do not have a conceptual framework within which to assimilate what they are being taught. To help develop such a framework, the cell is studied in lecture, laboratory and non-traditional recitation (Lifeline). By structuring the learning environment to provide reinforcement and application, a scaffold is created to promote student learning.

While the first two learning components (i.e., lecture and laboratory) are conceptually aligned, learning theory tells us that complex concepts are learned when students have opportunities to discuss and apply concepts leading to conceptual understanding. The non-traditional recitations provide a small-group, cooperative learning environment that supports student construction of their own understanding . Hence, given its pivotal role in the learning cycle, it is critical that these non-traditional learning experiences be well designed by applying a Curriculum Design Model that links conceptual learning in all three course components. By focusing their attention on the workings of the cell during lecture, visualizing different cell types in the laboratory, and engaging in meaningful discourse about the underlying concepts in the Lifeline sessions, the student learns about cell structure and function in three increasingly more focused instructional contexts. In doing so, multiple instructional activities are provided for learners to construct meaningful understanding. Using multiple pathways to enhance student understanding is an important cognitive strategy as it provides a well designed vehicle to reinforce and clarify student understanding and misconceptions (Bleicher, et al., 2001). Learning of complex concepts requires multiple instructional interventions with the same or similar

ERIC

concepts in order to provide opportunities for learners to construct their own understanding (Bleicher & Romance, 2001).

Student Performance

Students expressed more confidence in their ability to reason-through and solve chemistry and biology problems. Over 70% of students indicated that the non traditional recitations were helpful to their success in the course.

To assess the impact of the CDM on student performance, the grade distribution for the course taught in the current year was compared with those of the previous three years. These data show a 20% reduction in the percentage of students receiving D's, F's, or withdrawing from the course. Withdrawals alone dropped to 5% this year compared to over 22% previously.

Implications for College Science Teaching

Building a Professional Learning Community among college professors is a challenging endeavor. Faculty had a common purpose and were willing to invest time and energy in addressing the complex issues and changes which needed to be made. Faculty were willing to put aside their prior conceptions and become more open to each other's ideas and to those ideas suggested in current research journals in order to expand their own understanding of the problems. In the process of meeting for the past several years, faculty participated in conversation following presentations by distinguished science and science education researchers studying teaching and learning. While much of this early collaborative work was initially spearheaded by efforts of the science education faculty, the scope of the work has become a shared partnership best described as a Professional Learning Community. Even with a positive working relationship within and outside each college, faculty needed to establish an action plan so as to clarify goals and objectives, identify tasks and responsibilities and plan for resulting evaluation of activities.

References

ACEPT, Arizona Collaborative for Excellence in the Preparation of Teachers. (2000). *Reformed teaching observation protocol (RTOP)*. ACEPT Technical Report IN00-3. Arizona State University: Arizona Board of Regents.

Andersen, J.R. (1993). Problem solving and learning. *American Psychologist*, *48*, 35-57.

Bleicher, R. (1998). Classroom interactions: Using interactional sociolinguistics to make sense of recorded classroom talk. In J. Malone & B. Atweh (Eds.), *Aspects of postgraduate supervision and research in mathematics and science education* (pp. 85-104). Mahwah, New Jersey: Lawrence Erlbaum.

Bleicher, R. & Romance, N. (2001, January). *Nurturing confidence in preservice elementary science teachers*. Paper presented at the annual meeting of the Association for the Education of Teachers of Science (AETS), Costa Mesa.

Bleicher, R., Romance, N, Haky, J., Carraher, C., & Louda, D. (2001, April). *Developing deeper conceptual understanding in undergraduate chemistry students*. Paper presented at the annual meeting of the AERA, Seattle.

Carey. S. (1985). Are children fundamentally different kinds of thinkers and learners from adults? In S.F. Chipman, J.W. Segal, and R. Glaser (Eds.), *Thinking an learning skills* (pp. 485-517). New York: Basic Books.

Carnine, D. (1992). Introduction. In D. Carnine & E. J. Kameenui (Eds.). *Higher order thinking* (pp. 1-22). Austin, Texas: Pro-Ed.

Chi, M.T., Glaser, R., & Rees, E. (1992). Expertise in problem solving. In R. Sternberg (Ed.), *Advances in the psychology of human intelligence* (pp. 7-76). Hillsdale, NJ: Lawrence Erlbaum.

DeJong, T., & Ferguson-Hessler, M.G. (1996). Types and quality of knowledge. *Educational Psychologist*, *31*, 105-113.

Frechtling, J., & Sharp, L., (Eds.). (1997). *User-Friendly Handbook for Mixed Method Evaluations*. Division of Research, Evaluation and Communication (RED 94-52965): National Science Foundation.

Glaser, R. (1991). The maturing of the relationship between science learning and cognition and educational practice. *Learning and Instruction*, *1*, 29-44.

ERIC

Glaser. R., & Bassok, M. (1989). Learning theory and the study of instruction. *Annual Review of Psychology. 40*, 631-6.

Grossen, B., Carnine, D., Romance, N. & Vitale, M. (1998). Effective strategies for teaching science. In E. Kameenui & D. Carnine (Eds.), *Effective teaching strategie that accommodate diverse learners* (pp.113-134). Upper Saddle River, NJ: Merrill.

Kean, E. & Middlecamp, C. (1994). *How to survive and even excel in general chemistry*. NY: McGraw-Hill, Inc.

Kozma, R.B., Russell, J., Jones, T., Marx, N., & Davis, J. (1996). The use of multiple linked representations to facilitate science understanding. In S. Vosniadou, E. DeCorte, R. Glaser, & H. Mandl (Eds.), *International perspective on the design of technology supported learning environments*. Mahwah, NJ: Lawrence Erlbaum.

Maloney, D.P. (1994). Research on problem solving: physics. In D.L. Gabel, (Ed.), *Handbook of research on science teaching and learning* (pp. 327-354). New York: Simon & Schuster.

Maloney, D.P., & Siegler, R.S. (1993). Conceptual competition in physics learning. *International Journal of Science Education, 15*, 283-295.

McDermott, L.C., & Shaffer, P.S. (1992). Research as a guide for curriculum development: An example from introductory electricity. Part I: Investigation for student understanding. *American Journal of Physics, 60*, 994-1003.

Miles, M., & Huberman, A.M. (1994). *Qualitative data analysis: an expanded sourcebook* (2nd ed.). California: Sage Publications.

National Research Council. (1996). *National science education standards*. Washington, DC: National Academy Press.

Reif, F., & Heller, J. (1982). Knowledge structure and problem solving in physics. *Educational Psychologist, 17*, 102-127.

Romance, N. R., & Vitale, M. R. (1997). *Knowledge representation systems: Basis for the design of instruction for undergraduate course curriculum*. Paper presented at the Eighth National Conference on College Teaching and Learning, Jacksonville, FL.

Romance, N. & Vitale, M. (1999). Concept mapping as a tool for learning: broadening the framework for student-centered instruction. *College Teaching, 47*, 74-79.

Royer, J.C., Cisero, C.A., & Carlo, M. (1993). Techniques and procedures for assessing cognitive skills. *Review of Educational Research, 63*, 201-24.

Schmidt, W.H., McKnight, C. & Raizen, S. (1996). *A splintered vision: An investigation of US science and mathematics education*. Norwell, MA: Kluwer Academic.

Vosniadou, S. (1996). Learning environments for representational growth and cognitive flexibility. In S. Vosniadou, E. DeCorte, R. Glaser & H. Mandl (Eds.), *International perspective on the design of technology supported learning environments*. Mahwah, NJ: Lawrence Erlbaum.

ERIC

STUDENT

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
National Library of Education (NLE)
Educational Resources Information Center (ERIC)

ERIC®

REPRODUCTION RELEASE

(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: Proceedings of the 2002 Annual International Conference of the Association for the Education of Teachers in Science

Editors: Peter A. Rubba, James A. Rye, Warren J. DiBiase, & Barbara A. Crawford

Organization: Association for the Education of Teachers in Science

Publication Date: June 2002

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic media, and sold through the ERIC Document Reproduction Service (EDRS). Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following three options and sign at the bottom of the page.

The sample sticker shown below will be affixed to all Level 1 documents	The sample sticker shown below will be affixed to all Level 2A documents	The sample sticker shown below will be affixed to all Level 2B documents
PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 1	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE, AND IN ELECTRONIC MEDIA FOR ERIC COLLECTION SUBSCRIBERS ONLY, HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2A	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2B
Level 1	Level 2A	Level 2B
[X]	[ ]	[ ]
Check here for Level 1 release, permitting reproduction and dissemination in microfiche or other ERIC archival media (e.g., electronic) *and* paper copy.	Check here for Level 2A release, permitting reproduction and dissemination in microfiche and in electronic media for ERIC archival collection subscribers only	Check here for Level 2B release, permitting reproduction and dissemination in microfiche only

Documents will be processed as indicated provided reproduction quality permits.
If permission to reproduce is granted, but no box is checked, documents will be processed at Level 1.

I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche or electronic media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries.

Sign here, please

Signature: Peter A. Rubba	Printed Name/Position/Title: Peter A. Rubba, DAP, World Campus	
Organization/Address: Dr. Jon Pederson, AETS Exec. Secretary College of Education, University of Oklahoma 820 Van Velet Oval ECH114 Norman, OK 73019	Telephone: 814-863-3248 E-Mail Address: par4@psu.edu	FAX: 814-865-3290 Date: 6/24/02

(over)