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ABSTRACT
        A literature review synthesized the qualitative
research from science education that described students' cognitive
processes in conceptual change and the related effects of context.
Studies were located by manual and on-line searches of more than 15
data bases to retrieve the published, unpublished, and fugitive
research. The actual case studies that were located centered around
themes of metacognition, motivation, and collaboration. Like the case
studies, much of the research using interviews and observations
focused on students' constructs and how those constructs were
manifested in the classroom. Pursuing questions like the ones raised
in studies from science education (the influences of students' views
of science, their folk language, their interaction patterns in
collaborative groups, and their texts, instruction and curriculum)
may help to identify the influences that affect students' conceptual
change. Researchers in reading education should heed the call from
science education researchers to conduct studies that include more
multicultural samples and more longitudinal observations of students
across grades. Expanding the focus and design of such studies in
these ways offers the potential for developing effective instruction
and for creating texts that are sensitive to individuals. Contains 27
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Critical Review of Qualitative Research on Conceputal Change

from Science Education

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Critical Review of Qualitative Research on Conceptual Change

in Science Education

Meta-analysis of instructional interventions to promote
conceptual change in science from reading education and science
education (Guzzetti, Snyder, Glass & Gamas, 1993) revealed the
need to examine extant naturalistic research and to create future
studies from a new paradigm. Our first decade of research on
conceptual change from reading education consisted of empirical
investigations, although some of our studies used naturalistic
techniques, like interviews (Guzzetti, 1990) or on-line
observations of students (Alvermann & Hynd, 1987).

This quantitative research enabled us to identify particular
instructional strategies that consistently showed high average
effects, like refutational text (Guzzetti, Snyder, Glass & Gamas,
1993). Nevertheless, several questions could not be addressed
through quantitative research. First, experimental research did
not allow us to describe how or why particular strategies produce
conceptual change. Strike and Posner (1992) have wondered what
conceptual processes a student experiences during instruction.
Second, empirical research has provided only average effects for
groups of students; we still do not know how individual student
characteristics, like age, culture, ethnicity, and gender enhance
or interfere with students' abilities to change their thinking.
Bloom (1992) suggested that investigations into students'
sociocultural contexts, as well as their attitudes, interests and
motivation might shed some light on these questions. Pintrich,
Marx and Boyle (in press), have called for studies of the

influence of students beliefs' about themselves as learners, and their roles as individuals in a learning community.

Purpose

I conducted this review to synthesize the qualitative research from science education that described students' cognitive processes in conceptual change and the related effects of context. By examining the qualitative research from science education, I hoped to find reports of the influences of cultural, social and contextual conditions on the process of conceptual change. Perhaps these descriptions might lead us in reading education to design new instructional approaches and texts that would be more sensitive to individuals. I also anticipated discovering recommendations for future inquiry that might assist us in reading education to design our second generation of research in conceptual change.

Procedures

Studies were located by manual and on-line searches of more than 15 data bases to retrieve the published, unpublished and fugitive research. Retrieval of the most recent literature was accomplished by perusal of conference programs from professional meetings. Despite these extensive search processes, this review is not all-inclusive of the extant qualitative research.

Case Study Research

The actual case studies (i.e., complete studies of a bounded system as described by Stake and Easley, 1978) that were located centered around themes of metacognition, motivation and collaboration. One such study was conducted by Hennessey and

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Beeth (1993), and was based on the premise that metacognition is necessary for conceptual change learning. This study reported a three-year instructional intervention in grades 1-6, Project META (Metacognitive Enhancing Teaching Activities). Instruction was designed to explicitly enhance students' metacognition by enabling students to consider the implications of their reflective thoughts. The project aimed to describe the impact of this kind of instruction on the formation of students' ideas.

Students were exposed to the technical language of conceptual change theory, i.e., that conceptions should be considered on the basis of their intelligibility, plausibility and fruitfulness. Individuals worked in small groups and whole-class discussions to build a consensus about a set of descriptors that for them best exemplified the meaning of each of these technical terms. Students were then given application exercises to determine if they had developed the concepts of intelligibility, plausibility and fruitfulness, if they could sufficiently differentiate between these terms, and if they could apply them to their own conceptions of particular topics. Exercises were written extracts taken from the professional literature, doctoral dissertations, sixth grade students' writings, and the students' own writings that described each of these three terms. Students were asked to comment on whether the extracts were intelligible, plausible and fruitful to them; they were also asked to provide their reasons why or why not. A final set of descriptors for each term was arrived at by consensus. Following this phase, students in grades four through six focused on applying the technical language to

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four through six focused on applying the technical language to their conceptions of science content. Students were audiotaped and videotaped extensively and regularly.

Data analysis yielded five types of metacognitive reflections. These included reflections that explicitly referred to students' personal constructs or knowledge claims; reflections that explicitly referred to the reasoning behind students' constructs or knowledge claims; reflections that explicitly considered the implications or limitations inherent in the students' constructs or knowledge claims; reflections that explicitly referred to the status of students' conceptions; and reflections that explicitly referred to the components of students' conceptual ecologies. An illustration of the latter type of reflection was provided by the following excerpt from a discussion (pp. 25-26):

"Melinda: Everybody seems to be talking about whether the pictures were intelligible or not so I'll start with intelligible too. Well, their intelligible to me I can understand what the pictures are trying to say about atoms, but they're not plausible to me because I cannot believe from anything that I have done, or anything than I have seen anybody do, that atoms are dead but they can still move. That part is intelligible but not plausible. The pictures are intelligible alright but not the ideas behind the pictures. I cannot understand how molecules can do that [move] if they are dead."

Based on data like these, Hennessey and Beeth (1993) reached four conclusions. First, they noted that students can provide extensive and varied evidence of their metacognitive abilities. Second, they stated that differences exist in the types of metacognitive statements produced by students instructed in the

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technical language of conceptual change. Third, they concluded
that analyses of these statements provide insight into the
reasoning and justification behind students' ideas and the
components of their conceptual ecologies. Finally, the authors
advised that to promote conceptual change, it is necessary for
students to engage continually in metacognition.

It is difficult to evaluate the merits of this case study and
its conclusions because of the vague description of the study's
design, particularly for data collection and analysis. The reader
is not informed of the extent and duration of data collection or
who collected the data (from the spelling and grammatical errors
in the sample transcription excerpt, it appears as if students
did the transcriptions of the videos and audiotapes). No mention
is made of any formal procedure for data analysis, either. The
brief excerpts from videotapes or audiotapes do not convince the
reader that they illustrate the propositions attributed to them.
For example, Melinda's statement that the photos (of what we are
not informed) are intelligible, but not plausible to her, is not
particularly revealing of her conceptual ecology (related ideas)
regarding matter. She stated that she believed molecules move,
but that she also thought molecules were dead, and that these two
ideas were incompatible. Why, however, would she consider this
incongruity intelligible, but not plausible? The authors do not
inform the reader how the students defined each of these terms.

Despite its flaws, this case study suggests direction for
future inquiry in reading education. A study might be designed in

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which articulate students who hold alternative conceptions are followed longitudinally. Students might be interviewed and observed in activity focused on the scientific concepts for which they hold alternative conceptions to examine how their conceptions change. Students might also be asked to think aloud when reading refutational text and to describe their reactions.

A related study examined motivation with 12 students from two sixth-grade science classrooms (Lee, 1991). This inquiry was also conducted within the context of a conceptual change approach, using instructional materials and curriculum developed by the researcher. Students were described as ethnically mixed and representative of high, medium and low achievement levels. Focused observations were conducted of students' task engagement to determine their levels of motivation. Individuals were observed on 10-12 occasions of about 10-20 minutes each. Six patterns of classroom motivation were identified, indicating different goals and levels of task engagement in science activity. These included: 1) intrinsically motivated to learn science, 2) motivated to learn science, 3) intrinsically motivated (but inconsistent), 4) not motivated to learn science -- task completion, and 5) not motivated to learn science -- task avoidance. Findings demonstrated a lack of motivation for various reasons, including inconsistent interest across tasks, determination to avoid mental effort, apathy and indifference to learning science, and disruptive behavior and discipline problems due to negative attitudes. Lee concluded that, "teachers need to

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be aware of the various reasons for students' lack of motivation
to learn so that they can provide assistance for the specific
needs of individual students" (pp. 26-27).

Explanations of how teachers can use this knowledge to
provide individual assistance within a conceptual change approach
has not been offered. The need to identify students' motivation
as an influence in conceptual change has also been seen as
important by other researchers, however. Like Hennessey and Beeth
(1993), White (1993) emphasizes the importance of metacognition
by stating that for conceptual change to occur, students must
recognize their beliefs, consider their worth, and compare them
with the new information. Hence, metacognition is an essential
element of conceptual change. White suggests that in addition to
Flavell's (1976) three aspects of metacognition (knowledge about
thought processes, awareness of one's own use of them, and their
purposeful control) a vital fourth exists - - willingness to
exercise that control. The first three aspects of metacognition
can be taught, and are considered vital to securing the fourth.

Case studies in reading education might follow this directive
by examining the influences of students' metacognitive ability on
their motivation and conceptual change. This focus seems useful
in light of Hewson and Thorley's (1989) advice to note that
changes in students' conceptions cannot be derived from details
of the content of the conception itself, but can only come from
students' comments about the conception - - "dissatisfaction,

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intelligibility, plausibility and fruitfulness all refer to the learner's viewpoint" (p. 550).

A third case study conducted within the context of an intervention was one in which teachers became action researchers. This study was described in several manuscripts (Roth & Bowen, 1993; Roth & Bowen, 1993b; Roth & Bowen, in press). The purpose of the study was to determine how students learn and change their understandings within an open-inquiry setting. The teacher and other adults who interacted with the students used the metaphor of graduate research advisor to describe their role. Adults emphasized engagement in practice by modeling expertise in use, coaching, or scaffolding students' initial attempts in a new skill on a need-to-know basis, and served as advisors in the students' independent projects.

The authors refer to recommendations from reports on science and mathematics education (American Association for the Advancement of Science, 1989; National Council of the Teachers of Mathematics, 1989) to enculturate students into authentic practice. They note that these practices are "fundamentally collaborative in nature" (p. 3), and they cite the benefits of cooperative learning on achievement. As a result, this study was also designed to address questions about "the mediational and interactional processes which lead to the benefits of cooperative learning, the cognitive processes that are evoked by peer collaboration, and the students' beliefs and task conceptualizations in collaborative groups" (p.3).

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Data were collected in a private school with eighth-grade
students (predominantly boys) from middle, upper middle and upper
class families. Students experimented in groups of self-selected
pairs throughout the year; at times pairs were asked to form a
triad with another individual for discussions of their
findings. Data collection focused on a 10 week ecological study
of the campus in which students were to study the interrelations
between abiotic and biotic features in a small plot of land
called an ecozone. Data were gathered from audiotapes and
videotapes, students' field notebooks and laboratory reports,
students' answers to specially designed word problems, and the
researcher's field and reflective notes.

In light of the research on collaborative groups from reading
education, this study is most interesting for its emphasis on and
analysis of language in collaborative dialogue. For example, the
researchers concluded that:

> At the level of the conversation, the above excerpt made
> evident the recurrent contingency who should talk now; the fact
> that someone continues is an outcome coordinately achieved out of
> that contingency (Schegloff, 1982). The students took t ir turns
> at contributing to the emerging construction or relinquished
> their turn to allow another to complete this construction.
> Relinquishing one's turn in the context of another's contribution
> is in itself part of the collaborative achievement" (p. 11).

Roth and Bowen (1993) conclude that as students increased
their familiarity with the setting, their discourses increasingly
included appropriately scientific concepts. Students could test
their emerging constructions through collaborative conversation
and negotiation. The authors stated that, "It is through

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interactions, negotiations of meaning, interactive problem-solving and collaborative constructions that students learn, rather than through hands-on activities per se" (p. 15).

Despite their positive reports of the effects of interactive discussions, the authors did report at least one instance captured in a transcription in which they conceded that arguments and counterarguments were used by students to convince each other of their positions. The "better" or more convincing argument was the one students accepted. The authors dismissed this as a part of the collaborative nature of inquiry. Recent studies in reading education (Marshall, 1992; Hynd, McWhorter, Phares & Suttles, 1991) and instructional design (Snyder, 1993) have shown, however, that students in collaborative groups convince each other of their misconceptions. The dominant individual who has the most persuasive argument tends to "win" the disagreement. Those of us in reading education conducting research in the effects of collaboration on conceptual change would agree that the role of the teacher in such a setting would be crucial to facilitating conceptual change in the direction of the scientific conception. Studies by Alvermann and Hynd (1989) and Guzzetti and Kowalinski (1992) showed that small group discussion was only effective in producing conceptual change when interactive between teacher and students and students and students, focused around a central question or statement, and requiring supportive evidence from text.

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These case studies in science education share a commonality
in focus by emphasizing language. Researchers in reading
education focusing on conceptual change can provide thick
descriptions and analyses of language between students and
teacher and among students when engaged in instructional
activity. In doing so, we should be aware of Tull's (1992)
observation that children's explanations of concepts may appear
naive from the scientific viewpoint, but often the child's
explanation is consistent with the viewpoint of the adult lay
person, and represents a common sense framework. That framework
is influenced by folk language, rather than by scientific
language, which is not surprising since folk language comprises
the majority of terms used in our language. Familiarity with and
use of these folk terms may impede conceptual change when the
folk term is inadequate, imprecise or incorrect in describing a
phenomenon or at variance with the scientific term. Terms
represent concepts, and Tull (1992) reminds us that a concept is
an abstraction or a generalization; communication of those
concepts depends on how well students can construe the construct
system of others.

<u>Interview and Observation Research</u>

Like the case studies, much of the research using interviews
and observations focused on students' constructs and how those
constructs were manifested in the classroom. Linn and Songer
(1992) focused on middle school students' ideas about the nature
of science. These researchers noted that the stance students take

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toward science lends insight into the roles they assume in rationale and critical thinking and provides insight into their reasonings about science. They asked students questions like, "Will the science principles in textbooks always be true? Explain your answer. Can scientists look at the same experiment and reach different conclusions? Explain. To verify their findings, do scientist compare their results to those of others? Explain" (pp. 13-14). Responses indicating that scientific ideas develop were scored as dynamic; those indicating that ideas do not change were scored as static. Linn and Songer found that some students view science as static, as a collection of established ideas to be memorized, while others view science as dynamic, as ideas to be understood. Students with dynamic views were more likely to acquire integrated understandings of scientific ideas.

These researchers posit that students acquire their static views of science from science texts and curriculum, particularly from lectures and science texts that communicate a view of science as established by authority rather than resulting from logical analysis. They cite Reif and Larkin (1991) who note that science textbooks hide the details of scientific discovery, do not communicate that scientists grapple with conflicting observations, and provide a model of scientific behavior incompatible with research science. Tull (1991) agrees, stating that textbooks have placed an emphasis on science as a body of knowledge rather than as a way of thinking, and contain false or misleading concepts. Teachers who use texts may adopt an

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authoritarian lecture mode that discourages debate and
discussion, a mode often adopted in peer discussions when
students take turns asserting opposing views.

Although teachers' practices may influence students' views
of science, researchers have found that teachers' views do not
influence their students' views of science (Lederman & Druger,
1985). Observations of 18 high school biology classrooms were
conducted to compare teachers' and students' conceptions of
science. The data revealed that teachers did not pass on their
conceptions of science to students. Observations revealed,
however, that teachers' conceptions of science do not necessarily
match their instruction.

In designing our studies, Dickie and Kato (1993) ask us to
consider the learning environment, the teacher's style, the
teacher's conceptualization of teaching, the types and effects of
assessment, and the student's approaches to problem solving and
beliefs about learning. These researchers interviewed 13 college
students in honors physics and found that students saw themselves
learning physics by solving problems and by struggling with the
ideas on their own or in collaboration with others, rather than
by merely listening to an exposition of ideas. These self-
reported learning styles are congruent with constructivist theory
that students actively create their own meanings.

<u>Implications</u>

Pursuing questions like the ones raised in these studies from
science education (e.g., the influences of students' views of

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science, their folk language, their interaction patterns in
collaborative groups, and their texts, instruction and
curriculum) may help to identify the influences that affect
students conceptual change. In doing so, researchers in reading
education should heed the call from science education researchers
to conduct studies that include more multicultural samples and
more longitudinal observations of students across grades
(Cummings, Good & Peebles, 1993). Expanding the focus and design
of our studies in these ways offers the potential for developing
effective instruction and for creating texts that are sensitive
to individuals.

References

Alvermann, D.E., & Hynd, C.R. (1989, November). The influence of
discussion and text on the learning of counterintuitive
science concepts. Paper presented at the annual meeting of
the National Reading Conference, Austin, Texas.

Alvermann, D.E., & Hynd, C.R. (1987, December). Overcoming
misconceptions in science: An on-line study of prior
knowledge acquisition. Paper presented at the annual meeting
of the National Reading Conference, St. Petersburg, Florida.

Bloom, J.W. (1992, April). Conceptual change or contextual
flexibility: The myth of restructuring and replacing
conceptions. Paper presented at the annual meeting of the
American Educational Research Association, San Francisco,
CA.

15

Cummins, C.1., Good, R.G., & Peebles, P. (1993). <u>Biological</u>
<u>subject matter knowledge: The extent to which students</u>
<u>incorporate the theory of evolution into the evaluation of</u>
<u>evidence</u>. Paper presented at the annual meeting of the
American Educational Research Association, Atlanta, Georgia.

Dickie, L.O., & Kato, C.K. (1993, April). <u>Student beliefs about</u>
<u>the learning task in physics</u>. Paper presented at the annual
meeting of the American Educational Research Association,
Atlanta, Georgia.

Flavell, J.H. (1976). Metacognitive aspects of problem solving.
In L.B. Resnick (Ed.), The nature of intelligence.
Hillsdale, New Jersey: Erlbaum.

Guzzetti, B.J. (1990). Effects of textual and instructional
manipulations on concept acquisition. <u>Reading Psychology</u>,
<u>11</u>, 49-62.

Guzzetti, B.J., & Kowalinski, B.J. (1992, April). <u>Using text-</u>
<u>based discussion to promote conceptual change in science</u>.
Paper presented at the annual meeting of the American
Educational Research Association, Atlanta, Georgia.

Guzzetti, B.J., Snyder, T.E., & Gamas, W.S. (1993). Promoting
conceptual change in science: A comparative meta-analysis of
instructional interventions from reading education and
science education. <u>Reading Research Quarterly</u>, <u>28</u>, 117-159.

Hennessey, M.G., & Beeth, M.E. (1993, April). <u>Students'</u>
<u>reflective thoughts about science content: A relationship to</u>
<u>conceptual change learning</u>. Paper presented at the annual

16

meeting of the American Educational Research Association, Atlanta, Georgia.

Hewson, P.W., & Thorley, N.R. (1989). The conditions of conceptual change in the classroom. _International Journal of Science Education, 11_, 541-553.

Hynd, C.R., McWhorter, Y., Phares, G., & Suttles, B. (1991). _The role of cognitive, affective, and instructional variables in conceptual change_. Paper presented at the annual meeting of the National Reading Conference, Palm Springs, California.

Lee, O. (1991, April). _Motivation to learn subject matter content: The case of science_. Paper presented at the annual meeting of the American Educational Research Association, Chicago, Il.

Linn, M.C., & Songer, N.B. (1992, January). _How do students make sense of science?_ unpublished manuscript. Berkeley, CA: University of California.

Marshall, N. (1992, December). _A case study of conceptual change in preservice elementary teachers_. Paper presented at the annual meeting of the National Reading Conference, San Antonio, Texas.

Pintrich, P.R., Marx, R.W., & Boyle, R. (In press). Conceptual change and student motivation in the classroom context. In A. Pace (Ed.). _Beyond prior knowledge: Issues in text processing and conceptual change_. Ablex.

17

Reif, F., & Larkin, J.H. (1991). Cognition in scientific and everyday domains: Comparison and learning implications. _Journal of Research in Science Teaching_, _28_, 733-760.

Roth, W.M., & Bowen, G.M. (1993b). An investigation of problem framing and solving in a grade eight open-inquiry science program. Unpublished manuscript. Burnaby, BC, Canada: Simon Frazer University.

Roth, W.M., & Bowen, G.M. (in press). Mathematization of experience in a grade eight open-inquiry environment: An introduction to the representational practices of science. _Journal of Research in Science Teaching_.

Roth, W.M., & Bowen, G. M. (1993). _Knowing and interacting: A study of culture, practices, and resources in a grade eight open-inquiry science classroom guided by a cognitive apprenticeship metaphor_. Unpublished manuscript, Burnaby, BC, Canada: Simon FrasGr University.

Snyder, T. (1993). _The effects of cooperative and individual learning on student misconceptions in science_. Unpublished doctoral dissertation, Arizona State University, Tempe, Arizona.

Stake, R.E., & Easley, J.A. (1978). _Final Report: Case studies in science education_. National Science Foundation Contract No. C7621134. Urbana, Il.: School of Education, University of Illinois.

18

Strike, K.A., & Posner, G.J. (1992). A revisionist theory of
        conceptual change. In R.A. Duschl & R.J. Hamilton (Eds.).
        Philosophy of science, cognitive psychology and educational
        theory and practice. Albany, NY: University of New York
        Press, 147-176.

Tull, D. (1991, April). Elementary textbooks versus the child:
        Conflicting perceptions of biology. Paper presented at the
        annual meeting of the National Association for Research in
        Science Teaching, Lake Geneva, Wisconsin.

Tull, D. (1992, April). Social constuctivism: Botanical
        classification schemes of elementary school children. Paper
        presented at the annual meeting of the American Educational
        Research Association, San Francisco, CA.

White, R.T., (1993, April). Insights on conceptual change derived
        from extensive attempts to promote metacognition. Paper
        presented at the annual meeting of the American Educational
        Research Association, Atlanta, Georgia.