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TEACHER AND STUDENT ACTIONS TO CONSTRUCT BIOLOGY LITERACY
AT A COMMUNITY COLLEGE: A BOUNDED CASE STUDY

by

Patricia Griesel

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A Dissertation Submitted to the Faculty of the
DEPARTMENT OF LANGUAGE, READING, AND CULTURE
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2000
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STATEMENT BY AUTHOR

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SIGNED: Patricia Grice
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ABSTRACT

Science content area literacy, particularly literacy development in college level biology, is the focus of this study. The study investigates the actions and activities of an instructor and six students over the course of 16 weeks. The study is in response to interest in the literate practices in science classes (NSES, 1996) and to the call for contextual studies that facilitate the learning of science (Borasi & Siegel, 1999; Moje, 1996; Nist & Holschuh, 1996; Prentiss, 1998). A collaborative study between the biology teacher and the researcher, this study investigates the practices believed to be effective for the development of biology literacy. Data sources, in the qualitative bounded case study (Bogdin & Biklin, 1982; Glaser & Strauss, 1967; Miles & Huberman, 1994), include: field notes of classroom observations, in-depth interviews (Seidman, 1992), class surveys, and literate artifacts. The data were coded and analyzed using a constant comparative method (Glaser & Strauss, 1967).

The six students reveal similarities and differences regarding the actions, patterns, practices and use of materials and their beliefs about effective practice in the development of biology literacy. The results indicate that a variety of actions and activities are needed to facilitate the development of biology literacy.

The common themes to develop from the students' data about effective teacher actions are the following: (a) involves and engages students in inquiry learning through group projects, hands-on, and group discussions; (b) relates examples, experiences, and stories; (c) exhibits expertise, (d) encourages a relaxed classroom atmosphere; (e) facilitates and coaches students; and (f) credits creativity. Further, students report their
teacher to be an expert, in terms of science knowledge and literate practices, and that her
dextrise contributes to their understanding of biology literacy. The teachers' data reveals
three themes embedded in her classroom actions: science as a language, science as a
social activity, and science as an experiential activity. The researcher's role in the study
suggests that other researchers may benefit from a similar collaborative effort where the
teacher and researcher learn from each other and from their students while supporting
content literacy development. Content literacy practice from a constructivist paradigm
(Anders & Guzzetti, 1996; Staver, 1998) has merit beyond high school and powerful
implications for practice at the college level.
CHAPTER 1

A COMPLEX PROBLEM: CHANGING TIMES, CHANGING NEEDS, AND
CHANGING UNDERSTANDINGS OF LITERACY

At present, the majority of undergraduate introductory science content courses are dominated by fact-driven instructional models that assume that students passively receive information imparted through lectures and assigned textbook readings. (Stofflett, 1998, p. 1)

The quotation above reflects a condition that many national science educators want to change. Indeed, the educators who favor change have been involved in the development of the Benchmarks for Science Literacy (1993) and the National Science Education Standards (NSES) (1996). The need for change is due largely to the complexity of changing needs in a rapidly changing world. Fact-driven instructional models are considered especially unsatisfactory for students who may take only one science course in their college career (Stofflett, 1998). Learning facts is important, but there is much more at stake in our changing world: "In a world filled with the products of scientific inquiry, scientific literacy has become a necessity for everyone" (NSES, p. i).

The terms "science literacy" and "scientific literacy" are used interchangeably in science education literature. The authors of the National Science Education Standards (1996) provide an expansive and working definition of scientific literacy. They claim that the content standards define scientific literacy as "... the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity" (p. 22). Science literacy is expressed in content areas such as biology. The term literacy implies more
than just reading. For the purposes of this study, I use expanded notions of literacy and what it means to be literate. Within the field of literacy, some content area literacy specialists (Anders & Guzzetti, 1996; Gould, 1995) define content area literacy beyond the older traditional view of literacy which involved "a set of skills for deciphering written text" (Anders & Guzzetti, 1996, p. 2) by including such notions as:

- the use of different texts for different purposes
- text-supported thinking and doing through critical and reflective thought, or "literate thinking"
- the recognition of the similarity between reading and writing and other modes of symbolic communication, e.g., computer, television
- recognition of the collaborative nature of literacy (Anders & Guzzetti, 1996, pp. 2-3)
- the recognition that being literate is personal and situational (p. 20)
- the understanding that the communication processes of reading, writing, listening, and speaking are tools learners use to "negotiate the meaning" of their world (p. 54)
- the recognition that students need to be actively involved in reading to learn, writing to learn, discussing to learn, listening to learn, and questioning to learn
- the understanding that literacy develops in response to both social and individual needs and that it is an extension of speaking, listening, questioning, writing, reading, and interacting with one's environment
• the recognition that literacy "... is functional, real, and relevant, and involves an active constructing and interpreting of ongoing and changeable texts, not an absorption of rules and models." (Gould, 1995, p. 101)

The purpose of this chapter is the following: (a) to discuss some of the complexities of the perceived need for change in college classrooms, (b) to describe the purpose of the study, (c) to present the questions investigated in this study, (d) to reveal the importance of the study, (e) to provide an overview of the methodology, and (f) to report the potential contributions of this study to practice.

Complexities

Some teachers choose to continue in a fact-driven lecture mode, but a small and growing number of college biology teachers are coming to believe that biology instruction is dynamic (Mintzes, Wandersee, & Novak, 1998). Several strong influences are affecting these educators' understandings about the dynamics of biology instruction. Among the more outstanding influences are the following: (a) an awareness of current research about teaching and learning, (b) knowledge about the changes in the student classroom population, (c) an ever-expanding readily available knowledge base about scientific developments and classroom ideas for teaching them, and (d) the National Science Education Standards put forth by concerned scientists and science educators. Instead of lecturing, these teachers are striving to increase their understandings of multiple ways to approach biology instruction (Mintzes, Wandersee, & Novak, 1997).
More and more, teachers are challenging students with inquiry-based and research-oriented course work (Ebert-May, 1998; Kincaid & Johnson, 1998).

Another influence is the teachers' growing awareness and understanding of the wide range of student experiences and backgrounds present in today's classroom (AACC, 1996). Some students enter the college classroom from a "reformed" science curriculum, others from traditional curricula, others from non-traditional curricula such as home schooling or Charter Schools, and others return after years away from school. These students bring with them various literacy experiences and prior knowledge that varies qualitatively and quantitatively (Maxwell, 1994; Mintzes, Wandersee, & Novak, 1997). The experiences may or may not coincide with assumptions made by the teacher and by the students themselves. For example, teachers may assume students have the necessary abilities to tackle a difficult content course, and that they have some high school experience and background knowledge related to science. Similarly, many students begin a course with high expectations of competence and confidence. Unfortunately, reality sets in for both the teacher and for the students when they lack the needed knowledge and/or competencies. Teachers often become frustrated when students fail to comprehend readings or fail to understand lectures of the science content being taught. Students become frustrated when they are unable to develop understandings of the concepts being taught, or they are unable to meet the reading demands of college (Chase, Gibson, & Carson, 1994). Historically, the well-prepared students pass the tests, the partially prepared sometimes surprise themselves, and the ill prepared are forced to leave
college (Tinto, 1987; Traub, 1994). Even so, despite an awareness of student diversity, some instructors still may not modify their classroom practices. But, there is more.

The massive amount of new information and research in biology is another influence for change. It is overwhelming to experts and novices alike. Though new textbooks are considered by some to be 90% factually and technically correct (Bauer, 1992), students often fail to read and understand the complex and detailed language (Maxwell, 1994). In addition, new technological developments and the integration of new information into course materials provide added changes and challenges as colleges try to stay current with continual reports of new scientific advancements (Bauer, 1992; Stofflelt, 1998; Tobin & Tippins, 1993).

Probably the most powerful influence for change comes from the National Science Education Standards (1994) and the national goal for all students to achieve scientific literacy. The Standards have been established for kindergarten through twelfth grade (K-12) schools to promote lifelong learning in science and the continual development of science literacy among students and the public. In a lengthy explanation, the authors included specific types of abilities expected of students, including the ability to formulate questions, to find solutions, and to satisfy their own curiosity about questions from everyday events. The Standards also imply expectations for students to develop their descriptive and predictive abilities and their ability to read and communicate in science in varied situations. The rationale behind the Standards is the perceived need for a national workforce in a global economy that is able to demonstrate advanced skills in reasoning, learning, thinking creatively, making decisions, and solving
problems (National Science Education Standards, 1995). Though the Standards are aimed for the most part toward the K-12 schools, they are also aimed at colleges. With the Standards come specific directions and expectations for science teachers and for science teacher preparation (NSES, 1998).

These influences, changes, understandings, and perceived needs call for a serious inquiry of what it means to develop literacy in a biology classroom at the community college level.

Purpose of the Study

The purpose of this study was to investigate scientific literacy as expressed by a curriculum and pedagogy designed to accommodate the new science literacy goal. The theoretical perspective of this study is constructivist, as interpreted by content area literacy researchers Anders and Guzzetti (1996) and science educator Staver (1998). The constructivist classroom setting was coincidental as the study focus was on content literacy development in a science classroom.

Though abundant and sometimes controversial definitions grace the literature, Fosnot (1995) provides an introductory definition of constructivism for this study:

...a theory about knowledge and learning: it describes both what "knowing" is and how one "comes to know." Based on work in psychology, philosophy, and anthropology, the theory describes knowledge as temporary, developmental, nonobjective, internally constructed, and socially and culturally mediated. (p. ix)

Anders and Guzzetti (1996) wrote of a constructivist approach, of content literacy development classroom practice and research. Such an approach implies applications of ideas and strategies that can be adapted to fit the diverse student population present in
community college classrooms. Staver (1998), a science educator, argues that constructivism provides a sound theory to explain the practice of science and science teaching. His arguments are discussed in the literature review.

Constructivism, content literacy, and science education are linked through practical application. For example, a constructivist classroom in biology might include all or some of the following practices: problem solving, hands-on investigation of student initiated inquiry, active involvement through discussion, readings, computer searches, formulation of hypotheses and alternate hypotheses, written and oral presentations, small group activities and projects, and alternate forms of assessment and evaluation (Crowther, 1997). These practices correspond to an expanded notion of literacy as promoted by content literacy specialists (e.g., Alvermann, Hinchman, Moore, Phelps, & Waff, 1998; Anders & Guzzetti, 1996). The implications of the theoretical perspective are discussed in the literature review.

Specifically, the purpose of this study was to investigate the use and development of content literacy practices by students and a teacher in a community college entry level biology course for non-biology majors. The research questions were developed to advance the purpose of the study.

Research Questions

The following questions for this inquiry relate to the teacher and to the students:

1. Questions about the teacher:
   
   (a) What actions does a teacher take to communicate biology literacy to students?
(b) What patterns and combinations of teacher actions and use of materials does the teacher believe are effective for the development of biology literacy? Why?

2. Questions about the students:
   
   (a) What actions do students take to learn biology literacy?

   (b) What patterns and combinations of student actions and use of materials do students believe are effective for the development of biology literacy? Why?

Importance of the Study

My personal experiences and curiosity prompted me to conduct this study. I discuss these experiences and examples of other research also calling for the need to study content literacy development in an instructional context in this section.

The development of this study is a response to interest expressed by a university teacher in another science content course, a basic geology course at the university level, and my own developing notion that content literacy practices, as presented by Anders and Guzzetti (1996), can contribute to effective literacy development in a content area and make a difference in student understanding. The initial exploratory study involved a collaboration of the geology teacher and me. In the context of several informal chats in the teacher's office we shared information. My role was to provide three workable active learning (Bonwell & Eison, 1991) strategies for a large lecture situation in Geosciences 101 while contributing to my own and the teacher's knowledge base on teaching and learning in a content area such as Geosciences 101. (The underlying premise for the
initial study was my notion of active learning in the form of constructivism in a content area. This will be discussed in chapter 2.) The teacher's role was to refine the suggested active learning strategies to meet the teacher's goals and department requirements.

Our discussions and questions covered a wide range of ideas: philosophy of teaching and learning, what seems to work and what doesn't, the course content, the syllabus, the text, the tests, the quizzes, the linked activities such as field trips and related student organizations, etc. These discussions and the literature searches conducted for current research-based practices contributed greatly to my understanding of teaching and learning. The questions, discussions, and experiences with the three experimental active learning strategies and the students' evaluations of them left me with more questions. Through my extensive reading and experiences, I began to see a need to investigate scientific literacy development in a contextual setting of an actual classroom.

In addition, recent research indicates a need for further study in the classroom context by researchers themselves. For example, researchers study areas related to content literacy, including teacher action, teacher change and how teachers contribute to students' learning in a content area (Alvermann, Hinchman et al., 1998; Barr, 1986; Anders & Guzzetti, 1996; Bandura, 1997; Dornan, Rosen, & Wilson, 1997; Lapp, Flood, & Farnan, 1996; Richardson, 1994) and argue for the need to study the context of the classroom. In addition, much of the existing research focuses on K-12 schools (e.g., Driver, 1995; Schauble, Glaser, Duschl, Schulze, & John, 1995; Shapiro, 1994; Steffee & Gale, 1995).
Few studies at the community college level or the university level have investigated how scientific literacy develops. Some studies have evaluated the teacher or strategies (Stofflett, 1998), or student performance using innovative methods (Mintzes, Wandersee, & Novak, 1997), but few have examined students' behavior or cognition except in the area of developmental reading (e.g., Gebelt, Parilis, & Kramer, 1996). One exception was a study conducted by Nist and Holschuh (1996). They investigated the study behaviors of students who improved their test scores by two grades or better in a freshman biology course. Nist and Holschuh (1996) wanted to understand the change in the students' improved test scores. On the basis of a short telephone interview with five students, the researchers concluded that the students with improved performance had not increased their study time; rather they had learned to become more actively involved in their reading and learning. They concluded that research is needed to describe instruction and that curriculum is needed that encourages students to be more active. Their finding was supported by Mintzes, Wandersee, and Novak (1997) who concluded that "the principal difference between successful and unsuccessful students is the extent to which they 'take charge' of their own learning" (p. 438).

This study addressed the need for research about literacy practices in actual content classrooms as called for by researchers interested in content literacy development. More specifically, the research investigated the use and development of content literacy practices by the students and a teacher over a 16-week course to find out what actions, patterns and combinations of actions and use of materials they believed effective.
Methodology

Permission to study the instructional and literacy practices of a science teacher in a small branch of a southwestern community college biology class was obtained from the teacher and from the teacher's community college research department. The fact that the teacher professed a constructivist paradigm was an unexpected bonus. The biology class targeted for study was a four-credit course that met twice a week over a 16-week period. The biology course involved fundamentals of ecology and environmental biology and the relevance of those fundamentals to human impact on natural ecosystems. The course included studies of various local and global ecosystems and the processes that help to maintain them and the biodiversity within them. Officially limited to 24 students, the class began with 30 students and ended with 27. Informed consent forms were signed by the teacher and members of the class at the beginning of the semester. The participants (teacher and students) agreed to take part in the study which included surveys, observations, and audiotaped interviews. As a member check, each audiotaped interview was transcribed and a drafted copy given to the participant for verification and correction. In addition, the teacher involved in the study read and approved the finished dissertation.

The design of the study was a bounded case study in which the researcher was a participant observer (Bogdan & Biklin, 1992; Merriam, 1988). The teacher and six purposefully selected students were the members of the case.

A qualitative research process (Seidman, 1991) approach was used to discover the events, actions, text, and literacy artifacts of the students and teacher. Primary data sources included the following: field notes of classroom observations and transcribed
audio tapes of in-depth interviews with the six purposefully selected students and the
teacher, memos of casual conversations, selected artifacts and student surveys.

Analysis was an ongoing process that considered relationships, outstanding
characteristics, meanings, and explanations as recommended by Glesne and Peshkin
(1992). Analysis of the data sources were coded and analyzed using a constant
comparative approach (Miles & Huberman, 1994). Emergent themes and patterns were
related to a conceptual and structural framework in the initial stage of analysis and later
refined as the data became more familiar.

Potential Contributions

This study is likely to make contributions to both theory and practice. The
findings may inform constructivist theories on teaching and learning and also
perspectives about teacher beliefs and their relationship to teaching. The practical
contribution may be a better understanding of college learners and how they contribute to
an elaborated definition of scientific literacy and biology literacy. In other words, what
we learn from these students and the teacher about effective communication of biology
content literacy and the development of that content literacy may link the theory of
constructivism and biology literacy as a way to inform practice.

Chapter 2 presents a review of literature related to science literacy from the
theoretical perspective of constructivism (Anders & Guzzetti, 1996; Staver, 1998). The
review includes a discussion on two competing major paradigms (transmission model and
the constructivist model), a historical background of the controversy surrounding
constructivism in the field of science and in the field of content literacy, constructivism
as it is defined by the National Standards, and constructivist content area literacy practices.
CHAPTER 2
REVIEW OF THE LITERATURE:
CONSTRUCTIVISM IN SCIENCE EDUCATION

The study of science as an intellectual and social endeavor—the application of human intelligence to figuring out how the world works—should have a prominent place in any curriculum that has science literacy as one of its aims. (Rutherford et al., 1993)

The purpose of this chapter is to present a review of the literature related to constructivism and content literacy development as it pertains to science. The theoretical themes will be limited to two major paradigms: the transmission model and the constructivist model as described by Anders and Guzzetti (1996) and Staver (1998). The order of presentation is as follows: (a) a brief historical background of parallel paradigms; (b) a discussion about the major competing paradigm to constructivism in both the science field and in the field of content area literacy; (c) a brief overview of constructivism including historical relationships, some of the definitions, and the controversy surrounding constructivism; (d) constructivism as it is broadly defined by the National Science Standards; and (e) content area literacy practices and constructivism.

A History of Parallel Paradigms

Kuhn (1996) described a paradigm as "intrinsically circular. A paradigm is what the members of a scientific community share, and, conversely, a scientific community consists of men who share a paradigm" (p. 176). As members of a community, they have in common "shared goals, including the training of their successors" (p. 177). A paradigm in the scientific community is a model or example. Misunderstanding and
disagreement occur when scientific communities focus on different matters (Kuhn, 1996). As a result, communication breaks down and fringe groups develop alternate paradigms. Such is the case with two parallel paradigms or teaching models: the transmission model and the constructivist model. The fact-driven transmission model of teaching/learning in science and content literacy traces many of its characteristics to behaviorism in the field of psychology (Lambert & McCombs, 1998; Miller, 1993). In the field of education and in "reading in the content areas," as content literacy was referred to previously, the behaviorist influence resulted in drills and skills for classroom curriculum (Anders & Guzzetti, 1996). In science education especially, the influence of behavioral psychology was felt during the 1960s and 1970s when attempts to publish competing views "were virtually shut out from the academy" (Mintzes, Wandersee, & Novak, 1998, p. 9). Mintzes et al., (1998) reported a "battle of educational paradigms" where writers of cognitive learning ideas and alternate paradigms of teaching and learning were ignored and silenced by the many "who failed to see the limiting psychological and epistemological foundations of behavioral objectives" (pp. 9-10). The behaviorist influences had a detrimental effect for those who held alternative views. The authors reported being virtually alone, with a few exceptions, in their criticisms of a narrow and rigid view of Piaget's ideas and as a result were prevented, for a time, from receiving National Science Foundation grants and from publishing their objections. A shift began to take place during the 1970s for both paradigms. The shift in paradigms for science has been attributed to the launch of Sputnik in October of 1957 (Mintzes, Wandersee, & Novak, 1997). The Russian accomplishment
was seen as a threat to national security and an embarrassment to a country that took pride in scientific advances. Mintzes et al. (1997) reported that blame was placed on an insufficient science curriculum in the nation's schools. Money began to flow from Washington to support improved curricular materials. At first the classroom practice and newly designed curricular materials were still heavily influenced by behavior modification from Skinner's theory of operant conditioning. A gradual paradigm shift from the transmission model occurred as science educators and content literacy educators considered alternative models and ideas, in particular, constructivism.

**The Transmission Model**

The major competing paradigm to constructivism in science and in content area literacy is the transmission or information transfer model of teaching and learning (Anders & Guzzetti, 1996; Mintzes, Wandersee, & Novak, 1998). In science, the transmission model is often characterized by a traditional lecture format where the teacher is the transmitter of knowledge and the students are the receptors. The teacher is the authority who delivers the content and the students are the receivers and future transmitters of the valued knowledge. Friere (1970) metaphorically described the model as the "banking concept of education" (p. 53). The students are viewed as inactive receivers and depositories for the gift of knowledge deemed valuable by the knowledgeable. In this model, students are expected to "patiently receive, memorize, and repeat" (p. 53). Friere (1970) listed teacher and student attitudes and practices characteristic of the banking model. The teacher teaches, knows everything, thinks, talks, disciplines, chooses, enforces the choice, acts, chooses the content, and is the subject of
the learning process. The students are taught, know nothing, listen, adapt and comply with program content, have little freedom, "have the illusion of acting" and are considered "mere objects" (p. 54).

In content literacy, the transmission model or the information transfer model can be illustrated by the skills model of reading. The skills model of reading is often characterized with skills, drills, and workbooks following a scope and sequence of progressively more difficult material. For example, the teacher might have students read out loud to make sure they get the correct pronunciation. The students progress step by step with decoding skills, grammar skills, main ideas, and more complex skills (Anders & Guzzetti, 1996). Anders and Guzzetti (1996) reported that the model has appeal because "it is simple, it can be taught, and the extent to which a reader has mastered the skill can be measured by multiple choice items on a standardized or criterion referenced tests" (p. 42). However, content teachers "often rejected the role of teaching reading and responded that students need to have acquired those skills before entering content areas" (p. 43). In addition, the reader is isolated from the text in that "... it is the reader's responsibility to 'get the meaning' from the text" (p. 43). The teacher and text are viewed as the authorities and the learner is required to learn from them.

Sund and Trowbridge (1973) offered an explanation for the continuation of the transmission model in science. Prospective teachers of science have had instruction that "emphasized the products rather than the process of scientific research" (p. 15). Instead of developing an understanding of science, the prospective teachers have had to learn science words, memorize material, and produce results. "Teachers falsely assumed that
learning the products of science will enable them to use the processes of science" (p. 15).


In college science, the transmission model implies the teacher as expert and the students as passive receivers of knowledge. The well-organized presentation of "facts, rules, and definitions" is the most common way to transmit the information (Anderson, 1987, p. 76). Likewise, in the transmission model of content literacy, the teacher transmits strategies, reading techniques, and skills to help students learn content material. In the transmission model, or the information transfer model as it is sometimes referred to, the teacher mainly lectures.

Problem with the Transmission Model

In the history of higher education, many faculty members choose the transmission model based solely on the premise of tradition (Bonwell & Eison, 1991). Therefore, it is not uncommon for a professor to repeat the same series of lectures year after year without the consideration of students and how they learn. These professors often assume that the failing students are inadequately prepared in reading and writing. They feel the inadequacies can be addressed by teaching reading and writing in their English classes (Boyer, 1987). Certainly, there are arguments for continuing in the lecture-examination
format for college courses and many students do, after all, construct knowledge and learn in a lecture format.

Some of the arguments for the continuance of the lecture method has been the belief that (a) more content material could be covered over a period of limited time, b) other types of learning modalities take too much time with questionable results, (c) large lecture classes with many students prevent the use of alternatives, and (d) resources of additional materials required for innovative practice are not easily accessible and can be costly (Bonwell & Eison, 1991). Bonwell and Eison (1991) reported that the greatest argument and barrier to change from the traditional lecture method has been the instructor risk factor. The perceived risk may have to do with the instructors' own personal experiences at innovation or lack of support. Instructors are often unwilling to let go of the control and fear that students will not willingly participate or students will not learn as much content. In addition, many students expect a passive environment in many of their classes.

The lecture method has long been considered the benchmark of performance in college teaching (Bonwell & Eison, 1991). In reviewing past literature, Bonwell and Eison (1991) raised important conceptual issues and questioned why the lecture method is considered the benchmark performance when research has clearly demonstrated that the more college students become involved with the educational process, the more they learn (p. xvii). Despite reported research to the contrary "... most faculty continue to use one of the most student passive forms of teaching: the lecture" (p. xvii). The most frequently reported reason for their preference "... is that they are comfortable with it"
They also questioned the measurement of student achievement based only on examinations of factual information given in lecture or through required readings rather than on questions involving such skills in solving problems, writing, or communication. More importantly, missing from the lecture-examination equation are complex variables. They wrote, "When lecture classes are compared to active learning classes and statistical analyses are performed on group means, the powerful impact of such important characteristics of students as academic ability and preferred learning styles is overlooked" (Bonwell & Eison, 1991, p. 77).

Bonwell and Eison (1991) also reported that much of the research on the lecture method is outdated in view of the "significant changes in the characteristics of today's undergraduates compared to those who attended college 20 to 30 years ago" (pp. 76-77). There has been a decline in freshmen students' entry level skills. "Thirty to forty percent lack basic competency in computation, reading, and writing. These differences alone will have a powerful effect on students' responses to teaching methods" (p. 77). The noted differences demand attention. Boyer (1987) called for educators to confront academic deficiencies of entering freshmen. "Failure to do so will leave them shockingly unprepared to do college-level work. This is unfair to both faculty and students" (Boyer, 1987, p. 77). Due to these and other similar issues, Bonwell and Eison (1991) suggested that an expanded research agenda that includes study of alternatives to the traditional transmission lecture, the variable conditions present in today's college classes, and the reasons for the reluctance on the part of the instructor to change.
The problems with the transmission model relate to the characteristics of the people involved, i.e., the instructor and the students, how people learn and construct knowledge or fail to develop accepted scientific principles (Guzzetti & Hynd, 1998), their beliefs and attitudes about teaching and learning, and the conditions or context of the learning. The simplicity of a lecture-examination format also failed to consider these other factors.

Taking these problems into consideration, more educators are understanding that learning is a much more complex process. Learning what scientists think and learning what scientists do are important in science education (Guzzetti & Hynd, 1998). And, the lecture format often provided a way to present expert knowledge and placed the transmission of ideas and knowledge over the process. The notion that understanding is a creative process (Guzzetti & Hynd, 1998) was largely ignored. The ideas behind the constructivists' model expand and counter the limitation of instructors telling students what scientists know and do. The alternative paradigm attempts to understand and address the complexities of what actually occurs in a teaching/learning situation by having students thinking and doing as scientists. The constructivists' views provide an alternative paradigm to incorporate the complexities of what actually occurs in a teaching/learning situation.

Overview of Constructivism

Historical Perspectives in General

Constructivism has some interesting bedfellows which might help explain its easy access and adaptations to a number of fields including family therapy, education,
psychology, mathematics, and science (Lambert & McCombs, 1998; Steffe & Gale, 1995). Crowther (1997) traced the ideas of constructivism to Socrates, Plato, and Aristotle (470-320 B.C.) who wrote and spoke of the formation of knowledge. Crowther (1997) also mentioned St. Augustine (mid 300s A.D.) who reasoned that "the search for truth . . . must depend on sensory experience" and John Locke (17th and 18th centuries) claimed that "no man's knowledge can go beyond his experience" (p. 3). In addition, Crowther (1997) cited Henrich Pestalozzi (1746-1827) from Switzerland. Pestalozzi's ideas are similar to constructivist ideas: he advocated a natural approach to learning through the child's senses, he emphasized connecting the children's experiences with home and family, he abhorred mindless memorization (Crowther, 1997). Duit (1994) traced the roots of contructivism to ideas in philosophy, educational practice, and to empirical research on students' conceptions of science prior to instruction. He wrote that some of the ideas were expressed over 150 years ago by German educator Diesterweg (1790-1866) in the Guide to Education for German Teachers. This has been more recently supported by Ausubel (1968) who stressed the importance of assessing what the student knows prior to instruction.

In the United States, Lambert and McCombs (1998) wrote of learner-centered and constructivist approaches to learning. They traced the constructivist perspective to Piaget (1896-1990), who is sometimes referred to as the father of constructivism. Lambert and McCombs (1998) also credited John Dewey (1859-1952) and Jerome Bruner (1915-) with constructivist ideas. Table 2.1 lists four main contributors traditionally associated with constructivists' views and some of the synthesized ideas shared in constructivism.
Table 2.1 Contributors and Contributions to Ideas in Constructivism

|-------------------------|-------------------------|---------------|------------------------|

**Note:** Ideas contributed to constructivism though he did not use the term.

1. Students learn and make sense of new knowledge based on individual and collective experience.

2. Emphasized the social construction of learning.

3. Education should allow students to experience life and that experience is a key feature of learning.

4. Central to education was the development of the self into a "self-directing, inquiring, and reasoning human being" (p. 19).

5. Believed teachers should make the decisions about curriculum, instruction, and assessment of student progress.

6. Early notions of shared decision making and schools as communities of learners and leaders contributed to current growth of constructivism.

**Note:** Here, the focus is on the work done the last 10 - 15 years prior to his death. Constructivism is seen as basic to Piagetian theory.

1. Individuals of whatever age acquire understandings of the world about them through an analysis of their own actions upon the world, not by passive 'growth,' or by imitation or by memorization although these factors make contributions (Piaget, 1970).

2. He viewed knowledge-construction as a process that involves self-regulation. He saw the importance of active involvement, interpretation of current knowledge, transformation by an internal process, and resolution of contradictions and computabilities (equilibration). He stressed the importance of opportunities and challenges in the environment.

3. Piaget's ideas on cognition and child development contributed much to Bruner's ideas.

**Note:** More recently, Bruner seemed to draw on Cognitive structure (i.e., schema, mental models) as a base for his constructivist theory of instruction.

1. Emphasized the learner as constructor of knowledge and the role of prior experience in enriching the learning experience.

2. Refuted Piaget's stage theory by claiming that maturation alone could not account for cognitive growth and schemas. Other factors such as development and complexity of language in use and prior experiences also contributed.

3. Bruner wrote that making sense is a social process. As an activity, it takes place within a cultural and historical context.

4. Learning is an active process involving: prior and current knowledge, selection and transformation of information, construction of hypotheses, decision making while relying on cognitive structure.

5. Introduced Vygotsky to educational thinkers in America.

1. The strengths of Vygotsky's contribution to constructivism lies in his attention to the social-cultural context of development and the integration of everyday learning and development.

2. Insists on an active construction of knowledge and focuses on speaking and thinking.

3. Emphasized the culturally mediated nature of thinking particularly through psychological tools (i.e., related to language, various systems for counting; mnemonic techniques; algebraic symbol systems; works of art; writing; schemes, diagrams, maps, and mechanical drawings; all sorts of conventional signs) provided by the culture.

4. The incorporation of tools or new artifacts into actions transforms mental function in fundamental ways.

5. The Zone of Proximal Development contributes as a social-political context for an interactive learning process in which knowing is mediated and negotiated.
The four listed contributors are John Dewey, Jean Piaget, Jerome Bruner, and Lev Vygotsky. John Dewey emphasized educative experiences, social construction of learning, thought processes, the development of community, and shared decision making. Piaget's later-held views reflected an emphasis on the importance of active involvement, of opportunities and challenges, and analysis of actions. Bruner emphasized the learner as the constructor of knowledge, prior experiences, social processes, and the development and complexity of language. Another contributor mentioned in the literature is Lev Vygotsky (1896-1934) who is explicitly tied to Marxist political-social-economic theory. He is revered by some because he brought in the social aspect of learning; and, he used spatial metaphors such as the "zone of proximal development," i.e., the distance between actual and potential development where learning is reported to take place; and "scaffolding" a supporting structure to hang ideas and concepts on; and tools, these are sometimes expressed at a concrete level and sometimes at an abstract level (Miller, 1993; Vygotsky, 1978). Signs and symbols are viewed as psychological tools, are social in origin, and are used for social purposes. The signs and symbols are seen as mediators for sociocultural participation. The strength of Vygotskian theory is due to the emphasis on the importance of the sociocultural context in which learning takes place (Vygotsky, 1978).

Historical Perspectives of Constructivism in Science

The types, explanations, and brands of constructivism abound in the literature (Phillips, 1995; Staver, 1998; Steffe & Gale, 1995; von Glasersfeld, 1995). Steffe and Gale (1995) reported that the reason behind the literature explosion on the subject "was
the belief that traditional Cartesian epistemology continues to misguide education despite available alternatives" (p. xii). According to the Cartesian view, knowledge must mirror reality. However, since there are alternatives, "... it no longer makes sense to talk of knowledge of an absolute reality" (p. xii). Steffe and Gale (1995) wrote, "Knowledge is regarded as being constructed by the individual, such that the individual creates meaning of the world, rather than discovers meaning from the world" (p. xii).

Duit (1995) claimed that it was no accident to have constructivism as a leading idea in science education research. He traced its compatibility with "main lines of contemporary thought that take counter positions to traditional empiricist and positivist ones" (p. 274). "Joining the constructivist party" indicated that a person preferred the "mainstream of alternative (vs. traditional) thought" (p. 274). Yet, these same proponents also have strong objections to constructivism. For example, Duit (1995) cited Strike's arguments against contemporary constructivism in science. Strike (1987) compared it to the word "democracy" and claimed that it served to unify people even though they might not agree on what it means. Duit (1995) agreed with Strike (1987) in that science educators often adopt constructivism in a superficial way. Alternatively, Duit (1995) argued "democracy is a very powerful and fruitful idea despite all of its pitfalls and limitations, and so is constructivism" (p. 273).

Duit (1995) viewed most aspects of constructivism as not really new ideas but as ideas developed from "a long-standing tradition" (p. 274). The tradition is an important feature, he wrote, because currently emphasized ideas have roots in the history of science teaching and learning. However, he believed there was a need for a "consistent and
comprehensive constructivism" and "that the basic ideas of constructivism have to be consistently and comprehensively used" (p. 274). In an example he provided, Duit (1995) thought it "unwise to consider only students' conceptions of scientific phenomena, concepts, and principles from a constructivist perspective as is done in several approaches in the literature" (pp. 274-275). Other conceptions must be considered such as students' meta-knowledge of science, students' views of learning, and students' attitudes. Recent research on prior knowledge supports his view (Dochy, Segers, & Buehl, 1999). The authors overviewed research on 183 studies that involved the role of prior knowledge on students' performances. The following are among the conclusions they reached: (a) there was "a strong relationship between prior knowledge and performance," and (b) "other learning variables" and "other student characteristics influence the learning process, and interact with the effect of prior knowledge" (Dochy, Segers, & Buehl, 1999, pp. 170-171).

Some Definitions

Constructivism has a long and controversial history (Confrey, 1994; Duit, 1994: Phillips, 1995; Steffe, 1994; von Glasersfeld, 1996). The controversy begins with how it is defined and continues with how it is described and debated. For example, Phillips (1995) discussed multiple issues and problems arising from constructivism. He compared the good, the bad and the ugly of constructivism. He identified as ugly the quasi-religious or ideological aspects of constructivism. He likened them to religious sects who harbor suspicious beliefs and distrust of the nonbelievers. The good he identified as what many constructivists hold in common, i.e., the need for active
participation by the learner and the recognition of the social aspect of learning. Phillips (1995) praised constructivism for bringing into discussion the epistemological issues related to learning and curriculum. The bad, though he admitted to inadequate documentation, is derived from the tendency by some "...towards relativism, or towards treating the justification of our knowledge as being entirely a matter of sociopolitical processes or consensus...or the inclination to discard...any substantial rational justification" (Phillips, 1995, p. 11).

In addition to problem issues associated with constructivism, the following definitions demonstrate the range of descriptions used to define it. Constructivism is defined by Fosnot (1995) as "...a theory about knowledge and learning: it describes both what 'knowing' is and how one 'comes to know'" (p. ix). Constructivism has its foundation in psychology, philosophy, and anthropology. Fosnot (1995) described constructivism as a theory that "...describes knowledge as temporary, developmental, nonobjective, internally constructed, and socially and culturally mediated" (p. ix). Brooks and Brooks (1993) defined constructivism in a similar way but further explained: "Learning from this perspective is understood as a self-regulated process of resolving inner cognitive conflicts that often become apparent through concrete experience, collaborative discourse, and reflection" (p. vii). Crowther (1997) explained it as a process internalizing a new experience through previously established past experiences or knowledge constructs. He cited Scott (1987) who viewed students as active learners who construct meaning by using ideas they already have.
Marshall (1998) proposed that "... new experiences and materials are interpreted through previously constructed cognitive structures and interaction with the experiential world and thus may lead to somewhat unique representations of the world" (p. 451), and that "... [t]his is not to deny the existence of external reality, but rather point out that there is no way of knowing whether what people perceive and believe they understand exactly matches that reality" (p. 451).

Frequently, researchers make their objections known and then sidestep the arguments to agree with Phillips (1995) who placed an emphasis on commonalities as seen in social constructivism and in radical constructivism. Mayer (1998) presented two recurrent themes of constructivism and the constructivist approach: (a) active learning, and (b) learning in context. "Active learning refers to the idea that people learn by engaging in a process of sense making" (p. 368). Hands-on activities may or may not be included in this particular category. "Active learning seeks to engage the learner's cognitive processes" (Mayer, 1998, p. 368). For hands-on to be considered active learning, the student must be cognitively engaged for the purpose of understanding. "Learning in context refers to the idea that each subject discipline requires its own ways of thinking--best learned from concrete experience on realistic tasks" (p. 368). The themes in common are also seen in constructivism as it is broadly defined by the National Science Education Standards (1995).
Constructivism as It Is Broadly Defined

by the National Science Standards

The driving force for a changed curriculum is a reform effort that established The National Science Education Standards (1995). Prior to this development, the Benchmarks for Science Literacy, by the American Association for the Advancement of Science (AAAS), was published in 1990. The authors of both documents sought reform in Kindergarten through college (K-16) based on recent research of how students learn.

These documents were designed in cooperation with "... teachers, school administrators, parents, curriculum developers, college faculty and administrators, scientists, engineers, and government officials" (NSES, 1995, p. 3) to address a perceived national need for everyone to develop scientific literacy. The Standards defined scientific literacy in the following way: "Scientific literacy is the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity" (NSES, 1995, p. 2). The implication for scientific literacy is "... that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed" (NSES, 1995, p. 2).

According to the Standards, everyone needs to be able to use scientific information in making informed personal and policy decisions (Donmoyer, 1995; NSES, 1995), and to prepare people for jobs requiring advanced scientific literacy. The Standards outlined what this means for students and teachers. For students it means being given multiple opportunities to achieve expected outcomes while recognizing that
students "... will achieve understanding in different ways at different depths ... at
different rates ..." (NSES, 1995, p. 2). The writers of the Standards advocated an active
learning of science that includes more than hands-on experiences; students need "minds-
on" experiences (NSES, 1995, p. 20).

For teachers and for teacher preparation programs, the expectations support a
constructivist approach and are linked to constructivism through the use of specific
recommendations such as the integration of topics from various content areas, active
engagement of scientific experiences, and the use of scientific inquiry. The Standards
suggest that the use of inquiry offers a way for teachers to keep pace with the increases
and changes in scientific knowledge. As students pose questions through inquiry, the
students and the teacher explore new avenues. The teacher's role is not one of
transmission, but one of guidance. Inquiry, as explained by the multiple authors of the
Standards, "... refers to the diverse ways in which scientists study the natural world and
propose explanations based on evidence derived from their work" (p. 23). The Standards
emphasize inquiry as one way to approach science teaching because it provides students
with multiple opportunities to learn to act as scientists. Such experiences may include the
following opportunities for students to pose questions; design experiments; plan
investigations; research multiple text sources; and use tools to gather, analyze, interpret,
and report data.

Constructivism as a Theory and Staver's Principles

Staver (1998) addressed the issues and arguments against constructivism and
claimed that constructivism is a sound theory to explain the practice of science and
science teaching. In his discussion, Staver (1998) focused on two of the more widely recognized versions of constructivism: radical and social. These two forms are very briefly explained here to provide background for his arguments. A leading proponent of radical constructivism is von Glasersfeld (1995), who believed that knowledge is actively built up with a thinking person, and that the purpose of cognition is to serve the individual's organization in his or her experiences. Social interaction is important to the construction of knowledge. Driver (1983) and Gergen (1985) as proponents of social constructivism believed that social interdependence is important and that meaning-making occurs through language. They believed that collective meaning-making occurs through language-based social interactions. Knowledge is created and legitimized through social interchange in many forms.

Staver (1998) presented the main critical arguments against both types of constructivism in general, to include the following: (a) as a theory it is flawed and it should not be used to explain innovative practice (Osborne, 1996), (b) as a theory it tends towards relativism (Mathews, 1992; Phillips, 1995), (c) it maintains a traditional empiricist view (Mathews, 1992), and (d) it does not accurately represent science practices (Osborne, 1996). Table 2.2 shows the major arguments in favor of constructivism and major arguments against constructivism as they have been reported in the literature. Those who argued against constructivism also offered arguments in favor of constructivism. (For a more in-depth explanation of the arguments, see Staver, 1998, who discussed and explained epistemologic and philosophic perspectives.) At issue, according to Staver (1998), is the nature of science as a social institution to accept
### Table 2.2

**Arguments For and Against Constructivism**

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<tr>
<th>Arguments In Favor of Constructivism</th>
<th>Arguments Against Constructivism</th>
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<tr>
<td>Moves epistemological issues into the discussions of learning and curriculum (Phillips, 1995)</td>
<td>Flawed instrumental epistemology (Osborne, 1996)</td>
</tr>
<tr>
<td>Provides empirical data to enhance knowledge of difficulties in learning science (Osborne, 1996)</td>
<td>Tends toward relativism (Mathews, 1992; Phillips, 1995)</td>
</tr>
<tr>
<td>Fosters the development of innovative methods of science teaching (Mathews, 1991; Osborne, 1996)</td>
<td>Fails to break away from traditional empiricist views (Mathews, 1992)</td>
</tr>
<tr>
<td>Increases awareness of learners (Anders &amp; Guzzetti, 1996; Osborne, 1996; Staver, 1998)</td>
<td>Doesn’t accurately portray practice of science (Osborne, 1996)</td>
</tr>
<tr>
<td>Language-based social interactions are central to the building of knowledge by individuals and communities (Staver, 1998)</td>
<td>It’s a philosophical view—postmodern epistemology—not an educational theory with testable applications (Colliver, 1996)</td>
</tr>
<tr>
<td>The character of cognition and language which is employed to express cognition is functional and adaptive (Staver, 1998)</td>
<td>It’s considered “fashionable”—a means to belong to a group (Strike, 1987)</td>
</tr>
<tr>
<td>The purpose of cognition and language is to bring coherency to an individual’s world of experience and a community’s knowledge base, respectively (Staver, 1998).</td>
<td>Inherent tendency to invite misinterpretation (Strike, 1987)</td>
</tr>
<tr>
<td>Contemporary constructivism explicitly rejects the idea of solipsism (Duit, 1995; Staver, 1998)</td>
<td>The idea that individuals actively construct their knowledge on a basis of existing conditions is in danger of solipsism (von Foerster, 1984)</td>
</tr>
</tbody>
</table>
objective reality. He admonished constructivists to "... remain silent about an objective reality that exists independently of us" (p. 503). He further explained:

Constructivism does not challenge the practice of science, but constructivism does confront the wishes of science head-on, by providing an alternative epistemological paradigm to explain, interpret, and use science as a way of knowing as well as what we have learned through science. For constructivists, observations, objects, events, data, laws, and theory do not exist independently of observers. (Staver, 1998, p. 503)

The implications of constructivism for the practice of science are acknowledged even by its critics (Matthews, 1992, 1994; Osborne, 1996; Phillips, 1995) who value constructivism as a pedagogy in science (Staver, 1998, p. 517). Perhaps the strongest case for constructivism lies in the fact that it more readily explains the failure of students to change conceptions despite numerous efforts on the part of the teacher to do so.

To address the problem, Guzzetti and Hynd (1998) studied conceptual changes in science classes. Despite the variety of ways teachers address alternative conceptions in science (experimentation, demonstration, explanation, and discussion) students may hold on to their alternate conceptions. They reported some success with the use of refutational text. Refutational text anticipates students thoughts and ideas and counter argues the alternate conceptions with the "accepted" scientific principle in such a way that students develop understanding. They wrote: "As a theory of learning, constructivism helps explain why students learn or fail to learn what teachers teach" (p. 239). Constructivism also helps to explain students' alternate conceptions, conceptual change teaching, and the need for cooperative learning in practice.

Staver (1998) provided principles which have implications for science pedagogy and instruction. They are synthesized from radical (von Glasersfeld, 1995) and social
constructivists’ views that trace roots from Dewey (1906), Piaget (1970), Bruner (1987), and Vygotsky (1996). Staver summarized the four main principles important to the research at hand:

- Knowledge is actively built up from within by individuals and communities.
- Language-based social interactions are central to the building of knowledge by individuals and communities.
- The character of cognition and language which is employed to express cognition is functional and adaptive.
- The purpose of cognition and language is to bring coherency to an individual’s world of experience and a community’s knowledge base, respectively (p. 519).

Content Literacy Practices: A Constructivist Approach

An Historical Review

An account of content area literacy practices demonstrates a variety of trends in approaches to practice. The past approaches ranged from holistic, to skills and drills, and to specific strategies and study skills for a particular content area. Anders and Guzzetti (1996) traced the roots of the current understandings of the constructivist approach to content literacy from the early 1900s through the 1990s. They described how educators came to understand the need for content literacy development in classroom practice.

Between the 1920s and 1930s William S. Gray of the University of Chicago, a prolific writer on the subject of content reading, as it was referred to then, promoted the teaching of reading by every teacher. In the 1940s, 1950s, and 1960s teachers needed to teach reading and study techniques for each subject. Prescriptive materials and programs
were developed by Nila Banton Smith and Ruth Strang who made outstanding contributions to instructional approaches for reading content texts. Their content approaches were among the first to identify and to address the needs of readers through practical means such as the identifications of writing style patterns and the classification of paragraphs by types. For example, students could be taught to identify paragraph types such as definition and problem and solution. The emphasis at the time was on "unique differences between reading skills in each content area" (p. 7).

During the 1970s and 1980s a number of textbooks appeared devoted exclusively to content reading. Among the authors was Harold Herber, who wrote Teaching Reading in the Content Areas (1970). He was credited with writing the first text that presented reading in the content area as a unified process (Anders & Guzzetti, 1996). For Herber, the processes were similar; he saw no need for particular lists of skills for each content area. Later research supported his unified view "that readers at all ability levels consistently used syntactic (grammatical) and semantic (contextual) cues to reconstruct meaning" (Guzzetti, 1982, 1983; in Anders & Guzzetti, 1996). In addition, the same study concluded that a student's prior knowledge and interest influenced comprehension. The unified process was a holistic view of content reading expanded by the work of theorists Kenneth Goodman and Frank Smith during the 1970s and 1980s.

Schema theory contributed to content area literacy by explaining how students' prior experiences, personal knowledge, and interests impacted comprehension of text (Anderson, Spiro, & Anderson, 1978). In the 1970s and 1980s schema theory became the
impetus for changes in research and practice and in the area of content reading as a specialty area (Anders & Guzzetti, 1996).

Recent content area literacy has been directed toward studying literacy development in science and math classrooms at the middle and high school levels. One classroom setting in which the students and teacher were observed and interviewed to study the content literacy development of a high school chemistry course yielded surprising results about the relationships among participants. Moje's (1996) two-year study focused on how and why a high school chemistry teacher and her students engaged in literacy activities. The two-year study demonstrated the significance of establishing relationships between teacher and students as a motivation to engage in literacy activities. Moje reported that the students knew the teacher cared deeply for them and they responded positively to the strategies she taught. In addition to the importance of teacher-student relationships, Moje's study pointed out the need for additional studies to examine teacher beliefs and practice in the content areas as well as teacher beliefs about literacy in the content areas, about their students, and the sociopolitical context of learning. She further suggested a need for researchers to examine their own assumptions about literacy and literacy practices. Moje (1996) made a case for reported inconsistencies in teachers' beliefs and practices about literacy. She commented that past researchers may have erred and that their inconsistency may have more to do with a reinterpretation according to the researchers' own beliefs. She argued for the need to conduct more research on literacy practices in actual content area classrooms.
In another example, Borasi and Siegel (1999) suggested a direction for increasing the understanding of how content literacy development works in a classroom. Their suggestion related to the present study and to constructivism. They wrote in their research of inquiry in mathematics that "reading, writing, and talking do not work separately and if we want to understand how they work together, it is necessary to conceptualize and study them as interrelated" (p. 339). Prentiss (1998) examined teachers' and students' literacy practices and the culture of the classroom. She concluded that there was a mutual influence on their literate practices, that students and teachers shared the literate practices, and that the "process is constructed anew in each classroom" (p. 107). She wrote:

> In understanding teachers' and students' literacy practices, there is a need to consider the range of experiences they have had over time; what ways they have come to know how to be a teacher, student, or literate actor; and how those roles define and are defined in relation to those people and things around them. (Prentiss, 1998, p. 106)

Despite these examples of secondary-level content area literacy research, Alvermann, (1998) remarked that there is “a dearth of published research” on secondary education teachers’ beliefs and practices and their relationship to content areas (p. 144). She further explained the need for descriptive studies to allow for teachers and student voices to be heard from within the classroom settings (situational contexts).

**Content Literacy and Theoretical Implications for Practice**

Anders and Guzzetti (1996) promoted the theoretical principle of constructivism and they wrote "that students construct personal meaning based on how they interpret their experiences; students bring those interpretations with them to the classroom" (p.
This idea has implications for instructional practice. Teachers need to consider instruction that is appropriate "... for the students' purposes, prior knowledge and experiences, interests, or development" (p. 138). They reported that "... all views of constructivism have one principle in common—that students are active learners who bring their own ideas with them to the classroom" (p. 54). Moreover, they wrote of a critical component to their thesis: "The communication processes of reading, writing, listening, and speaking are tools learners use to negotiate the meaning of their world. The phrase 'negotiate the meaning of their world' is critical" (p. 54).

They viewed the inquiry cycle as a constructivist approach that "takes advantage of the students' social natures by providing a context for collaborative work. It also integrates content learning with language development" (Anders & Guzzetti, 1996, p. 151). The students have opportunities "to develop their reading, writing, speaking, and listening skills as they engage in meaningful and authentic work" (p. 151). They also reported that the very same opportunities are likely to help the ESL (English as a Second Language) students advance in the English language application of their general knowledge base to a particular content. ESL students may have considerable general knowledge, though the teacher may not be able to recognize it because of the teacher's own linguistic and cultural limitations. ESL students who have opportunities to become actively involved are more likely to progress in both language development and content development. Anders and Guzzetti (1996) qualified this by explaining that this works best when the ESL students work with students who have English as a primary language. They reported that teachers who teach with a constructivist perspective found teaching
and learning to be invigorating. In addition, "... constructivist teachers believe that instructional decisions are made on the basis of the unique and particular interactions that take place in the culture of the classroom" (p. 159).

In conclusion, this literature review has brought together the ideas of constructivists, science educators, and content area literacy specialists to show a need for systematic inquiry of teaching and learning science literacy in the science classroom. The next chapter describes how this inquiry was conducted.
CHAPTER 3
DESIGN AND METHOD: A COLLABORATIVE APPROACH

The purpose of this study was to investigate the use and development of biology literacy practices by six case students and a teacher in an entry-level biology course for non-biology majors. Specifically, the study investigated participants' beliefs about the actions and practices that contribute to biology literacy. It presupposed collaboration among the participants: the teacher, the students, and the researcher. The theoretical orientations implicit to the study relate to constructivism as "...a sound theory to explain the practice of science and science pedagogy" (Staver, 1998, p. 501).

Table 3.1 provides an overview of the constructs, research questions, data sources, and means of analysis. This table is elaborated upon in the body of this chapter, which is organized around the following topics: (a) the design of the study, including data sources and the collection and analysis of the data; (b) a description of the setting and overview of study participants; (c) a discussion of assumptions underlying the study; and (d) a consideration of ethical issues inherent in the study.

Design

The design of the study was a bounded case study in which I took the role of a participant observer (Bogdan & Biklin, 1992; Merriam, 1988). The bounded case study involved investigating the participants' actions and use of materials that they believed to be effective in the development of biology literacy. The teacher and six students were members of the case. I was present during the course of one semester, participating in
### Table 3.1

**Constructs, Research Questions, Data Sources, and Analysis**

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Research Questions</th>
<th>Data Sources</th>
<th>Citation &amp; Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Teacher</strong></td>
<td>a.) What actions does a teacher take to communicate biology literacy to students?</td>
<td>Participant observations</td>
<td>Glesne &amp; Peshkin (1992)</td>
</tr>
</tbody>
</table>
|            | b.) What patterns and combinations of teacher actions and use of materials does the teacher believe are effective for the development of biology literacy? | In-depth interviews, casual conversations, artifacts | Seidman (1991)  
|            |                                                                                   |                               | Merriam (1988)  
|            |                                                                                   |                               | (Coded and analyzed using a conceptual analysis approach as described in Miles and Huberman (1994).) |
| **Student** | a.) What actions do students take to learn biology content literacy?               | Participant observations     | Glesne & Peshkin (1992)                                                            |
|            | b.) What patterns and combinations of student actions and use of materials do students believe are effective for the development of biology? | In-depth interview, artifacts, surveys | Seidman (1991)  
|            |                                                                                   |                               | Merriam (1988)  
|            |                                                                                   |                               | (Coded and analyzed using a conceptual analysis approach as described in Miles and Huberman (1994).) |
class activities and field trips, observing, recording the observations, and talking with students about what they were learning.

In the case of the teacher, the focus was on the actions she took to communicate biology literacy to the students and on the patterns and combinations of her actions and use of materials that she believed to be effective for the development of biology literacy and her rationale for the beliefs. In the case of the students, the focus was on the actions they took to learn biology content literacy and on the patterns and combinations of their actions and use of materials that they believed to be effective for developing biology literacy and their reasons for their beliefs.

Data Sources and Collection

The principal means of data collection for the two constructs (see Table 3.1), i.e., the teacher and six students, were as follows: in-depth interviews, participant observations, and selected literate artifacts. In addition, notes and memos of casual conversations were recorded as reflective notes after the event. Surveys, given to all class members, were used to aid in selecting the six case study students. They also served as an ice-breaker during the interview process.

Interviews

Individual in-depth interviews (Seidman, 1991) were conducted by the researcher. The teacher interview questions (see Appendix A) were piloted with a colleague for appropriateness prior to the actual interviews. The teacher and the six participating students were interviewed three times during the course of the semester. The interview guides for both the teacher and the students are included in Appendices A and B.
The first interview established the context of the student’s background and understandings of literacy and more specifically, scientific literacy and biology literacy. In the second interview, the focus was on the concrete details of their biology literacy development. This asked the participant to reconstruct the details of their biology literacy experience upon which opinions may be built within the context of the current course experience. The third interview allowed the teacher and students to elaborate and focus on the details of their overall actions and understanding about biology literacy development.

The in-depth interviews varied in time from 30 minutes to an hour and a half. The teacher and students were audiotaped using an audiocassette recorder with the researcher taking notes in case of technical problems. A transcription machine was used to transcribe the audiotape interviews and researcher notes were used to help in the transcription. Though notes were always taken, two interviews had to be repeated due to poor quality of the cassette audiotape.

**Participant Observations**

Classroom observations were recorded over the 16-week period. The class met twice a week for approximately 2 hours and 40 minutes. Written field notes were taken during most of the class meetings to record the literate events, actions and practices of both teacher and students. For example, a literate event might involve groups of four or five students discussing the wording of a testable hypothesis and a null hypothesis. Each group would synthesize ideas, record them, write final hypotheses statements on the chalkboard and then present and explain these ideas to the rest of the class. On occasion,
my researcher role would change to facilitator or co-inquirer as I listened and participated in the group activities and discussions. Sometimes I would ask the students to help me understand how the group decided upon a final experimental design or plan of action and how they reached consensus. Other times, I put myself in the students' shoes and would ask the teacher questions to clear up some confusion. In addition to the written classroom observations, I made memos of conversations that took place in class and after class about classroom events.

Selected Literate Artifacts.

The literate artifacts included all items used in the classroom context such as required texts, copies of teacher handouts, mini-exams, written messages on the chalkboards by both teacher and students, field notebooks, copies of student work, and pictures of student posters. For reference, I organized and listed the copies of handouts by numbering and dating them. The list of items was considered part of the literate practices and events. Selected literate artifacts were used in the report as supporting evidence of conceptual themes or categories. For example, in some cases the literate artifacts produced by the students provide documentation and written evidence of the development of biology literacy. The list of the literate artifacts appears in Appendix C.

Surveys

At the beginning of the course, informal survey information aided in the selection of students (see Appendix D). I use the word informal to mean the surveys were not used for statistical analysis but rather to gather information about the students' views and to assist and inform the research process (Fink & Kosecoff, 1985). Two prepared surveys
(Bradley, 1987) were used with permission from the author prior to selecting the students. These were given to the students at the same time as the consent form, the explanation of my role in the classroom, and the purpose of the research. One survey asked questions about the student's reading and study habits. The other survey addressed reading and reading interests. These surveys were readily available and they helped in drawing out students' understanding about their literacy and reading backgrounds during the taped interviews. They also helped to make judgments about a student's quality and quantity of reading. And, in many instances the surveys contained information that helped to establish a shared commonality with the researcher during subsequent interviews. Acquired background information about the students in the class also helped in the purposeful selection (Bogdan & Biklen, 1982; Creswell, 1994; Merriam, 1988; Miles & Huberman, 1994) of the six case students. The selection process is described more fully in chapter 5.

Other survey-type questions were developed as the study continued and they supplemented teacher and researcher information. Some of these questions were asked during the interviews with the six case students. Other questions were used in the written final survey given to all of the students at the end of the semester. Part of the collaborative nature of the research, the exit surveys contributed students' suggestions for future teaching practice. In addition, they served as a cross-reference for what the six case students reported in their interviews. The survey results were triangulated with other data.
Data Analysis

Analysis was an ongoing process as I considered relationships, outstanding characteristics, meanings, and explanations as recommended by Glesne and Peshkin (1992). Data were coded and analyzed using a conceptual analysis approach as first described in Glaser and Strauss (1967) and later in Miles and Huberman (1994). First, the data were identified and categorized according to source, date, participant, and in some instances, directly related to a particular research question. For example, transcribed and typed data from the interviews and field notes were read and re-read at three different times using color coding to establish emergent themes or categories. Important concepts were underlined and key words linking those concepts were written in the margins. Framework categories were established based on the questions and later refined as emergent themes developed (see Appendix E). The key words and key concepts became the drafted coding categories (Bogdan & Biklin, 1994) placed in a matrix to be refined in the software program NUD*IST (Non-numerical, unstructured, Data: Indexing, Searching, and Theorising). Initially developed in Australia and New Zealand, the NUD*IST (QSR, 1997) program aided in the conceptual analysis and the management of data. The program is designed to assist in editing, memo writing, coding, searching, and reporting. Patterns and conceptual emergent themes were organized into matrices (Miles & Huberman, 1994) after data "reduction" and "interpretation" (Marshall & Rossman, 1989, p. 114). The matrices helped to organize and visualize the relationships among the categories, the participants, and the research questions.
Description of the Setting and Overview of Study Participants

Setting: A Sense of People and Place

A Varied Campus Population

Student demographics provide a general sense of the campus and classroom with a mixed student population reflective of a southwest community. Though the approximate full-time student enrollment for this particular campus is 2000, about 8000 students represent the total annual head count, of whom 56% are women. Eighty-seven percent of the students on this campus are enrolled part-time (less than 12 credit hours per semester). The student demographics for the campus are as follows: Native American 2%, African American 4%, Asian American 4%, Hispanic 17%, and Anglo/other 73%. Students are predominantly in the 20-29 age range (about 45%). The average age is 28 and the median age is 24. These demographics provide a sense of variety in the general profile of the student population, which was also true for the class.

An Intimate Campus Environment

The first requirement for the study site was accessibility. The next desirable criteria, though not a requirement, was a constructivist classroom. A setting where the teacher was attempting to make the broader considerations and principles of constructivism a viable part of the classroom experience would meet that criteria. Such a classroom was found at a small branch campus of a large community college in the southwestern United States. The physical description of the campus and classroom provides a sense of place for the inquiry classroom. The classroom extends beyond the four walls of the room, to the campus, to the student study site and beyond.
Lush desert vegetation surrounds numerous one-story buildings that make up the campus. The intimate campus environment includes several landscaped patio areas with patio tables, chairs, benches, and umbrellas. Designed to encourage student conversation and study, the patio areas and a few larger commons areas are daily gathering places for many students. A student union area provides additional space for student gatherings.

**The Physical Classroom Environment**

The biology classroom is located near the student union in a large modular building. The building contains four classrooms, toilet facilities, a laboratory preparation area, and a small computer/study area. Inside the biology classroom, a lecture/lab arrangement, there are six stationary workbench areas with room for 24 to 30 students. These are positioned with three bench sections on each side of a center aisle. Each section has a laboratory sink and faucet. One section accommodates up to five students. An extended waist-high counter or workbench with a sink, almost the length of the room, separates the student area from the lecture area. The lecture area has two chalkboard areas and one white board area at the center. On one side of the room there is an enclosed venting hood for hazardous materials and an exit. A student greenhouse is located just outside the exit door. On the other side of the room is a door into a small supply and preparation room. In the small room there is a computer with Internet access and a printer. The main entrance and exit into the classroom is diagonally opposite to the exit at the front of the room. Students enter from the back of the room where there is a wheelchair access ramp into the building. There is one movable table with adjustable height available for students with special needs.
One extension of the classroom is within short walking distance of the classroom. Made up of relatively undisturbed dense vegetation, this site of approximately five acres becomes an ideal outside classroom for students. Various forms of cacti, trees, perennials, shrubs and desert annuals grow on the site. Evidence of insect and wildlife is found on the ground surface and in the vegetation. Another extension of the classroom for this particular course is the Arizona Sonora Desert Museum located in Tucson, Arizona. The physical study site on campus and the Desert Museum are an integral part of the curriculum and the inquiry and an important part of the course.

The Biology Course

The teacher described the environmental biology course as one that involves the fundamentals of ecology and the relevance of those fundamentals to human impact on natural ecosystems. The course of study includes ecosystem structure, function, population dynamics, and human impact on air, water, land, and biodiversity. The biology course is offered in the spring, summer, and fall semesters and is designed for non-biology majors but biology majors sometimes take this course. The catalog lists the course as a four-credit environmental biology course with no prerequisites. Though the teacher suggested this particular course as one that might provide an interesting context for study, another biology course providing classroom access might have been suitable for the research setting.

Researcher Access to the Course and Setting

I sought and obtained access to this particular classroom setting for two reasons. One, the teacher knew me. Shelley Maxfield, referred to as Maxie, was a teacher of mine
several years ago. I had fond memories of taking two of her biology classes and completing a group project on the desert study site. A chance meeting at a faculty development meeting put me in contact with her again. At that time, I discussed the possibility of working collaboratively on a project concerning science literacy and asked if she would be interested. She agreed and we communicated over the course of several months to discuss the purpose of the study, her role, and my role. And two, Maxie's experience in science teaching and her own inquisitive nature and enthusiasm for teaching and learning made her an ideal teacher researcher with whom to work.

Throughout the course of the study, an important ethical consideration for me was that the research would be as collaborative as possible. Maxie agreed and we both strove for a mutual exchange of materials and ideas. For example, Maxie provided me with copies of all classroom materials given to the students (e.g., the course syllabus, see Appendix F). Also, she shared intuitive insights about the students and how they were doing. In informal conversations, she explained how she would adjust what she was doing to accommodate students and how important it was for her to create her own forms of assessment and do her own grading. Further, Maxie received copies of her transcribed audiotaped interviews and read much of the final dissertation report. She was also given copies of the student survey results after the final grades were submitted to compare her own beliefs with what the students wrote. Moreover, we met regularly and talked extensively about the nature of teaching and learning. We shared Internet information, books, and ideas about student success. The mutuality of this relationship ensured an enduring collaborative research process.
The Participants

The members of the bounded case study, the teacher and the six selected case students, contributed to the study. The teacher was interviewed, acted as an informant of her understandings about the students, and collaborated with the researcher. The six case students were part of a larger class. The particular class under study began with 30 students and finished with 27. Though the case students were a focus through audiotaped interviews and artifacts, the "non-case" students also contributed. They willingly completed surveys and answered incidental questions over the course of the semester and provided occasional copies of their course work. Additional background information and a brief description of each major participant and the selection process follows.

The Teacher and Some Constructivist Links

Maxie

Shelley Maxfield prefers to be referred to as Maxie, and has been a member of the faculty at the community college for more than 15 years. She has taught a number of courses, including anatomy, physiology, microbiology, and biology courses for majors and non-majors. Her background knowledge and experience is extensive and she reports being continually interested in updating her own content literacy and teaching skills. She saw participation in the research study as an opportunity to learn something new. Her role in the study was as a participant, informant, and collaborator. Information, ideas, observations, suggestions, materials, and books were shared freely between us. She made suggestions on the written interviews and surveys prior to the implementation. For example, she suggested several of the student interview questions at mid-semester. In
addition, Maxie explained her use of particular approaches and practices. Maxie's instructional approach is one of inquiry. Her teaching practices seem very much aligned with constructivist principles and Maxie admitted that she believed her practice to be closely aligned with a constructivist paradigm. Though a constructivist classroom was not actively sought out, study in such a setting provided an opportunity to research literacy development in one teacher's version a constructivist classroom. A more elaborate description of Maxie appears in chapter 4.

**The Students**

**Selection Criteria**

This section presents some of the student characteristics (see Table 3.2), describes the criteria used to select the case study students, and provides a brief background history of each student. *An elaborated description of the students appears in chapter 5.* We

<table>
<thead>
<tr>
<th>NAME</th>
<th>SELF-REVEALING</th>
<th>GENDER</th>
<th>ATTENDANCE RECORD</th>
<th>AGE</th>
<th>BACKGROUND</th>
</tr>
</thead>
<tbody>
<tr>
<td>LACEY</td>
<td>YES</td>
<td>FEMALE</td>
<td>GOOD</td>
<td>41</td>
<td>NAT. AM.</td>
</tr>
<tr>
<td>DENISE</td>
<td>YES</td>
<td>FEMALE</td>
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<td>17</td>
<td>ANGLO</td>
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<tr>
<td>MARIA</td>
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<td>HISPANIC</td>
</tr>
<tr>
<td>AMY</td>
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<td>FEMALE</td>
<td>GOOD</td>
<td>36</td>
<td>ANGLO</td>
</tr>
<tr>
<td>SCOTT</td>
<td>YES</td>
<td>MALE</td>
<td>FAIR</td>
<td>19</td>
<td>ANGLO</td>
</tr>
<tr>
<td>RON</td>
<td>YES</td>
<td>MALE</td>
<td>GOOD</td>
<td>25</td>
<td>ANGLO</td>
</tr>
</tbody>
</table>
wanted the case students to reflect a variety of characteristics, backgrounds, academic abilities, and experiences. For that reason they were purposefully sampled based on the following criteria and rationale:

1. **Age.** Representative age differences were sought to reflect various levels of maturity and to reflect the variety of students at a community college. The overall class age average was 23 years, which is younger than the average age of 28 on the campus at large. The average age for the six students selected was 28 years.

2. **Gender.** Gender was based on the class ratio of females and males. At the beginning of the semester 64% of the class was made of women and 36% were men. We wanted a representative ratio and an approximate ratio of two to one gave us four women and two men in our selected case study students.

3. **Cultural background.** We sought variety in the background of the students, particularly in terms of cultural beliefs and practices. The ethnic variation of the case students is representative of the class as a whole.

4. **Self-revealing and an Interesting Personal History.** We reasoned that the completion of the initial Reading Interest Inventory and the Reading/Study Survey (Bradley, 1982) would indicate students' willingness to reveal themselves. The surveys also provided background history and information about the students' reading interest and their reading and study practices. We also observed the students in the classroom during the first few weeks for their talkativeness during group activities.

5. **First Two Mini-Test Scores.** The first two mini-test scores provided a rough estimate of how the students might do in the class. The teacher-designed tests
were open book and open note mini-exams based on course content. The selected students' test scores are reported in chapter 5.

6. **Class attendance.** We suspected that regular attendance was an indication of commitment and that the chosen students were more likely to complete the interviews and the class. A "good" attendance record meant that the student had missed one or no classes prior to selection. A "fair" indicated the student had missed two classes.

Each of the six case study students is introduced below. A brief background profile on each of the students is also provided:

**Lacey**

Lacey is a 41-year-old married mother of four children. The youngest child, a boy, is 10 years old and the only child living at home. Lacey identifies strongly with her Native American heritage. She is receiving funding through a local Native American source. Her goal is to complete her education at a university and return to contribute to her tribe in some capacity on the nearby reservation. She is taking this course because it is a requirement of her program for transfer to the nearby university. Lacey was asked to be part of the study because she had some interesting background experiences, she was self-revealing, was the oldest student in the class, and she had a Native American heritage. She was also enthused about the idea of participating in the research study.

**Denise**

Denise is 17 years old and calls herself an only child. She grew up in a rural environment and was home schooled by her mother who is a teacher. She is unusual and interesting in that she has a home school experience. She is studying to become a
marine biologist and is concurrently enrolled in a marine biology class. She was selected mainly because she was the youngest student in the class.

Maria

Maria is a 32-year-old mother of two children. Maria’s first language is Spanish. She attended school in Mexico until the age of 12 and then her parents moved to the United States. She was very unhappy with the move and was not inclined to learn English even though she was enrolled in a bilingual program. She speaks mostly Spanish at home, though her children attend public schools and speak English. Maria was selected because she would be able to provide the perspective of a second language learner. Maxie and I also felt she would benefit as well in the suggestions we might make to facilitate her learning.

Amy

Amy is an anomaly. She already has a master’s degree in electrical computer engineering from the University of Colorado. Amy decided to take this particular class because she is a volunteer for a naturalist organization that hosts visits from school children at a local nature site. She wanted to know more about the desert environment. She is now a 36-year-old mother of two young children; one child is in preschool. Amy was selected because she was self-revealing and because her background was very interesting to Maxie and me. She was able to talk about her experiences in traditional science classes and compare them with the biology course in the research study. She also appeared to have leadership qualities and we were interested in how she might contribute to the study and to the classroom dynamic.
Scott

Scott is 19 years old, lives in the city during the week, and attends the community college full time. On the weekends he returns to his home in a nearby rural community to work with his father who owns a moving company. He has three sisters living at home and he holds the position of the oldest. Scott was asked to participate in the study because he was one of the youngest males in the class and he was interested in participating in the study.

Ron

Ron is a 25-year-old student who works full time in the Air Force while attending school part-time. Ron has been in the Air Force six years. He took this class because it “fit his schedule” and it fulfills part of the science requirement for transfer to the university. His goal is to get a degree in MIS (Managerial Information Systems). Ron was selected because he brought yet another view to the study. He came from a disciplined and regimented background. His early schooling, his high school experience and his Air Force experience offered an opportunity to compare his previous experiences with the constructivist approach taking place in the classroom.

The Researcher

As a researcher, I acted as a participant observer, an interviewer, and as an investigator. The purpose was to investigate literacy practices in the biology classroom. More specifically, I wanted to determine if there were patterns or combinations of literacy practices and use of materials by both the student and the teacher that they believed to be effective in the development of biology literacy. As a participant observer,
I wrote about the events and actions occurring in the classroom. My main focus was on the actions that contributed to the development of biology literacy. As an interviewer, I audiotaped the interview conversations with the teacher and with the students on three separate occasions. As a researcher, in light of my own research beliefs and background knowledge, I wrote analytic memos on the field notes, on the transcribed interviews, surveys, and on the literate artifacts. During the research process, a personal goal, as well as a research goal, was to maintain a stance that was accurate, non-judgmental, and collaborative. Though the threat of bias is always present, this stance seemed to align itself with my ethical considerations and the constructivist principles reported by Staver (1998). It is for this reason that I now briefly list and comment on my strengths and weaknesses as a researcher (Marshall & Rossman, 1989).

**Strengths**

1. My extensive knowledge of reading practice, content literacy, community literacy, and constructivism are a source of strength. I am a reading specialist and hold a specialist degree in Educational Leadership/Administration.

2. My teaching experiences with children and adults has changed over time through additional education and a broader understanding of theory and the practical applications.

3. Another source of strength is my strong science background; I have over 30 years of medical laboratory experience. The implication here is an understanding of how science works and develops. Things are not always clearly defined. Even expert scientists may differ in their views on scientific information, pedagogical views on
teaching, and in their approaches to research in science (Bauer, 1992; Trefil & Hazen, 1991).

4. I am an avid reader of topics in science, science teaching, and science learning and am very experienced in tracking down information in the library or on the Internet.

5. In addition, my awareness of studies mentioning past abuses (Fradd & Lee, 1999) of ethical issues in educational research and collaborations (Griesel, 1996) helped me advance a sensitive and respectful approach with people in the study. It was important to protect the privacy of the participants and to provide each person with a copy of his or her own transcribed interviews. When questions were asked by either the participants or other members of the class about the nature of the research, I tried to answer honestly and directly.

These strengths served as a means of support for the teacher and the students in the collaborative classroom setting. Next, I list and discuss some weaknesses that may contribute to a source for bias.

Weaknesses

1. The course material was not something that I was completely familiar with and in some respects, I played the role of novice learner along with many of the students. But the weakness was also an advantage at times because I had to grapple with developing biology literacy.

2. Another area of possible bias, viewed as a weakness, relates to the researcher’s judgments about the beliefs and practices attended to. There may have been a tendency to select and record the actions and practices that tended to support my own beliefs. My
judgments about what to pay attention to may result in inconsistencies despite the effort to avoid them.

Moje's (1996) study suggests that the inconsistencies in beliefs and practices found by researchers may have to do with the researcher's own beliefs. Therefore, I sought to avoid this particular pitfall in two ways: (a) I reflected on the data chosen to present the participants' voices with this in mind, and (b) I asked Maxie to review what I had written in the final report for any inconsistencies.

Other Participants

Other participants in the study were the "non-case" students in the class. On occasion comments, questions, and stories from these students were used to inform classroom practice and to corroborate research findings. For instance, Maxie's belief in the importance of student's background interests makes a link to content area literacy and constructivism. It is evident in the following story about Janice who seemed totally bored in the classroom. Her face remained expressionless during several class sessions. We wondered if anything was happening with her. Maxie's mini chalk-talk presenting weather patterns due to topography and what that meant for biomes on the other side of the mountains produced an abrupt change in Janice's interest level. Maxie asked "What happens all the time in Tucson?" and mentioned gardens and how gardeners might want to know what types of seeds to plant during certain weather patterns (FN, p. 29). All of a sudden, Janice's background experience in gardening came into play and made a connection with Maxie's mini-talk. Janice's interest soared to the extent that she remained after class for 15 minutes talking about gardens. Her interest and enthusiasm
continued as Maxie drew her out by asking interesting questions. The story serves to illustrate how "non-case" student examples in the research may support the findings noted in the six case students and the teacher. The additional support may also advance knowledge of content literacy practice that can contribute to a student's literacy development.

Assumptions

This study takes a constructivist perspective that shares in common underlying assumptions and principles that have implications for instruction. Anders and Guzzetti (1996) wrote that three considerations come together for content area instruction: "students' interests, prior knowledge, and questions; teachers' interests, expertise, and interpretation of the concepts they teach; and available resources, including community resources (e.g., guest experts and field trips), literature, and textbooks" (p. 55). These three considerations provide an overall methodological framework for the study. In addition, Staver (1998) provided principles which have implications for science pedagogy and instruction. They are synthesized from radical (von Glaserfeld, 1995) and social constructivists' views that trace their roots from Dewey (1906), Piaget (1970), Bruner (1987), and Vygotsky (1996). Staver (1998) listed the four main principles:

- Knowledge is actively built up from within by individuals and communities.
- Language-based social interactions are central to the building of knowledge by individuals and communities.
- The character of cognition and language which is employed to express cognition is functional and adaptive.
• The purpose of cognition and language is to bring coherency to an individual's world of experience and a community's knowledge base, respectively (p. 519).

These considerations and principles are reflected in the National Science Education Standards, a driving force in the nation's science classrooms. Many of the college introductory science courses use the lecture method (Stofflett, 1998), which is typically not considered constructivist pedagogy. In keeping with a constructivist approach, an open and cooperative style (Bogan & Biklen, 1992), a classroom dynamic was considered that would provide a rich contextual environment for the research.

Reciprocity and Ethics

Being aware of reported reciprocity and ethical issues (Marshall & Rossman, 1989) in research, I addressed them in the following ways:

1. Research Preparation. Prior to the beginning of the study, I met with the teacher to get approval from her and to learn of the requirements for doing research at a community college. We discussed my proposed role as a participant observer and my expectation to learn about literate actions and practices used in the classroom by both teacher and students to develop literacy in biology and the rationale for using them. My reciprocal role was to provide the teacher and students with classroom support, copies of their own transcribed audiotaped interviews, and survey results if requested. At the same time, I learned that research approval is required by the district research department to protect the college from potential negative publications. A written proposal and a signed copy of the university "exempt from human subjects review" were obtained for the
community college file. Verbal permission was granted by the research director of the district office and by the teacher.

2. Informed Consent. (See Appendix G.) The teacher and student participants were asked to sign a consent form informing them of the purpose of the research, their role in the research, their privacy rights, and their right to withdraw at any time. Every effort was taken to maintain their anonymity and confidentiality in the information they provided.

3. Privacy Protection. Artifacts, audiotapes, surveys and written reports were coded first by number and then participants were asked to provide a pseudonym for the actual report. Number and/or pseudonym identified results and summary reports. Artifacts such as student papers and notebook entries were coded to protect the privacy of the participants. The teacher had access to survey results after the grades were submitted but had no knowledge of the source. This was in keeping with the objective of informing the teacher of effective practices through the analyses of the data while protecting the privacy of the individual contributor.

4. Interview Protocol. The teacher and the participants who agreed to take part in interviews were giving of themselves (Marshall & Rossman, 1989) and therefore all interviews were scheduled according to their convenience. Most of the interviews took place following class in the small room adjoining the biology classroom. A few interviews were held off campus.

5. Participant Reciprocity. Each interview participant received copies of their own transcribed audiotaped interviews. Participants were given the opportunity to edit or
make corrections on their personal reports. At the end of the study a written note of thanks and a small gift was given as a token of my appreciation for their assistance in the research project.

Responsible and ethical research demands that a researcher make every effort to take appropriate actions to protect and respect the rights and privacy of those who willingly consent to take part in educational research. For this research I openly announced my role as researcher and participant observer and asked students and the teacher to participate in the study. The teacher and all of the students signed the Informed Consent document and were aware of the purpose and nature of the research before I began to collect the data for the study. In the study only the teacher and I use our real names.

Summary

A bounded case study was conducted to investigate the use and development of content literacy practices by students and a teacher at a community college. The research took place in an environmental biology course for non-majors. The primary participants were the teacher, six purposefully selected (Bogdan & Biklen, 1982; Creswell, 1994; Merriam, 1988; Miles & Huberman, 1989) case students, and the researcher. Background experiences, class attendance, gender, age, and cultural background were considered during the student selection process. Access, friendship, and interest were the primary reasons for the teacher selection. Data were collected from the participants through in-depth interviews, participant observations, casual conversations, selected literate artifacts, and surveys. These data were analyzed using Miles and Huberman's
(1994) conceptual analysis approach. The program NUD*IST was used to aid in data management. A number of matrices were used as tools to organize and visualize the conceptual relationships with each other and with the principles of constructivism (Marshall & Rossman, 1989).

Throughout the course of the study, an important ethical consideration for me was that the research would be as collaborative as possible. This means shared knowledge and shared authority. Thus, a mutual exchange was common among participants. Students contributed to the study with information, comments, and their written papers. The teacher contributed with information, discussions, and thoughtful questions. And I contributed by also sharing knowledge, providing copies of the interviews for each person interviewed, and by assisting the teacher and the students in the classroom.
"The most important thing is to get the students really involved in the topic."

- Maxie

Figure 4.1 represents three instructional considerations that come together for constructivist instruction in content literacy development (adapted from Anders & Guzzetti, 1996). The considerations imply complex relationships in the classroom dynamic for the communication and development of content literacy.

![Diagram](image)

**Figure 4.1.** Instructional considerations for content literacy development (adapted from Anders & Guzzetti, 1996).
The purpose of this chapter is to present the findings related to the teacher's perspective and to the teaching dynamic of biology literacy. The chapter begins with a framework (see Figure 4.1) of theoretical and practical premises of the teacher as characterized by the constructivist theoretical orientations advanced by Anders and Guzzetti (1996) in content literacy and by Staver (1998) in science education. According to Anders and Guzzetti (1996), students are active learners and the teacher assumes the role of active co-learner; the students are not empty vessels, and the teacher is not the sole transmitter of knowledge. The teacher's role in a constructivist classroom is dynamic. Instruction is never the same. Constructivist instruction involves three principles that come together for content literacy development: (a) the students' interests, prior knowledge, and questions; (b) the teachers' interests, expertise, and interpretation of the concepts they teach; and (c) the available resources, including community resources (Anders & Guzzetti, 1996). These three principles provide a logical framework for linking the theory to practical applications and also reflect a holistic approach to content literacy development that is consistent with constructivism in general. The logical framework also provides a theoretical structure on which to connect the three emergent themes evident in the data, i.e., science as a language activity, science as a social activity, and science as an experiential activity.

Major Instructional Considerations for Constructivist Instruction

Figure 4.1 depicts the instructional considerations that come together for constructivist instruction in content literacy development. This conceptual figure assumes a classroom culture that is dynamic. For a more thorough discussion on
classroom culture, see Prentiss (1998) in which the author addresses culture and the mutual influences of the teacher/learner connection with regard to literacy practice. The figure for constructivist instruction in content literacy development embodies the complex relationships and a classroom dynamic that considers the importance of those relationships. In this bounded case study, these considerations relate the research questions about the teacher and the students. The considerations with regard to the teacher are the following: (a) Maxie's actions related to her interests, expertise, and interpretation of the concepts taught; (b) Maxie's actions related to students' interests, prior knowledge, and questions; and (c) Maxie's actions related to available curricular resources, including community resources. This structure served to organize the data. Data analysis of each of the categories revealed three themes: science as a language activity, science as a social activity, science as an experiential activity. They are discussed following (a) re-statement of the research questions, (b) a discussion of the treatment of the research question, (c) a review of the method of data analysis, and (d) a profile of Maxie, the teacher in the study.

Research Questions about the Teacher

The specific teacher-related questions guiding my observations, interviews, and collection of artifacts were the following:

What actions did Maxie take to communicate biology literacy to students?

What patterns and combinations of her actions and use of materials did she believe to be effective for the development of biology literacy? Why?
These questions are related to the teacher's perspective and to the considerations for constructivist instruction in content literacy development.

Treatment of the Research Questions

These questions are related and thus reported as part of the teacher construct. This is in keeping with a holistic notion of literacy. In the preliminary analysis it became evident that they could not be easily separated. Moreover, unlike other studies reported by Moje (1996) where the teacher actions and beliefs were not aligned, these case study data support an alignment of teacher actions and teacher beliefs. That is, there was agreement between what Maxie did in the classroom and her reported beliefs, thus justifying a holistic approach. For the sake of organization and discussion, however, I do make some divisions.

Review of Data Analysis Procedures

In reporting the findings of the teacher research question, I refer mainly to data from analysis of the primary data sources, i.e., participant observations, in-depth interviews, and artifacts such as found on the list of materials (see Appendix C). Secondary data sources--analytic memos, reflective notes, and informal surveys--provide elaboration and examples of the findings that emerged from interpretation of the primary data sources. Initially, analysis of the data involved first reading through the field notes three times for words or ideas that seemed to stand out. The actions the teacher exhibited during class were separated and were listed in a matrix according to teacher actions, teacher use of materials, and teacher purposes. The data were then color coded according to conceptual themes of relationship to the teacher's interests, expertise, and
interpretations of concepts; teacher relationships to students’ interests, prior knowledge and questions; and available curricular resources, including community resources. These were then further refined, categorized, and coded. Coding notations were established, and items were lettered and numbered to be used in referencing the supporting data used to report the findings (see Appendix E).

Though science literacy is the broader category, biology literacy and science literacy are used interchangeably in this and subsequent chapters. Biology is considered a more specific area of science but shares in common many science concepts. When the concepts are more general and apply to science, the term science literacy is used.

Profile of a Biology Teacher

To begin this section, a detailed profile of Maxie, teacher of the community college biology course, is provided. Maxie's profile describes some of her background experiences and introduces her as a teacher with a wide range of interests, areas of expertise, and a passion for science and science teaching.

Through our formal interviews and informal conversations I learned about Maxie's background experiences. The conversations reflected a wide range of interests, a depth of knowledge in her discipline and a variety of experiences as a student of science and as a science teacher. Maxie reported that she came along "in a kind of traditional approach" where she had to "memorize a lot of facts" and classes were mostly lecture format. In graduate school she began to "accumulate knowledge in the 'right way'" and decided "students should have more participation" (T11, p. 46). She holds a Master of Science degree and has taken many additional advanced courses beyond the master level.
Her language experience includes: seven years of French, two years of Latin, one year of German, one semester of Spanish, one semester of Japanese and one semester of Russian. She has worked as a scientific illustrator, a medical technologist, a water-colorist, and a teacher. She has been teaching for almost 30 years and has taught such courses as invertebrate zoology, anatomy, physiology, marine biology, microbiology, botany, plant studies, and biology. Maxie's background experience shows breadth and depth in many areas of biology.

Though she has not had formal pedagogy education classes, Maxie reported learning how to teach from expert professors. She watched how they handled the undergraduates and the graduate level students and, under the guidance of two special professors, she learned how to assess learning. Maxie remarked during an interview that she “considered them experts in the field, and I was really glad that they were willing to share their techniques and I think I picked up the best” (TI1a, p. 34). She reported believing that “your powers of observation in science can help you understand what... your students are doing” (TI1a, p. 34). At the graduate level, she learned that the traditional approach to teaching was not what she wanted in her classroom. She wanted her students to learn through participation. Her goals and actions resonate with my understanding of "educative experiences" (Dewey, 1938, p. 29) and with Vygotsky's "zone of proximal development" (Vygotsky, 1978). An educative experience is one that involves growth and continuity. Maxie includes both in her classroom; she nurtures student growth and incorporates elaboration of prior experiences through active student participation. Vygotsky's "zone" is a central element of the educative process where
learning takes place. The teacher considers the strengths and weaknesses of the learner and the forms of cooperation and collaboration between a knowledgeable teacher and the learner or learners in individual and collaborative activities. A key feature here is the importance of the social aspect of learning (Moll, 1987).

She has been involved with preparing students for health careers in medicine, nursing, pharmacy, nutrition, technical and non-technical fields, and teaching (TI1a, pp. 1-46). Her knowledge of the requirements of the different fields helps her to understand the needs of the students and the areas of emphasis. In addition to teaching, Maxie is the "faculty coordinator of two district wide initiatives, the Student Success Task Force and Student Academic Assessment" (TI2, pp. 15, 21). Her experiences in these roles further Maxie’s professional experience and interests and qualify her as an expert and master teacher.

In addition to her professional expertise, Maxie’s enjoyment of books and movies, especially science fiction, enters into the classroom in sometimes subtle and not so subtle ways. For example, in one class session, she presented the "Kobayoshi Moru" which she explained to the students as a "Catch 22" from a Star Trek television show where Captain Kirk is given an impossible problem to solve as a condition for graduation from Star Fleet Academy. The problem under consideration in the classroom was about a pest. She told the students to develop a plan that will address the problem and manage a pest that is at times essential to pollination of a plant and at other times, in its larva stage, destructive to the standing crops and the harvested crops in storage. She wanted them to think and write about what was needed to develop the plan and to come up with some
ideas. She told them they would have some time to discuss their individual plan with their classmates before they handed in their paper at the next class meeting. Her connection with the show Star Trek and the impossible problem was to make the point that science is at times messy and requires very creative thinking (FN, pp. 117-118).

As an avid reader of science and science fiction she recommends books and magazines to her students. She asks her students for recommendations and shares the students’ findings with the rest of the class. She has a delightful sense of humor and enjoys humorous jokes, movies, and books. She seems to see the humorous side to many situations and humor and laughter have a place in her classroom. Her humor is sometimes in the form of gentle teasing of students who help others understand concepts. For example, in one class, she nicknamed Scott, “Graph Man,” because he did such a wonderful job explaining the Population Growth Curve to the rest of the class (FN, pp. 78-79). Scott smiled broadly when she called attention to him in a teasing way. Her connections with books, movies, humor, stories, and life experiences contribute to a rich classroom environment.

During the course of the semester, Maxie, the students, and I often talked about books, shared books, exchanged materials from the internet on environmental issues, teaching and learning issues, and discussed the readings. In the following interview excerpt, Maxie expresses her search for well written science books to share with students an awareness of science writing:

MAXIE: I am always cruising bookstores to see what new things are out there. For example, I like to read Steven J. Gould. He does a lot of things on evolutionary biology but writes in a very nice narrative form. I think scientists are learning to write more in popular narrative form simply from a standpoint of
getting the book sold. I think they have seen that people don’t want to wade through the scientific journals because they can be terribly boring. And, journals like Natural History have gone to writing in a more popular mode (T1, pp. 74-75).

Maxie’s interests, expertise, and interpretation of the concepts she teaches play a very definite role in the actions she takes to communicate biology literacy to the students.

Maxie’s passion for science and her value of it also play an important role in her communication of science and science literacy. Her passion for science and for teaching science was evident in the field notes of the classroom observations, the revelation of her beliefs in the interviews, casual conversations, and through the artifacts and materials she provides for her students. Several examples surfaced in a casual conversation after class at the beginning of the semester. Maxie expressed her role, values, respect for her students, and the importance of making decisions on environmental issues: "I'm more of a facilitator. . . . My emphasis is self-responsibility." She tells me she encourages students' initiative about bringing in published science-related articles with "I appreciate you bringing that in." And, she doesn't tell students they are wrong, she asks another question such as "Can we think of that in another way? You don't say that's wrong. You want to give them some limits of 'correctness.' What evidence do you have?" She continued, "In science one of the important things is evidence. What you build in class is the need for evidence and how you feel about that." In reflecting over the day's session, she emphasized the importance of letting the students know that, "They really have a lot of knowledge. They know things. They have a lot of personal knowledge" (C 1/25/99, pp. 10-11). She explained why she uses the environmental text in addition to the biology majors' text. "The environmental text has a lot of case studies, information, real-life
information and more practical views. It didn't get down and dirty with environmental information--[there is] a lot of practical information." She asked me and answered her own question "How does this pertain to me in my situation? I think biology is an interesting science. . . . [We're] not doing science for science sake. We're helping them make decisions--altruistic--the needs of many" (C 1/25/99, p. 11).

Maxie's profile demonstrates a strong commitment to science and science teaching. My observations and interviews with Maxie reveal that she reads extensively to keep up on new developments in science and also for her personal enjoyment. This extensive reading influences what she offers her students. In addition, she encourages and nurtures students' interests in and enthusiasm for science by providing interesting experiences that require active involvement. Maxie also participates in a number of outside activities at the professional level, which further substantiates her love of science and teaching.

Teacher Actions Taken to Communicate Literacy to Students

Findings Surrounding the Literacy Relationships of a Constructivist Teacher

In this section, I discuss the findings of Maxie's actions and beliefs. The observed actions are revealed by analysis of the participant observations, in-depth interviews, and artifacts. Information about her beliefs comes mostly from the interview data. Secondary data sources, casual conversations and analytic memos were used to confirm the observed classroom dynamic. In an effort to make sense of the major conceptual categories that emerged from the data, Maxie's actions were related to the three major instructional considerations depicted in Figure 4.1.
Maxie's profile provided a general view of Maxie's interests, expertise, and interpretation of concepts taught. These connect to her actions in the classroom. Under the headings Science as a Language Activity, Science as a Social Activity, and Science as an Experiential Activity, which represent the three major categories obtained from the data, I briefly discuss the theoretical aspect of each category for two reasons: (a) to show the relationship to practice and (b) to link some of the theoretical considerations and research to Maxie's beliefs and actions to classroom practice. The theoretical considerations are brought in to support themes that emerged from the data and do not appear in chapter 2, the review of literature. The actions and beliefs are more fully incorporated into the area of Maxie's actions related to students' interests, prior knowledge, and questions.

Science as a Language Activity Related to the Teacher

Science as a language activity implies actions related to language development, usage, and understanding. The universals of language learning put forth by Holdaway (1979) in *The Foundations of Literacy* requires that meaningful language development be supported through active events, through social connections, and by incorporating the literacy of the language through multiple ways such as speech, writing, reading text, visual representations, and symbolic means. Holdaway (1979) further explained that isolating learners and isolating language through skills and exercises makes learning
language more difficult. According to Holdaway (1979), learning language requires more complex ways to facilitate language development, usage and understanding than skills and drills.

Though the universals were written for language learners of any age, these appear to apply to science as a language in Maxie’s biology course. The data support the category "Science as a Language Activity" and an understanding that language and literacy are intricately intertwined. Maxie reported in her interviews that her students best learn science by doing what scientists do in a supportive environment (TI1, p. 4). She wants her students to face the challenges and puzzles scientists face by acting as scientists (TI2, p. 32). Her students ask and answer their own questions, use the scientific terms in group discussions, present their findings orally, in writing, and visually (TI1, p. 15; TI3, p. 43). Her emphasis is on the building of science concepts through active involvement. She engages her students in the science language and literacy through active reading and writing, listening, discussion, and the oral presentation of original science research they have developed (TI3, p. 43).

Maxie’s beliefs and actions are further supported by additional literature on second language acquisition (Au, 1993; Collier, 1995; Cummins, 1986; Valdés, 1996). Cummins (1986) takes a constructivist approach with his suggestions to involve students in oral and written actions with the teacher and other students, to encourage more complex thinking, to empower students to ask and answer their own questions. Collier (1995) also recognizes "... that second language acquisition is a dynamic, creative, innate process, best developed through contextual meaningful activities that focus on
language use, combined with guidance along the way from the teacher that sometimes involves a focus on language form" (Collier, 1995, p. 7).

Science literacy incorporates a science language specific to the discipline and the acquisition of the specific language is complex. Maxie's actions in the classroom support science literacy and the acquisition of the language.

In the past three years, Maxie and her colleagues "have been working with Diane Ebert-May" (Principal Investigator of the National Science Foundation grant that supported her work with Maxie), who has shown them the reality of bringing what they call, "inquiry into the whole format without sacrificing any information or skill" (TI1, p. 46). Maxie believes the biggest dilemma facing scientists and teachers of science is on what to spend quality time. She believes it is important for students "to be given the tools" that transfer to "whatever occupation." She reported an emphasis on critical thinking, logical oral presentation, and the use of technology in her courses for majors and especially for non-majors, all of which require excellent language usage. Her classes, especially beginning classes have become "a format for teaching communication." She explained, "If you can't communicate you are not going to be a very efficient person. Science teaches them a way of communicating" (TI1, p. 46). For Maxie, science as a language is as important as the social aspect of learning science.

Science as a Social Activity Related to the Teacher

In a constructivist classroom students need to "become actively involved in developing their own understandings" (Au, 1993, p. 72). "Emphasis is on students' academic learning and a recognition of the importance of positive social relationships in
supporting literacy learning" (Au, 1993, p. 90). Collier (1995) wrote of the relationship among complex factors and links language acquisition to the sociocultural, cognitive, and age factors. She recommended opportunities for peer interaction in addition to "classes that are highly interactive, emphasizing student problem-solving and discovery learning through thematic experiences across the curriculum" and explains the classes "are likely to provide the kind of social setting for natural language acquisition to take place" (p. 18).

Bruffee (1993) also emphasized a social aspect of science. He argued that students should work collaboratively to figure out how science works and to learn how to talk and write science. Incorporating collaborative classroom learning is one approach that provides students an opportunity to become socially involved in science problem solving and discussions (Ahern-Rindell, 1998; Caprio & Micikas, 1998; Driver, 1983, 1995). In a similar vein, Collier (1993) recognized that many different instructional approaches are needed to address the different learning styles, the various cultural and linguistic differences, and the emotional and personality differences of students. A holistic approach recognizes these differences. In addition, teachers "need to create a supportive classroom environment that values each student and the individual strengths and resources he or she brings to the learning process" (Collier, 1993, p. 26).

Maxie is keenly aware of science as a social activity in her own professional development as well as in the classroom. She belongs to "a biology interdisciplinary group where instructors get together and talk about different ideas" and "share techniques." She told me the group shares book selections and they "talk about the greater ideas in biology" (T11, p. 15). The group also connects through e-mail
"[S]ometimes there are differences of opinion, but we have a format that we are able to come together" and "We do a lot of talking by e-mail." She added that it is convenient and "We have really gotten to know each other better" (TI1, p. 16). In addition to the college connections, Maxie attends conferences along with her colleagues and they share the information. For example, Maxie mentioned a geology instructor who "brought a lot of information to us that shows us how to work geological and geographical concepts into the study of plant and animal diversity" (TI1, p. 16; C, p. 107). As a result, she introduces activities or sections into the course that she wouldn't have otherwise. She explained, "You can literally change your course from one semester to the next." Her professional contacts help her use new ideas in different ways. She stressed the importance of getting together with her colleagues and how sharing information and talking about things "helps you as much as it helps the student and it really helps keep you fresh." Maxie makes the connection of her own literacy to the students' literacy: "Your literacy will help the students with their literacy." Maxie's own professional role in science as a social activity connects her to conceptual concepts and to her classroom practice.

Science as an Experiential Activity Related to the Teacher

Science as an experiential activity infers active involvement by students, especially from the standpoint of content literacy development. The connection I want to make here is that content literacy development is not a spectator sport. In Maxie's classroom, the students encounter engaging experiences designed to support content literacy development. Maxie uses both implicit and explicit instruction as needed. Here,
I draw from Dewey (1938) who explained that experience is based on a plan for the subject under consideration, a method of instruction and a particular discipline, the resources, and social organization. It is not merely a discovery experience, which is not enough (Driver, 1995), as Dewey's (1938) specific criteria suggest. For example, the teacher must keep track of the direction of the experience, the experience must be social and involve "contact and communication," the teacher must also be able to judge attitudes "conducive to continued growth," and "have that sympathetic understanding of individuals" to understand what is going on in the students' minds (pp. 38-39). Dewey explained that this is a more difficult path to follow than patterns of traditional education; he expressed the responsibility of teachers to understand "the needs and capacities of the individuals who are learning at a given time" (pp. 45-46).

Dewey reflects Driver's view as she takes a constructivist perspective and reiterates the need "to take account of what learners bring to the learning situation" (Driver, 1995, p. 399). She wrote that the role of the teacher is to be both a presenter of knowledge and a provider of experience through discovery. The experiences and connections that students make with experiential activities are open to teacher intervention and negotiation as the students learning science become "initiated into the culture of science" (Driver, 1995, p. 395).

Science as an experiential activity also implies that a teacher has the expertise to provide students with types of learning experiences and necessary tools to succeed in the classroom. Anders and Guzzetti (1996) suggested some of the actions and practices an experienced teacher might demonstrate in a constructivist classroom. I include them here
as a descriptive reference to compare Maxie's version of a constructivist classroom with some possible characteristics. A teacher in a constructivist classroom might act in many of the following ways:

- assume a role of co-learner and facilitator
- negotiate curriculum with the learners [Doyle, 1983]
- activate prior knowledge
- initiate the use of inquiry and learning cycles
- use assessment to monitor student understanding
- use humor in the classroom
- demonstrate a driving compelling need to learn
- keep track of what students are learning
- use more than one source of information
- find the constructivist method of teaching is invigorating
- take advantage of the student's social nature by providing a context for collaborative work . . . integrate content learning with language development.

In addition, the authors suggest that the teacher in a constructivist classroom would probably have the following understandings about the teaching practice:

- learning is not linear
- the communication processes of reading, writing, listening, and speaking are tools learners use to negotiate the meaning of their world
Maxie's experiential activities with her own class and with the inquiry method when she was involved with a National Science Foundation grant helped convince her constructivist methods were working. Part of the method involves the use of inquiry. In Maxie's classroom, the inquiry cycle or learning cycle involves the investigation of ideas and questions that students have about environmental biology. As part of her own construction of knowledge and profession development, Maxie teaches what she learns. She worked "with adjunct faculty teaching them how to teach in the inquiry method using the group approach looking at a situation, having them ask a question, having them figure out how to answer the question and them having to answer the question" (T1, p. 16-17).

She uses inquiry learning in her classroom and tells me that the biology course is

... most demanding because of the many things that we have going on at the same time. It seems like we have four or five projects going on at the same time. And, you have to be able to put them all in context and you have to make sure that you wrap all of them up and don't leave any of them hanging. And you always have to be prepared to modify what you want to do based on where the students want to go with the information. You let the students help drive it. So you have to be more versatile. And if they bring up something you don't know, you've got to go look it up so you can help them with it, or you have them look it up, but you kind of want to make sure that they're getting the main point. (T12, p. 21)

She explains that it really takes time to convert to the inquiry method and compares it with the traditional lecture method:

[People who don't understand it say, well, it's easier to do it that way, but it's funny, when I'm beginning to feel lazy, I'll fall back on the lecture because it's easier to lecture if you think about it... there's nothing to draw together, there's nothing to tie up, there's no responsibility on your part to make sure that
everybody has gotten the information in a way they can use it. So lecturing really is not thinking, and that's a copout way to get the information across. (TI2, p. 24)

Maxie reflects her years of experience when she tells me that she is "getting pretty good at seeing the components of inquiry within a topic" but "other instructors have difficulty recognizing an opportunity for inquiry." They just don't see inquiry emerging from a topic. Maxie makes it appear natural and simple. Like an Olympic champion ice-skater on ice, she adjusts for the conditions and makes her classroom practice appear easy.

**Summary of Maxie's Actions Related to Interests, Expertise, and Interpretation of the Concepts Taught**

In summarizing the relationships of Maxie's actions, beliefs, and rationale related to interests, expertise, and interpretations of concepts taught, three important conceptual themes are found in the data, i.e., language, social, and experiential actions. Literature-based elaboration was used to support the three themes that emerged from the data. The themes linked theoretical understandings and practical application to Maxie's reported private and professional interests, expertise, and interpretations of concepts taught. These relate to the classroom dynamic. In Maxie's constructivist classroom, science is viewed as a language activity, a social activity, and as an experiential activity. Table 4.1 provides a summary of the relationships, teacher actions, and her rationale. Her reported beliefs are supported by research in each of the areas. Maxie's actions, i.e., a reader, a writer, personal actions involving language, i.e., reading, writing, speaking, reflect her own need to continue learning. Her private and professional actions link her to the
Table 4.1

<table>
<thead>
<tr>
<th>Relationship</th>
<th>Teacher Actions</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Teacher Related</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Teacher's interests, expertise,</td>
<td>- Reads extensively in science</td>
<td>Maxie believes you have to keep up as it keeps you fresh.</td>
</tr>
<tr>
<td>and interpretations of concepts</td>
<td>- Brings outside interests into classroom</td>
<td></td>
</tr>
<tr>
<td>taught)</td>
<td>- Writes messages and talks with teachers or pre-teachers about good techniques</td>
<td>Communicates with other professionals on issues, differences-believes it's important for classroom practice</td>
</tr>
<tr>
<td></td>
<td>- Seeks to widen her experience in science and in teaching</td>
<td></td>
</tr>
<tr>
<td><strong>Science as a Language Activity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Works with others at a at a professional level</td>
<td>&quot;Professional contacts give you new ideas to try out in the classroom.&quot;</td>
</tr>
<tr>
<td></td>
<td>• Attends conferences to help herself and others</td>
<td></td>
</tr>
<tr>
<td><strong>Science as a Social Activity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Actively involves herself in experiences to improve practice and knowledge</td>
<td>&quot;I learned by doing.&quot;</td>
</tr>
<tr>
<td></td>
<td>level</td>
<td></td>
</tr>
</tbody>
</table>

Social and experiential components of the science community. The actions and beliefs discussed in this section also relate to Maxie's actions involving students.
Maxie's Actions Related to Students' Interests, Prior Knowledge, and Questions

In the previous section I emphasized Maxie's connections outside the classroom. I discussed how her outside relationships entered into classroom practice. The focus under this section is on Maxie's actions related to what she knows and finds out about her students in the context of a community college classroom and how that knowledge becomes a primary consideration in her version of constructivist instruction. The objective is also to show the patterns and combinations of actions and use of materials that Maxie believes communicate and are effective for the development of biology literacy. I emphasize the student-centered nature of the related actions. In addition, Maxie's actions indicate a practice committed to science literacy development by the activities she orchestrates: she uses inquiry, learning cycles, and on occasion, mini-lectures. Maxie frequently incorporates the three activity areas into her classroom practice. Maxie, when going over these results was surprised by the quantity (see Table 4.2 and Table 4.3). Table 4.2 provides an example list and brief descriptions of a few of the 25 inquiries or learning cycles. Table 4.3 lists all of activities that transpired over the semester course. These were taken from the classroom observations and transcribed field notes. In addition, each item on the list includes elements of the three thematic activity areas: science as a language activity, science as a social activity, and science as an experiential activity. Some of these are reported below in a more descriptive way. The approach in this section is to incorporate the findings about Maxie's actions in the classroom into the three categories in a holistic manner. Therefore, the three areas are
Table 4.2

Examples of Inquiry/Learning Cycle Activities

<table>
<thead>
<tr>
<th>Date</th>
<th>Science Activity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/20</td>
<td>Good teaching/Good Learning</td>
<td>Language: Students discuss, write, and report, listen to others views.</td>
</tr>
<tr>
<td></td>
<td>Looks like ...</td>
<td>Social: Grouping around lab benches 5-6 students in a group; they introduce themselves.</td>
</tr>
<tr>
<td></td>
<td>Four questions:</td>
<td>Experiential: Session provides practice for working as a research team; also serves as an advanced organizer for the next activity.</td>
</tr>
<tr>
<td></td>
<td>What does good teaching look like?</td>
<td>(Note: Some students make value judgments instead of observations.)</td>
</tr>
<tr>
<td></td>
<td>What does good teaching sound like?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>What does good learning look like?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>What does good learning sound like?</td>
<td></td>
</tr>
<tr>
<td>1/25</td>
<td>Observation/Inference</td>
<td>Language: Students had to look up the words prior to class. Students discuss, describe, and write about the object. Every one turns in a completed form. Maxie wants them to observe from their experience. Maxie circulates among the groups. Maxie asks questions such as “Another observation?” and “How about an inference?” A student responds “It was once near a body of water.”</td>
</tr>
<tr>
<td></td>
<td>Unknown shell placed in front of student researcher team member to examine and report to group.</td>
<td>Social: Students discuss the object with each other and listen to the different view points. The idea is to work together as a research team.</td>
</tr>
<tr>
<td></td>
<td>Experiential: Students experience the words inference and observation in a context. Maxie asks each group for one observation and one inference to report to the whole group. She encourages them to use all senses. (Note: One student actually tasted the shell.)</td>
<td>Experiential: Maxie lists the science words of the students on the white board and adds a few more for students to record in a notebook: exoskeleton, endoskeleton, bilateral, symmetry, ochre, vertebrates, invertebrates, carapace.</td>
</tr>
</tbody>
</table>

Elaboration portion

Maxie poses a problem solving portion by explaining that the animals shed their shells and cannibalize each other. She asks “What would you do to prevent them from doing that?”

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<table>
<thead>
<tr>
<th>Date</th>
<th>Science Activity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/25</td>
<td>How does science measure?</td>
<td>Students discuss and write ten ways to measure things. Maxie: &quot;I didn't tell you this, but write everything out.&quot; She has students work in groups to write everything on the chalk board. Each group has a list.</td>
</tr>
<tr>
<td></td>
<td>Maxie tells students to look at the top of the page. &quot;It's on measurement. Measurements are often the first part or the second part of scientific observations. Let's take a few minutes (ten) to list ways to measure things.&quot;</td>
<td>Social: Students work together in their research team to think of the types measurements. (Maxie and I circulate among the groups and listen.) Experiential: Students actively involved in thinking, discussing, writing, reading other groups lists about measurements in terms of what they know.</td>
</tr>
<tr>
<td></td>
<td>Measurements</td>
<td>Students decide how to measure their right foot with their shoes off, discuss and record the measures on on paper and on the chalk board. Students must introduce themselves to new group members and make decisions about what roles they will have as research team members. They must work together to get done in the half-hour time slot. Experiential: Students experience first hand the problems with measurement and the limitations of a measuring instrument. They measure four group members' right and left feet. No one group does it the same way and no one adds a label to the numbers on the board. Elaboration: Maxie asks questions about how each group did the measuring, &quot;Can your foot size change if you are sitting or standing?&quot; &quot;Did you start at the end of your measuring instrument?&quot; &quot;What measuring system were you using?&quot; &quot;What's the measuring limit of your instrument?&quot; Next, they measure again to see how much more accurate they can get and to compare the results with the previous ones.</td>
</tr>
<tr>
<td>1/27</td>
<td>Maxie re-forms groups and gives each group a meter stick and tells them to measure four people.</td>
<td>&quot;This is a way to advance a simple idea. Everyone knows their feet.&quot;</td>
</tr>
</tbody>
</table>

(table continues)
<table>
<thead>
<tr>
<th>Date</th>
<th>Science Activity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/27</td>
<td>Making Sense of Science Terms</td>
<td>Language: Students discuss, write, research, and organize the words into a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>hierarchy based on their findings.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Social: Grouping around lab benches 5-6 students in a group; they are in</td>
</tr>
<tr>
<td></td>
<td></td>
<td>geographical groups.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Experiential: Students experience science words and diagram how the words</td>
</tr>
<tr>
<td></td>
<td></td>
<td>interrelate. They utilize their text, the books on the research cart, and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maxie shares with them an internet explanation of a few of the words.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>They have to argue the words hierarchical position among the group members</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and create a diagram.</td>
</tr>
<tr>
<td></td>
<td>Hypothesis/Null Hypothesis</td>
<td>Language: Students practice writing hypothesis and null hypothesis questions.</td>
</tr>
<tr>
<td>2/11</td>
<td>(An introduction to how to develop</td>
<td>After hearing a scenario about petunia plants they must think about and write</td>
</tr>
<tr>
<td></td>
<td>questions for their study project)</td>
<td>a testable question in preparation of their group desert study project.</td>
</tr>
<tr>
<td></td>
<td>Pre-assignment from *How to write</td>
<td>Each group discusses the questions and practices writing them to put on the</td>
</tr>
<tr>
<td></td>
<td>about biology.*</td>
<td>chalk board for all to see and discuss.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Social: Students practice writing the hypothesis and the null hypothesis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Groups get a chance to correct their first attempts. One corrected version:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;Sunny area plants will grow faster than shady area plants.&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Experiential: Students practice writing the hypothesis and the null</td>
</tr>
<tr>
<td></td>
<td></td>
<td>hypothesis questions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;Hypotheses should have no qualifiers.&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;We want to get down to the bare bones prediction.&quot;</td>
</tr>
<tr>
<td></td>
<td>Population Curve - Problem Solving</td>
<td>Language: The students use text and each other to understand a population</td>
</tr>
<tr>
<td>3/24</td>
<td>Text-support p. 944 *Biology The Science</td>
<td>growth curve.</td>
</tr>
<tr>
<td></td>
<td>of Life</td>
<td>Social: They talk about it in their groups.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Experiential: Students discuss possible reasons.</td>
</tr>
</tbody>
</table>

(table continues)
<table>
<thead>
<tr>
<th>Date</th>
<th>Science Activity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/5</td>
<td>Poster Day Discussion</td>
<td>Language: Each group of students turned in a poster and Maxie stops to talk with them about how she graded the posters and to ask questions to see if they understood what they did and what they learned.</td>
</tr>
<tr>
<td></td>
<td>Teacher/Group Meeting</td>
<td>Social: The groups talked about the posters shared information and techniques.</td>
</tr>
<tr>
<td></td>
<td>(This was an extension of the hypothesis and null hypothesis, study site project. The students created a scientific poster over a number of classes. Maxie provided mini lectures and support.)</td>
<td>Experiential: Student groups worked through the scientific process from start to oral presentation.</td>
</tr>
<tr>
<td>4/7</td>
<td>Biome Poster in One Day</td>
<td>Language: Groups pick a card with a specific biome. They have to research the biome, locations around the world, the climate and major weather patterns, major plants, major animal, two environmental topics, and one or two interesting facts using three other sources besides the text books. They have to make a poster and present it to the rest of the class.</td>
</tr>
<tr>
<td></td>
<td>(Specific criteria on white board)</td>
<td>Social: Groups work together to share ideas and poster creativity. (The poster is supposed to be interactive.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Experiential: Students practice team research and presentation at a higher level.</td>
</tr>
<tr>
<td>4/14</td>
<td>Pollution/Solution Problem Environmental Project</td>
<td>Language: Students spend time in groups talking about air quality in the city. Maxie: &quot;Think of how we get pollution in the city. Look in your environmental book and write the causes you find on the chalkboard.&quot;</td>
</tr>
<tr>
<td></td>
<td>Maxie: &quot;Come up with non-punitive incentives to help people stop polluting in these areas. You don't want to punish them. I want you to come up with non-punitive ideas.</td>
<td>Social: Students work together to find as many causes as possible.</td>
</tr>
<tr>
<td></td>
<td>Elaboration: Pick one and come up with an advertising campaign to sell us on your pollution solution.</td>
<td>Experiential: After finding and listing the groups work together to find a non-punitive solutions and to sell them.</td>
</tr>
</tbody>
</table>
Table 4.3

List of Inquiry/Learning Cycle Activities

<table>
<thead>
<tr>
<th>Date</th>
<th>Science Activity</th>
<th>Incorporates Science as a Language, Social, and Experiential Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/20</td>
<td>Good Teaching/Good Learning</td>
<td>X</td>
</tr>
<tr>
<td>1/25</td>
<td>Practice Making Observations</td>
<td>X</td>
</tr>
<tr>
<td>1/27</td>
<td>Science Words in a Hierarchy</td>
<td>X</td>
</tr>
<tr>
<td>2/01</td>
<td>Desert Study Research Project</td>
<td>X</td>
</tr>
<tr>
<td>2/08</td>
<td>Primary Succession/Secondary Succession</td>
<td>X</td>
</tr>
<tr>
<td>2/10</td>
<td>Mini-test Elaboration: Describe and Find</td>
<td>X</td>
</tr>
<tr>
<td>2/11</td>
<td>Writing Hypothesis Questions</td>
<td>X</td>
</tr>
<tr>
<td>2/15</td>
<td>Why do Hermit Crabs Cluster Problem</td>
<td>X</td>
</tr>
<tr>
<td>2/22</td>
<td>Elaboration Hypothesis/Null Hypothesis</td>
<td>X</td>
</tr>
<tr>
<td>2/24</td>
<td>Poster Practice: Design, Language, Organization</td>
<td>X</td>
</tr>
<tr>
<td>3/01</td>
<td>Poster Production on Desert Research</td>
<td>X</td>
</tr>
<tr>
<td>3/03</td>
<td>Group test on Hypothesis/Null Hypothesis/Results</td>
<td>X</td>
</tr>
<tr>
<td>3/22</td>
<td>Lumpers and Splitters (Biologists struggle with this)</td>
<td>X</td>
</tr>
<tr>
<td>3/24</td>
<td>Population Curve - Text Supported Problem Solving</td>
<td>X</td>
</tr>
<tr>
<td>3/24</td>
<td>Environmental Issue Poster - Students' choice</td>
<td>X</td>
</tr>
<tr>
<td>4/05</td>
<td>Desert Poster Presentation and Teacher/Group Discussion</td>
<td>X</td>
</tr>
<tr>
<td>4/07</td>
<td>Creating an Interactive Biome Poster in one class session</td>
<td>X</td>
</tr>
<tr>
<td>4/12</td>
<td>Oral Presentation of Biome Posters - Groups Report</td>
<td>X</td>
</tr>
<tr>
<td>4/14</td>
<td>Pollution Problem: Causes/Non-Punitive Solutions</td>
<td>X</td>
</tr>
<tr>
<td>4/17</td>
<td>Desert Museum Field Trip (Small Group Study Guides)</td>
<td>X</td>
</tr>
<tr>
<td>4/26</td>
<td>Problems with Pesticides/Management</td>
<td>X</td>
</tr>
<tr>
<td>4/26</td>
<td>Kobayoshi Moru (the impossible problem)</td>
<td>X</td>
</tr>
<tr>
<td>5/03</td>
<td>Solid Waste Inventory (Home Trash)</td>
<td>X</td>
</tr>
<tr>
<td>5/03</td>
<td>Oral presentations of Issues Poster</td>
<td>X</td>
</tr>
<tr>
<td>5/03</td>
<td>Rubric for final exam paper</td>
<td>X</td>
</tr>
</tbody>
</table>

combined to some extent and are also separated for the sake of discussion. For example, the next section focuses on language but includes some discussion of the social and the experiential aspects noted in the actions of the students. This is in keeping with the holistic nature of Maxie's approach. More recent research in content literacy
development supports "a holistic process that is stable across subject areas" (Anders & Guzzetti, 1996, p. 21).

Science as a Language Activity Related to Students

In this study, "Science as a Language Activity" implies the actions are intricately linked to language and literacy. In Maxie's version of a constructivist classroom, she links science language and literacy in a number of ways. She stresses the importance of building science language and its correct usage. On the very first day, she makes clear to students her expectations of sentences that make sense, with correct spelling and correct usage of terms. She tells the students that they will be building new vocabulary. In an excerpt taken from the field notes Maxie emphasizes high expectations about the students writing and about building vocabulary:

She tells students if they make a mistake "draw one line through the word" (FN, p. 4). Maxie explains the biology field notebook and tells them "Look up the word inference and look up the word observation. We will practice making observations." She asks the students "What are observations--as opposed to inferences?" She continues "You'll create your biology notebook. You will be building your new vocabulary. I'll put the new words on the board." (FN, p. 5)

Maxie wants them to see and hear the language of science. She also links science language and literacy through text materials. The first day of class Maxie has the students pick up a copy of the nine handouts lined up on the lab-bench at the front of the room. First she calls roll and then asks students to complete the pre-assessment form. Maxie uses the anonymous pre-assessment survey to learn about students' interests, prior knowledge and questions. In addition to completing the form, Maxie asks them to list their particular areas of interest of scientific interest. She uses these areas of interest to help determine the direction of the content. The form, with a one to five rating scale,
asks students to rate particular statements with regard to their knowledge about ecology, abilities to think critically, use of the scientific method, oral communication skills, written skills and experience in giving oral presentations.

Maxie links science language and literacy through experience. She involves students in a practice inquiry to help them through the social aspect of the "Research Team" idea. For some of the students it is a completely new experience (S1, I1). After explaining how inquiry works, Maxie provides the first to allow students practice in this type of learning and as a stepping stone to the next cycle of learning which is on "observations and inferences." They work in groups using the form "The Research Team" and the form on "Teaching and Learning" (see Appendix F, p. 8; and item #3 in the List of Text Materials, Appendix C). The six stationary lab benches form a geographical group; Maxie tells them that anyone at the lab bench is a member of your group. Maxie asks them to read over the roles of each team member and take on a role for the team, write the findings, proof read, and share their findings with the whole class, and turn in one report for the group. The questions for inquiry ask: "What does good teaching look like?," "What does good teaching sound like?," "What does good learning look like?," and "What does good learning sound like?" During the discussion part of the inquiry, Maxie and I circulate among the groups to listen to what students are discussing. In a casual conversation, Maxie points out that some of the students did not pay attention to the key words "look like" and "sound like" (C, 1/20). In one fairly short time frame, the students have been involved in a language, social, and experiential activity towards the development of science literacy. The next exercise, an extension of this one,
addresses the meanings of observations and inferences. Maxie tells the students that each lesson builds on the previous one and it's important to attend class.

Science as a Social Activity Related to Students

Maxie links science literacy with social activity. Dewey writes, "Education is essentially a social process" (1938, p. 58). Science literacy as a social process and as a social activity is evident in Maxie's classroom. The activities involved teacher-student transactions and student-student transactions. The term "transaction" is credited to Dewey (1896) and was borrowed by Rosenblatt (1938) in reference to the reader and text. Interaction, Rosenblatt contends, implies the notion of separateness, one entity acting on another while Dewey's term, transaction, designates "relationships between reciprocally conditioned elements" (Rosenblatt, 1995, p. 291) and an "ongoing process" whereby the elements are part of the whole (Rosenblatt, 1997, p. 17). I use the term transaction to emphasize the notion that the literacy practices are socially negotiated among the participants and actively built up. For example, when students were involved in a group activity on the Biome Poster, they decided among themselves which research resources they would use and who would look a specific topic on the internet (FN, p. 87). This also ties in with Vygotsky's "zone of proximal development" (Vygotsky, 1978). Maxie encouraged students to use multiple resources, to talk about science with each other, to get to know each other, and to work together on projects. Frequent group changes gave students the opportunity to learn from listening, speaking, and writing about science. As students got to know each other better, it wasn't unusual for them to share information, class notes, internet sources, and tips of technique. In Maxie's classroom there was
evidence of science as a social activity and of transactive relationships with regard to literacy development.

Maxie is very much aware of the social nature of the classroom and of the need for students to experience diversity. She describes how she spends more time to support students in their direction of study and especially of the need to keep track of how students work in a group and on projects:

That's a component of it, so you have to be aware of those dynamics. You just have to really pay attention to what's happening, and sometimes that's really difficult when you have 25 plus students, especially at first when you don't know them very well, and when you keep changing the groups, which you should do. I don't think you should keep the same groups all the time because you want to introduce the students to diversity within the classroom. If you keep changing the groups, you have whole new dynamics to try to figure out and assist with. Because you're not just helping them with their topics. You're helping them work through a group dynamic. (TI2, p. 22)

Maxie engages students to get them to think about their ideas and to write their ideas clearly by involving them in their group discussion. She views this as an especially important connection when she notices a particular student not writing clearly or being fearful of participating in a group. First, she questions the student about his or her role in the group. Next she draws group attention to the fearful student. Here she explains how she approaches such a student who seems afraid to participate in a group situation:

And I often ask them if they feel like they can talk within their group and share ideas. Sometimes that comes a little slowly for people. . . . So if their group is not engaging them, you have to go stand by the group and engage that person so that so the group will see you, and you draw the rest of the group in but you engage that person . . . they need to see that. They need to value that person's input or at least give them a chance.
She tells me it doesn't always work and comments, "... Some people will not say anything, as you know, if given the chance. They will not cooperate ... those are the tough nuts to crack" (TI2, p. 32). Her comments are in reference to two students who do seem to involve themselves in the class.

According to Maxie, one of the most helpful actions in the development of biology literacy is the opportunity to "discuss things with each other in a very casual friendly manner. They find that they're in a non-threatening situation. They are not being asked to memorize ... and it's amazing how much they remember" (TI2, p. 32).  

Science as an Experiential Activity Related to Students

Part of developing science literacy requires the experience of understanding how to use various texts. Maxie tells me "It's important to have everything you want them to know very close in proximity." If a book has lots of appendices "you need to take them there routinely" she explains. "Let's go look at Appendix A and see what is in there. Because that is the only way they will see the value of it. And that is why I put the page numbers on the board and say 'Let's go there'" (TI1, p. 14; FN, p. 52, 77).

Another student-related element of science as an experiential activity pertains to the importance of hands on methods. Maxie is very aware of the different methods used to teach biology. She believes that eventually there will be biology courses on television and on the internet. The problem, she explains, is that

... you begin to compromise what you can have in the laboratory situation. I feel that the hands on experience that students have in creating their own laboratory questions and then finding out the answers is very valuable in critical thinking. (TI1, p. 15)
Critical thinking is closely tied to students' misconceptions or alternate conceptions (Anders & Guzzetti, 1996). Maxie is aware that students sometimes make errors or mistakes. Here she explains her rationale behind allowing them to make errors:

So a lot of times you just have to think, "OK, I'm going to let them go out there and let them learn from their mistakes." And, it's not really a mistake. It's just looking at it a different way and they could've looked at it... in a more efficient way. So they come back in and say, "Well, you know we discovered we should have done this." I said yeah, ok, so do it that way. (TI2, p. 29)

She is also aware of students' "history of ideas" and their lack of evidence for supporting the ideas or not supporting them. Some of the ideas they've gotten "from somebody else and they need to go back to the beginning and take a look at it... They don't have personal contact with the concept as I call it" (TI2, pp. 30-31). She explains that sometimes students have done a lot of reading in the social sciences and have read popular versions of science and there is a blurring of information. For example, "Steven J. Gould really blurs some of his information when he starts writing popular social ideas and tries to connect them to science" (TI2, p. 31). Part of the confusion, according to Maxie, is due to "... always borrowing words from each other and we're changing the context and changing the meanings of those words." She continues, "... It's often a handicap for the well-read person who can't filter out the differences especially if they've never had a science course"(TI2, p. 31). Her solution for a few students who have difficulty with misconceptions or alternate conceptions is to

... have them go back to the beginning and grapple with the topic themselves, not through somebody else's eyes, but grapple with it themselves, see what they think, and then ask others what they think. But they need to have that initial, they need to go back and take a look at it themselves. And some of them will just not give up parts of what they believe. (TI2, p. 31)
Her solution for a whole group of students "not getting it" is to do another
learning cycle involving the topic. She tells students "you learn this in the beginning and
you take it with you. You don't drop it" (TI2, p. 31). Maxie explains "through more
learning cycles and more projects, you have to link all those materials . . . ideas and the
concepts." She reveals her expectations to students, "I will expect you to use the term
biome and not write out a sentence describing the same thing. You will use that term
replacing that." In Maxie's view, the process of learning conceptions is accumulative and
the experience of "grappling with ideas" while building and using the language
contributes to literacy development. She adds "And this all goes to literacy I think. So
you [means students] accumulate these ideas and you accumulate the means to express
those ideas and you just don't drop them after you've been assessed or tested over them"
(TI2, p. 32).

Maxie facilitates science as an experiential activity in a number of ways: inquiry
projects, learning cycles, the interactive reading of science texts, poster projects, reading
science in an interactive way with text and computers, and field trips. She summarizes
what she believes to the important features of science learning and science literacy:

The most important thing is to get the students really involved in the topic. The
lecture format really doesn't do that. They have to look at problems, they have to
ask questions, they have to find answers to questions, they need to probe the
literature for the terms, they need to look up information on the internet, and they
need to have a chance to discuss the information among themselves to find out
what they're opinions are. . . . They need to learn how to write down materials and
then speak on those materials because it is one thing to read information; it is
another to write up a synopsis in your own words and then . . . to present that
synopsis to the class . . . you have to take a chance and throw out your
information for public viewing and that is all part of literacy . . . (TI3, p. 43)
Summary of Maxie's Actions Related to Students' Interests.

Prior Knowledge, and Questions

Maxie explains her global view of biology related to students. Students need "to be able to read and figure out what the good science versus bad science is" and to "deal with some of the issues" and to "find answers to questions" (TI3, p. 43). She further explains that in class "We spend a lot of time in biology learning where to look for the answers, and learning how to ask the right questions about new topics of interest. The learning of how to do biology is a literate exercise" (TI3, p. 43). Maxie advances the students by showing them "how to access those new topics" and by showing them "how to reflect on which information seems to be better than others" (TI3, p. 43). She makes every effort to learn what her students are thinking through their writing and by speaking with them. The activities she arranges involve students in content literacy practices that advance student learning through three thematic areas: science as a language activity, science as a social activity, and science as an experiential activity. Table 4.4 summarizes Maxie's actions related to the students.

Maxie's Actions Related to Curricular Resources

Science as a Language Activity Related to Curricular Resources

The following curricular resources are related to science language and science literacy development in Maxie's classroom: study guides, varied forms of assessment and mini-tests, mini-lectures, field notebooks, multiple text sources and computers. These contribute to the development of science literacy in Maxie's classroom. I discuss each resource or tool separately and include Maxie's reasons for using them.
## Table 4.4

### Summary of Teacher Relationships, Actions, and Rationale (Student Related)

<table>
<thead>
<tr>
<th>Relationship</th>
<th>Teacher Actions</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Student Related</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Teacher awareness of students'</td>
<td>• Uses discussions</td>
<td>Important to be able to communicate and understand good science</td>
</tr>
<tr>
<td>interests, prior knowledge and</td>
<td>• Incorporates oral presentations in classroom</td>
<td></td>
</tr>
<tr>
<td>questions.)</td>
<td>• Emphasizes reading, writing, thinking, and wants students to apply what they</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Provides opportunities to practice science literacy</td>
<td></td>
</tr>
<tr>
<td><strong>Science as a Language Activity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Science as a Social Activity</strong></td>
<td>• Gets to know students</td>
<td>Wants students to value themselves and others</td>
</tr>
<tr>
<td></td>
<td>• Creates group activities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Uses and encourages humor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Uses inquiry and learning cycles to actively involve students</td>
<td></td>
</tr>
<tr>
<td><strong>Science as an Experiential Activity</strong></td>
<td></td>
<td>&quot;We like students to develop their own ideas.&quot;</td>
</tr>
<tr>
<td></td>
<td>• Provides activities that actively involve students</td>
<td>&quot;Majors and non-majors alike can really profit from original research.&quot;</td>
</tr>
</tbody>
</table>
Study guides. Study guides are one way for students to develop and construct their understanding of the science terms and concepts. Students practice making meaning through the text with the support of the study guides. The study guides are handouts Maxie provides for assigned readings that facilitate the topic under study. The study guides have questions that focus on applications of science concepts. For example, the questions might involve examining a graph for specific understanding of the meaning.

Maxie tells me why she uses the study guides for textbook readings:

I want them to be at a pretty high reading level. There is leeway that we can have as they learn to more critically look at information. This is why I give them study sheets as we look at the chapter because I believe it will give them more to look for. (T11, p. 6)

Maxie reports some mixed feelings about the study guides. Some students still don't read the chapter. In this excerpt she refers to some students who in an in-class activity failed to read the second paragraph in a section which elaborated on a definition and provided the necessary application information:

Sometimes they take the outline and that is all they look at. It is what you have keyed and so you are almost shooting yourself in the foot with some students. This is a guide but you [means students] need to read the entire chapter. It is a guide, but don't just look this up. Read everything because then you will see the second part of this definition is in the second paragraph. (T11, p. 13)

Maxie likes using study guides because she can ask "thoughtful questions" and "it's kind of like a treasure hunt, I think, a scavenger hunt. You're looking for those little gems and pieces." She tells me she likes to have questions about things "hidden in pictures" or in "the discussion parts of the diagrams" because students "have to hunt for them" (T12, p. 28). On the other hand, a disadvantage of the study guide is that it "is not hands on. You need to apply it" (T12, p. 40).
**Field notebook.** Maxie asks the students to purchase a graph paper field notebook for class notes, science vocabulary, and for diagrams and pictures. She wants them to be actively involved in class. The students are responsible for whatever happens in class and they might like to take notes on whatever happens in class. These might include notes written on the white board, questions they or other students ask, observations they make at the desert study site and on anything else they think might be connected to environmental ecology (FN, p. 7). She tells the students she sometimes creates test questions related to concepts they have worked on in class.

**Assessments and mini-tests.** Maxie assesses students in a number of ways. She records some of the group activities and some of them serve as a constant reassessment of her own actions. She tells me she is aware of what students are doing and not doing in the classroom and explains "It's a shame that they're still kind of driven by the test. They are driven by assessment" (T11, p. 12). Even so, she provides multiple opportunities for assessment. She assesses the group activities, the group projects, and the individual work of students. In an informal telephone conversation after the study was completed (C 9/19, p. 108) Maxie mentions the difficult dilemmas that grading imposes. The use of rubrics (see Appendix H for sample rubrics) helps her to establish a frame of reference for what she considers objective measures. There are times she likes being able to use subjective measures for students' creativeness. This allows her some leeway with students who need a little extra incentive.

Maxie is very much aware of and in tune with the needs of the students. Her actions indicate she constantly monitors what is happening with students. She has her
"antennae" out at all times listening to the "chatter" in the classroom to determine if students are on-task (C 1/25). For example, Maxie noticed one student, a non-native English speaker, was having difficulty on the mini-tests. Maxie suggested the student read other biology texts in the student's own language to understand the concepts.

Another student, with some physical disabilities, needed to have help and more time to complete the tests. This was arranged by having him take the test in another area with a person who could read the test for him and write the answers (FN, p. 26).

She uses seven mini-tests to see where the students are and to find out if she needs to do another learning cycle if students are having difficulty. Though she doesn't count the two lowest scores, she uses the mini-tests to respond to and question students and as an introduction to new material (FN, p. 26). The tests are open-book and open-note designed to be user-friendly, non-threatening, and challenging. Maxie also uses the mini-test as an extension or an elaboration of the learning cycle and as an advanced organizer.

She tells students "I don't ask you to regurgitate information. I might have several statements and I might ask you if it's an observation or inference. I might ask you to write some observations. Make sure you can apply these definitions" (FN, p. 24). Her emphasis is on application. Here she explains to me why she gives open book mini-tests:

A simple definition question will never get you at that interpretation level. That is why I give open book open note exams so that they know I don't want the mechanics of the test to interfere with their ability to show me how they can work with the material. (T11, p. 10)

**Mini-lectures and questions.** The questions and mini-lectures contribute to content literacy development and serve as a curricular resource in Maxie's classroom.

Maxie is constantly asking thinking questions. Thinking questions are questions that do
not have easy answers, they require further investigation, discussion, or research using additional resources. For example, during a mini-lecture on speciation and systematics she talks about how populations were identified. In "the old days we went by morphology." She explains "morph means shape and morphology means the study of shape" (FN, p. 74). She stops and poses a scenario for the groups and asks them to pretend that they are aliens visiting the planet. She says, "Look around the room. How many different species do you think aliens would believe are represented?" and tells them to find out if you are a "lumper [sic] or splitter" (FN, p. 74). She asks the groups to write the differences. She also wants to know if their group members agreed or disagreed with each other on the decision. Some groups agree and some disagree and Maxie tells them "Biologists struggle with this" (FN, p. 75). Maxie means for students to become actively involved through interesting questions. Maxie scatters thinking questions throughout her mini-lectures. In the following excerpt, Maxie justifies the mini-lectures and questions:

There are some topics that I also struggle with because the students have no background or no feeling for the topic. And you feel like you have to lay some kind of groundwork. . . . And for some of those topics, I feel I just have to do a little introduction, and I think that's ok doing a little introduction for them. . . . [O]nce I feel they have a little more under their belt, and especially if they know how to use study tools, they know how to use their book as a study aid . . . know how to find evidence, then I'm not so worried about introducing new topics. . . . That's why I spend so much time on what I call the technical objectives (see Appendix F, p. 6), because you take a little time to do the technical objectives, with simple introductory learning cycle and you create that skill, and then they can do a lot with that. Like Lacey doing the poster for another class. And that's--I see that as a long-term benefit. If we can give them the technical skill to find evidence for information, then we've gone a long way. (TI2, pp. 25-26)
Multiple text sources and computers. Maxie is very aware of textbook selection, she tells me, "Textbooks are a lot better now. Textbook selection is important." She explains why the textbook selection is important:

Textbooks have special inserts where they give you real life situations and they show you how these words go together. . . . I think you should choose a text book that does that. The student is not just reading the material but they are looking at these little inserts. (TI1, p. 12)

In addition to the textbooks students bring to class, Maxie provides a large two-tiered rolling cart of biology related texts books, journals, science magazines and nature books. The cart includes reading materials of different levels. She encourages students to look at more than one source, to go outside the classroom for internet searchers and to use the library. Even during in-class scenarios, students use the computer in the adjacent room to do a quick search on a specific topic. Some of the students took advantage of computer technology and experimented with sophisticated programs to create graphs and diagrams.

Science as a Social Activity Related to Curricular Resources

In Maxie's classroom, the social aspect of learning is almost always connected to some type of curricular resource. Her use of inquiry and learning cycles and projects involve students working together to produce some type of report or results. For example, she brought out meter sticks for students to measured their feet. Some students used the edge of a battered meter stick, some students sat as they measure feet, some stood on the meter stick and bent over to read it, some stood next to the meter stick. In this example, they were working together to measure without any directions. They had to decide how they would measure, the method, and the limits of the measuring instrument
through discussion and an experiential activity. The group discussion and the groups’ presentations brought home the reality of how each group's first measurements were quite different from the repeated measurements. The second time around they developed a closer approximation to accuracy (FN, pp. 14-16). The poster projects were an end component of student group inquiries and learning cycles. Students were challenged to create a visual representation of their inquiry project and they often worked together outside of class. Each curricular resource was socially constructed and extended.

**Science as an Experiential Activity Related to Curricular Resources**

Hands-on materials and curricular resources that incorporate experiential type activities are an important feature of Maxie's classroom. These may be viewed as tools (Vygotsky, 1986) chosen by the teacher and at times chosen by the students. For example, the students chose the topic and framed the questions. Inquiry, learning cycles, problem-solving exercises, poster projects and field trips are experiential activities related to curricular resources or tools to enhance learning. For example, at the concrete level, Maxie uses mini-field trips on campus as a means for students to explore and describe what they see, to develop science language, and to have students share information in their discussions and observations. Students also develop their own questions to study on the site as Maxie guides and monitors them through the process. In another example, the off campus field trip at the Desert Museum later in the semester extends the experiences. At the Desert Museum, Maxie provides groups with one of two types of worksheets. One has more structured questions and the other has open-ended questions for students to think and write about as they explore the site. The students write their findings on their
Summary of Maxie's Actions Related to Curricular Resources

Maxie uses a number of materials and resources in her course. These tools both concrete and abstract are part of the classroom dynamic. Table 4.5 summarizes the materials, resources or tools used in Maxie's classroom related to the three themes. The following curricular resources are part of Maxie's format in the biology classroom: study guides, field note books, varied assessments and mini-tests, mini-lectures and questions, computers, white board, index cards, text books, and a two-tier cart filled with books on biology related subjects. In addition, project end-products such as posters, group reports, the group mini-test, the desert study site and the field trip to the Desert Museum are considered as part of the curricular resources that contribute to the development of biology literacy in Maxie's classroom.

Summary

This chapter responds to the research question by discussing the important relationships in content literacy development in Maxie's version of a constructivist classroom. The case study data supports an alignment of teacher actions and teacher beliefs. Anders and Guzzetti's (1996) research provides the framework for discussing the instructional considerations that come together for constructivist instruction in content literacy development. Maxie's actions were first related to her own interests, expertise and interpretation of the concepts taught, next related to students' interests, prior knowledge, and questions, and then finally related to available curricular resources,
Table 4.5

Summary of Teacher Relationships, Actions, and Rationale (Resource Related)

<table>
<thead>
<tr>
<th>Relationship</th>
<th>Teacher Actions</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curricular/Resource Related</td>
<td>• Provides study guides goes over study guides; asks students if they have anything to add</td>
<td>Maxie believes that students best learn by doing what scientists do and that means thinking, listening, talking, reading, recording, reporting, writing, seeing relationships, and applying what’s learned to a new situation.</td>
</tr>
<tr>
<td></td>
<td>• Text books and book cart are resources</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Encourages use of computer and internet resources</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Uses mini-tests to support and advance science concepts</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Uses mini-lectures and &quot;thinking&quot; questions</td>
<td></td>
</tr>
<tr>
<td>Science as a Social Activity</td>
<td>• Facilitates group projects group tests</td>
<td>Maxie believes students need practice working together and in trying different roles in a group.</td>
</tr>
<tr>
<td></td>
<td>• Incorporates group activities</td>
<td></td>
</tr>
<tr>
<td>Science as an Experiential Activity</td>
<td>• Uses Desert study site, and field trips</td>
<td>Students need opportunities to try out new things, to practice, and to elaborate on the experiences.</td>
</tr>
<tr>
<td></td>
<td>• Advances learning through inquiry projects/learning cycles</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Integrates science literacy with poster projects</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Provides &quot;hands on&quot; materials</td>
<td></td>
</tr>
</tbody>
</table>
including community resources and field trips. Three conceptual themes emerged from the data: science as a language activity, science as a social activity, and science as an experiential activity. One of the most surprising findings to emerge from the data was how frequently Maxie incorporates the three activity areas into her classroom practice. These were listed in Table 4.2. The actions in all three areas reflect a dynamic classroom and the relationships that come together in the development of science content literacy in Maxie's constructivist classroom.
CHAPTER 5

STUDENTS' PERSPECTIVES IN BIOLOGY LITERACY DEVELOPMENT

We promote the idea that students construct personal meaning based on how they interpret their experience; students bring those interpretations with them to the classroom. (Anders & Guzzetti, 1996, p. 54)

The purpose of this chapter is to report the students' perspectives related to three considerations that come together for students' construction of meanings and beliefs about biology literacy development (see Figure 5.1). These three areas provide structure for the findings that emerged from the data. The three areas of student focus are listed below and depicted in Figure 5.1.

- What the Students Bring to the Course (interests, questions prior knowledge and experiences)
- What Students Do in the Course (actions they take and actions they perceive as effective)
- Tools Students Use in the Course (curricular resources, setting, multiple texts, computers, field trips)

The findings are divided into the same three sections that focus on the students' perceptions of the actions they take and actions they perceive as effective for biology literacy development. The three sections include the following: (a) students' profiles and histories as an indication of their background and experiences, i.e., what they brought to the classroom; (b) a section on what the students did in the classroom and what they believed to be effective teacher actions or influences; and (c) a section on the tools they used and the extent to which they believed the tools to be effective.
Research Questions Related to Students

The questions guiding my observations, interviews, and collection of artifacts are the following:

1. What actions did students take to learn biology literacy?

2. Specifically, what patterns and combinations of student actions, teacher influences, and use of materials did students believe to be effective for the development of biology literacy?

Review of Data Gathering and Analysis Procedures

These primary data sources were collected and analyzed to address the research questions: (a) in-depth interviews, (b) field notes, and (c) artifacts of student work such as
found in the "list of materials" (see Appendix D). On occasion, secondary data sources were used, such as the informal surveys. Initially, analysis of the data involved three readings. During each of these first three readings of the students' interviews and the field notes, I underlined words or ideas that seemed to stand out and made comments in the margins. Next, I experimented with several matrices to organize ideas related to the questions. The data were then numerically coded according to the three major conceptual considerations in Figure 5.1. The figure provided structure for the conceptual themes that emerged from the data. The data were re-read several times more and further refined and coded. Coding notations were established and items were lettered and numbered for use in referencing the supporting data (see Appendix E). The program NUD*IST was used to aid in the preliminary sorting of coded data. Appropriate matrices were finally selected to help organize the data references for each of the six students upon whom I focused to develop the case. The artifacts were used to provide support for what the students told me in the interviews and to demonstrate samples of students' coursework.

Findings Related to What Students Bring to the Classroom

Students' Profiles

The six students selected for study provide a number of perspectives and they generally represent the variety of student characteristics often seen in a community college classroom. The variety of characteristics noted at the community college level were representative of the classroom observed in the study. I sought variety and differences when I selected the six student participants out of the class of 27 students. The information gathered and used to select the participants served two purposes. First, it
provided background information of their experiences, and second, it made more likely the selection of a representative sample of students. The selection of four female and two male students represented the female to male ratio of the total class. The six students differ from each other in terms of their ages, prior experiences in science, and ethnic backgrounds.

Students’ mini-test scores suggest a variety of achievement levels. Test scores on the first and second mini-tests were used in the selection process. The mini-tests were teacher-constructed tests given every two weeks on course content and used for grading purposes. The two tests differed in content; the first test included more introductory material and the second covered more detailed information and applications of what was covered in class. The scores tended to drop on the second test, possibly because the content was a little more difficult (see Table 5.1). Table 5.1 depicts the students' pseudonyms and codes along with the test scores for the first and second mini-test. The range of mini-test scores seems to indicate variety in the students. The table shows Amy and Ron in the high range, Denise and Scott in the middle range, and Maria and Lacey appear to be in a somewhat lower range.

At the beginning of the semester, students wrote their predicted grade on the consent form (see Appendix G). During the semester and again at the end of the semester I asked the students the approximate number of hours they spent studying biology. Their actual final grades were then recorded at the end of the semester (see Table 5.2). Table 5.2 summarizes some of the findings about the selected students and shows their age,
Table 5.1

Students' First and Second Mini-Test Scores on Course Content

<table>
<thead>
<tr>
<th>Name/ Code</th>
<th>First Mini-test Score</th>
<th>Percentage</th>
<th>Second Mini-test Score</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amy (S1)</td>
<td>49/50</td>
<td>98 %</td>
<td>48/50</td>
<td>96%</td>
</tr>
<tr>
<td>Denise (S2)</td>
<td>47/50</td>
<td>94 %</td>
<td>41/50</td>
<td>81%</td>
</tr>
<tr>
<td>Maria (S3)</td>
<td>35/50</td>
<td>70 %</td>
<td>33/50</td>
<td>66 %</td>
</tr>
<tr>
<td>Lacey (S4)</td>
<td>40/50</td>
<td>80%</td>
<td>31.5/50</td>
<td>63 %</td>
</tr>
<tr>
<td>Scott (S5)</td>
<td>44/50</td>
<td>88 %</td>
<td>33.5/50</td>
<td>67 %</td>
</tr>
<tr>
<td>Ron (S6)</td>
<td>46/50</td>
<td>92%</td>
<td>43.5/50</td>
<td>92%</td>
</tr>
</tbody>
</table>

Table 5.2

Student Variety Profile

<table>
<thead>
<tr>
<th>NAME</th>
<th>AGE</th>
<th>BACKGROUND</th>
<th>STUDY HR/WK</th>
<th>PREDICTED GRADE</th>
<th>FINAL GRADE</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMY</td>
<td>36</td>
<td>ANGLO</td>
<td>7-8</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>DENISE</td>
<td>17</td>
<td>ANGLO</td>
<td>4-8</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>MARIA</td>
<td>32</td>
<td>HISPANIC</td>
<td>15-18</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>LACEY</td>
<td>41</td>
<td>NAT. AM.</td>
<td>6-8</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>SCOTT</td>
<td>19</td>
<td>ANGLO</td>
<td>5</td>
<td>A or B</td>
<td>C</td>
</tr>
<tr>
<td>RON</td>
<td>25</td>
<td>ANGLO</td>
<td>4-5</td>
<td>A</td>
<td>A</td>
</tr>
</tbody>
</table>
ethnicity, number of hours a week they reported spending outside of class on biology, and their predicted grade contrasted with the final grade. Four of the students accurately predicted their final course grade and two of the students differed by one letter grade.

In addition to the test scores and grade scores, I asked all of the students to complete the Reading and Study Skills Survey and a Reading Interest Inventory (Bradley, 1982). The students' survey (see Appendix D) responses suggest that the students have different areas of strengths in their reading and study strategies. Table 5.3 displays the scores for each section category. The two highest areas for each student are underlined. These appear to be areas of strength for that particular student. For example, Ron's reported apparent strengths are in location and memory strategies. Amy's reported strong areas are in vocabulary strategies and reading strategies. Maria, the second language learner, reported the use of fewer strategies when compared to the other five students. However, her areas of self-reported strengths appear to be in survey strategies and reading strategies.

**What Students Bring: A History**

A brief review of the students' histories demonstrates further variability among the students. For example, two of the students, Lacey, 41, and Maria, 36, report negative prior experiences with science courses and a tendency to avoid them. Ron, 25, says that he enjoys the outdoors but does not particularly gravitate to science courses. Amy, 36, a seasoned student with an advanced degree, has limited background knowledge in biology but a high degree of interest. Amy holds a degree in electrical computer engineering,
although she reports that her science background is not as strong as desires. Denise, 17, the youngest female student, is a biology major and is studying to be a marine biologist.

Table 5.3

<table>
<thead>
<tr>
<th>NAME</th>
<th>Location Strategies</th>
<th>Survey Strategies</th>
<th>Survey Processing</th>
<th>Reading Strategies</th>
<th>Memory Strategies</th>
<th>Vocabulary Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amy</td>
<td>11/20</td>
<td>28/40</td>
<td>32/40</td>
<td>27/30</td>
<td>8/20</td>
<td>46/50</td>
</tr>
<tr>
<td>Denise</td>
<td>15/20</td>
<td>24/40</td>
<td>24/40</td>
<td>21/30</td>
<td>14/20</td>
<td>35/50</td>
</tr>
<tr>
<td>Maria</td>
<td>9/20</td>
<td>23/40</td>
<td>19/40</td>
<td>17/30</td>
<td>9/20</td>
<td>24/50</td>
</tr>
<tr>
<td>Lacey</td>
<td>17/20</td>
<td>34/40</td>
<td>28/40</td>
<td>20/30</td>
<td>17/20</td>
<td>35/50</td>
</tr>
<tr>
<td>Scott</td>
<td>13/20</td>
<td>20/40</td>
<td>28/40</td>
<td>18/30</td>
<td>16/20</td>
<td>31/50</td>
</tr>
<tr>
<td>Ron</td>
<td>19/20</td>
<td>29/40</td>
<td>33/40</td>
<td>23/30</td>
<td>18/20</td>
<td>39/50</td>
</tr>
</tbody>
</table>

She is highly interested in science and claims learning science comes easy for her. Scott, at age 19 and among the youngest male students, reports a number of experiences with laboratory sciences. Scott repeatedly mentions the importance of hands-on learning.

In this chapter I use a coding notation to reference direct quotation of data (see Appendix E). These appear at the end of a quote. They usually refer to the student (S), the source (interview 1, 2, 3), and a page number of the original data source. For example, the letters "FN" refers to field notes and "I" refers to an interview. The coding notations serve as a useful organization and data management tool. The quoted examples have been edited in small ways to make reading easier without changing the meaning or intent of the person quoted.
Histories from Students' Interviews

In this section, I use students' interviews and reading interest surveys to further elaborate on the students' histories and what they bring to the classroom. In the first interview, the Reading Interest Inventory (Bradley, 1982) serves as an icebreaker and as a frame of reference for getting at literacy and what it means for each of the students. It gives me an opportunity to put the student at ease about the questions and about my researcher role. It also provides a means to chat informally about their early reading experiences at home and in school, and about the types of reading they enjoy. I also ask questions about what being literate means to them, about science literacy, and about biology literacy to explore the students' current understandings about literacy. As a comparison, I provide some sample definitions of literacy from a member of the scientific community.

Amy

Amy's interest in the environment stems from her role as a volunteer naturalist. She gives one-hour tours and lessons to area school children and tells me, "It has been a real kick, a lot of fun." Her presence in the biology course is unexpected in that she has worked as a computer engineer, and she already holds a master degree in computer engineering.

During the first interview, Amy provides some background history and tells me about her reading experiences. Amy informs me that she "read a lot as a kid," and she continues to be an avid reader. She was one of four children in her family. She told me
about her literacy experiences, as she was growing up and her alternative conception about science in school.

AMY: You mean what kinds of things did I read? I read a lot as a kid. By the time I was old enough to remember--I've never forgotten all the books. I read a lot and remembered all the stories. I used to read fiction. I do remember that I told my mom that I don't like science and she laughed at me because I was always the one of all the kids that would be out doing things, scientific things. I collected tadpoles and frogs. I think that was because in school we did a lot of book reports and stuff. We had a discussion and later I realized that I like science a lot. I was glad she had laughed at me and pointed out how wrong I was. . . . I didn't like science at school and she said that doesn't mean you don't like science it just means you don't like science in school. (S1 II, p. 1)

Amy also explains why she is taking this particular course.

AMY: I moved here and worked full time for eight years and after I had my kids I decided to stay home with them and my second kid is in preschool now and he will be kindergarten next year so right now I have time to take classes. . . . I am kind of looking around to decide if I want to do that and I just found that I am really interested in biology but yet I didn't have the background classes. So if I wanted to do something more biologically based I would take the biology classes so that is why I am here and in this particular class. I found that biology is a subject that I am passionate about. This is such a sensitive environment (means the desert area) I guess. (S1 II, p. 3)

We chatted about books and I loaned her my copy of Barbara Kingsolver's book, The Poisonwood Bible (1998), when I found out she was on a waiting list at the public library. She was the only student in the study who reported reading for pleasure during the semester.

Amy's educational background reveals numerous experiences. She explains that "school in general was pretty easy for me. I don't remember studying at all till I got to college." She admits "Luckily, I had the skills to study when I needed to--otherwise I would be completely lost." Amy tells me her science background is not adequate and that she "should have taken physics or biology two." She reports that she "didn't find
biology all that exciting" which she thinks is "funny," because she "loves biology now."

She expresses confidence as she reminisces:

AMY: I just think ... it was the idea that we did a lot of dissecting of frogs, and it just wasn't as exciting as how I see biology now. It is a much wider subject. I think I could have taken more science classes and been relatively good. (SI II, p. 3)

Amy brings into the classroom a high degree of interest in biology and extensive successful advanced educational experiences. For her, school comes easy, and she appears very competent and confident in her abilities.

Amy's understandings of literacy. Here Amy explains what "being literate"

means in terms of language and concepts:

AMY: Being literate means ... being able to read the written word. You know people are literate or illiterate. Whether they can read or not. Read and understand---not just read but understand it as well. You can go beyond that and say can you read complex material and be able to understand it well because I think some people can read well enough but something very complex is hard for them to understand the underlying meaning of what's going on other than just the words. (SI II, p. 1)

Amy perceives science literacy as confusing to some people especially because the media report on conflicting scientific investigations. "They really think that scientists are changing their mind ... [on a particular research study] ... but, no, they are doing more investigation, and they are finding things that are different. It doesn't mean that they have changed their mind" (SI II, p. 5). Amy explains science literacy as being "able to read scientific reports" and being able "to glean useful information." She faults scientists and engineers for being "notoriously bad writers." She explains, "They write to impress instead of writing to enlighten" and "They sometimes use highfalutin' language too that might boil down to something simpler ..." (SI II, p. 5). She believes science
literacy is "not just reading about science" but about being "able to read scientific reports." Then she tells me "There is kind of a knack to that, I think" (S1 II, p. 5).

Denise

At 17, Denise is the youngest student in the study. Denise is a biology major and wants to be a marine biologist. She is concurrently enrolled in a marine biology course. She is a full-time student and works 20 to 22 hours a week.

In the first interview she talks about her reading experiences growing up and about her early experiences with science and her enthusiasm for learning science.

DENISE: I always read a lot of stuff when I was growing up. I have always been a little bookworm. I have a couple of bookshelves just full of books that I like looking at. I don't think I have read them all but I always like to read. I was always reading going through high school. Mom was always pushing me to read more and more so I just got into reading more and learning more.

Denise talks about her interest and ease in learning science. She has a high level of interest in science and in particular, marine biology. Her mother, a teacher, home schooled her. Denise reports that her mother has strong background in English and math and a weak background in science. Nonetheless, she managed to provide Denise with a number of experiences in environmental science and marine biology. Here she shares her home schooling experiences about science:

DENISE: I really liked science. I grasped it really fast. I would rather spend 5 hours on science than 20 minutes on something else. . . . I liked marine biology. We had them (refers to people from Sea Camp who came all the way to Tucson to teach home schooled students about marine animals) come over a lot so I went to every single one even if I had been to that one I would do it again to get it. I never did chemistry or physics I don't think we had the resources. We never had any of the labs or anything. Mom didn't have much background in sciences and her background is mostly math and English. Mom figured if I got a lot of math, it would be really helpful in science. We did a lot of environmental science. I
remember going out and getting leaves and making sketches of what the veins inside would look like. (S2 II, p. 3)

Denise talks about hands-on experience and makes the following connection to language: her home schooled science activities in biology were experiential in nature. She explains, "It was always easier to have hands-on learning. We did the dissecting ourselves. You could—like—touch the parts of the fish. You could see that one of the sharks had babies inside it" (S2 II, p. 3). She emphasizes, "You have first-hand knowledge instead of just reading it. You see it and feel it. I think it makes you remember it a lot better. You use your senses to perceive it. The hands-on thing is really helpful" (S2 II, p. 4). Denise explains the follow-up process her mother used, "... [T]o make sure I understood, my mom would always make me write a little report right away. Write a one page report on what you just learned. ... You have to explain it step by step. It really makes you remember things" (S2 II, p. 4).

**Denise's understandings of literacy.** Denise explains being literate in terms of a language activity beyond reading. For Denise, being literate means "Well-educated ... I don't think that is really it. It's like some people don't like to read. ... I don't think that just reading is a ... [criterion for] whether you are literate or not" (S2 II, p. 3).

Denise defines science literacy as "... Just knowing—having more of a knowledge of science—more than basic facts. A lot of people have basic knowledge as to what science is but they don't really know until they ... take a course in science or something. Understanding the terms—understand what they do" (S2 II, p. 4). For Denise, science literacy is knowing concepts and understanding the terms.
Denise’s contribution provided an important perspective to the study. She was the youngest student, she had been home-schooled, and she was a biology major. She was very surprised and pleased by the way the biology class progressed. In her first exposure to public schooling she had expected a lecture class.

Maria

Maria grew up in Mexico and moved to the United States when she was 12. Her early years were spent in a border town between Mexico and the United States. She says she reads very little, only required textbooks and sometimes magazines. At first, she did not want to learn English in school because she thought she would be returning to Mexico. Maria reports that she has had negative experiences with learning English and with school science. She is taking this class because it is required for her program. Her goal is to transfer to the university to become a bilingual teacher.

During the first interview Maria shares some of her family history about reading and her early years of schooling. Her parents didn’t encourage her to read.

MARIAM: They never read to us when we were little and it is important because now with my children I read to them and there is a closeness between the children and mother. I like it. I don’t blame my parents because they didn’t do that to me. But it would’ve been nice. (S3 II, p. 1)

Maria’s schooling was in Spanish and here she shares some of the difficult experiences she remembers as well as some lingering fears:

MARIAM: Schooling was in Spanish. I never thought I was going to learn English. I thought we were going to stay there and finish. ‘Cause I never thought that we were gonna come to the United States. I didn’t want to come from Mexico because all my friends were over there and I missed them. So, when I came here I said, “I am not going to learn English” because I was mad because we moved. But I know that I made a mistake. I was 12 and you know at that age I was very embarrassed to pronounce something... in English. ... I was kind of
embarrassed. It was hard. You’re used to your native language and at the same
time I was experiencing a new language different from my own—very different
from my own. . . . I am still afraid. I don’t know why because nobody is perfect.
I know, but my husband, he tells me, “If they laugh at you, oh well, everybody
makes mistakes.” But I don’t know why I have that fear in myself. (S3 II, p. 1)

Maria reports that learning in science is not easy for her. Maria considers her past
negative experiences with English and with school science as she shares views of herself
as a learner and explains the need for support with her learning:

MARIA: I’m a very slow learner sometimes it takes reading and have somebody
read it to me and then explain it. I know more or less what’s going on but like for
[sic] I think they have to show me this is what they are talking about--then I get a
view about what is going on. (S3 II, p. 4)

Maria tells me she has very little memory of science courses. The two courses
she remembers taking were a health course in ninth grade and a general science course in
seventh grade. She shares one negative experience of science from her seventh grade
course:

MARIA: I remember I took one class in seventh . . . we had to do an experiment
on a pig. We had to open it they had to put chemicals on it so the pig wouldn’t
. . . [decompose]. It was a horrible experience, it was horrible. (S3 II, p. 2)

Maria wrote a personal note to me on her survey. She wanted me to know that
she needs a lot of help:

MARIA WROTE: Pat, with my answers in this survey you would think
that I’m a negative person. But I’m not. I’m learning from my own mistakes.
I know if I practice my daily routine as student I would improve a lot more.
I know I need a lot of help. (S3 S 1/26)

Maria’s understanding of literacy. Maria, bilingual in Spanish and English, has an
expanded view of what being literate means. She infers an understanding of being
literate to include language, social interaction, and experiential activity. She includes thinking, reading, writing, and speaking as language activities.

MARIA: Learning. Being able to express your thoughts. Sometimes I think that we are not expressing ourselves when we talk, but there are other times that you can express yourself in writing because you say everything that you want to. Sometimes I don’t express myself very well in talking. I think it is in both. Sometimes in writing and sometimes in talking . . . I feel comfortable reading in Spanish. I am not a reading person . . . I know that reading is gonna help my vocabulary. I don’t know why I don’t read too much. I read like for the classes. I read because I have to read but other than that, if I don’t have to, I won’t read. (S3 I1, p. 2)

Maria relates first her definition of biology literacy, "I think it's like an introduction to the environment" (S3 I1, p. 3). Maria's sense of biology literacy is a result of reading the introduction of the Environmental Science textbook. Her ready response indicates she has read the text to gain an understanding of what the course is about. Her newly acquired knowledge contrasts sharply with her efforts to understand the new terminology and the science concepts while building on her English. Next, she tells me of her difficulty in understanding the first assignment:

MARIA: . . . [I]t was so funny because at the beginning, the first word that she [Maxie] gave us to look for . . . was observation. So I went through the dictionary and I looked at it and I felt she meant to search for the dictionary . . . but [she meant] the glossary. . . . On Wednesday when we came back, I felt so stupid because the meaning I found for observation - it wasn't what she was looking for. So . . . I am going to look in the glossary . . . now this is what I have to do. (S3 I1, p. 3)

Even though she gave an accurate and succinct definition, Maria's approach to biology literacy makes evident a level of frustration often expressed by second language learners as they try to learn unfamiliar content (Collier, 1995). Maria expresses
frustration as she tries to navigate through a course of new vocabulary, materials, and expectations.

Lacey

Lacey is a full-time student and is taking the course because it is required for her program. She hopes to transfer to the university in the near future. She grew up in a mining town in Arizona where her father did not believe in renting a company house; her parents owned their home. She relates her childhood memories of growing up in a large family and some of her reading experiences:

Lacey: I first have to tell you that I am from a family of 11 children. I have five brothers and five sisters. But my mom always found time to read to us and we always had a place and time to do our homework at home, plus our chores, plus work it around where we would be there to help out with the dinner and all sit down and eat dinner together every day. She really didn't worry about us not having enough to read during the school year being that we went to Catholic school. And of course you always have homework and there is never a day without homework and in the summer time she always enrolled us in the summer reading program. (S4 II, p. 1)

Lacey explained that some of her early motivation to do well in school was to some extent due to her placement in the family: "I am the eighth child so I'm kind of down at the bottom." Some of the motivation is also due to an early brush with competition in grade school, and an awareness of racism.

Lacey: I remember this one boy, and this was my first experience with competition, and he always wanted to know what grade I received in this test or that test. So it was, oh well I got one more right than you or, you did better than I did type of thing. . . . So I really wanted to do well so that they wouldn't (means her parents) have to worry about me. So that was another incentive to do well. Going back to this competition thing . . . it was like just as long as you do well and you know that you do the best that you can, you know, that should count for something. But he kept asking, asking, asking so I thought and he would make fun of me if I got one less like if he got a 99 and I got a 98. Oh I did better than you. So I got tired of this. . . . So that was another incentive and I think too
because of my age and stuff. Racism was still going on. . . . I mean you still have it. And being a Native American, you always heard these sayings about stupid Indian and we were not and that was another point I needed to prove, I guess. (S4 II, p. 4)

Lacey has had some rather unpleasant experiences with previous science classes in high school and has put off taking science classes at the community college as long as possible. Here she explains her reasons for avoiding science classes until the very last before transferring to a four-year college:

LACEY: You read the book, you memorized it. You work with a lab partner and like I said, they always set up where it was boy/girl and I didn’t feel comfortable in that situation. It was—just hurry and get this over with—I wish this class would hurry and end. I would rather face tests every class because I didn’t have to work with anybody. And, I would be able to just do my work. Test me out—whatever—let me get out of here. It was very unpleasant.

I asked her if the science courses she took were easy or difficult. Her response suggests some unresolved gender issues are also a possible source for Lacey’s negative beliefs about science courses:

LACEY: Difficult. I did well in math courses, and I was told that science courses should come just as easy, but I know that growing up in grade schools and in junior high, I would hear these stories from my brothers and sisters that you know you had to dissect frogs and do this and do that, and I think that was when I started painting a negative picture of science because . . . how can they do this to this animal? . . . In my mind I was thinking that this frog was still alive. So when it came to high school I took the sciences that I had to take. Physical science, biology and chemistry was what I had to take, and I didn’t enjoy any of them. . . . Part of the reason was because you were paired up with a lab partner, and I never cared for my lab partners because it had to be girl and boy. And I was real shy in high school, and I didn’t speak unless spoken to, and I didn’t feel comfortable working with a boy. If it had been a girl, I think that probably would have helped out too but I wasn’t one to question the teacher or ask if it is okay if I can have a different partner so I just dealt with it. (S4 II, p. 4)

Lacey’s understanding of literacy. Lacey explains being literate as "... just being able to understand another person - making a connection and then being able to read and
understand what you are reading" (S4 II p. 4). Lacey's definition of science literacy suggests a holistic view. She explains: "I think understanding the effects—relationships that plants, animals, the weather and how it all brings them together" (S4 II, p. 6). She elaborates on her definition by discussing where she believes science is headed, "You know—like for astronomy or any of the other fields of science would have to deal with space and what it holds for the future for us" (S4 II, p. 6). Lacey informs me of her mistrust of science because of the "outdated stuff" on the news, but she pays attention so that she can explain what she knows to others when they ask her opinion (S4 II, p. 6). In her definition of biology she refers to "how things work and how things connect to each other" (S4 II, pp. 5-6).

Scott

Scott is one of the youngest male students and seemed to be very interested in biology. Scott also has had some interesting background experiences related to biology. His farm experiences provided him with a connection to biology.

SCOTT: I spent a lot of time on a farm. I have seen a lot of real life things growing up. We would irrigate, fertilize and you pretty much get the feel for different animals and there is a ton of different animals out there. We had javelinas, deer, mountain lions, cattle, sheep, pigs all kinds of animals. We did vaccinations and everything, branding all that fun stuff. Oh with biology I've seen a lot of things. Probably a lot of people haven't had to do with biology. With all the cattle and all, we saw birthing, how they are happy, what makes them satisfied, how much food they need, how much space they need. (S5 II, p. 3)

Scott also was one of the few students who seemed to have had a number of related courses in high school. Scott seemed to be confident about his knowledge and ability, which suggested he might also contribute to the leadership dynamic of the class.
In the following excerpt he named the courses he took and emphasized the importance of experience:

In high school ABC, Applied BioChemistry class, it was chemistry and biology combined - that course was pretty good. I thought it wasn't really difficult but I feel I learned quite a bit in it. Besides the basic functions of an organism, I learned a little bit about protozoa and small organisms. Hands on learning and bookwork--it was a combination and I found that most effective--did a lot of labs. We didn't use the computer in science. We never had to research anything--a lot of experiences. (S5 I, p. 2)

For Scott, experiences are a very important feature of his learning process.

Scott relates his formal education experiences in science and indicates, for the most part, science classes were easy, "I found high school biology to be easy. Basically, a lot of science classes were easy in high school. Chemistry was the one that was hard" (S5 I, p. 2). Here he explains the difficulty and mentions "hands-on" three times:

SCOTT: It was the memorization. It wasn't like a science class I had. It was more bookwork than actual hands-on. And for me, I need hands-on a little bit. I need to actually do it not just sit there and read out of a book and try to memorize everything. It just doesn't work for me. I can do it but I can learn better hands-on. (S5 I, p. 3)

Scott's understanding of literacy. Scott's definition of being literate incorporates reading, understanding, and relating to other people. His view on reading suggests a skills-based belief about learning to read and an idea that meaning is important. "Being literate is being able to read clearly and understand what you are reading . . . and to be able to relate to other people. If you can read and sound out words, but you don't get anything from it, you are not literate" (S5 I, p. 2). Scott makes language, social, and experiential connections with being literate.
For Scott, science literacy "means not just being able to read but being able to understand scientific things like: How do you use a ruler or what ever apparatus you are using for a lab?" He qualifies the definition with a need for knowledge, "You have to know basic things like what temperature water boils at. You have to have a pretty good background to be a pretty good biologist" (S5 I1, p. 4). Scott's definition reflects a desire to understand how things work: "I think that would be more along the lines of living organisms even protozoa the circulatory system all the different systems of an organism-- even simple one. Everything living--being able to understand how they work as much as we can understand them" (S5 I1, p. 4).

Ron

During the first interview Ron talked about his background experiences, his current experiences in the service, and the importance of memorization. An only child of divorced parents, he remembers his strict parents, a disciplined school environment and compares that to learning in the Air Force:

RON: I went to a parochial school from kindergarten through my freshman year of high school so a lot of it was memorization - we had to do that -it's the biggest thing I remember. Just reading the chapters from the bible that got me into my study habits. . . . To this day I still say that is where I got a lot of my study habits from. The memorization--we had to know so many verses out of the Bible and we had to know hymns. And I think that is where I get it from and then the military--especially Air Force it's probably 95% school work at least the first year and a half that you are in. Whereas in the Army or the Marines you are in the field a lot. So my study habits kind of carried over into there and it was either you pass or fail so there was a lot riding on whether or not you passed the tests and--that is all three Air Force groups--it is either pass or fail go or no go as they call it. (S6 I1, p. 2)
Ron reflected on past experiences and attitudes about school and learning. He
told me how he changed as a result of being in the Air Force. He also compared his life
as a student in high school with his experiences in the Air Force.

RON: I guess I wasn’t the best. I was just there getting through it. I wasn’t
interested in it in high school I was more interested in work. I was a horse shoer
for a while and I worked . . . bussing tables so I always worked and I think that is
why I just took the bare minimum. I think I can say that about a lot of colleagues
in high school. I wasn’t that good of a learner I was just there to get through it.
. . . I moved out when I was 18 . . . I just look back on it and think I should have
stuck with it. I didn’t have that stick-to-itiveness that I do now. My life
experiences have definitely helped me. I never thought I’d get over the--I can’t
attitude--and that has definitely changed. I was in basic training . . . It wasn’t the
roughest basic training. It’s not like the Air Force is a piece of cake but yea they
just instilled this thing that you can’t fail and you can do anything that you want.
They also teach you if you do fail . . . don’t get discouraged. You know you learn
from it. It’s that “adapt and overcome theory” and just don’t do it again. I can
see I am much more confident in my classes in just about everything I do. I
definitely learned through the Air Force. I was a lost soul out of high school
didn’t know what I wanted to do. (S611, p. 2)

Ron brought yet another view to the study. He came from a disciplined and
regimented background.

Ron is working full-time in the Air Force and taking a full-course load at the
community college. He explains to me that he is taking the course because he needs a
science credit, and that the course fits his schedule. I ask him about his prior experiences
in science, and Ron tells me that his science classes were easy in high school.

RON: You know they were pretty easy. I kind of coasted through high school . . .
I remember taking a biology class. We had to dissect a worm and that was about
as complicated as it got. I had to learn the Table of Elements, but I know there
were more difficult science courses than that offered . . . (S611, p. 2)

Ron’s understanding of literacy. Ron’s explanation is in practical terms: “Being
literate means it plays a role in everyday life to be able to read something and
comprehend it or to be able to decipher what you read. The first thing that pops into my mind is not being able to read the newspaper—what’s the news—what is going on around you” (S6 I, p. 1). Ron's view of the term "being literate" seems to refer to language and experiential activity.

Ron relates a personal experience that surfaces when I ask "What does science literacy mean to you?" Ron makes personal connections to his own health and to the health of his grandfather.

RON: The first thing that popped into my mind was knowing your own body, especially, knowing how to take care of yourself. Especially my age bracket 25-26 sexually active and ... is all these worries--AIDS. But even the other things--hepatitis and all the venereal diseases, and then cancer is a big thing. I just lost my grandfather about a year ago. He had kidney cancer . . . he worked for a beer distributor here in town. A lot of my grandfathers' friends worked in the mines in Bisbee, and they had all kinds of problems. And these guys were 40 and 45 years old dying of cancer and they had a lot of respiratory problems. (S6 I, p. 3)

When I ask Ron to tell me how he would explain biology literacy to someone who doesn't know, he says, "You have to have [a specific] . . . kind of vocabulary [about] . . . how things develop. I think biology literacy is being able to carry on a conversation about something in biology--have some kind of background" (S6 I, p. 3). Ron seems to understand that biology is a field with its own concepts and language.

Summary of the Findings Related to What Students Bring to the Classroom

The differences in each of the six students in the bounded case study contribute to understanding the classroom dynamic of content literacy development at the community college. The findings indicate that what the six case students bring to the classroom are varied histories of experiences and understandings about literacy. The students differ from each other in terms of their ages, prior experiences in science, and ethnic
backgrounds. Their first two biology content mini-test scores suggest some differences in how they might do in the course. The data on the first and second mini-test scores seem to indicate a stratified student sample, with Amy and Ron on the high range, Denise and Scott in the middle range, and Maria and Lacey in a somewhat lower range. The hours per week students report spending on studying varies. In addition, four students predicted grades match their final grades; two of the students' final grades differ by one letter grade. Students' responses to the Reading and Study Skills Survey (Bradley, 1982) seem to suggest that students have different areas of strengths in their reading and study strategies. The six students' educational experiences differ. Denise, Scott, and Amy report a high degree of interest and fairly positive school experiences about learning science. Lacey, Maria, and Ron report some negative past experiences in science courses.

And finally, students' understandings of what being literate means, about science literacy, and about biology literacy vary. Amy explains science literacy as being "able to read scientific reports" and "being able to glean useful information." For Denise, science literacy is knowing the concepts and understanding the terms. Maria's definition comes from her understanding of the beginning pages of the textbook: "I think it's like an introduction to the environment." For Scott, science literacy "means not just being able to read, but being able to understand scientific things." In addition, his elaborated version reflects a desire to know how things work. Ron believes "... You have to have [a specific] ... kind of vocabulary [about]... how things develop."
Discussion

Great differences between students present a challenge all teachers need to consider. Some educators try to ignore these differences and treat students as if they were a “blank slate” or a “savings account” into which information might be “banked” (e.g., Freire, 1993; Watson, 1924). In contrast, educators, who identify themselves with constructivist theories of learning, recognize that student differences influence what is learned—and it, therefore, behooves the teacher to create an instructional context whereby prior knowledge and experience can be used as a basis for new learning or can be challenged and changed if it is unconventional or inaccurate knowledge. Constructivist teachers help each other to accommodate these differences by sharing experiences and practices. As the findings presented in this chapter unfold, we will learn more about how these differences are accommodated.

Findings Related to What Students Do in the Classroom

In this section, I discuss the students’ perspectives in relation to what they did in the classroom. This is the second consideration in the framework (Figure 5.1) that relates to students’ construction of meaning and beliefs about the effectiveness of content literacy development. The six student members of the bounded case study provide dramatic examples of their perspectives as a group. Teacher-initiated actions that students believe effective for biology literacy development or that they perceive in some way helpful to their understanding emerged from the data. I describe these emergent themes in Table 5.4 and in the discussions surrounding the themes. Students' interviews and the end of semester surveys provide the data presented in Table 5.5.
Table 5.4

Themes and Descriptions of Perceived Effective Teacher Actions

<table>
<thead>
<tr>
<th>Theme</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>• involves students</td>
<td>Refers to the types of classroom practices that engage students in active and action-oriented events such as group discussions, projects, research, questions, problem solving, group mini-exam, researching alternative text resources, presenting and listening to oral presentations.</td>
</tr>
<tr>
<td>- groups</td>
<td></td>
</tr>
<tr>
<td>- hands-on</td>
<td></td>
</tr>
<tr>
<td>- discussion</td>
<td></td>
</tr>
<tr>
<td>• relates examples, experiences, and stories</td>
<td>Refers to the teacher action of providing additional information to inspire interest, to make a concept clearer, or to demonstrate how a process can be improved.</td>
</tr>
<tr>
<td>• exhibits expertise</td>
<td>Reference to students recognition of the teacher's expertise in biology through her knowledge and actions.</td>
</tr>
<tr>
<td>• relaxed atmosphere</td>
<td>Refers to student recognition of a relaxed classroom climate as a good place to learn.</td>
</tr>
<tr>
<td>• facilitates/coaches</td>
<td>Students reflect an awareness of the teacher's supporting role in the classroom.</td>
</tr>
<tr>
<td>• credits creativity</td>
<td>Refers to an appreciation of the teacher's practice of giving additional credit for creative work.</td>
</tr>
</tbody>
</table>

Table 5.5 shows students' perceived themes of effective teacher actions for the development of biology literacy. The themes are scored numerically from 0 to 3 with 3 indicating the theme most emphasized by the student as an effective teacher action.
Table 5.5

Students' Perceptions of Effective Teacher Actions in the Development of Biology Literacy Rated According to Student Emphasis in Interviews and Surveys

<table>
<thead>
<tr>
<th>Theme (teacher action)</th>
<th>Ron</th>
<th>Maria</th>
<th>Scott</th>
<th>Lacey</th>
<th>Amy</th>
<th>Denise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Involves Students</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Relates Examples</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Exhibits Expertise</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Relaxed Atmosphere</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Facilitates/Coaches</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Credits Creativity</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 5.2, Students' perceptions of effective teacher actions in the development of biology, is a visual representation depicting students' perceived effective teacher actions in the foreground with stacked representations of the student emphasis. The students' names are arranged in this order to show their different emphases. These were rated 0 to 3 based on what students wrote in the surveys and what they talked about in the interviews. A 0 on the scale means the particular student did not mention the particular action. A 3 on the scale, the highest rating for a particular student, means the student emphasized the particular action. The most prominent category for the six students is "involves students." The least prominent category is "credits creativity." Figure 5.2 presents data from the summary tables for each student and compares the students' perceptions of effective teacher actions in the bounded case study. It is a graphic
Figure 5.2. Students' perceptions of effective teacher actions in the development of biology literacy.
representation of Table 5.5. Tables 5.4 and 5.5, and Figure 5.2 suggest that a variety of teacher actions are perceived effective by the students.

**Major Theme: Teacher Involves Students**

The category "involves students" refers to the types of classroom practices that engage students in active and action-oriented events such as group discussions projects, research, questions, problem solving, a group mini-exam, researching alternative text resources, presenting and listening to oral presentations. These were common occurrences in Maxie's classroom and students often refer to them as group activities and hands-on. I discuss these as the more prominent sub-categories of "involves students."

**Involves Students Through Groups**

One of the more frequent references in the interviews under this category is the subject of groups and group actions. Groups are an important component of Maxie's classroom practice and they are one way in which science is viewed as a social activity in the development of biology literacy. (See chapter 4 and science as a social activity.) The groups changed membership periodically and the students talked about groups in their interviews. A comparison of the case students and with the rest of the class reveals positive reactions to this particular practice of involving students in group actions. Interpretations of the six students' responses to the end of the semester survey and interviews are the basis for the finding discussed below.

The end of the semester written survey provides information on students' perceptions of group activities. Table 5.6 quantifies the responses into percentages for
comparison. Most students responded favorably, some were ambivalent, and only a few were negative.

Table 5.6

Has Group Work Been a Positive or Negative Experience for You?

<table>
<thead>
<tr>
<th>Case Students' Response Compared to Total Students' Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case Students</td>
</tr>
<tr>
<td>Positive</td>
</tr>
<tr>
<td>Ambivalent</td>
</tr>
<tr>
<td>Negative</td>
</tr>
</tbody>
</table>

The six students wrote or spoke about group work. Table 5.7 displays students' perceptions of the group work. Students wrote their rating and an explanation in the end-of-semester survey. For Amy, the group activities represent a means of growth that she had not experienced very often in her prior educational experiences. Denise's comment infers a sense of safety. Maria does not complete the survey, and her comment, taken from an interview, suggests an unexpected benefit for her, especially with regard to working on the group poster project; for her, it works. Lacey reports valuing the diverse points of view, and Scott declares group work helps him learn. Ron is undecided, and he qualifies the experiences as dependent on the people in the group.
Table 5.7

Students' Ratings and Comments about Groups

<table>
<thead>
<tr>
<th>Student</th>
<th>Student Rating and Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1 Amy</td>
<td>Positive. More interesting, fun, not many more people than in other classes. I haven't had as much experience working in groups as I would like. This was a growing experience for me.</td>
</tr>
<tr>
<td>S2 Denise</td>
<td>Positive. Because I am chicken when it comes to presenting. So I like having the ability to play more roles and still be made to present.</td>
</tr>
<tr>
<td>S3 Maria</td>
<td>Positive. &quot;I mean we gather different ideas and we put them together and it works&quot; (S3 12 p 7).</td>
</tr>
<tr>
<td>S4 Lacey</td>
<td>Positive. Each student brings in their own experiences (or lack of—which is fine) and we discuss the topic at hand.</td>
</tr>
<tr>
<td>S5 Scott</td>
<td>Positive. I think the group work helped me learn the material better.</td>
</tr>
<tr>
<td>S6 Ron</td>
<td>Undecided. Some groups did not have the same initiative to help or research.</td>
</tr>
</tbody>
</table>

He was not alone, a sampling of students from the class provides insight. A student who views the experience as both positive and negative, writes, "If you get a group of intelligent individuals you can learn more. If you are [sic] not, then you are actually at a disadvantage because you don't have many options to explore" (S12).

Two students write negative commentaries: "In group work I always seem to end up doing all the work and it's very hard to coordinate people's schedules" (S14) and
"Negative. It has been negative because most of the people in my groups did not contribute their adequate share" (S{20}). The positive responses outnumber the negative responses. These include comments such as "a good way to practice your social skills" and, "It's nice because everyone voices their ideas" and "You interact with more people, get to know people, get help from people" (S {4, 7, 18}) and "I enjoy working in a group now more than I used to" (S {22}).

The survey results suggest the students appreciate the group work. The interviews provide details that help clarify the value of the group work. For two students, it made a dramatic impression. Here, Amy responds to me when I ask what really stands out or has made a dramatic impact on her understanding of science or biology.

AMY: The working in groups. I don't think I have done that a lot in my background of science. . . . Most science classes we have lab groups, but I probably haven't worked in a group since high school when we did dissection . . . Very few group projects [in her experience] . . . so I think that can be really valuable.

PG: How has that helped you?

AMY: Mostly because in the real world . . . you don't work alone very often. You almost always have to work in a group and I think a lot of fine education before just did not help me in that aspect at all. I did a lot of things alone. . . . But being able to work in a group--I work in groups fairly well. . . . It can be really good--really helpful. Mostly not just helpful to learn . . . but prepare you for real life. . . . (S1 12, p. 14)

The impact of working in groups is also quite dramatic for Lacey. On three occasions she explains how much the opportunity to work in groups has meant for her.

LACEY: The interaction. I can't get over how good it feels to hear somebody else's ideas and not just Lacey. Here is a question, take it home and answer it and bring it back. They grade it and give you back your paper. But when we are discussing it--it is 'oh okay'. 'What about this idea?' or 'What about that idea?'
And then we will just kind of keep going on from there. I really enjoy that. (S4 I2, p. 14)

LACEY: For me having or being able to work in groups and discuss situations and what have you, [gives me] a bigger picture of what is going on. Hearing four or five other opinions about what we are learning helps, otherwise I'm stuck with my own answer... and somebody will throw in a different idea, and it is like—oh yeah, that's possible. (S4 I1, p. 7).

LACEY: The group work—I like that idea because you have more than one person inputting, and you have a discussion going on. And, where are we going to go from here and what angle are we going to take when it pertains to a poster. So yea, groups, I love them. I really enjoy doing them. I think I have learned quite a bit from that. (S4 I2, p. 12)

Lacey and Amy are among the strongest positive voices of the supporters of group activities and group projects.

Involves Students: "Hands-On" Activities

Another area of emphasis that comes under the heading "involves students" was the reference to hands-on experiences. The reference to "hands-on" is present in the transcribed interviews of four of the students. Denise references it 12 times; Scott, seven times; Bruce, three times; and Lacey, once. Amy never mentions the term but implies it through discussion. Maria also never mentions that term. However, in her case "hands-on" may represent an idiomatic expression that is not part of her vocabulary.

Amy infers hands-on in her description of the contrast between traditional labs and her view of the this classroom experience:

AMY: People do learn things in traditionally taught class, but I think it is too repetitious. . . . The labs we do are always more effective—to do it yourself. . . . I think it is more interesting the way we are doing it now. We are designing our own experiment which . . . is 90% of science—is how the experiment is designed. The way you design your experiment can really change the matter. Being able to design a good experiment is a lot of the skill of being a scientist. (S1 I1, p. 6)
In this next instance, Amy takes a teacher's perspective to again emphasize the importance of experiential activity in science.

AMY: I was talking to [Maxie] about this. This sort of class is perfect. . . . [What] is important for a non-science person to remember from this class is . . . how to run an investigation—that we went outside and did these things, how we did that—those sort of things—some of the stuff we are discussing. I bet they will remember because we are discussing it instead of just being given the information. (S1 II, p. 6)

Denise emphasizes the interactive nature of the classroom, hands-on learning, the opportunity to ask questions, and that she can learn more:

DENISE: Wow! What is hard to say. There are a lot of things that are really helpful. She doesn't just sit there . . . and like lecture, and like okay--you are going to take 400 pages of notes. And, she really makes it interactive. That is the really important because I think a lot of people are very hands-on learning. And since we get to ask questions back and forth and stuff like that, it really makes us think about what we are doing and how we can learn more. (S2 I2, p. 8)

Involves Students Through Discussion

Amy references the hierarchy exercise in which student groups were required to order vocabulary words based on the researched definitions and discuss their decisions for the order. Additional types of activities are helpful to her. In this excerpt, she substantiates Maxie's casual conversation (C 1/25/99, p. 11) and demonstrates her belief in the importance of discussion and getting students involved:

AMY: I like how she takes things . . . like definitions--like lists of definitions that would normally be just terribly tedious but then gives us an assignment on how to relate them together--or asks questions related to them that people will actually learn the definitions. You know, really learn them--not just memorize them. With those assignments, I think they can take some time. Whereas just giving us the definition would be faster, but I think it is a much more long lasting way of learning. And having us do the projects, like the poster projects, that really makes us do some research and expands us. And everybody does it differently and so we learn not just what our own project is about but the other ones. She gets a lot of
audience participation, class participation asking questions—and I don’t think I have ever heard her say, "Well that is wrong," or even indicate that that is a wrong answer. It is always—that is an interesting concept or that is an interesting idea. It is interesting that you brought that up even if it didn’t quite fit in with what she was thinking it was going to be about. That is very helpful. And mixing our groups around—otherwise people do tend to—I have gotten to know most everybody in class which is probably a new and unusual experience for me. Usually, I get to know the people around me and that is about it. And so that is really helpful. (S1 I2, p. 12)

**Major Theme: Relates Examples, Experiences, and Stories**

The theme in this category refers to the teacher action of providing additional information to inspire interest, to make a concept clearer, or to demonstrate how a process can be improved. Maxie provides many examples orally and visually in her classes. For example, the poster project requires students to provide information and graphic representations of the desert study. Maxie explains how these are done. She shows the students how posters are organized for scientific meetings using the white board in the classroom. She also brings into the classroom samples of students' projects from prior classes and involves students in a few practice sessions.

Students remark on the impact of the teacher's use of examples, stories, and experiences. For Maria, this was very important. "When she explains the meaning of the words, she gives examples. She works with the class trying to see if the class understood what she meant . . . she explains and gives examples" (S3 I2, p. 8). Scott also refers to the use of examples and stories " . . . a lot of time, she will give an example of something. . . . Then she will show you this is how it happens, and she will tell a story . . . she doesn't just tell . . . she gives examples" (S5 I1, p. 5). Ron considers this an important aid to
understanding difficult material: "If it's a difficult process, I think somebody's personal experiences... She brings in her own stories. Not just out of a book" (S6 I2, pp. 10-11).

Major Theme: Exhibits Expertise

This theme refers to students' recognition of the teacher's expertise in biology through her knowledge and actions. Ron recognized and appreciated Maxie's expertise:

She actually knows what she is talking about. She is not just teaching out of a book, she is actually knowledgeable... I guess you have to... like the research things she has done... went to Mexico and camped there on the beach... I think it is good to know instead of sticking to examples in the book... had some experience. (S6 I2, p. 7)

Amy also recognized Maxie's knowledge and refers to the first day of class when Maxie explained how she uses inquiry and how she expects the students to be actively involved. Amy reports: "... She got up in front of the class and said this is what our class is gonna be like. And I have heard that before. But I have never seen it put into practice nearly as effectively" (S1 I3, p. 21). Denise remarked on Maxie's references to other sources and resources. Here she refers to teacher knowledge: "It is good that she uses different references and different information other than what is in the book" (S2 I2, p. 9). Maria also recognizes Maxie's expertise: "She is a good instructor--she tries to [get] the students to understand. We can see it right away" (S3 I2, p. 8).

Major Theme: Encourages a Relaxed Classroom Climate

This theme is an important one for the few the students who report on the relaxed atmosphere. It refers to students' recognition of a relaxed classroom climate.

Three of the students expressed how the classroom atmosphere helped them. Denise reflects on how it affects her learning:
DENISE: [. . .] She has made it . . . a really comfortable place to just ask questions . . . and not worry that everybody is thinking [that] is pretty stupid or something. It is a safe place to take risks. (S2 12, p. 9) I think that . . . since she made out tests open book . . . it may have been kind of easy but I think it was a lot better that way . . . it takes the stress off and I think it is easier to learn something. . . . (S2 13, pp. 14-15)

Lacey comments on what it means for her:

LACEY: Just a relaxed atmosphere— you don't feel this pressure . . . you come into class— it is not fun and games— you are really going to come in here and learn something. . . . By getting over that real strict type atmosphere . . . I feel I am learning more. (S4 12, pp. 12-13)

Scott also "... liked the general atmosphere of the whole class." He told me, "It was very non-pressure and relaxing . . . yet you still did a lot of activities . . . more in this class than I did in my other classes but it didn't really seem like it" (S5 12, p. 7).

**Major Theme: Facilitates/Coaches**

This category refers to students' awareness of the teacher's supporting role in the classroom. In the classroom, Maxie often coaches students and encourages other points of view from different sources. Amy remarks on Maxie's practice of throwing out a question and asking the students to talk among their groups. She believes as helpful: "A combination of several ideas . . . other peoples' points of view. . . . The teacher asking people instead of telling what the answer is. . . ." (S1 12, p. 14). Maria also finds it helpful: "I like when she goes to your table and she goes Do you think this will be better? . . . or she walks around the class. . . ." (S3 12, p. 8). Lacey finds Maxie's practice of visiting the groups helpful to see if the group was on the right track. Lacey mentions how she asks questions "... What about that--something else to think about that we haven't brought up in our group discussions" (S4 12, p. 14). Scott also refers to benefits
of Maxie's coaching practices. "I think I probably gained a lot . . . the way she coaches you in the right direction. . . . When you ask a question, . . . she will lead you to what she wants you to gain from it" (S5 12, p. 10).

Major Theme: Credits Creativity

The theme credits creativity refers to an appreciation of the teacher's practice of giving additional credit for creative work or for doing something extra. Two of the students appreciated Maxie's practice of giving students points for creativity. Ron relates the following experience:

There was one take-home [problem] . . . if they had an earthquake and the Sierra Nevada's were leveled, what would happen? I looked on the Internet and got this radar image and it showed clouds moving and she gave me a point for those. I thought it was kind of cool. (S6 12, p. 7)

Amy observes that Maxie was tough when she graded student papers but appreciates "... how she grades assignments--she doesn't let people off easy. But at the same time, she gives a little credit for creativity--unusual things--she gets a kick out of that" (S1 12, p. 15).

Summary of Findings Related to What Students Do in the Classroom

The students' perspectives on the types of teacher-initiated actions that the students believe are effective for biology literacy development or are in some way helpful to their understanding vary. Students were compared as a part of the case and then again separately. Six themes developed from the interviews and surveys to answer the research questions about effective teacher actions. Table 5.4 lists and describes the following six themes: (a) involves students, (b) relates examples, (c) exhibits expertise, (d) create a relaxed atmosphere, (e) facilitates/coaches, and (f) credits creativity.
Tables 5.8 through 5.13 summarize the teacher actions each student perceives effective for biology literacy development. The supporting quotations are in the second column to the right of the action. The actions are listed in order of importance to the particular student. These were derived from the interviews and from the end of the semester surveys. The order of importance was based on the emphasis the student places on particular theme. The tables also identify certain actions as being related to language, social, or experiential activities. These were the themes which were used to describe the teacher's (Maxie's) theory and practice of teaching.

Findings Related to Tools Students Use in the Course

The third consideration for the students' construction of meaning relates to the tools, the concrete and abstract materials and resources the students use in the course (see Figure 5.1). In this section, I discuss the students' perspectives of what they did in relation to the tools they used. In some cases the tools were teacher directed and teacher chosen. In other cases, the students chose the tools. The following are some examples of the tools: group/poster projects, multiple text resources, reading/taking notes, study guides, mini-tests, field notebook, and field trips (see Table 5.14). Students' individual evaluation of the tools each believed to be useful are summarized and presented in tables at the end of this section.
<table>
<thead>
<tr>
<th>Action/Teacher Influence (In order of importance to student)</th>
<th>Amy's Perspectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Involves Students (language, social, experiential)</td>
<td>&quot;I think it is more interesting ... we are designing our own experiment. ... Getting us involved ... not just on the surface. ... in-depth. ... She gets a lot of audience participation. ... I have gotten to know most everybody in class. ... Active learning works much better--just through the activity you are learning. ... people will remember. ... (SI 11-2, pp. 6, 11, 15)</td>
</tr>
<tr>
<td>• Relates Examples, Stories, and Experiences (language, experiential)</td>
<td>&quot;... [N]ot just verbatim out of the book ... examples. ... leads us in those sorts of exercises in class when she is lecturing. (S1 I2, p. 14)</td>
</tr>
<tr>
<td>• Facilitates/Coaches (language, social)</td>
<td>Helpful: &quot;A combination of several ideas ... other peoples' points of view. ... The teacher asking people instead of telling what the answer is. ...&quot; (S1 I2, p. 14)</td>
</tr>
<tr>
<td>• Demonstrates Expertise (language, social, experiential)</td>
<td>&quot;... [S]he got up in front of the class and said this is what our class is gonna be like. And I have heard that before. But I have never seen it put into practice nearly as effectively.&quot; (S1 I3, p. 21)</td>
</tr>
<tr>
<td>• Credits Creativity (language, social)</td>
<td>&quot;... [H]ow she grades assignments--she doesn't let people off easy. But at the same time, she gives a little credit for creativity--unusual things--she gets a kick out of that.&quot; (S1 I2, p. 15)</td>
</tr>
</tbody>
</table>
Table 5.9

Denise's Beliefs on Teacher Actions/Influences Effective for Biology Literacy Development

<table>
<thead>
<tr>
<th>Action/Teacher Influence (In order of importance to student)</th>
<th>Denise's Perspectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Involves Students (language, social, experiential)</td>
<td>&quot;She makes it really interactive. That is really important because I think a lot of people are very hands-on learning... and since we get to ask questions back and forth... it makes us think about what we are doing and how we can learn more.&quot; (S2 I2, p. 9) &quot;When she gives us something difficult... she has us go home and look it up or write about something... to get us to better understand it... it is really helpful... I try to find out as much as I can... write down some key points.&quot; (S2 I2, p. 11)</td>
</tr>
<tr>
<td>• Encourages a Relaxed (language, social, experiential)</td>
<td>&quot;...[S]he has made it... a really comfortable place to just ask questions... and not worry that everybody is thinking [that] is pretty stupid or something. It is a safe place to take risks.&quot; (S2 I2, p. 9) &quot;I think that... since she made out tests open book... it may have been kind of easy but I think it was a lot better that way... it takes the stress of and I think it is easier to learn something....&quot; (S2 I3, pp. 14-15)</td>
</tr>
<tr>
<td>• Demonstrates Expertise (language, experiential)</td>
<td>Here she refers to teacher knowledge: &quot;It is good that she uses different references and different information other than what is in the book.&quot; (S2 I2, p. 9)</td>
</tr>
<tr>
<td>Action/Teacher Influence (In order of importance to student)</td>
<td>Maria's Perspectives</td>
</tr>
<tr>
<td>-------------------------------------------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>• Relates Examples, Stories and Experiences (language, social)</td>
<td>&quot;When she explains the meaning of the words and she gives examples. She works with the class trying to see if the class understood what she meant . . . she explains and gives examples.&quot; (S3 I2, p. 8) &quot;Maxie explains and takes her time to make sure the students understand.&quot; (S3 I2, p. 9)</td>
</tr>
<tr>
<td>• Facilitates/Coaches (language, social)</td>
<td>&quot;I like when she goes to your table and she goes 'Do you think this will be better' . . . or she walks around the class. . . .&quot; (S3 I2, p. 8)</td>
</tr>
<tr>
<td>• Demonstrates Expertise (language, experiential)</td>
<td>&quot;She is a good instructor--she tries to [get] the students to understand. We can see it right away.&quot; (S3 I2, p. 8)</td>
</tr>
<tr>
<td>• Involves Students (language, social, experiential)</td>
<td>Prefers active learning: &quot;I retain more with Maxie.&quot; (S3 I2, p. 9)</td>
</tr>
</tbody>
</table>
Table 5.11

**Lacey’s Beliefs on Teacher Actions/Influences Effective for Biology Literacy Development**

<table>
<thead>
<tr>
<th>Action/Teacher Influence (In order of importance to student)</th>
<th>Lacey’s Perspectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Involves Students (language, social, experiential)</td>
<td>&quot;I can't get over how good it feels to hear somebody else's ideas. . . . When we are discussion it is . . . 'What about this idea?' or what about that idea and . . . we just keep on going from there. I really enjoy that.&quot; (S4 I2, p. 14) . . . [H]aving hands-on experience . . . the Desert Museum . . . the desert study . . . how we all picked a different plant and had various reason on why we wanted to do a study on that plant.&quot; (S4 I3, p. 20)</td>
</tr>
<tr>
<td>• Encourages a Relaxed Classroom Climate (social, experiential)</td>
<td>&quot;Just a relaxed atmosphere--you don't feel this pressure . . . you come into class--it is not fun and games you are really going to come in here and learn something . . . by getting over that real strict type atmosphere . . . I feel I am learning more.&quot; (S4 I2, pp. 12-13)</td>
</tr>
<tr>
<td>• Facilitates/Coaches (language, social)</td>
<td>&quot;. . . [H]aving the instructor making sure that we are on the right track or . . . what about that--something else to think about that we haven't brought up in our group discussions.&quot; (S4 I2, p. 14)</td>
</tr>
<tr>
<td>• Relates Examples, Stories and Experiences (language, experiential)</td>
<td>&quot;Good report--being able to talk at a level I am able to understand. . . . She enjoys this subject so much--she wants to share it with you --what she has learned and some of her experiences --she just has this chemistry that makes you want to learn.&quot; (S4 I2, p. 15)</td>
</tr>
</tbody>
</table>
### Scott's Beliefs on Teacher Actions/Influences Effective for Biology Literacy Development

<table>
<thead>
<tr>
<th>Action/Teacher Influence</th>
<th>Scott's Perspectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Involves Students (language, social, experiential)</td>
<td>&quot;I feel I am learning a lot. I like the different kinds of activities we are doing... a large variety... the actual hands-on... You do things... research... it gives me my best understanding of science when I actually get to do it.&quot; (S5 I2, p. 6)</td>
</tr>
<tr>
<td></td>
<td>&quot;... [T]he active learning helps pound it home to me....&quot; (S5 I3, p. 10)</td>
</tr>
<tr>
<td>• Relates Examples, Stories and Experiences (language, social, experiential)</td>
<td>&quot;... [A] lot of times she will give an example of something... then she will show you this is how it happens and she will tell a story.... [S]he doesn't just tell... she gives examples... plus she gets you interactive....&quot; (S5 I1, p. 5)</td>
</tr>
<tr>
<td>• Encourages a Relaxed Classroom Climate (social, experiential)</td>
<td>&quot;I liked the general atmosphere of the whole class. It was very non-pressure and relaxing... yet you still did a lot of activities... more in this class than I did in my other classes but it didn't really seem like it.&quot; (S5 I2, p. 7)</td>
</tr>
<tr>
<td>• Facilitates/Coaches (language, social)</td>
<td>&quot;I think I probably gained a lot... the way she coaches you in the right direction... when you ask a question... she will lead you to what she wants you to gain from it.&quot; (S5 I2, p. 10)</td>
</tr>
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</table>
Table 5.13

Ron's Beliefs on Teacher Actions/Influences Effective for Biology Literacy Development

<table>
<thead>
<tr>
<th>Action/Teacher Influence (In order of importance to student)</th>
<th>Ron's Perspectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Relates Examples, Stories, and Experiences (language, experiential)</td>
<td>On understanding difficult material: &quot;If it's a difficult process, I think somebody's personal experiences. You can see it from a personal perspectives... She brings in her own experience. She brings in her own stories. Not just out of a book.&quot; (S6 I2, pp. 10-11).</td>
</tr>
<tr>
<td>• Demonstrates Expertise (language, experiential)</td>
<td>&quot;She actually knows what she is talking about. She is not just teaching out of a book, she is actually knowledgeable... I guess you have to... like the research things she has done... went to Mexico and camped there on the beach... I think it is good to know instead of sticking to examples in the book... had some experience.&quot; (S6 I2, p. 7)</td>
</tr>
<tr>
<td>• Involves Students (language, social, experiential)</td>
<td>&quot;Involved us to ask questions. She doesn't want answers from the book... back it up with sources. She stops and asks our point of view... I like taking time to talk about it. (S6 I2, p. 11) Teachers need to incorporate: &quot;The hands-on stuff where we went out to the desert site and we went to the Desert Museum.&quot; (S6 I3, p. 14)</td>
</tr>
<tr>
<td>• Credits Creativity (language, social, experiential)</td>
<td>&quot;There was one take home problem... if they had an earthquake and the Sierra Nevadas were leveled, what would happen? I looked on the Internet and got this radar image and it showed clouds moving and she gave me a point for those. I thought it was kind of cool.&quot; (S6 I2, p. 7)</td>
</tr>
</tbody>
</table>
### Table 5.14

**Students' Use of Tools/Actions and a Description**

<table>
<thead>
<tr>
<th>Tool/Action</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group/Foster Projects</strong></td>
<td>Refers to the projects students worked on together and individually to incorporate original research projects and environmental issues into the presentation format of a poster following the acceptable guidelines. A rubric was used in the assessment; technical and conceptual objectives were assessed based on a point system (see Appendix H for an example of one student's assessment).</td>
</tr>
<tr>
<td><strong>Multiple Text Resources</strong></td>
<td>Multiple text resources refers to materials available in the classroom or near the classroom such as Maxie's double-tiered book cart, the library and the computers with Internet access. It also refers to other resources such as magazines, newspapers, journals, and copies of Internet printouts that students, teacher, and researcher brought to the classroom and the use of the library.</td>
</tr>
<tr>
<td><strong>Reading/Taking notes</strong></td>
<td>Refers to actions students took during their reading and any related references to their own reading processes.</td>
</tr>
<tr>
<td><strong>Study Guides/Sheets</strong></td>
<td>The teacher furnished study guides to help students focus on particular areas of the text. The students answered questions beyond the factual information in the book; they had to read and carefully think about the application of concepts.</td>
</tr>
<tr>
<td><strong>Mini-tests</strong></td>
<td>The mini-tests were used to review and reinforce concepts, to advance the application of concepts, and to introduce new material. They were open-book and open notes. Usually they were one hour in-class exams. However, there was one group test and two take home tests. Seven tests were taken and two of the lowest scores were not used in the final grade.</td>
</tr>
<tr>
<td><strong>Field Notebook</strong></td>
<td>The field notebook was a small notebook (9.75 in. by 7.5 in.) with either blank paper or quadrille lines. Maxie asked students to get these to take notes, keep new vocabulary words, record data, and to make sketches and drawing of their observations.</td>
</tr>
<tr>
<td><strong>Field Experiences</strong></td>
<td>Refers to the field trip to the Desert Museum and the field experiences on the campus desert study site.</td>
</tr>
</tbody>
</table>
Group/Poster Projects

This tool served as a visual representation of what students had done in groups. First, the students went out to the desert site to find something that they would like to study. Next, with Maxie's guidance, they wrote a hypothesis, a null hypothesis and devised a plan to answer their question. They collected data, wrote up the procedures, results and conclusions, and created a poster using some graphic representations that would explain what they did. The posters were presented by the groups and then displayed around the room. All six of the students reported the group/poster projects in a positive light. A rubric was used in the assessment; technical and conceptual objectives were assessed based on a point system (see Appendix H for an example of one student's assessment).

Denise emphasizes hands-on learning and the posters. She tells me "... I think the posters were a really good idea. That just made you learn ... visual aids ... you had to explain it so it is reinforced. ..." (S2 I3, p. 14). In a previous interview session Denise says, "The posters are a really good idea ... [I] get really excited about it. That is really cool" (S2 I2, p. 8). Maria also finds the poster project beneficial, "Making posters, making posters with other people helps a lot ... because we gather different ideas, and we put them together, and it works" (S3 I2, p. 7). Lacey feels the group discussion part of a project such as making a poster was rewarding. Here she describes the benefits: "... being able to work as a group or part of a group ... if you found something that pertained to another ... we were able to ask each other and share information" (S4 I3, p. 20). Scott specifically mentions the posters as a good teaching tool:
SCOTT: I thought the posters were a good teaching tool. I feel I learned a lot about a lot of different subjects... a lot of little activities we did in class in groups gave us a really wide perspectives instead of a narrow one. . . . (S5 II, p. 7) I like it when we work together on the same thing. . . . The actual hands on. . . . You actually get to do the things and research yourself and I think that. . . . gives me my best understanding of science when I actually get to do it." (S5 II, p. 6)

Ron also believes the poster projects helpful: "... the poster projects made you get in in and look for stuff and it made you think..." (S6 I2, p. 10).

Multiple Text Resources

Multiple text resources refer to materials available in the classroom or near the classroom such as Maxie's double-tiered book cart, the library and the computers with Internet access. It also refers to other resources such as magazines, newspapers, journals, and copies of Internet printouts that students, the teacher, and the researcher brought to the classroom. Students report using multiple text resources in a number of ways. For example, Amy tells me she used the Internet to look for things and "... that has been helpful to me--just expanding my knowledge" (S1 I2, p. 12). Denise also reports using multiple resources for classroom projects:

DENISE . . . [T]here are other books over there for us to use that are really helpful. We found a lot of stuff in there that we needed for our posters this time. . . . [A]nother good thing is to make us look for other resources. . . . You can go on the Internet and go everywhere. (S2 I2, p. 11)

Lacey tells me what she finds helpful, "Text books, the Internet, library, and newspapers because I will find interesting articles here and there regarding the environment" (S4 I2, p. 14). She had checked out Maxie's book cart and mentions: "I remember seeing a book on the push cart . . . got it off the cart and sure enough, there is the information" (S4 I2, p. 15).
In addition to the reference materials in the back of the room and computers, Scott notices something the other students did not. He tells me "It seems she keeps a lot of posters up in the classroom even though it doesn't pertain to the subject we are currently on. I find those interesting" (S5 II, p. 5). He favors the Internet, "I think the Internet is highly effective for learning information on just about anything" (S5 II, p. 4). Ron finds the books in the back helpful as well as the Internet. He used the Internet "... for that one poster. ... I looked on the Internet just to find different pictures ..." to add a colored photo of a desert plant (S6 I2, p. 10).

**Reading/Taking Notes**

Reading/Taking Notes refers to actions student took to help themselves during their reading and any actions they took related to their own reading processes. Amy tells me "... I definitely read assigned stuff ... I rarely take notes when I read, I find it interrupts my train of thought ... I find I absorb better if I don't take notes" (S1 I2, pp. 11, 13).

Maria reports an action that helps her understand difficult material: "When I visualize after I read it. If I don't visualize after I read it, I am lost" (S3 I2, p. 9). Maria further describes the difficulty she faces when she reads:

MARIA: ... I read the whole chapter 45 ... But you should have seen the book. I had to go to the dictionary to see what [almost every] word meant and I had [try to understand the] sentence with the word and that is why I find it so hard for me to understand the whole chapter. I have to look up each word. I take more than two or three hours sometimes to finish one chapter because I am trying to understand those new words. (S3 I1, p. 4)

Maria has difficulty understanding the words in sentences and in specific contexts. Some of the biology of terms have complex meanings, and these are sometimes explained in the second or third sentence in the text.
Lacey's action when she is reading an assigned chapter is to:

LACEY: ... [T]ake as many notes as possible. ... I can connect the two and figure out ... what the instructor is considering as important information. ..." (S4 12, p. 12) ... When I am having difficulty, I will go ahead and hi-light things in the chapter ... and record them on tape and I can pop them in the car ... while I'm driving." (S4 12, p. 12)

Because Scott has an understanding of biology he tells me, he just keeps notes

"... on words I haven't heard before ... I will go over the things we discuss in class and my text until I get familiar ... and get a better idea of what is going on." (S5 12, p. 5).

Ron's approach is based on his assessment of the kinds of tests in the class:

RON: For this class because it is open book test ... I take lots of notes and then I try to read ahead. ... I just get into some of those chapters and I just keep reading and reading. There isn't really much memorization for this class. (S6 12, p. 6)

**Study Guides**

Maxie provides study guides to help students focus on particular areas of the text. The students answer questions beyond the factual information in the book; the guides require students to read and carefully think about the application of concepts. The study guides are a way to call attention to important concepts. The study guides serve to help students prepare for the mini-tests and four of the students felt they were useful toward that end. Amazingly, Amy develops a study system that none of the other students thought of: "One thing I found helpful ... I go through and put the page number [on the study guide] where I got the stuff. It helped--I got more in-depth stuff" (S1 11, p. 11).

"Helps us figure out what she thinks is important ..." (S1 12, p. 12). In retrospect, at the end of the semester, Amy tells me ". ... [I]t wouldn't have been necessary for me to do ... I probably did better because of it, but it took a lot of time. ... I'm not sure it was worth
... but I remember what I read really well" (S1 I3, p. 20). Denise tells me, "The study guides are pretty good" (S2 I2, p. 10). She adds, "I'm sure she's having us study them because there's something important to it . . ." (S2 I2, p. 8). Lacey uses the study guide as a learning tool and expands her understanding by putting into her own words. Ron, who is very much aware of tests and test taking skills, remarks,

RON: The study sheets are helpful because the tests in class are right off those, so if you answer those . . . the test it is that much easier. (S6 I2, p. 7) . . . I found that study sheets pick out the main ideas and . . . I have got interested in going through the study sheets and have read some of the chapters. (S6 I2, p. 7)

Mini-Tests

The mini-tests were used to review and reinforce concepts, to advance the application of concepts, and to introduce new material. They were open-book and open notes. Usually they were one-hour in-class exams. However, there was one group test and two take-home tests. One of the take-home tests was actually a study guide. Seven tests were given to students. The two lowest scores are not used in the calculation of the final grade. Maria had the most difficulty with the in-class tests but did very well on the take home tests. Lacey barely talked about the tests; these did not seem as important as learning for her.

Amy talked positively about the mini-tests:

AMY: The mini-tests instead of several big tests—I really like that a lot better. It just kept me studying more throughout the semester instead of having several big times—forces you to keep up (S1 I3, p. 18). The different type of mini-tests I thought were nice . . . some take home . . . some group . . . it was a nice variety. (S1 I3, p. 17)

For Denise, the mini-tests were easier because they were open book. She tells me, "I think it is easier to learn something . . . rather than memorize it for a test because if
you memorize it for a test... you just forget it after the test..." (S2 I3, p. 15). Scott also feels they took the pressure off, "I like the mini-tests simply because they didn't have the pressure of the actual exam... it allowed us to do a lot better... I think we worked more but we felt like we were working less..." (S5 I2, p. 7). For Ron, the mini-tests brought things together for him, "I think those take home mini-tests made us get into the books and draw up the key points of all those chapters... helped me most... we did research on biomes in our groups—that helped too" (S6 I3, p. 12).

Field Notebook

The field notebook was a small notebook (9.75 inch by 7.5 inch) with either blank paper or quadrille lines. Maxie asked her students to get these to take notes, keep new vocabulary words, record data, and to make sketches and drawings of their observations. I observed all of the students using these during class and during the mini-tests. The books were meant to help students keep notes together. Denise was the only one of the case students who emphasized its value. She was amazed at how she was able to keep track of her notes because they were in one notebook and not scattered all over. She told me that it was the most helpful thing for her:

DENISE: I think the most helpful thing is the reading material and writing down stuff—the key information and then just taking the notes from class... having us bring it up on tests... really makes you take better notes. (S2 I2 p 8) I'd rather study from my notes... notes are more in your own words... notes you can elaborate more on. (S2 I3, p. 14)

Field Experiences

In general, students had favorable comments about the field experiences. The experiences included a field trip to the Desert Museum and the field experiences on the
Scott and Lacey perhaps place the strongest emphasis on the need for these types of experiences. Scott believes he learns the most from the field experiences. When I ask him, "What stands out for you?" He replies, "The way we went out in the field . . . a good change—get out of the classroom and the Desert Museum trip mixed fun with learning, and I think that is when you learn the most" (S5 12, p. 6). Lacey also emphasizes the importance of the field experience:

LACEY: I think not just having the text but having hands-on experience like how we went to the Desert Museum we were able to see all these different animals and plants . . . rather than just looking at colored pictures in the book we were able to tell the size the actual height that they really grow . . . you were actually able to see the variations in size from when they little seedlings just coming up or even the animals and their habitats. You read about it in the book but actually seeing them and the way they interact with other animals that has really been helpful. The desert study--actually being able to walk among the variety of desert plants out there. . . . [It's] interesting how each group was able to pick out their plant—the plant that they wanted to do a study on and how a variety of plants were covered by the different groups. I think there was just one group you know that may have overlapped a plant but it was interesting how we all picked a different plant and had various reasons on why we wanted to do a study on that plant. (S4 13, p. 18)

Summary of Findings Related to the Tools Students Use

The third consideration for the students' construction of meaning relates to the tools they use. In the findings, I discuss the tools the students mention in their interviews and in the end of the semester survey. The tools include the concrete and abstract materials and resources such as the group/poster projects, multiple text resources, reading/taking notes, study guides, mini-tests, field notebook, and field trips (see Table 5.13). Students share some common beliefs about the tools they believe effective in biology literacy development. For example, the group/poster projects and the multiple text resources are the most prominent tools students find to be effective. Students also
differ in belief about the effectiveness of some of tools. They seem to emphasize certain tools over others.

Tables 5.13 through 5.18 summarize the individual student’s perspective on the actions and use of materials that each believes effective for literacy development. They are again listed in order of importance to the student. This was determined from each student’s interview and survey. While the six case students emphasize different materials and actions, they agree in the categories of Group/Poster Projects and the Multiple Text Resources. There are some personal differences. For example, Maria, the bilingual student, emphasizes the more concrete elements of literacy development. The left-side column lists the tool or action. The actions are listed in order of importance to each student. The tables also identify certain actions as being related to language, social, or experiential activities. These are the themes which were used to describe the teacher’s (Maxie’s) theory and practice of teaching. In the right side column is a summary of the individual student’s perspectives.
Table 5.15

Amy's Actions and Use of Materials Believed Effective for Biology Literacy Development

<table>
<thead>
<tr>
<th>Action/Use of Materials</th>
<th>Amy's Perspectives</th>
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<tbody>
<tr>
<td><strong>(In order of importance to student)</strong></td>
<td></td>
</tr>
</tbody>
</table>

- **Group/Poster Projects (language, social, experiential)**  
  "I work in groups fairly well . . . the dynamics of it can be really good--really helpful . . . prepare you for real life because you hardly ever work alone"  

- **Reading (language)**  
  
  
  
  "... I definitely read assigned stuff . . . I rarely take notes when I read, I find it interrupts my train of thought . . . I find I absorb better if I don't take notes." (SI I2, pp. 11, 13)

- **Multiple Text Resources (language)**  
  "I get on the web [computer/Internet] and you start looking at things. . . [T]hat has been helpful to me--just expanding my knowledge." (SI I2, p. 12)

- **Study Guides (language)**  
  "One thing I found helpful . . . go through and put the page number where I got the stuff. It helped--got more in-depth stuff"  
  (SI I1, p.11). "Helps us figure out what she thinks is important. . . ." (SI I2, p. 12) "... [I]t wouldn't have been necessary for me to do . . . I did probably better because of it but it took a lot of time . . . not sure it was worth all that time . . . because I remember what I read really well." (SI I3, p. 20)

- **Mini-tests (language, social, experiential)**  
  "The mini-tests instead of several big tests--I really like that a lot better. It just kept me studying more throughout the semester instead of having several big times--forces you to keep up."  
  (SI I3, p. 18) "The different type of mini-tests I thought were nice . . . some take home . . . some group . . . it was a nice variety. . . ." (SI I3, p. 17)
### Denise's Actions and Use of Materials Believed Effective for Biology Literacy Development

<table>
<thead>
<tr>
<th>Action/Use of Materials (In order of importance to student)</th>
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</tr>
</thead>
<tbody>
<tr>
<td>• Group/Poster Projects (language, social, experiential)</td>
<td>&quot;Hands-on learning . . . visual aids . . . I think the posters was a really good idea that just made you learn . . . visual aids . . . you had to explain it so it is like reinforced . . .&quot; (S2 13, p. 14) &quot;Group projects were really good because you got to discuss things instead of being your own independent person.&quot; (S2 13, p. 14)</td>
</tr>
<tr>
<td>• Field Notebook (language)</td>
<td>&quot;I think the most helpful thing is the reading material and writing down stuff—the key information and then just taking the notes from class . . . having us bring it up on tests . . . really makes you take better notes.&quot; (S2 12, p. 8). &quot;I'd rather study from my notes . . . notes are more in your own words . . . notes you can elaborate more on.&quot; (S2 13, p. 14)</td>
</tr>
<tr>
<td>• Study Guides (language)</td>
<td>&quot;The study guides are pretty good.&quot; (S2 12, p. 10) &quot;I'm sure she's having us study them because there's something important to it. . . .&quot; (S2 12, p. 8)</td>
</tr>
<tr>
<td>• Multiple Text Resources (language, experiential)</td>
<td>&quot;... [T]here are other books over there for us to use that are really helpful. We found a lot of stuff in there that we needed for our posters this time. ... [A]nother good thing is to make us look for other resources, . . . you can go on the Internet and go everywhere.&quot; (S2 12, p. 11)</td>
</tr>
<tr>
<td>• Mini-tests (language, social, experiential)</td>
<td>On open book, open note tests and group tests: &quot;I think it is easier to learn something . . . rather than memorize it for a test because if you memorize it for a test . . . you just forget it after the test. . . .&quot; (S2 13, p. 15)</td>
</tr>
<tr>
<td>Action/Use of Materials (In order of importance to student)</td>
<td>Maria's Perspectives</td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>• Individual Discussions (language, experiential)</td>
<td>&quot;The individual discussions with Maxie [the teacher] is good. This helps most.&quot; (S3 I2, p. 9)</td>
</tr>
<tr>
<td>• Group/Poster Projects (language, social, experiential)</td>
<td>&quot;Making posters, making posters with other people helps a lot . . . because we gather different ideas and we put them together and it works.&quot; (S3 I2, p. 7)</td>
</tr>
<tr>
<td>• Multiple Text Resources (language, experiential)</td>
<td>&quot;Books, dictionaries, library books in Spanish of biology and other books of biology. They help a lot too. . . . I use the Internet.&quot; (S3 I2, p. 9)</td>
</tr>
<tr>
<td>• Reading (language, experiential)</td>
<td>An action that helps Maria understand difficult material: &quot;When I visualize after I read it. If I don't visualize after I read it, I am lost.&quot; (S3 I2, p. 9).</td>
</tr>
<tr>
<td>• Glossary (language, experiential)</td>
<td>&quot;I'm going to look in the glossary . . . it really helps a lot. Now I know where to look and if I don't find it there we're to go on. It helps a lot.&quot; (S3 I1, p. 3)</td>
</tr>
</tbody>
</table>
### Table 5.18

**Lacey's Actions and Use of Materials Believed Effective for Biology Literacy Development**

<table>
<thead>
<tr>
<th>Action/Use of Materials (In order of importance to student)</th>
<th>Lacey's Perspectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Reading/Taking Notes (language)</td>
<td>&quot;... [R]eading the assigned chapter... I try to take as many notes as possible... I can connect the two and figure out... what the instructor is considering as important information. ...&quot; (S4 I2, p. 12) &quot;When I am having difficulty, I will go ahead and hi-light things in the chapter... and record them on tape and I can pop them in the car... while I'm driving.&quot; (S4 I2, p. 12)</td>
</tr>
<tr>
<td>• Discussions (language, social, experiential)</td>
<td>Things that stand out: &quot;... smaller group discussions... elaborate on a certain subject... like the biomes.&quot; (S4 I3, p. 19)</td>
</tr>
<tr>
<td>• Group/Poster Projects (language, social, experiential)</td>
<td>&quot;... [B]eing able to work as a group or part of a group... if you found something that pertained to another... we were able to ask each other and share information.&quot; (S4 I3, p. 20)</td>
</tr>
<tr>
<td>• Multiple Text Resources (language, social, experiential)</td>
<td>&quot;Text books, the Internet, library, newspapers because I will find interesting articles here and there regarding the environment.&quot; (S4 I2, p. 14) &quot;I remember seeing a book on the push cart... got it off the cart and sure enough, there is the information.&quot; (S4 I2, p. 15)</td>
</tr>
<tr>
<td>• Study-Guides (language, social, experiential)</td>
<td>&quot;I will fill it in as I am going along... go back and put some of these... into my own words... and that way if I can put something down I know that I have... grasped the idea from beginning to end...&quot; (S4 I2, p. 12)</td>
</tr>
<tr>
<td>• Field Experiences</td>
<td>&quot;... [H]ow we went to the Desert Museum we were able to see all these different animals and plants and rather than just looking at colored pictures in the book...&quot; (S4 I3, p. 18)</td>
</tr>
</tbody>
</table>
Table 5.19

Scott's Actions and Use of Materials Believed Effective for Biology Literacy Development

<table>
<thead>
<tr>
<th>Action/Use of Materials (In order of importance to student)</th>
<th>Scott's Perspectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Group/Poster Projects (language, social, experiential)</td>
<td>&quot;I thought the posters were a good teaching tool. I feel I learned a lot about a lot of different subjects... a lot of little activities we did in class in groups gave us a really wide perspective instead of a narrow one....&quot; (S5 II, p. 7) &quot;I like it when we work together on the same thing.... The actual hands-on. ... You actually get to do the things and research yourself and I think that... gives me my best understanding of science when I actually get to do it.&quot; (S5 II, p. 6)</td>
</tr>
<tr>
<td>• Multiple Text Resources (language, social, experiential)</td>
<td>&quot;...[T]he reference materials in class... the computers... It seems she keeps a lot of posters up in the classroom even though it doesn't pertain to the subject we are currently on. I find those interesting.&quot; (S5 II, p. 5) &quot;I think the Internet is highly effective for learning information on just about anything.&quot; (S5 II, p. 4)</td>
</tr>
<tr>
<td>• Mini-tests (language, social, experiential)</td>
<td>&quot;I like the mini-tests simply because they didn't have the pressure of the actual exam... it allowed us to do a lot better.... I think we worked more but we felt like we were working less....&quot;(S5 II, p. 7)</td>
</tr>
<tr>
<td>• Reading/Taking Notes (language)</td>
<td>&quot;...[W]ith my understanding of biology I keep notes on words I haven't heard before... I will go over the things we discuss in class and my text until I get familiar... and get a better idea of what is going on.&quot; (S5 II, p. 5)</td>
</tr>
<tr>
<td>• Field Experiences (language, social, experiential)</td>
<td>&quot;The way we went out in the field... a good change--get out of the classroom and the Desert Museum trip mixed fun with learning and I think that is when you learn the most.&quot; (S5 II, p. 6)</td>
</tr>
</tbody>
</table>
Table 5.20

Ron's Actions and Use of Materials Believed Effective for Biology Literacy Development

<table>
<thead>
<tr>
<th>Action/Use of Materials (In order of importance to student)</th>
<th>Ron's Perspectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Study Guides (language)</td>
<td>&quot;The study sheets are helpful because tests in class are right off those, so if you answer those you have to give complete answers and ... on the test it is that much easier.&quot; (S6 I2, p. 7) &quot;I found the study sheets kind of pick out the main ideas and then ... I have got interested in going through the study sheets and have read some of the chapters.&quot; (S6 I2, p. 7)</td>
</tr>
<tr>
<td>• Group/Poster Projects (language, social, experiential)</td>
<td>&quot;I didn't use to like the way she does the group things--that is okay I guess ... the idea of getting involved and the actual hands-on get your fingers dirty kind of thing.&quot; (S6 I2, p. 8) The poster projects made you get in and look for stuff and it made you think ... the research part ... The toughest thing is the groups.&quot; (S6 I2, p. 10)</td>
</tr>
<tr>
<td>• Reading/Taking Notes (language)</td>
<td>&quot;For this class because it is open book test ... I take lots of notes and then I try to read ahead ... I get into some of those chapters and I just keep reading and reading. There isn't really much memorization for this class.&quot; (S6 I2, p. 6)</td>
</tr>
<tr>
<td>• Multiple Text Resources (language, experiential)</td>
<td>&quot;The books in the back--I looked in those for that one poster and I looked on the Internet just to find different pictures or whatever.&quot; (S6 I2, p. 10)</td>
</tr>
<tr>
<td>• Mini-tests (language, social, experiential)</td>
<td>&quot;I think those take home mini-tests made us get into the books and draw up the key points of all those chapters ... helped me most ... we did research on biomes in our groups--that helped too.&quot; (S6 I3, p. 12)</td>
</tr>
</tbody>
</table>
Summary

This bounded case study recognizes the students' perspective in biology literacy development by examining their relationships in the classroom dynamic. Specifically, the study responds to two questions:

1. What actions did students take to learn biology literacy?
2. Specifically, what patterns and combinations of student actions, teacher influences, and use of materials did students believe to be effective for the development of biology literacy?

Six case students were selected on the basis of criteria that provided a variety of student characteristics reflective of a community college classroom. The focus of the study was on three particular areas: (a) what the students brought to the classroom such as their backgrounds, experiences and histories; (b) what the students did in the course and believed effective actions in the classroom; and (c) what tools the students used in the course such as multiple texts, computers, and field trips. In the first section, to address what students brought to the classroom, the findings indicate that the six case students differ in several ways. In the second and third section, to address what the students did in the course and what tools the students used, the students report the kinds of actions they use to develop biology literacy and the kinds of teacher actions that seem to be effective for their literacy development.

The findings in the first area reveal that the students differ from each other in terms of gender, age, prior experience in science, and in their ethnic backgrounds. The selection of four females and two males relies on the female to male ratio of the class.
The students differ in age; the age range for the study is 41 years at the highest and 17 years at the lowest. Some of the students report considerable experience with science courses and some had very limited exposure. The students' first two mini-test scores approximately assess the students' abilities and help to select a stratified sample of students. Two students appear to be in the high range, two students in the middle range, and two students in the lower range. The results of the reading and study skills survey seem to indicate that the students have different areas of strengths in their reading and study strategies. Amy shows strengths in reading and vocabulary strategies. Denise shows strengths in location strategies and vocabulary strategies. Maria shows strength in survey strategies and reading strategies. Lacey's areas of strength appear to be in location strategies and in survey strategies. Scott's strong areas are in survey processing and in memory strategies. And Ron's areas of strength are in location strategies and in memory strategies. Students' predicted grades closely match their final grades. In four cases, they exactly match the final grades and in two cases, the predictions were within one letter grade. Three students, Lacey, Maria, and Ron revealed negative prior experiences and three students proclaimed a high degree of interest in biology.

The six students differed in their understandings of being literate, science literacy, and biology literacy. Amy and Denise defined the words in terms of language and concepts. Maria's definitions reflected science as a language activity, as a social activity, and as an experiential activity. Scott's definitions suggested language and social connections and Ron's definitions inferred a specific vocabulary and application.
The findings about what students did in the course showed similarities and differences among the students. Table 5.4 provides a description of the six themes students believe effective teacher actions for the development of biology literacy. The themes in common with the six case students are: (a) involves students, (b) relates examples, (c) exhibits expertise, (d) creates a relaxed atmosphere, (e) facilitates/coaches, and (f) credits creativity. Students hold individual differences and place more emphasis on certain thematic categories.

In the third area, students' use of tools, students share in common their positive use of the group/poster projects and the multiple text resources. They seem to find these two tools the most useful of all the tools in their development of biology literacy. There were differences, however, among students' perceptions of the other tools and actions. This suggests that students hold individual preferences surrounding their actions and the use of the tools.
CHAPTER 6

CONSTRUCTIVE RELATIONSHIPS: THE TEACHER, THE STUDENTS, AND THE RESEARCHER

"I had no idea that science could be such fun." - Ron

The present study investigated the use and development of content literacy practices by students and a teacher in an entry-level biology course for non-biology majors. More specifically, the study was undertaken to understand and describe the actions and practices a teacher and her students used to develop biology literacy at the community college level. This study was done from a theoretical perspective of constructivism. The research questions were the following:

1. Questions about the teacher:
   (a) What actions did the teacher take to communicate biology literacy to students?
   (b) What patterns and combinations of teacher actions and use of materials did the teacher believe to be effective for the development of biology literacy? Why?

2. Questions about the students:
   (a) What actions did students take to learn biology literacy?
   (b) What patterns and combinations of student actions and use of materials did students believe to be effective for the development of biology literacy? Why?
These questions were addressed through a bounded case study design (Bogdan & Biklin, 1992). Data collection included a semester of participant observations, paper and pencil surveys of the students, and teacher and student interviews. Analytical procedures were most similar to Glaser and Strauss' (1967) constant comparative method. The next two sections of this chapter summarize the related literature and the methodology in more detail.

Summary of Theory and Related Literature

The literature was reviewed as it related to constructivism and content literacy development. Constructivism is defined by Fosnot (1995) as "... a theory about knowledge and learning; it describes both what 'knowing' is and how one 'comes to know'" (Fosnot, 1995, p. ix). The theoretical themes were limited to two major parallel and competing paradigms, i.e., the transmission model and the constructivist model. The dominant paradigm, the transmission model or information transfer model of teaching has been described as the "banking concept of education" (Freire, 1970). The problems with the transmission model relate to the failure to consider such complex factors as the characteristics of the people involved, i.e., the instructor and the students, how people learn and construct knowledge or fail to construct accepted scientific principles (Guzzetti & Hynd, 1998), the beliefs and attitudes about teaching and learning, and the conditions and context of learning. The alternative paradigm of constructivism attempts to understand and address the complexities of the actual teaching/learning situation.

The literature review traced the history of constructivism to explain the trend towards wider acceptance. The notion of constructivism in instruction and learning can
be traced back to ancient Greece. Crowther (1997) traced the ideas of constructivism to
Socrates, Plato, and Aristotle (470-320 B.C.). Duit (1994) traced the roots of
constructivism to ideas in philosophy, educational practice, and to empirical research on
students' conceptions of science prior to instruction. Duit (1994) suggested a rationale
for the wide acceptance of constructivist ideas and constructivism in modern times.
Many conceptions of constructivism are not new. The conceptions embody ideas
developed from "long standing tradition" (Duit, 1995, p. 274).

In the United States, Lambert and McCombs (1998) wrote of learner-centered and
constructivist approaches to learning. They traced the constructivist perspective to Piaget
(1896-1990) who is sometimes referred to as the father of constructivism. Lambert and
McCombs (1998) also credited John Dewey (1859-1952), Jerome Bruner (1915- ), and
Lev Vygotsky (1896-1934) with constructivist ideas. Some of the ideas that contributed
to constructivism are the following: (a) the social construction of learning, (b) the
importance of active involvement and the active construction of knowledge, (c) the
importance of opportunities and challenges in the environment, and (d) the incorporation
of tools or new artifacts into actions that transform mental function (Vygotsky, 1987).

The review also focused on the literature related to science literacy from the
The implications for science pedagogy were summarized by Staver (1998) to include four
main principles:

1. Knowledge is actively built up from within by individuals and communities,
2. Language-based social interactions are central to the building of knowledge,
3. The character of cognition and language which is employed to express
cognition is functional and adaptive, and
4. The purpose of cognition and language is to bring coherency to an individual's world of experience. (p. 519)

The implications for content literacy development relates to a common principle. Anders and Guzzetti (1996) explained that all views of constructivism have one common principle: "... students are active learners who bring their own ideas with them to the classroom" (p. 54). A constructivist model of instruction considers the classroom dynamic and complex relationships.

Recent research suggested that there is a need to examine the contextual relationships for the actions that contribute to content literacy development in a classroom situation. Often the focus of study was on the teacher, or on the students, or on the curriculum. Prentiss (1998) and Alvermann (1998) called for descriptive studies to allow for the teachers' and students' voices to be heard from within the classroom settings.

Summary of the Design and Methodology

**Pilot Study**

The pilot study was in response to interest expressed by a professor and me regarding a basic geology course at the university level. The partnership with the professor and my independent research on ways to promote active learning in a large geology lecture class contributed to my professional growth about teaching and learning and led to this study. Also, through my graduate studies, I was in the process of developing the notion that content literacy practices, as presented by Anders and Guzzetti (1996), can contribute to effective literacy development in a content area to make a positive difference in students' constructed understanding.
The initial exploratory study involved a collaboration of the geology teacher and me. In the context of several informal chats in the teacher's office we shared information. My role was to provide three workable active learning strategies for the large lecture situation in Geosciences 101 while contributing to my own and the teacher's knowledge base on teaching and learning in that content area such as Geosciences 101. (The underlying premise for the initial study was my notion of active learning in the form of constructivism in a content area.) The process contributed greatly to my own understanding of teaching and learning but left me with more questions. I began to see a need to investigate scientific literacy development in a contextual setting of an actual classroom. In addition, reported literature indicated a need for further study in the classroom context to discover how teachers contribute to students' learning in a content area (Alvermann et al., 1998; Anders & Guzzetti, 1996; Dorman, Rosen, & Wilson, 1997). Borasi and Siegel (1999) suggested the need to study literacy as a holistic process rather than as isolated and separate events of reading, writing, and talking.

The Main Study

The study took place in a biology classroom at a community college in the Southwestern United States. The participants were the teacher, Maxie, and six students selected to be members of a bounded case study. The students were selected to reflect a variety of characteristics, backgrounds, academic abilities, and experiences. The following criteria were used to select the six case students: (a) age, (b) gender, (c) cultural background, (d) self-revealing and interesting personal history, (e) the first two mini-test scores in the course, and (f) class attendance. During the course of one
semester, I was a participant observer, participating in class activities and field trips, observing, recording the observations, talking with students about what they were learning, and interviewing Maxie. A microethnography of the teacher and the six purposefully selected (Bogdan & Biklen, 1982; Creswell, 1994; Merriam, 1988; Miles & Huberman, 1989) students was conducted. A qualitative research process (Seidman, 1991) approach was used including in-depth interviews and observations (Glesne & Peshkin, 1992) to search for any actions and beliefs of the participants that seemingly contributed to the development of biology literacy. Furthermore, surveys were used to discover students' background experiences. The surveys were used to select for the bounded case, to verify information gathered in the interview, and to learn the students' perspectives about what they believed were effective classroom practices.

Summary of Data Analysis

The data sources were my participant observer field notes, in-depth interviews, surveys, and artifacts of student work such as found in the list of materials and in the rubric examples (see Appendices C and H). The program NUD*IST was used as a preliminary data management tool. Initially, analysis of the data involved three readings of the participants' interviews and the field notes. I underlined words or ideas that seemed to stand out and made memos in the margins. Next, I experimented with several matrices to organize ideas related to the research questions. The data were then numerically coded according to major conceptual themes. These were re-read several times more and further refined and coded. Coding notations were established and items were lettered and numbered to be used in referencing the supporting data (see Appendix
E). Appropriate matrices were finally selected to help organize the data references for
the teacher and each of the six students upon whom I focused to develop this bounded

Review of the Findings and Conclusions

Teacher Findings and Teacher’s Perspectives

The teacher-related questions corresponded to the three principles that represent
the dynamic of constructivist instruction in content literacy development: (a) the
students’ interests, prior knowledge, and questions; (b) the teachers’ interests, expertise,
and interpretation of the concepts they teach; and (c) the available resources, including
texts, teacher provided materials, and community resources (Anders & Guzzetti, 1996).

Analysis of the data from the teacher’s interview and the field notes from the classroom
observations provided insights related to each of these principles. Three main themes
emerged from the data. The three themes that cut across the principles were: science as a
language activity, science as a social activity, and science as an experiential activity.

These three themes related to the classroom dynamic.

Science as a Language Activity

Science as a language activity implies actions related to language development,
usage, and understanding. The theme supports an understanding that language and
literacy are intricately intertwined. The examples in Table 6.1 briefly capture some of the
language actions Maxie took and believed to be effective for biology literacy
development.
Table 6.1

**Examples of Maxie’s Actions Related to the Three Considerations That Come Together for Constructivist Instruction and Science as a Language Activity**

**Principles:**

<table>
<thead>
<tr>
<th>Teacher’s interests</th>
<th>Students’ interests</th>
<th>Curricular resources (or tools)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Language Activity</td>
<td>Language Activity</td>
<td>Language Activity</td>
</tr>
<tr>
<td>• Reads extensively in science</td>
<td>• Uses small group discussions</td>
<td>• Provides study guides to help students focus on key ideas</td>
</tr>
<tr>
<td>• Brings outside interests into the classroom</td>
<td>• Incorporates oral presentation</td>
<td>• Provides additional text books and a book cart filled with books at different reading levels</td>
</tr>
<tr>
<td>• Writes messages (E-mail) and talks with teachers or pre-teachers.</td>
<td>• Emphasizes reading, writing, thinking, and wants students to apply what they learn; has high expectations for students’ projects</td>
<td>• Encourages use of computer and internet resources</td>
</tr>
<tr>
<td>• Seeks to widen her experience on issues and differences in science and in teaching</td>
<td>• Provides multiple opportunities to practice science</td>
<td>• Uses mini-tests to support and advance science concepts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Uses mini-lectures to introduce new topics and new language; and to initiate “thinking” questions and inquiry</td>
</tr>
</tbody>
</table>

**Science as a Social Activity**

The theme science as a social activity was evidenced by collaboration among participants as they figured out how science works and learned how to talk, read, write, and think science. The examples in Table 6.2 captured some of the social actions Maxie took and believed effective for science literacy development.
Table 6.2

Examples of Maxie's Actions Related to the Three Considerations That Come Together for Constructivist Instruction and Science as a Social Activity

<table>
<thead>
<tr>
<th>Teacher's interests</th>
<th>Students' interests</th>
<th>Curricular resources (or tools)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Activity</td>
<td>Social Activity</td>
<td>Social Activity</td>
</tr>
<tr>
<td>• Works with others at a professional level</td>
<td>• Gets to know students</td>
<td>• Facilitates group projects and group tests</td>
</tr>
<tr>
<td>• Attends conferences to help herself and others to improve practice</td>
<td>• Creates cooperative group activities</td>
<td>• Incorporates group activities in inquiry and learning cycles</td>
</tr>
<tr>
<td></td>
<td>• Uses and encourages humor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Uses inquiry and learning cycles</td>
<td></td>
</tr>
</tbody>
</table>

Science as an Experiential Activity

Science as an experiential activity suggested that the six students were constructing their understanding of biology and developing content literacy. Students encountered engaging experiences and curricular resources and tools designed to support content literacy development either concretely or abstractly. The examples in Table 6.3 captured some of the experiential actions Maxie took and believed to be effective for science literacy development.

Discussion

These findings suggested that Maxie used multiple actions to communicate biology literacy. One such action was her use of multiple materials to create a dynamic engaging classroom for biology literacy development. When I showed Maxie the lists, the number of activities and the extensive content material included in the course, she was surprised. In addition, she was surprised and pleased by the number of times the
Table 6.3

Examples of Maxie’s Actions Related to the Three Considerations That Come Together for Constructivist Instruction and Science as an Experiential Activity

<table>
<thead>
<tr>
<th>Principles:</th>
<th>Teacher’s interests</th>
<th>Students’ interests</th>
<th>Curricular resources (or tools)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiential Activity</td>
<td>Actively involves herself in experiences to improve her practice and knowledge.</td>
<td>Provides activities that actively involve students in multiple opportunities</td>
<td>Uses desert study site, and field trips</td>
</tr>
<tr>
<td></td>
<td>“I learned by doing.”</td>
<td></td>
<td>Advances learning through inquiry projects/learning cycles</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Integrates science literacy with poster projects</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Provides &quot;hands on&quot; materials</td>
</tr>
</tbody>
</table>

literacy-related themes—literacy as language activity, literacy as social activity, and literacy as an experiential activity—were woven within and across the course.

In Maxie’s version of a constructivist classroom, she engaged students so that they became involved in their own construction of knowledge and biology literacy development. She provided language, social, and experiential opportunities that encouraged students to connect with their own background knowledge and experiences. The multiple experiences enabled students to discuss, write, think, research, read, and present the answers to their own questions. Maxie also embedded learning in realistic and relevant contexts with real issues and real problems. She communicated an awareness of current events, issues, and trends such as recycling efforts and endangered environments in the local community. Maxie’s actions encouraged learning through
social experiences, group activities and group projects. And, finally, Maxie's self-awareness, reflective practice and actions indicate she seeks to improve her practice.

Students' Findings and Students' Perspectives

Summary of the Findings Related to What Students Bring to the Classroom

The findings indicated that the six case students brought varied histories, experiences, and understandings about literacy. The students differed from each other in terms of their ages, prior experiences in science, and ethnic backgrounds. The data on the first and second mini-test scores seem to indicate a stratified student sample with Amy and Ron on the high range, Denise and Scott in the middle range, and Maria and Lacey in a somewhat lower range. The hours per week students reported spending on studying varied. In addition, four students predicted grades that matched their final grades; two of the students' final grades differed by one letter grade. Students' responses to the Reading and Study Skills Survey (Bradley, 1982) suggested that students have different areas of strengths in their reading and study strategies. In addition, the six students' educational experiences differed. Denise, Scott, and Amy reported a high degree of interest and fairly positive school experiences about learning science. Lacey, Maria, and Ron reported some negative past experiences in science courses.

Students also revealed varying prior understandings of the meanings of science literacy, and biology literacy. These demonstrated the personal and situational nature of definitions (Anders & Guzzetti, 1986; Riggs, 1985). Amy explained science literacy as being "able to read scientific reports" and "being able to glean useful information." For Denise, science literacy meant knowing the concepts and understanding the terms.
Maria's definition came from the textbook "I think it's like an introduction to the environment." For Scott, science literacy "means not just being able to read, but being able to understand scientific things." In addition, his elaborated version reflects a desire to know how things work. Ron believes "You have to have [a specific] . . . kind of vocabulary [about] . . . how things develop."

Summary of the Findings Related to What Students Did in the Classroom

It was found that the students' perspectives varied regarding the types of teacher-initiated actions they believed to be effective for biology literacy development and helpful to their understanding. Six themes emerged from the interviews and surveys to answer the research questions about effective teacher actions. In a comparison across the group, the themes regarding effective teacher actions were: (a) involves students, (b) relates examples, (c) exhibits expertise, (d) create a relaxed atmosphere, (e) facilitates/coaches, and (f) credits creativity. Individual student perceptions were also reported (see Tables 5.8-5.13). The order of importance was based on the emphasis the student placed on particular themes and the actions reported as being related to language, social, or experiential activities. These were the themes which were used to describe the teacher's (Maxie's) theory and practice of teaching.

Summary of the Findings Related to the Tools Students Used

The third consideration for the students' construction of meaning related to the tools they used. The term tools comes from Vygotsky (1978) and refers to concrete as well as abstract tools. The tools included concrete materials and resources such as group/poster projects, multiple text resources, reading/taking notes, study guides, mini-
tests, field notebook, and field trips (see Table 5.14). Students shared some common beliefs about the tools they believed to be effective in biology literacy development. For example, the students found the group/poster projects and the multiple text resources to be the most effective. Students also differed in their belief about the effectiveness of some of tools. Tables 5.15-5.20 summarized the individual student's perspective on the actions and use of materials that each believed effective for their literacy development. They were again listed in order of importance to the student. There were some personal differences. For example, Maria, the bilingual student, emphasized the more concrete elements of literacy development.

**Discussion**

The variation that students bring to a classroom—their multiple experiences, interests and questions—is remarkable. These experiences affect the students' relationships, actions taken, and their use of tools. All responded favorably to the activities that involved and engaged them. While inquiry learning may be the normal course of events for students in elementary schools, and perhaps some middle schools, it is not as common at the community college. In their last interviews, the six students mentioned how much they learned and how surprised they were about the in-depth learning that they experienced as a result of their active involvement. The differences between and among the six students in the bounded case study contributed to understanding the classroom dynamic of content literacy development at the community college.
Implications

The following sections outline the various implications for practice and further research.

Implications for Practice

The collaboration of the teacher and researcher in support of science literacy development in the community college classroom has meaning for the teacher, for the researcher, and for the students. The findings from this study have implications for practice and for further research.

- Students believed that the variety of activities and the multiple opportunities and use of tools contributed to their biology literacy. This suggests a need to provide multiple language, social, and experiential activities in the community college classroom.

What Maxie Learned and Took to Her Teaching Practice

In our conversations throughout the semester Maxie revealed what this study meant for her. First, she was interested in understanding how students develop science literacy. Second, the collaboration contributed to her professional development in intellectual and practical ways. She mentioned that she enjoyed my comments about the actions she took in her classroom. I supported my comments with my understandings of current educational research. If I needed to clarify a concept or question, I would search for supporting research in journals and on the Internet. I made copies for Maxie and for myself. Sometimes I needed to reaffirm the concepts. For example, Maxie asked me about concept mapping, and I was able to find Internet resources on concept mapping,
graphic organizers, and mind mapping. Maxie reported that she enjoyed my little comments on the side, suggestions she might like to consider. She told me they were always done in a very thoughtful way and as a result, she began thinking "How might Pat bring this up or make this more clear to students?" She liked the idea of having another person in the classroom who understood how to respond to students' questions with other questions that guided students or who was able to zero in on a group in need of her expertise. Her past experience with some visiting pre-service biology teachers was contrary to her beliefs; they simply gave out the answers. She also mentioned that my questions often reaffirmed her practice and the use of inquiry and had made her much more aware of what it means for the students to develop science literacy and biology literacy.

Finally, I want to include Maxie's thoughts on the implications of the study.

I think that studies like this can show administrators and teachers and learners that there are other very viable ways of communicating science. If they see the topics that we have accomplished and gone through and studied in this one semester using this format I think they would be astonished. . . . I am hoping that with the students' responses that it will also help them to see from the students' standpoint that this is valid. They don't have to take our word for it. I think it can bring them closer to their students because I think that is the one thing that our relationship has done is that we have really looked at the needs of the second language learners, the needs of the individuals who might have personal problems. . . . (TI3, p. 48)

• Here, the implication for practice is that content area teachers and literacy researcher should team teach or do research together.

What I Learned and Took to My Practice

During the research process, I had the good fortune to learn at several levels from a very experienced science teacher. The experience provided me with ideas to take to my
own developmental community college reading class. I was aware of the theory behind constructivists' practices but lacked Maxie's extensive expertise and practical experience. My practice had been active and action oriented before the research study, but it became even more so. As a result of the study, Maxie's practice showed me the types of actions to incorporate into my teaching to make learning meaningful for my own students. In addition, I became much more aware of my own actions. My classroom became more action oriented as I tried to engage and involve my students in a number of language, social, and experiential activities. For example, the class went on a field trip to a local historical museum. Maxie helped me prepare an interactive writing assignment that would better engage the students in that experience. The students created historical stories from some of the early southern settlers' pictures. In my classroom we read and discussed relevant issues, we discussed and thought about how literacy varies in the different subject areas, and we worked on a poetry poster project. My students' poster projects were displayed in the classroom for several weeks. I reported to them about how my colleagues and other students had read and admired them. I learned more about my students, and I learned more from them. I also learned what it means to be a literate member of a science classroom community.

- The implication for practice is that supportive research offers a rewarding opportunity to learn for the person doing the research.
- Another implication for practice is that there is a need to engage researchers, who are also teachers, in inquiry-type experiences.
Implications for Practice of Teacher Education in Content Literacy and Science Literacy

The findings of this study led to several practical considerations for teachers who wish to support science literacy and content literacy development.

- Content area teachers need to conduct inquiry in their own classes, to study and reflect on their own teaching practices, to discover where and how they are making connects with students and where teaching and learning are breaking down.
- Content teachers need opportunities to investigate content literacy development.
- Content teachers need to have opportunities to form partnerships with other teachers to learn how content literacy can be better supported.
- Teacher educators need to encourage student educators to investigate literacy development in content areas.
- Science educators and educators need to collaborate and form partnerships around content literacy development. These types of relationships should be encouraged and strengthened by university colleges of education and by science departments at the university level, in community colleges, and in high schools.

Implications for Further Research

This research project, like most naturalistic research, leaves many questions unanswered. For example, another researcher might wonder about the following:

- To what extent are the findings related to the students' adaptation to the classroom culture and common educational experiences?
• Maxie and I were able to discuss teaching and learning practices quite easily. Did the fact that we were friends have something to do with the satisfaction we both derived from the study? Did our friendship affect the students' responses about their satisfaction with the course? How might other researchers construct a similar study?

• Does this type of inquiry contribute to practice in other ways that are not described here? In other words, we focused on literacy development in this study but what else happened that was beyond its scope?

• The theoretical orientation of constructivism might suggest that we were also co-constructing our teaching and learning processes. This implies a practical application to teacher preparation. How might this be studied in greater depth?

Implications for Research

One other issue came up during the study that might have implications for additional research. It began innocently enough in a discussion with my husband as I was enthusiastically explaining the value of the study and the fact that Maxie's version of a constructivist classroom included a high number of activities that supported science language development. He asked, "What did she do wrong?" and then commented, "She couldn't have done everything right." I explained that my research project was intentionally designed to look for the actions that supported an expanded notion of literacy development. While some might walk into the classroom and be critical or immediately say this isn't inquiry or constructivism, I think a study of a small segment of
a class time does not tell the whole story. Past research-based negative criticisms of classroom practice has resulted in a reluctance by many teachers to allow research to take place. To address this problem, Fradd and Lee (1999) suggested that research be "conducted in a spirit of tolerance and acceptance of what teachers and students know and understand" (p. 19). Mediated negotiation exists between the teacher and the students and that is where the learning takes place. The questions about literacy consider a mutual and supportive environment for the teacher, for the researcher, and for the students. When the focus is on literacy development, research becomes a much more supportive endeavor.

Additional implications and questions for further research might include:

- Similar investigations in other classes and content areas.
- What is the relationship of gender and the constructivist classroom?
- What is the relationship of scientific language and student language (i.e., ESL) background in a constructivist science class?
- How did students conceptions of learning science and using literacy tools change during one semester?
- How does a researcher's active participation in a science classroom regarding interview and survey questions affect their science learning and content literacy development?

Conclusions

The theory behind this study is complicated because studying and researching are complicated. Teaching and learning is complicated. Constructivism and content area
literacy construction and content area literacy as portrayed by Anders and Guzzetti (1996) provided the framework for this investigation. This is graphically represented as Figure 6.1 (also used as Figure 4.1) to examine the teachers' perspective:

- Teacher's interests, expertise, and interpretations of the concepts they teach
- Students' interests, prior knowledge and questions

Three considerations for constructivist instruction in content literacy development

Available curricular resources, including community resources (e.g., guest experts and field trips, literature, and text books)

Figure 6.1. Instructional considerations for content literacy development (adapted from Anders & Guzzetti, 1996). This figure duplicates Figure 4.1 in Chapter 4 and is repeated as part of the summary.

This was extended to include the students' perspective. The graphic used to organize the students' perspectives is Figure 6.2.

Beach (1994) recommended multiple stances in the conduct of literacy research. Multiple stances allow researchers to examine literacy in increasingly complex ways and
in so doing, the research moves away from simplistic and trivialized notions of literacy development. It takes into consideration complex social, cultural, language-related, and field stances that are often neglected in narrowly focused studies. This bounded case study considered these complex relationships. The research focused on the types of actions that took place in a biology classroom that the students and the teacher believed were effective for biology literacy development. This research contributes to a small but growing body of educators who care about students exploring their world and using the tools to do so.
APPENDIX A

SAMPLE TEACHER INTERVIEWS
First In-Depth Interview: To establish the context of the participant's background and understandings of literacy and more specifically, scientific literacy and biology literacy. The focus is the participant's past experiences and background beliefs and in any situations or experiences related to the study (Seidman, 1991).

Teacher Interview Questions PAST EXPERIENCES - INTERVIEW #1

During the first part of the interview I'd like to develop a background profile of your past experiences and beliefs.

BACKGROUND
Please discuss your background in teaching.
Number of years teaching - level - types of students.
Preservice education. Where? Special programs? Reading program? Student teaching. Where? When? How did Cooperating Teacher teach reading? Any innovative instruction in his/her class? (Probe: Quality of student teaching experience.) You might like to include your teaching philosophy from early years to how and why you've changed in your approach.

READING AND LEARNING TO READ
Discuss to the extent possible, your own experiences with reading and reading in biology, and the kinds of actions you believe helped you learn in biology.

When you first began teaching college biology at the community college, what did you believe students in biology should be able to do in terms of reading? (Probe: What were your beliefs or convictions in the early years of your teaching experience?) What were your early beliefs about what a really good reader could do? (difference between good and poor reader qualitative or quantitative?) When a student left biology what could she do? How do you believe students learned to read in biology in your early years of teaching? What accounts for the difference between a good and poor reader? Did you believe it was possible for a teacher or other person help a poor reader become a good reader? How do you define reading comprehension? What is included in that?
Do you remember learning (early teacher experience) any methods, strategies etc. to help students learn in biology? If so, discuss some of the actions you undertook in your classroom that you believed helped students understand what they read. Were there other actions you included in the classroom in later years? (for example, vocabulary, remembering ideas, memorizing facts? Questioning students - types of questions. Anything else?

The Students: Describe your students over the years and what you were able to observe about their reading abilities. How did you respond to the various abilities of students? What kinds of actions did you undertake when you noticed students having difficulty understanding biology? What kinds of actions by students influenced how you taught and communicated biology literacy? Have you noticed changes over the years in yourself and in your students?

The Community College:
Do you feel there are characteristic ways at the community college that biology teachers communicate biology literacy? If not, describe the differences. If so, describe the similarities. Do you have an awareness of what other instructors are doing? How do you know? Do you exchange materials, ideas, methods, or communicate with other teachers? How does that work or not work for you? Do you exchange materials, ideas, methods, or communicate with other biology instructors? What role do you play in the exchange of ideas? Describe some of the activities you were involved in the past that helped shape your current understandings about helping students develop biology literacy?

Personal Reading:
What types of things did you read in the past?
Second In-Depth Interview: To allow the participant to reconstruct the details of her literacy experience upon which her opinions may be built within the context of the biology course experience. In this second interview, the focus is on the concrete details of her experience (Seidman, 1991).

Teacher Interview Questions PRESENT EXPERIENCES - INTERVIEW #2

Definitions of Science Literacy and Biology Literacy (I want to see how closely the students align themselves with the Maxie’s definitions)

1. Describe your own literate practices during the course of the semester (Field journal and notes for class, internet searches, magazines, buying and reading books, e-mail, sharing of papers with other biology professionals, colleagues, etc.)

2. Talk about your experiences with students that seem to stand out as important in the biology course so far... You might also cover specific actions you take to find out more about students and their understandings of course material (i.e., mini tests, study guides, 3 x 5 cards.)

3. How does the knowledge of the students and what is happening with them help you make adjustments?

4. Are you aware of any alternative conceptions with the students? Mention alternative conceptions you might have noticed -- ideas that are perhaps unconventional. Talk about some specific actions you take. Do students for the most part, change to the conventional conception? How are you able to determine that? What made them readjust?

5. What do you do when students need further explanations about course work? How do the students respond?
6. What actions do you think students take that are most helpful for them in becoming literate in biology?

7. What actions or inactions do students demonstrate that help or hinder their acquisition of biology literacy?

8. Talk about the actions you take during the course of a semester that seem to help communicate biology literacy? Why have you included particular actions?

9. What role does technology play in your course during the semester? How does this help/hinder students' learning? Why?

10. Talk about the kinds of things you are more aware of as a result of our collaboration during the course of the semester. What's been most helpful? Least helpful?

11. Talk a little bit about your use of humor in the classroom.
Quick Survey Questions for the Instructor:

1. Have you read any books for pleasure during the semester? If so, what?

2. What other classes are you teaching during this semester? Which course is the most demanding?

3. What other responsibilities (besides teaching) do you have that demand your time and attention?

4. How many hours a week do you spend on preparation for this course? Do you think your preparation time has increased, decreased or stayed the same?

5. How has Inquiry Learning affected the way you teach?

6. How much more time is needed to teach this way (through inquiry)?

7. How long have you been teaching using inquiry in your classroom?
Third In-Depth Interview: To allow the participant to reflect on the meaning of the biology literacy experience. The purpose is to examine in part cognitive, intellectual and emotional connection the instructor may have made during the course of the semester (Seidman, 1991).

Teacher Interview Questions REFLECTIVE EXPERIENCES - INTERVIEW #3

1. How would you define science literacy? How would you define biology literacy?

2. Talk about the kinds of actions you’ve taken over the course of the semester to communicate biology literacy.

3. What patterns and combination of teacher actions and use of materials do you believe are effective in the development of biology literacy?

4. What do you think you’ve accomplished this semester?

5. What do you think your students have accomplished?

6. We’ve talked informally about alternate conceptions in science over the semester. Have you noticed anything this semester? If yes, discuss some of the actions you take to address them. If no, discuss how you’ve addressed them in the past.

7. One of the discussions we’ve put off has been you understanding of constructivism in science and biology. Would you mind discussing your beliefs about how people come to understand things in science?

6. How do you see our study and relationship over the course of the semester as being useful to the larger community of teachers and learners?

7. Is there anything else that you would like to add?
APPENDIX B
SAMPLE STUDENT INTERVIEWS
First In-Depth Interview: To establish the context of the participant's background and understandings of literacy and more specifically, scientific literacy and biology literacy. The focus is the participant's past experiences in school and in any situations they might have been involved in before taking the Biology course (Seidman, 1991).

Student Interview PAST EXPERIENCES - INTERVIEW #1 [revised 2/19/99]

1. Tell me about your own literacy experience growing up. (Talk about both the positive and negative experiences that you remember. In your response, think about your early experiences in the home, in school, or any situations that connect you with your own understanding about literacy. Mention experiences with friends, family, school mates, teachers etc. that seem to stand out as important past experience and background.)

2. What does being literate mean to you? (What does reading mean to you? What does writing mean to you? What understandings do you have about what being literate means to you?)

3. In school, were the science courses you took easy or difficult for you? (How do you think they were easy or difficult? What made them easy or difficult? How did you respond? What kinds of things were most effective in your understandings? What helped you learn science? ex. sci. fair)

4. What background experiences have you had in biology? (Include education and anything that has contributed to your ideas about where you are right now in your thinking. Consider also non-traditional experiences. Discuss one or more of your past experiences with science courses.)

5. What does science literacy mean to you? What does biology literacy mean to you? How would you explain it to someone who doesn’t know?

6. What kinds of actions and use of materials seemed effective for you?

7. How did you view yourself as a teacher and learner of science? Is there anything else you’d like to add about your past experience that I haven’t asked?
Second In-Depth Interview: To allow the participant to reconstruct the details of their literacy experience upon which their opinions may be built within the context of the biology course experience. In this second interview, the focus is on the concrete details of their experience (Seidman, 1991).

Student Interview Questions  PRESENT EXPERIENCES - INTERVIEW #2

1. Tell me about your current literacy experiences in biology. (What kinds of things are you doing that seem helpful to you? Ex. notes, study habits, homework, study sheets, inquiry projects).

2. How is the biology course going for you? How are you doing? What kinds of teacher actions are helpful to you?

3. Have your background experiences influenced what you have been able to accomplish for this course? Do you see your past experience as having influenced how you are doing now at the middle of the semester?

4. In the context of the present course, what does literacy and being literate mean to you? What current understandings do you have about literacy in biology?

5. What does science literacy mean to you now? What does biology literacy mean to you? How would you explain it to someone who doesn't know?

6. What literate materials and actions have been helpful to you? Or, in the context of this course, which actions and materials are most helpful to your own learning? What really stands out or has made a dramatic impact on your understanding of science or biology?

7. What kinds of actions or activities seem to help you understand difficult material? Please talk about both your own actions, teacher actions, and group actions.

8. Is there anything else you’d like to add about your present experience that I haven’t asked?
Additional questions suggested by the teacher.

Do you understand Maxie's expectations for the class? What do you think they are? How did you learn of them?

Do you think the assignments are related to Maxie's expectations? Explain or give an example.

You have seen two styles of course presentation. (Lecture, Active learning) What seems to work better for you? How would you compare the two methods? What seems to make a difference for you in your learning?

How has the in-class practice affected outside study time compared to a traditional lecture class? Which applies to you: "I have to study" or "I want to study?"

Does this type of study lead you to ask more questions? Have the number and types of increased as you study?
Quick Survey Questions for Biology 105 (Interview 2):

1. Have you read any books for pleasure during the semester? If so, what?

2. What other classes are you enrolled in this semester? Which course is most demanding?

3. What other responsibilities do you have that demand your time and attention? (Ex. children, job, parental care, family illness...)

4. How many hours a week do you spend on biology? Do you think your study time has increased, decreased or stayed the same?

5. What seems to be the most difficult reading material you face for your college courses?

6. What grade do you think you’ll earn for this course based on your current assessment?

7. Do you feel you get enough in-class time for the various activities? Do you feel like you have enough time to develop major ideas?

8. In class, do you think you are learning in pieces or through a process?

9. Do you see a pattern or theme in the course work? Yes/No Please explain.

10. What have you learned that you see as useful to other areas or other classes? (What do you think will be valuable to you?)
Third In-Depth Interview: To allow the participant to reconstruct the details of their literacy experience upon which their opinions may be built within the context of the biology course experience. In this third interview, the focus is on the concrete details of their experience (Seidman, 1991).

Student Interview Questions  EXPERIENCES - INTERVIEW #3

1. Talk a little bit about the things you’ve learned over the course of the semester? What strikes you as most important?

2. Talk a little about the literacy experiences in biology that seem most helpful to you i.e., actions and activities, the materials you used, the things you did, and the things Maxie did. (notes in required notebook, study habits, mini tests, problem solving homework, study sheets, inquiry projects, poster projects, computer searches). What three(or more) things stand out for you?

3. What does science literacy mean for you now?

4. What does biology literacy mean to you now? What current understandings do you have about biology literacy?

5. What surprised you about this course?

6. Have you made any changes in the way you read or study for this course. Yes/No  If yes, please explain.

7. What actions and activities do you think teachers need to incorporate into a biology course such as this one?

8. Is there anything else you’d like to add about your experience as a participant in this study that I haven’t asked? (Comments, suggestions)
Additional Questions for Third Interview:

Think about how your problem solving skills may have changed during the course of the semester. What have you noticed about your approach?

As a result of working in a group, would you be more inclined to work on your own?

What kinds of study habits have you adapted?

In what ways have you changed the use particular materials? Examples: Might use more computer searches, might use the text book more as a reference, might pay more attention to class notes and take more class notes during class.

What did you learn about biological research?

Has this experience affected the way you think about biology?

What did you learn about yourself through the research experience?
Semester Survey for Biology 105

THANK YOU for taking the time to help me in my research!  pat

Name________________________________________ Date:__________

1. What suggestions would you give to the next group of students who sign up for this course?

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

2. What surprised you about this course?

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

2. How many hours a week did you spend on biology?____ Do you think your study time has increased, decreased or stayed the same?____ Why?__________

____________________________________________________________________

____________________________________________________________________

3. Has the group work been a positive or negative experience for you?________
Please explain.

____________________________________________________________________

____________________________________________________________________

5. In what ways have you changed in the use of particular materials? (Examples: more likely to use computer searches, use of more than one text as a reference source, take better notes, would use posters in a presentation, more conscious of writing, etc.)

____________________________________________________________________

____________________________________________________________________

6. What three things did you learn about biology research and scientific investigation?

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

7. How has this course affected the way you think about biology and ecology?____

____________________________________________________________________
8. How valuable has this course been to your understanding of biology and ecology? What do you think you’ll remember 10 years from now?

9. What did you learn about yourself through the inquiry experience?

10. Would you take another course in science if it were taught using similar methods as experienced in this course? (YES/NO)

11. Would you feel confident to take another course in science even if it was not taught using similar methods? (YES/NO) Why or why not?

12. What suggestions would you give to biology teachers new to teaching at a community college? (Suggest actions, materials, and activities that worked for you. Please be specific.)
APPENDIX C

LIST OF MATERIALS AND DESCRIPTION
List of Text Materials and a Brief Description of Item

<table>
<thead>
<tr>
<th>Date</th>
<th>Item Number</th>
<th>Item and Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-20-99</td>
<td>1</td>
<td>Pre-Assessment for Environmental Biology given to students to complete on the first day of class as an idea of a starting point</td>
</tr>
<tr>
<td>1-20-99</td>
<td>2</td>
<td>Syllabus with general and specific course information including scheduled mini-tests, grading policies, conceptual and tactical objectives, research team organization, possible rubrics for short assignments, and an explanation of science literacy</td>
</tr>
<tr>
<td>1-20-99</td>
<td>3</td>
<td>Form for group activity on Teaching and Learning</td>
</tr>
<tr>
<td>1-20-99</td>
<td>4</td>
<td>Form for group activity on Science Literacy and expectations</td>
</tr>
<tr>
<td>1-20-99</td>
<td>5</td>
<td>Form for group activity on measuring instruments and measuring</td>
</tr>
<tr>
<td>1-20-99</td>
<td>6</td>
<td>Form for group activity on distance in miles from home to Tucson</td>
</tr>
<tr>
<td>1-20-99</td>
<td>7</td>
<td>Form for group activity on Observations and Measurement</td>
</tr>
<tr>
<td>1-20-99</td>
<td>8</td>
<td>Form for group activity on observations of the desert study site</td>
</tr>
<tr>
<td>1-20-99</td>
<td>9</td>
<td>Form for Chapter 4 Interactions: Environment and Organisms Study Guide - includes terms, relationships, thinking questions</td>
</tr>
</tbody>
</table>
| 1-20-99 | 10          | Course Texts:  
Biodiversity and You. Teacher shares terms from the internet |
<p>| 1-30-99 | 11          | 1999 Earthwatch Expeditions - teacher shares with students the projects going on around the world related to environmental research projects. |
| 2-03-99 | 13          | Chapter 45: Individuals and Populations - study guide and outline (from Wallace, Sanders, &amp; Feri) |
| 2-03-99 | 14          | Chapter 46: Communities, Ecosystems, and Landscapes - study guide and outline            |
| 2-03-99 | 15          | Chapter 47: Biospheres and Biomes - study guide and outline                              |
| 2-03-99 | 16          | Environmental Biology Minitest One (open book, open notes)                             |
| 2-17-99 | 17          | Environmental Biology Minitest Two (open book, open notes)                             |
| 3-03-99 | 18          | Minitest Three a group test on Hypothesis, Null Hypothesis variables. Requires student groups to work together to use the data of 5 different scenarios |
| 3-31-99 | 19          | Environmental Biology Minitest Four (open book, open notes)                            |</p>
<table>
<thead>
<tr>
<th>Date</th>
<th>Item Number</th>
<th>Item and Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-07-99</td>
<td>20</td>
<td>Environmental Issues Minitest (a take home test using the text Environmental Science)</td>
</tr>
<tr>
<td>4-17-99</td>
<td>21</td>
<td>Interactive Arizona Desert Museum Field trip- Students work in groups to complete worksheets. There are two versions. One has an open ended approach and the other one is more structured.</td>
</tr>
<tr>
<td>4-21-99</td>
<td>22</td>
<td>Biology 105 Chapter 17 Air Pollution - a study guide using Environmental Science</td>
</tr>
<tr>
<td>4-21-99</td>
<td>23</td>
<td>Biology 105 Chapter 15 Water Management - a study guide using Environmental Science</td>
</tr>
<tr>
<td>4-28-99</td>
<td>24</td>
<td>Biology 105 Solid Waste Inventory Sheet - requires students to keep track of the family trash generated over a weekend. These are sorted into categories of paper, plastic, glass, metal, and wood</td>
</tr>
<tr>
<td>5-05-99</td>
<td>25</td>
<td>Semester Survey for Biology 105 - A teacher and researcher survey that asks questions about the student's experiences</td>
</tr>
<tr>
<td>5-05-99</td>
<td>26</td>
<td>A single copy of a note to a student who needs to take the final early because of some family conflicts</td>
</tr>
<tr>
<td>5-05-99</td>
<td>27</td>
<td>Biology 105 - The Last Mini Test</td>
</tr>
<tr>
<td>5-12-99</td>
<td>28</td>
<td>Environmental Poster Assessment Sheet given to students after grading is complete</td>
</tr>
<tr>
<td>5-12-99</td>
<td>29</td>
<td>Student generated rubric for final report</td>
</tr>
</tbody>
</table>
APPENDIX D

PERMISSION

AND

INITIAL SURVEY
READING AND STUDY SURVEY
by John Bradley

Name: ___________________________  Date: ________________

DIRECTIONS: Read the following statements silently and fill in the bubble of the number that best shows what you actually do when you have to read and study a book chapter. Do not spend a lot of time thinking about an item, simply mark the response which, for you, fits best. You will learn valuable information about yourself if you try to answer honestly.

Response Scale

(1) = never
(2) = almost never
(3) = about half the time
(4) = almost always
(5) = always

LOCATION STRATEGIES. While reading, if you want to find out about something, do you use . . .

1. the table of contents to locate units, chapters, etc.  (1) (2) (3) (4) (5)
2. the index to locate information in the book?  (1) (2) (3) (4) (5)
3. the glossary to learn about unfamiliar words?  (1) (2) (3) (4) (5)
4. the appendixes to find information?  (1) (2) (3) (4) (5)

SURVEY STRATEGIES. Before reading a chapter in the textbook, do you spend a few minutes looking and reading . . .

5. the chapter title?  (1) (2) (3) (4) (5)
6. the introduction or advanced organizer?  (1) (2) (3) (4) (5)
7. the summary?  (1) (2) (3) (4) (5)
8. questions or exercises at the end of the chapter?  (1) (2) (3) (4) (5)
9. headings?  (1) (2) (3) (4) (5)
10. topic sentences (or the first sentence of paragraphs)?  (1) (2) (3) (4) (5)
11. unfamiliar or technical words?  (1) (2) (3) (4) (5)
12. graphs, table, pictures, maps, etc.?  (1) (2) (3) (4) (5)
Response Scale

(1) = never
(2) = almost never
(3) = about half the time
(4) = almost always
(5) = always

SURVEY-PROCESSING STRATEGIES. Before reading a chapter in a textbook, do you try to interest yourself in it and develop some reasons for reading it by . . .

13. reading the chapter title and trying to predict what the chapter is about?   (1) (2) (3) (4) (5)
14. looking through the chapter to call to mind additional information and to see if your initial thoughts are correct?   (1) (2) (3) (4) (5)
15. reading the introduction and summary to get a general idea of the organization and content of the chapter?   (1) (2) (3) (4) (5)
16. reading the headings and subheadings to see how they relate to the chapter and how they relate to each other?   (1) (2) (3) (4) (5)
17. looking for unfamiliar or technical words and spending a moment or so trying to learn what they mean by reading the sentences around them?   (1) (2) (3) (4) (5)
18. looking for unfamiliar or technical words and spending a moment or so trying to learn what they mean by reading the sentences around them?   (1) (2) (3) (4) (5)
19. reading charts, graphs, maps, picture captions, etc. to see how they relate to the chapter topic?   (1) (2) (3) (4) (5)
20. developing questions to be answered later concerning things in the chapter that you are uncertain of?   (1) (2) (3) (4) (5)

(Note about item 20. Your questions can come from any source e.g., headings, unfamiliar words, graphs, pictures, supplied questions, etc.)
READING AND STUDY SURVEY (3)  Bradley

Response Scale
(1) = never
(2) = almost never
(3) = about half the time
(4) = almost always
(5) = always

READING STRATEGIES. While reading do you . . .

21. say or think every word to yourself? (1) (2) (3) (4) (5)
22. read everything at the same speed despite its importance, its difficulty, and your familiarity with it? (1) (2) (3) (4) (5)
23. try to remember everything, even irrelevant unimportant details? (1) (2) (3) (4) (5)
24. try to answer your own questions? (1) (2) (3) (4) (5)
25. try to relate headings, subheadings, paragraph main ideas, pictorial aids to each other and to the chapter topic to become more aware of the chapter's organization and content? (1) (2) (3) (4) (5)
26. evaluate the accuracy and relevancy of information? (1) (2) (3) (4) (5)

MEMORY-PROCESSING STRATEGIES. While reading or after reading, do you try to remember important information by . . .

27. stopping after you have read a paragraph or section to underline important information? (1) (2) (3) (4) (5)
28. stopping after a section or unit to summarize its main points to yourself? (1) (2) (3) (4) (5)
29. outlining or taking organized notes concerning major points? (1) (2) (3) (4) (5)
30. developing a structured overview, a diagram or time line?

SCORING: To score the Reading and Study Survey, a very positive response receives a score of 5, and a very negative response receives a score of 1.

All of the items except #21, #22, and #23 are the positively stated items. Positively stated items receive the following scores: "always" = 5, "almost always" = 4, "about half the time = 3, "almost never" = 2, and "never" = 1.

Items #21, #22, and #23 are negatively stated items. On these three items "always" = 1, "almost always" = 2, "about half the time = 3, "almost never" = 4, and "never" = 5. That is, the scoring pattern is reversed on the negative items.

The possible range of scores is 5x30 (150) to 1x30 (30).
VOCABULARY STRATEGIES SURVEY
by John Bradley

Name: ___________________________ Date: ________________

DIRECTIONS: Read the following statements silently and fill in the bubble of the number that best shows what you actually do when you have to read and study a book chapter. Do not spend a lot of time thinking about an item, simply mark the response which, for you, fits best. You will learn valuable information about yourself if you try to answer honestly.

Response Scale
(1) = never
(2) = almost never
(3) = about half the time
(4) = almost always
(5) = always

1. When I hear or read a word that's unfamiliar, I look up its meaning in a dictionary if practical. (1) (2) (3) (4) (5)
2. I typically only read the dictionary's first definition of a word if there are several listed. (1) (2) (3) (4) (5)
3. I try to learn and use new words in conversation. (1) (2) (3) (4) (5)
4. I try to learn and use new words when I write. (1) (2) (3) (4) (5)
5. I work crossword puzzles or word puzzles in my free time. (1) (2) (3) (4) (5)
6. I try to analyze unfamiliar words by separating them into their parts (prefixes, suffixes, roots) to predict meaning. (1) (2) (3) (4) (5)
7. I skip over unfamiliar words when I read. (1) (2) (3) (4) (5)
8. I can discover the meaning of unfamiliar words by using context to predict their meanings. (1) (2) (3) (4) (5)
9. Reading is hard for me because I don't know a lot of the words. (1) (2) (3) (4) (5)
10. I like learning new words and using them. (1) (2) (3) (4) (5)

Items #2, #7, and #9 are negatively stated items. On these three items "always" = 1, "almost always" = 2, "about half the time" = 3, "almost never" = 4, and "never" = 5. That is, the scoring pattern is reversed on the negative items.
CATS LIT LAB INTEREST INVENTORY

<table>
<thead>
<tr>
<th>Name</th>
<th>Age</th>
<th>Sex</th>
<th>Date</th>
</tr>
</thead>
</table>

Examiner __________________________ Educational Level ______ Setting ______

1. Tell us about the things that you like to do or the things that you don't like to do.

   What is...
   1a. your favorite school subject (academic) ________________________________________
   1b. your favorite school activity (non academic) ______________________________________
   1c. your least liked school subject (academic) ________________________________________
   1d. your favorite out-of-school activity ____________________________________________
   1e. your favorite play activity ____________________________________________________
   1f. your favorite sport _________________________________________________________
   1g. your hobby ________________________________________________________________

2. How much time do you typically spend reading.....:

   2a. books ( ) none ( ) a little ( ) average ( ) a lot
   2b. newspapers ( ) none ( ) a little ( ) average ( ) a lot
   2c. magazines ( ) none ( ) a little ( ) average ( ) a lot
   2d. comic books ( ) none ( ) a little ( ) average ( ) a lot
   2e. hobby related ( ) none ( ) a little ( ) average ( ) a lot
   2f. computer software ( ) none ( ) a little ( ) average ( ) a lot
   2g. other ( ) none ( ) a little ( ) average ( ) a lot

3. How much time do you spend each day.....:

   3a. reading things of your choice: ______ minutes
   3b. writing things of your choice: ______ minutes
   3c. watching television: ______ minutes
   3d. playing video games: ______ minutes
   3e. listening to the radio: ______ minutes
   3f. playing (exercising) outdoors: ______ minutes
   3g. Watching movies (videos) ______ minutes
   3h. doing homework: ______ minutes
   3i. talking with parents: ______ minutes

4. Do you like to read? (Check one answer)

   ( ) not at all ( ) a little ( ) average ( ) a lot

5. Name some comic books that you read ____________________________________________
6. Name some magazines or newspapers that you read.

7. Name some things or hobbies that you do.

8. Name some of your favorite TV programs.

How late can you watch TV on a school night?

9. Name some of your favorite video games.

10. What kinds of movies do you like to watch?

Name some of your favorite movies.

Where do you watch movies? VCR at Home? _____ At theater? _____

11. Who are your favorite TV or movie stars?

12. What kinds of books do you read?

What are three of your favorites?

13. If you could buy as many books as you wanted, what would they be?

14. What do you like to read about?

15. What do your friends like to read about?
16. What books have you read that you disliked a lot? Why? ________________

______________________________________________________________

17. If you wanted to write a book, what would be its title? ________________

______________________________________________________________

18. What do you like to do most in school? ______________________________

______________________________________________________________

19. What job would you like to have when you finish school? ________________

______________________________________________________________

20. Who are your favorite heroes (men or women)? _______________________

______________________________________________________________

21. Check the kinds of things you like to read about (as many as you wish):

( ) Baseball  ( ) Football
( ) Basketball  ( ) Other sports
( ) Nature Stories  ( ) Horses
( ) Animals  ( ) Cowboy Stories
( ) Funny Stories  ( ) Travel
( ) War Stories  ( ) Murder Mysteries
( ) True life Adventure  ( ) Super Heros
( ) Science Fiction  ( ) Space Travel
( ) Horror  ( ) Mythology
( ) Movie Stars  ( ) Love Stories
( ) Famous People  ( ) Historical Tales
( ) How To Make Things  ( ) Art
( ) Poetry  ( ) Politics
( ) Dictionaries  ( ) Encyclopedias

Other Things ____________________________________________________
October 14, 1999

Ms. Patricia Griesel
6422 E. Shepherd Hills Drive
Tucson, Arizona 85710

Dear Ms. Griesel:

You have my permission to reproduce and use for your dissertation study my Reading and Study Survey. I would appreciate it if you informed me about the findings of your research. Let me know if there is anything else that you might need.

Sincerely,

John Bradley, Ed.D.
Associate Professor
Language, Reading and Culture
APPENDIX E

CODING CATEGORIES
Coding Notations

<table>
<thead>
<tr>
<th>Participants</th>
<th>Interview Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1 Amy (8)</td>
<td>2/22/99, 4/7/99, 5/5/99</td>
</tr>
<tr>
<td>S2 Denise (11)</td>
<td>2/24/99, 4/12/99, 5/5/99</td>
</tr>
<tr>
<td>S3 Maria (25)</td>
<td>2/22/99, 4/12/99, no show 3 times</td>
</tr>
<tr>
<td>S4 Lacey (21)</td>
<td>2/24/99, 4/7/99, 5/10/99</td>
</tr>
<tr>
<td>T Maxie (Teacher)</td>
<td>2/1, 3, 8, 4/17, 23, 5/18/99</td>
</tr>
<tr>
<td>R Researcher</td>
<td></td>
</tr>
</tbody>
</table>

Primary Data Source I interview
FN field notes: 1,2,3
A artifacts (includes student work)
S Surveys (informal)

Secondary Data Source AM analytic memo
C casual conversation
R researcher notes/ reflection

Major Categories
1.0 Question 1 - Teacher construct
2.0 Question 2 - Student construct

Conceptual Categories
3.0 Considerations for constructivist instruction
  3.1 Teacher's interests, expertise, and interpretations of concepts
  3.2 Students' interests, prior knowledge and questions
  3.3 Available curricular resources, including community resources

4.0 Science as a Language Activity
5.0 Science as a Social Activity
6.0 Science as an Experiential Activity
7.0 Staver's Constructivist Principles
   7.1 Knowledge activity built up
   7.2 Language based social interactions central
   7.3 Character of cognition and a language functional adaptive
   7.4 The purpose of cognition and language is to bring coherency to an
      Individual's world of experience

8.0 Relationships in the student's construction of meaning and beliefs about
effectiveness in the development of biology literacy
   8.1 Student's interests, prior knowledge, questions, and
       interpretations of science concepts
   8.2 Student's preconceptions, attitudes and beliefs
       about learning in the science content area,
       about the teacher, and about the setting
   8.3 Student's action and use of available curricular
       resources, including community resources
       (e.g., guest experts and fieldtrips, literature,
       and text books)

9.0 Anders and Guzzetti's Expanded Notions of Literacy
   9.1 Uses different texts for different purposes
   9.2 Text supported thinking and doing through critical
       and reflective thought or literate thinking
   9.3 Recognizes the similarity between reading and
       writing and other modes of symbolic communication
   9.4 Collaborative nature of literacy

10 Teacher Values
SAMPLE OF CODED RAW DATA

EXCERPTED FROM SCOTT'S INTERVIEWS

PG: What was it about chemistry that was difficult for you?
Scott: It was the memorization it wasn't like a science class I had. It was more book work than actual hands on and for me. I need hands on a little bit I need to actually do it not just sit there and read out of the book and try to memorize everything. It just doesn't work for me. I can do it but I can learn better hands on. Needs hands on.

PG: What kinds of things were most effective in your understanding would help you to learn science.
Scott: Get a lecture on it and have the instructor tell the students what they are seeing and what this is and visuals maybe even the real life thing that works good for me. If you can actually see it. It is hard for me to visualize unless I can see it. If he is talking about the heart of a frog and this is how it works it would be a lot better for me if we could just actually see it. Effective.

PG: What does science literacy mean to you?
Scott: Science literacy means not just being able to read but being able to understand scientific things like how do you use a ruler or whatever apparatus you are using for a lab. You have to know basic things like what temperature water boils at you have to have a pretty good background to be a pretty good biologist.

PG: What does biology literacy mean to you?
Scott: I think that would be more along the lines of living organisms even protozoa the circulatory system all the different systems of an organisms even the simple ones. Everything living being able to understand how they work as much as we can understand them. I'd start with a basic organism and introduce it to them and say do you know how that works as them the question and if they can’t answer you then you help them along and give them a little background knowledge and explain to them that is what literacy is it is when people can understand why that works the way it does not just that you see it is better when you can actually understand. Just like reading you can read the words but if you don't understand it it is the same thing.

PG: What kinds of actions and use of materials seemed effective for you?
Scott: Use something that is real. A lot of specimens a lot of maybe slides and things to look at under a microscope hands on things. Guides, posters, overhead to show you different parts and label them clearly if you look at them in a book you see animation that is not going to look like it does in real life they will look close but you might not be able to tell the difference. Not so many books. Books are good for defining terms and so on.
but you can't learn everything out of a book. They're good to use a dictionary like for a reference—to help you understand. EFFECTIVE ACTIONS AND USE OF MATERIALS 6.0 7.1 8.3 9.1 8.3

PG: How did you view yourself as a teacher and learner of science?
Scott: I saw myself as a visual learner or actually as a hands on learner or something like that. As a teacher I don't know maybe in group activities me and other people have worked to come to a conclusion. I have helped with things but a pretty strong visual learner. I think the internet is highly effective for learning information on just about anything. I think it may eventually replace a lot of paper we have now. It will replace some books and lot of things won't ever get published because of that. VISUAL LEARNER HANDS ON INTERNET 6.0 7.1 9.1 9.3

PG: Did you enjoy flipping through science books?
Scott: Yea I did. I found flipping through them a lot better than actually reading them cause you can get whatever you want to find out about. You can just look at you don't have to wait till you get to that chapter or whatever it can be used as a reference and I find that more effective. I focus on certain subjects and I know when I was in school if we were reading a chapter and I would get bored I would flip through and start reading something else in the book a different subject just because you get bored on one and want to learn about something else for a while. I think it is a good thing to do just flip through. FLIPPING THROUGH BOOKS EFFECTIVE 8.3 9.1

PG: Tell me about your current literacy experiences in biology. (What kinds of things are you doing that seem helpful to you? Ex. Notes, study habits, homework, study sheets, inquiry projects.)
Scott: The poster project was really helpful the research we had to do off the internet and everything I thought that was good. A lot of the things that we do in class pertain to where you have to go research in the books I think that helps a lot with my understanding of biology I keep notes on words I haven’t heard of before just for a reference if I need to go back and find out until I get familiar with them. For biology I study the same as probably everyone else. I will go over the things we discuss in class and my text and just till I get familiar with them try and figure out get a better idea of what is going on. HELPFUL: POSTER PROJECT, RESEARCH INTERNET, BOOKS, RECORDS WORDS, REVIEW 8., 8.2, 6.0, 9.1, 9.3, 9.4, 5.0 7.2 7.3

PG: Does that help you?
Scott: Yea.

PG: How is the biology course going for you? How are you doing? What kinds of teacher actions are helpful to you?
Scott: It is going well lately it has been kind of down just because I haven’t been feeling well but in general it is going real good I feel like I am learning a lot. I like the different kinds of activities we are doing. I have a pretty good understanding of everything we
have learned so far. Nothing has been confusing so I found that. LIKES THE DIFFERENT ACTIVITIES I FEEL LIKE I AM LEARNING A LOT 8.2

PG: What kinds of teacher actions are helpful to you?
Scott: I like the way that she goes into a lot of times she will give an example of something like she will say this is this but then she will show this is how it happens and she will tell us a story about how it happens. She doesn’t just tell you she gives you examples. TEACHER GIVES EXAMPLES 8.2 7.3 7.4 3.2

PG: So the examples are real helpful. EXAMPLES
Scott: Yes. Plus it makes it more interesting. I usually fall asleep but she kind of gets you interactive. TEACHER GETS YOU INTERACTIVE

PG: In the context of the present course, what does literacy and being literate mean to you? What current understanding do you have about literacy in biology?
Scott: A lot like I thought. In the past it means just to be able to able to understand what you are reading not just being able to read it and being able to relate your ideas to others on paper. BEING ABLE TO UNDERSTAND AND RELATE YOUR IDEAS TO OTHERS (CONNECTIONS) 4.0 8.2 9.2

PG: What current understanding do you have about literacy in biology?
Scott: It is just that I don’t really have an answer for it.

PG: What literate materials and actions have been helpful to you? Or, in the context of this course, which actions and materials are most helpful to your own learning? What really stands out or has made a dramatic impact on your understanding of science or biology?
Scott: The poster projects a lot of the homework assignments are helpful. The study guides are helpful not the homework. The reference material she has in class were helpful also the availability of computers in class where we can come use these sometimes and that is helpful. It seems like she keeps a lot of posters up in the classroom even though it doesn’t pertain to the subject we are currently on. I find those interesting. HELPFUL: POSTER PROJECT, STUDY GUIDES, REFERENCE MATERIALS, COMPUTERS, POSTERS IN CLASSROOM 8.3 4.0 9.1 9.2

PG: So you like the fact that the posters are there.
Scott: Yea it gives you some background on a different subject.

PG: What really stands out or has made a dramatic impact on your understanding of *science or biology?*
Scott: The actual hands on experiences that is the one subject where you usually do it yourself and it is not just told to you. You actually get to do the things and research yourself and I think that is what makes it gives me my best understanding of science when I actually get to do it. HANDS ON 8.2 6.0 7.4
PG: What kinds of actions or activities seem to help you understand difficult material? Please talk about both your own actions, teacher actions, and group actions?
Scott: Going over it multiple times until it is clear especially if it is very difficult and you have to go over more than once. Showing again and having it demonstrated to you is the best way I think. MULTIPLE EXPERIENCES, SHOWING AGAIN, DEMONSTRATION 9.2 8.2 8.1 7.1 7.2 6.0

PG: Please talk about both your own actions, teacher actions, and group actions?
Scott: In a group we usually do the posters we usually separate into little subdivide and do different activities trying to accomplish different things and then we will come together and we will try and piece it together from there so we will each have an individual job and then we will try and piece it together. I like it when we work together all work together on the same thing but it is a little slower. It is more efficient to do it this way. Maxie clears things up a lot for when we have a problem with something she will kind of lead us in the right direction so we can find the answer. She will give us a clue or something put you on the right track just by maybe a little something or it depends. 5.0 7.2 7.4 8.2 9.2

PG: Is there anything else you’d like to add about your present experience that I haven’t asked?
Scott: The way we went out in the field before in the beginning of the semester I thought that was a good change get out of the classroom and the Desert Museum field trip it kind of mixed fun with learning and I think that is when you learn the most. 6.0 FIELD TRIP 8.2 9.2

PG: Talk a little bit about the things that you’ve learned over the course of the semester? What strikes you as most important?
Scott: The intensive talk about the what we learned a lot about the environment as to the animals and how it pertains to them and the difference species that incorporate and many different environments like we talked a lot about the plants that live in different areas and why it is important that these areas stay the same to keep the same species that are native to them. We talked a lot about unnatural species and the problems they can cause. We talked about biomes we talked about some of the behavior patterns of some animals and animals that can benefit from human influence such as the coyotes and animals actually benefit from humans. We say how extinction is a natural process for some animals it is not just human influence but it is when the animals just can’t develop. They have to adapt to their new environment and those that don’t adapt are usually the ones that die off for instance the Panda. I thought she had a good explanation about that where it just hasn’t developed to like the others and its group its relatives like the kangaroo and it didn’t develop a pouch so that hurt it in the long run. We talked a lot about natural resources and how valuable they are we looked at some alternative resources for maybe when our current natural resources aren’t around any more. We planned a lot for the future. SCOTT'S MEMORIES OF THE CLASS STRONG EVIDENCE FOR CONTENT MATERIAL 8.1 7.4
Bio 105 Environmental Biology

Instructor:

Office:

Phone: Office: Lab:

E-mail:

Office hours: Mon. and Wed.: 11:15 to 1:00
By appointment

Welcome to Environmental Biology 105. We will be using the inquiry method of teaching in this class which includes many group activities. You often get to ask the questions as well as generate some answers. Hopefully there will be little formal lecturing and lots of hands on, roll up your shirt sleeves and work it out activities. We will also hone your communication skills to make you an all-round, accomplished college student.

We will be taking you into the realm of computers. I will be learning some new applications right along with you! I will sponsor everyone for an e-mail account through the college and internet access. I will give you five points if you e-mail me a message in the first three weeks of school.

We are looking forward to a fun and challenging semester with you. Keep your roller blades handy!
Bio 105 Important Dates

Minitest Dates:

I  February 3
II  February 17
III March 3
IV  March 24
V  April 7
VI April 21
VII May 5

Final Exam: May 12

Research Team Posters Due:
Desert Field Research Project: March 10
Environmental Research Project: April 28

Holiday Dates, No Classes:

Rodeo: February 25-26 (Our class is not affected.)
Spring Break: March 15-21
Final day to drop with a W: April 8

Last day of classes: May 18
General Policies for Bio 105

Grading Policy:

There will be seven Minitest:
Each Minitest is worth 50 points. You will get to drop your two lowest scores.
There are no makeups on Minitest. If you have to miss one, then that will be one of
the ones you must drop.
The Bio 105 class will have a 100 point field report that will be completed at the Desert Museum.
Student research groups in Bio 105 will produce two posters worth 50 points each for a total of
100 points on the semester.
The Final Exam is comprehensive and is worth 100 points. The exam must be taken on the day
indicated. No sooner or later. All students must take the final exam.

Students will also be graded on laboratory assignments and inquiry learning cycle assignments
which will be kept in their laboratory notebooks or turned in on special handouts. The point
totals on these will vary with each assignment.
Students can usually expect to have 300 to 400 points worth of these assignments.
Students missing days may not copy these assignments from their research group and
turn them in for a grade. You must be present in class to receive credit.
There will be no makeup on some of these assignments. It is the student’s
responsibility to initiate discussion of makeup opportunities.

Students can generally expect to have between 750 and 850 total points available for the
semester. Final grades will be determined by the following percentages of the total points
possible:

90% - 100% = A
78% - 89% = B
68% - 77% = C
58% - 67% = D (generally not acceptable for transfer)
Below 58% is not passing.

Attendance Policy:

Attendance will be taken on a daily basis. Students missing three classes in a row can be
administratively dropped by the instructor. Even if you have a good reason for being absent, too
many absences will still generally impact your grade in an adverse way. You need to carefully
think about your personal and professional commitments to determine if you can successfully
complete the course. If you feel at any time that you are having a problem meeting the
requirements of the class because of attendance problems then you need to talk with the
instructor.
General Policies for Bio 105

Cheating Policy:

Cheating consists of:
- copying other's work during a test or quiz;
- copying other's lab work when you were absent for that lab and turning it in as your own;
- having unauthorized materials in your work area after being asked to remove them prior to testing;
- copying other's work during any project and turning it in as your own;
- any other policies as stated in the student code of conduct for Pima College.

The first incident of cheating:
- student will be given a zero on the particular assignment or test in question;
- student's name will be referred to the Dean of Students;
- student is urged to seek counseling to prevent further problems.

The second incident of cheating:
- student will be given a failing grade for the entire course;
- student's name will again be forwarded to the office of the Dean of Students.

Students may appeal the procedure under the rules of the student code of conduct guide.

Grade of Incomplete:

A grade of incomplete will only be awarded if the student has failed to complete approximately the last 15 - 20% of the course. A grade of "I" will not be awarded to the student automatically. The student must contact the instructor with an explanation for requesting the grade. A student who is failing the course or making a low grade will not be awarded an incomplete. The student will keep all existing grades and only make up the 15 - 20% or work not finished to satisfy the completion of the "I" grade. In this course the "I" is not a "bail out of class" grade.

Students are encouraged to check with their individual instructors on all policies because we are given some latitude in these different areas.
Bio 105 Course Objectives

The reference texts for this section are: Biology: Wallace, Sanders, and Fertl: Fourth Edition (=B) Environmental Science: Enger and Smith: Fifth Edition (=E)

CONCEPTUAL OBJECTIVES

1. Viewing man's role in the environment, an introduction: E - 2, E-11
2. Understanding environmental interrelationships: E - 1
3. Defining populations and understanding their place within the environment: B - 45
4. Defining and understanding the complexities of communities, ecosystems and landscapes: B - 46, E - 4
5. Defining and understanding the broader concepts of biomes and the biosphere: B - 47, E - 5
6. Defining the needs and adaptations of plants and animals as they cope with specific environmental situations: B - 22 through 26
7. Defining and understanding the natural and manmade components of environmental issues.
   a. Soil and its use: E - 13
   b. Water management: E - 15
   c. Wetlands
   d. Forest management
   e. Agriculture and pest control: E - 14
   f. Air pollution: E - 17
   g. Solid wastes: E - 18
   h. Hazardous wastes: E - 19
8. Reviewing man's role in the environment, an ongoing process.

These objectives will be studied in an overlapping fashion as the method of inquiry - based teaching allows.
Bio 105 Course Objectives

The following objectives are sets of skills associated with the scientific method. You will fulfill these objectives by using information from other biological concepts that in themselves are also course objectives; sort of "two for the price of one!"

The numbers in parentheses refer to reference pages in the text: A Short Guide to Writing About Biology.

TACTICAL OBJECTIVES

I. Be able to view learning as a cumulative, life-long process
   A. What does good learning look like?
   B. What does good learning sound like?
   C. What does good teaching look like?
   D. What does good teaching sound like?
   E. Learn now, apply now.
   F. Learn now, apply later.

II. Be able to explore and use new and different learning tools. (36 – 51)
   A. E-mail accounts
   B. Internet accounts
   C. Library materials
   D. General and specific reference materials

III. Practicing science using the scientific method
   A. Learn how to make critical observations
      1. The difference between an observation and an inference
      2. Observations and empirical data
   B. Learn to develop questions based on observations
      1. Questions from direct observations
      2. Questions from indirect information
      3. Questions that can be answered by "scientific means"
         a. Can it be defined?
         b. Can it be measured?
         c. Can it be controlled?
         d. Can it be tested?
   C. Learn to convert questions to statements
      1. Statements of correlation
      2. Statements of cause and effect
      3. Stating a hypothesis
         a. Positive statements
         b. Null hypotheses (124 – 128)
         c. Accepting or rejecting a hypothesis (90, 91, 128 – 136)
   D. Learn to think and write about science (1 – 36, 152 – 161)
      1. Keeping and organizing the laboratory and field notebook (52 – 60)
      2. Experimental protocols: testing the hypothesis
         a. Defining the variables (levels of treatment)
            1.) Dependent variables
            2.) Independent variables
            3.) Controlled variables
         b. Procedure (materials and methods) (61 – 66)
         c. Record keeping
         d. Organizing and presenting data (results) (66 – 95)
            1.) Developing the narrative portion (87 – 95)
            2.) Designing figures (67 – 87)
         e. Discussion portion (98 – 108)
         f. Introduction and title (108 – 117)
            1.) Using multiple research resources (36 – 51)
            2.) Citing resources (95 – 98)
   E. Learn to make effective oral presentations of scientific materials (183 – 194)
   F. Learn to prepare effective audio-visual materials for scientific presentations (191-194, 258-265)
THE RESEARCH TEAM ORGANIZATION FOR BIOLOGY

A research team is a group of individuals working together to share ideas, ask questions, make observations, explore literature, and solve problems. This team approach is designed to bring together students of varied backgrounds and skills. We may not all have the same problem-solving skills or educational experiences. A group situation can enhance learning possibilities and foster cooperation and the appreciation of diversity.

The team generally consists of four members:

- **Director:** will keep things moving in an orderly manner; keep members on task; assist any team members with their responsibilities.
- **Recorder:** will write down ideas and questions; write down conclusions in formal form using team input (many times individual team members will also record their own information in their own lab books).
- **Researcher:** will hunt for information in books, library, Internet, etc. as appropriate; will receive assistance from other team members as needed.
- **Presenter:** will present group's finding to class; prepare handouts, etc.

These team positions will be rotated through the team with each new exercise. Team positions and names will be recorded in your lab books for each exercise. Even with the assignment of specific responsibilities, each member needs to be alert to the needs of other team members and assist where necessary.

Ideally a team should consist of four members. Sometimes a team may have three or five members.

If a team member does not perform adequately, the members will discuss their concerns collectively with that member. The team is still responsible for completing all phases of the exercises. If the poor performance continues, the team can ask the student to leave the team. The team will notify the instructor of the pending action. The instructor will meet with the entire team to discuss the situation. If the student cannot be reconciled with other members, that student will complete all exercises on his/her own.

Some labs and homework will be evaluated with a team grade, active members receiving the same grade. Some labs and homework will be evaluated as grades for individual team members (could receive different grades) following team cooperation or independent exercises.
Possible Rubrics for Short Assignments

5 points: Understands the question completely.
Answers the question correctly in a clear, logical and concise way.
Uses 2 or more ideas, examples, or arguments that support the answer.
Uses good grammar. (No errors)
Includes some discussion or thoughts on the subject.

4 points: Understands the question adequately.
Answers the question as above, but less thoroughly.
Uses at least one example, and acceptable grammar (one error)
Includes some discussion.

3 points: Understands the question.
Answers the question correctly, but does not elaborate, or give any thoughts or discussion.
Uses acceptable grammar.

2 points: Does not understand the question, but attempts to answer with related information and evidence in a discussion with acceptable grammar.

1 point: Does not understand the question.
Answers the question with no relevant answers.
Does not provide any evidence to support the answer.
Uses poor grammar (2 or more errors).
Science Literacy

"Scientific literacy is the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity. Scientific literacy means that a person can ask, find or determine answers to questions derived from curiosity about everyday experiences. It means that a person has the ability to describe, explain and predict natural phenomena. Scientific literacy entails being about to read with understanding articles about science in the popular press and to engage in social conversation about the validity of the conclusions. Scientific literacy implies that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed. A literate citizen should be able to evaluate the quality of scientific information on the basis of its source and the methods used to generate it. Scientific literacy also implies the capacity to pose and evaluate arguments based on evidence and to apply conclusions from such arguments appropriately."

"Learning science is something students do, not something that is done to them. In learning science, students describe objects and events, ask questions, acquire knowledge, construct explanations in many different ways and communicate their ideas to others."

To achieve scientific literacy greater emphasis will be placed on promoting the inquiry approach:

- understanding scientific concepts and developing abilities of inquiry
- learning subject matter disciplines in the context of inquiry, technology, science in personal and social perspectives, and history and nature of science
- integrating all aspects of science content
- studying a few fundamental science concepts
- implementing inquiry as instructional strategies, abilities and ideas to be learned

activities that investigate and analyze science questions
investigations over extended periods of time
process skills in context
using multiple process skills-manipulation, cognitive, procedural
using evidence and strategies for developing or revising an explanation
science as argument and explanation
communicating science explanations
groups of students often analyzing and synthesizing data after defending conclusions
doing more investigations in order to develop understanding, ability, values of inquiry and knowledge of science content
applying the results of experiments to scientific arguments and explanations
management of ideas and information
public communication of student ideas and work to classmates"

From: National Science Education Standards:
National Research Council; National Academy of Sciences
National Academy Press, 1996
Washington DC
APPENDIX G

INFORMED CONSENT
Teacher and Student Actions to Construct Biology Literacy
at the Community College: A Bounded Case Study
Researcher: Pat Griesel, University of Arizona

Participant’s Consent Form

I am being asked to read this material to make sure that I am informed about
the purpose and intent of this research and my participant’s role in it. If I
agree to sign this form, it will mean that I have been informed about the
purpose and intent of the research and that I willingly agree to participate.
Federal laws require written informed consent before participation in
research so that I understand the responsibilities and risks of my
participation role and can decide whether or not I agree to participate.

Purpose: Part of a dissertation research study, the purpose of the study is (1.) to learn
how instructors help students better understand new material, (2.) to learn how students
help themselves to better understand new material, and (3.) to learn how collaborations,
interactions, actions and activities among participants (one researcher, one instructor, and
and one group of learners) effect science literacy in an introductory biology course.

Procedure: If I agree to participate, I will be asked to participate in a survey and at least
one to three interviews. My participation is voluntary and I have the right to withdraw
consent at any time. I will be able to review a draft of the finished report and make
suggestions for changes if I choose to do so.

Confidentiality: I will collaborate with the researcher on whether notes, video tapes, or
audio tapes of my interview are permitted. Whatever recording method is decided upon,
these records will be kept strictly confidential. Excerpts from some of the transcripts
may be used in the final report document. A copy of the final report will be available to
me for my personal use. I understand that my personal name will not be used and the
researcher and I will agree upon either an initial or pseudonym to be submitted for my
personal name.

I have read and understand the above information; my signature indicates agreement
to allow my interview to be used in an article for publication.

Name (please print) __________________ Signature __________________ Date __________

Initial or pseudonym to be used in the report ____________________________________
☐ If chosen, I am willing to participate in three in-depth interviews (about 1 - 1.5 hours each) and a reading evaluation survey.

☐ During the course of the semester, I am willing to discuss on an informal basis, my own progress in biology and what helps me learn.

☐ I am willing to have my conversations about biology and biology learning audio taped.

HOME ADDRESS & PHONE (in the event I need additional information)

Name: ___________________________ Phone: ____________________

Address: _________________________________

City, State, Zipcode: _______________________________

Initial or pseudonym to be used in the report __________________________
APPENDIX H

SAMPLE STUDENT GRADED POSTER RUBRIC
ENVIRONMENTAL ISSUE POSTER ASSESSMENT

POSTER TITLE:_____________________________________________________________

______________________________________________________________

FINAL GRADE:__________

Rubric

Technical

_____/2  1. Clear and interesting title
_____/1  2. Titles for different sections
_____/2  3. Titles and appropriate descriptions and/or labels
       for pictures, figures, maps, graphs, etc.
_____/open 4. Spelling, grammar, punctuation, etc.
_____/1  5. Lettering appropriate size, easily read
_____/2  6. Pleasing, clear layout of information; read up
       and down and left to right
_____/4  7. General style points

Conceptual

_____/4  1. Clear definition or presentation of issue
_____/8  2. Presentation of both (or all) sides of the issue
_____/4  3. Locations
_____/8  4. Man's role in the issue historically and at present
_____/8  5. Suggested solutions and/or solutions in progress
_____/4  6. Interactive component between the viewer and
       poster

Comments:

maxfield/4-28-00
Bio 105 Environmental Poster Assessment Sheet

Poster Title: Global Warming (Blue Circle)

Final Grade: 48/50

Rubric

Technical

1. Clear and interesting title
2. Titles for different sections
3. Titles and appropriate descriptions and/or labels for pictures, figures, maps, graphs, etc.
4. Spelling, grammar, punctuation, etc.
5. Lettering appropriate size, easily read
6. Pleasing, clear layout of information; read up and down and left to right
7. General style points

Conceputal

1. Clear definition or presentation of environmental issue
2. Presentation of both (or all) sides of the issue
3. Locations
4. Man's role in the issue historically and at present
5. Suggested solutions and/or solutions in progress
6. Interactive component between the viewer and poster

Comments:

This poster is well presented and contains good information. The details are nicely covered.

The interactive portion is also well done.

It is difficult to give both sides of the issue but there are some individuals who think this is a natural phenomenon. You might want to look up some information from the "side of the house." --check out Trombe Wall Effect.
Bio 105 Rubric for Final Report

Name ____________________________

Final Grade: 95/100

9/10 Format: paragraph construction, opening and closing paragraphs
9/10 Style: spelling, grammar, punctuation, etc.

Content Categories

10/10 Key vocabulary; literacy; usage
   a. general information about deserts
   b. biodiversity
   c. climate
   d. geography
   e. topography

Application of geography/topography to local climate and biodiversity compared to other deserts

8/10 Topography and geography
8/10 Comparisons

10/10 How is climate affected?
10/10 Comparisons

10/10 How is biodiversity affected?
10/10 Comparisons

9/10 Synthesis Summary

Comments:

You jump back and forth from general desert descriptions to specific descriptions of the Sonoran Desert and the Sahara. I would have given the general descriptions and one or two sections.

Your comparisons are good.

You should have spent a little time discussing the specific mountain ranges that affect our weather and provide more niche life for our organisms.

All in all you have done a good job.
REFERENCES


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NUD*IST. (1997). Non-numerical, unstructured, data: Indexing, searching, and theorising. A qualitative data program initially developed in Australia and New Zealand, the NUD*IST (QSR, 1997).


