WHAT DO YOU SEE? A CASE STUDY
OF COMMUNITY COLLEGE
SCIENCE PEDAGOGY

by

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ABSTRACT

Community colleges educate almost half of all American undergraduates. These students include but are not limited to under-prepared high school graduates, and individuals who are working full-time while attending school, as well as students of diverse cultural, socioeconomic, and ethnic backgrounds. With such a diverse student population, science educators may find it difficult to teach science, especially since the language of science is exceptional and contains some inner hierarchy that most other disciplines do not (Osborne, 2002).

The study examined a community college science faculty's notion of learning to use visuals in science instruction to develop a community of practice through collaborative professional development. Through this examining, insight was gained on how to implement relevant science pedagogy in community colleges, leading to further studies in multiliteracies, professional development, and student perception of visual images.

DEDICATION

This dissertation is dedicated to my grandmother, Iola Howze Burroughs, and my great aunts, Gladys Howze Lee and Mattie Howze Horn. These women exhibited strength, courage, and love in all of their endeavors. From them, I learned three things: the value of an education; the worthlessness of regret; and the importance of seizing presented opportunities. All of you are truly missed.

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CHAPTER I:

INTRODUCTION

Teaching is often viewed as a rote function, something almost anyone can do (Boyer, 1990, p. 23). Oftentimes the instructor concludes, "I do not care if the students liked the class or not, as long as they learned the material," which translates to "I just want to see how they performed on the final" (Bain, 2004). However, this flawed mentality on the part of the instructor must be abandoned. Teaching is a dynamic endeavor involving analogies, metaphors, and images that build bridges between the teacher's understanding and the student's learning. Pedagogical procedures must be carefully planned, continuously examined, and directly related to the subject taught (Boyer, 1990). "Community college faculty receive scant attention from postsecondary researchers—or worse, are simply dismissed as a separate, and by implication lesser, class of college professors" (National Center for Postsecondary Improvement, 1998, p. 43). Even a decade later, Twombly and Townsend (2008) asserted that a lack of scholarship on community college instruction continues to be the norm. It was the aim of this study to change this trend—seeing possibilities for community college science teaching being enhanced through collaborative explorations of teaching practices.

Statement of the Problem

The American Association of Community Colleges (2009) stated that 46% of undergraduates in the United States are enrolled in community colleges. Community colleges typically have an 'open admissions' policy, which allows all students the opportunity to earn an associate degree or job training certification. Community colleges are often labeled as 'teaching colleges' because faculty focuses on teaching rather than research and community service.

Community college faculty, like their colleagues at four-year institutions, still address problems such as lack of enthusiasm, attitude, poor work ethic, and lack of commitment (Straw, 2003), as well as diverse cultures and socioeconomic backgrounds, and under-prepared high school graduates.

There are concerns about the quality of teaching in community college classrooms because of the lack of emphasis placed on the initial preparation and ongoing development of community college faculty pedagogical practices (Haworth & Wilkin, 2004). Although many college professors teach as part of their jobs, most disciplines require little to no pre-service training on how to teach. Therefore, most pedagogical training or professional development comes from on-the-job experience and formalized in services, often in the form of single exposures to experts (all day workshops or brown bag lecture series) (Erklenz-Watts, Westbay, & Lynd-Balta, 2006). This study focuses on using visual illustrations in science instruction through collaboration in order to develop a community of practice amongst science educators.

Multiliteracies refer to the range of literacies and literate practices used in all sectors of life and how these literate practices are similar and different (Anstey & Bull, 2006). For the purpose of this study, visuals are viewed as a form of multiliteracy that includes the following: category/classification organizers (concept maps), sequence organizers (cycles), and concept development organizers (flowcharts) that can be used in community college science instruction. Collaboration amongst science faculty on how various multiliteracies and visuals could be used in science instruction will foster a community of practice. A community of practice is defined as a group of people who share a concern, a set of problems, or a passion about a topic (Wenger, McDermott, & Snyder, 2002). Through collaborative efforts, science faculty can share ideas and expand their expertise to provide better science education at community colleges.

Building communities of practice requires a different type of professional development in addition to yearly institutional wide meetings or monthly departmental meetings. Although many community colleges across the nation have instituted faculty and staff development programs to meet the changing needs of a more diverse study body (Stolzenberg, 2002), collaborative professional development would allow time for faculty to share pedagogical ideas and would shift community college instructional practices from teaching to scholarship (Kelly-Kleese, 2004; Sperling, 2003; Van Ast, 1999) and teaching excellence.

Rationale for the Study

One day there was a knock on my office door. It opened and my co-worker asked me, "Have you ever used concept maps?" I responded, "Yes, but not since I taught high school biology. Why do you ask?" My co-worker and I engaged in a brief conversation about different instructional strategies that I have employed in the past. We exchanged information about websites, animations, and virtual labs that could be used in science pedagogy. Underlying our discussions was a shared concern: Why aren't students "getting" the science? What I did not share with my colleague, however, was my deeper concern that the problem was likely due to how faculty were presenting science content and that our pedagogical practices needed to be changed or improved upon to enable students to discover, inquire, and learn science.

A week later as I walked by the classroom where my colleague was teaching, I noticed students talking and writing in small groups. That sparked my interest, so I quietly stepped into the room and asked her what they were doing. She replied, "I did some research on concept maps and decided to use them with my students." Reflecting on my co-worker's initial visit to my office and how the students were working on their concepts maps, I asked myself these initial questions:

1. Why is it so difficult for students to understand and learn science at the post-secondary level, and specifically in our community college setting?
2. How can we, as science teachers, change students' ways of learning science to enhance science literacy?
3. What instructional approaches should be taken to address student learning concerns?

More often than not, the science instructor and student are disengaged partners, presumably gathered in classrooms to engage in teaching and learning. Some theorists believe that science educators need to increase students' science literacy as a teaching goal. To me, science literacy means introducing science for understanding for application in everyday experiences. Other science educators say to teach for scientific knowledge – through practice and study – viewing students as potential scientists, engineers, and physicians. In my opinion, it is a combination of both science literacy and scientific knowledge that most benefits students, but this study focuses on the application of science literacy practices and the presentation of science using visuals and multiliteracies.

Science Literacy

Science literacy is defined as the habit and ability to construct understandings of science; to apply these ideas to realistic problems and issues involving science, technology, society and the environment; and to inform and persuade other people to take action based on these science ideas. Science literacy embodies two essential senses: the fundamental sense and the derived sense (Yore, Bisanz, & Hand, 2003). The fundamental sense involves the traditions of being a learned person and the abilities to speak, read, and write about science. The derived sense involves knowing the corpus of knowledge in science. Should science education focus on the "science knowledge" or "real world" application for better understanding of science and conceptual thinking of science concepts? There should be a combination of science knowledge that incorporates science literacy practices for real world application.

"Science" literacy should be constructed by the student via the facilitation of the instructor, moving from a fundamental sense to a derived sense of science. Scientists and educators have long recognized the importance of the need for "science" literacy for all. Today, many science educators are pressing to make sure that science literacy occupies a more central place in standards and curricula, as well as in textbooks and teaching materials (Cavanagh, 2008). Bonnie Mizell, science coach at Howard Middle School in Orlando, Florida, encourages teachers to promote science literacy, even at early grades, by asking students to justify their answers in scientific terms. In an interview with Cavanagh (2008), Mizell stated, "Being able to think scientifically in our modern world is tantamount to success. Students who can't think scientifically, based on evidence and data, rather than emotion or belief, [are being sent] out into the world unprepared" (p. 12). As science educators, it is our responsibility to ensure that all students, regardless of major or career goals, can acquire and demonstrate science knowledge for real world application.

Multiliteracies in Science Education

After observing students struggle with learning science and listening to fellow science faculty voice concerns over teaching and learning, the research concept for this study became clear: explore ways to address the use of visuals as a viable mode to communicate understanding of science. This study is a reflective, collaborative investigation of a science instructor's use of visuals as an instructional tool.

One must have an understanding of literacy and how literacy can be addressed in teaching and learning. Freire defines literacy as “a strategy of liberation that teaches people to read not only the word but also the world” (as cited in Harris & Hodges, 1995, p. 141). People enact literacy in the past and present as part of their everyday social, cultural, working, leisure, and civic lives. Additionally, literacy entails teacher and student extrapolation of knowledge, skills, and processes deemed requisite to operate successfully as citizens of the local and global community in the present and future (Anstey & Bull, 2006). Using multiliteracies in science instruction expands literacy beyond reading and writing text.

Anstey and Bull (2006) view multiliteracies as a concept that has evolved in response to concerns about how literacy teaching can equip students for the changing world.   Because science is constantly changing, multiliteracies may be a useful means to teach ways to discover and construct science as it applies to world and life experiences. Literacy encompasses not only reading, writing, listening, and speaking, but also printed words on paper, graphics, digital technology, sound, music, words, and still and moving images (Anstey & Bull, 2006). Teachers who employ multiliteracies offer their student’s ample opportunities to access, evaluate, search, sort, gather, and read information from a variety of multimedia and multimodal sources; they invite students to collaborate in real and virtual spaces (Borsheim, Merritt, & Reed, 2008). When engaging students using various visuals and multiliteracies in instruction, science teachers facilitate rather than dominate learning.

Literacy is a part of everyone’s everyday experiences and practices (Hamilton, 2006). Many educators may be uncertain about how to use multiliteracies in instruction due to their own lack of knowledge, or their everyday literacy practices may not involve the same practices used by their students (Tiernery, Bond, & Bresler, 2006). Educators must be aware that literacy and literacy practices have no boundaries; rather, they encompass oral and written language as well as images, graphics, equations, symbols, sound, music, and gestures for students to access while learning (Hamilton, 2006). One can only imagine the possibilities and challenges faced by educators trying to extend their range of pedagogical practices, thus making teacher learning an even more pressing need to address.

Visual Illustrations as a Visual Tool

In this study, graphical representations are viewed as visual illustrations to communicate science (Moline, 2011) in community college science instruction. According to Moline's (2011) classification system of graphics, visuals include simple diagrams (show the surface), analytic diagrams (look close up or inside), process diagrams (show a sequence), structure diagrams (show relationships), and graphs (measure, rank, and compare) (see Appendix A). Graphical representations are visual tools that convert science concepts from text format to visual data. Due to the abstract nature of many science principles, visuals-graphical representations can play a powerful role in illustrating and explaining science to novices by making concepts more concrete (Coleman, McTigue, & Smolkin, 2010).

Visual illustrations can be an essential component of science education today. Visual illustrations, which specifically include any graphic, chart, table, or concept maps, are instructional tools that could allow students to communicate science literacy (Coleman & Goldston, 2011). Science instructors can collaborate to implement this instructional strategy, fostering a community of practice in community college science education. For this study, the use of graphical illustrations was limited to the use of only concept maps and referencing diagrams and flowcharts in the assigned textbook.

Building a Community of Practice in Science Teaching

The idea of cultivating communities of practice has been used in business and industry for years. Communities of practice are groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis (Wenger et al. 2002). The idea of cultivating or building a community of practice is similar to growing a plant. All the nutrients, sunlight, and water have to be provided so that the plant can grow. This same concept should be applied when building a community of practice in science teaching. Researchers assert that science teachers become more reflective when opportunities to critique and struggle with the dilemmas of practice are grounded in a social constructivist framework; "ideas are constructed through interaction with the teacher and other students" (Powell & Kalina, 2009, p. 241) in a framework in which teachers collectively and in a situated manner make sense of their practices (Grossman, 1992; Harrington, 1995; Howe & Nichols, 2000).

Accordingly, this study shifted from cognitive constructivism, "ideas constructed in individuals through personal process" (Powell & Kalina, 2009, p. 241) to reflect more contemporary notions of learning drawn from social constructivism. This shift leads to sociocultural learning, which encourages a community of teaching and learning. A sociocultural perspective of learning recognizes the social-interactional, organizational, and sociological; the biographical and historical; linguistic, semiotic, and cultural means by which individuals and groups make sense as "learning" (Lemke, 2001). Science teacher learning should highlight teachers' ways of knowing as a discursive practice mediated in a particular community context (Goldston & Nichols, 2009; Nichols & Tobin, 2000). "Effective teaching methods include creating an environment where students feel free to create unique concepts and structures to place in their memory for further retrieval" (Powell & Kalina, 2009, p. 248). This study examined the use of visuals by a community college science educator enacting her pedagogical practices in science instruction.

Research Questions

The following research questions guided this study:

1. What are the teacher's understanding of multiliteracies that could be used in a community college science teaching;
2. How might to use of visual illustrations and multiliteracies help both the science instructor and researcher learn about science instruction; and
3. How might the collaborative teacher-learning in this study provide useful insights for re-thinking professional development practices in the community college science context?

Significance of the Problem

Further study of the pedagogical practices of community college science instruction is needed. Therefore, it is paramount to take a deeper look at how "science" is presented. This pressing need, coupled with the fact that community college education is the foundation of learning for many students in higher education, means that this impact on student learning can no longer be a whisper in academia; it must be a loudly definite shout. With the many discourses in the science classroom, it is difficult to identify what approach is best, but observant science faculty will be willing to be reflective in their pedagogical practices. This study examined a community college science educator's use of visual illustrations as an instructional tool in her presentation of science. Results of this study may enhance fundamental notions about science learning and extend literacy practices to better support faculty through more collaborative professional development approaches.

Key Terms

Bricolage: the sense of research activity as "a pieced-together, close knit set of practices that provide solutions to a problem in a concrete situation" (Geelan, 2007, p. 35).

Case study: a study "of the particularity and complexity of a single case, coming to understand its activity within important circumstances" (Stake, 1995, xi).

Community of Practice: groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis (Wenger et al., 2002).

Graphical Representations (GR): visual illustrations of verbal statements (Jones, Pierce, & Hunter, 1988/89) including relational organizers (charts and storyboards), category/classification organizers (concept maps and KWL tables), sequence organizers (chain and cycle), compare contrast organizers (Venn diagrams), and concept development organizers (flow chart and word web).

Literacy: "a strategy of liberation that teaches people to read not only the word, but also the world" (Harris & Hodges, 1995, p. 141).

Multiliteracies: refer to the range of literacies and literate practices used in all sectors of life and how these literate practices are similar and different (Anstey & Bull, 2006).

Multimodal: when written linguistic modes of meaning interface with visual, aural, gestural, and spatial patterns of meaning (Gilster, 1997; Mitchell, 1995).

Narrative: reflecting the participant's voice so that readers can understand their story or experience being examined (Holley & Colyar, 2009);[2] making meaning of personal experiences through a process of reflection in which storytelling is the element (Clandinin & Connelly, 1990).

Science literacy: abilities and habits of mind required to construct understandings of science, to apply these big ideas to realistic problems and issues involving science, technology, society and the environment, and to inform and persuade other people to take action based on these science ideas (Yore et al., 2003).

Summary

The traditional method of teaching science should move beyond lectures. Science faculty should not mock the science instruction that they received, but be empowered to use new pedagogical practices in undergraduate science instruction.

Chapter II addresses scholarship and professional development in the community college culture, science education in higher education, social learning through building a community of practice among science teachers, and the notion of teacher science learning. Chapter III will describe the research methodology framing this investigation, study context details, and specific method. Chapter IV presents the insights gained by the researcher through the study. Chapter V provides reflective discussion of the study, implications of the study insights, and recommendations for possible future studies.

CHAPTER II:

REVIEW OF THE LITERATURE

Community colleges have evolved over the years to now play a vital role in postsecondary education. The American Association of Community Colleges (2009) states that community colleges educate more than half of the nation's undergraduate population, making them a critically important site for conducting educational research to ensure quality instruction. The role of the faculty is very important in the educational process at community colleges, yet research is rarely dedicated to exploring the professional development and teaching practices of faculty in this academic context (Fugate & Amey, 2000). The following study explores a community college science instructor's pedagogical practices.

This chapter discusses four areas of concern, beginning with an historical overview of community colleges in Alabama and followed by a discussion of shifting from old literacy notions to new "multiliteracies" for science learning and teaching. The chapter concludes with research pertaining to graphical representations as visual tools that can be used to incorporate multiliteracies in science instruction and issues of professional development for community college science faculty.

The American Community College

Community colleges are the center of educational opportunity. Cohen and Brawer (2008) define a community college as any institution regionally accredited to award the associate in arts or the associate in science as its highest degree. That definition includes the comprehensive two-year college as well as many technical institutes, both public and private. It eliminates many of the publicly supported area vocational schools and adult education centers and most of the proprietary business and trade colleges that are accredited by the National Association of Trade and Technical Schools, but not by regional accrediting associations. The mission of a community college is to provide education for individuals in its service region. Community colleges have increased in numbers and have greatly changed over the past 100 years since being established (American Association of Community Colleges, 2009).

History of Community College and Alabama Community College System

Public community colleges were developed as an extension of secondary schools to prepare students for university (Cohen & Brawer, 2008). The first community college, Joliet Junior College, was founded in 1901 in Joliet, Illinois, making Joliet Junior College the oldest public two-year institution in the United States. Initially, Joliet Junior College focused on providing a general liberal arts education, but this focus changed in the 1930s during the Great Depression. During this era, the majority of community colleges began to provide job training as a way to assist with the high unemployment rates. The community college mission changed again in 1948 with the passage of the Truman Commission, which supported the creation of a network of public, community-based colleges to serve local needs (American Association of Community Colleges, 2009).

The 1960s saw the establishment of many of the country's public community colleges (Weiger, 1999). The need for more community colleges was fueled by the baby boomers as well as the Civil Rights Movement. The number of community colleges has steadily increased since the 1960s. According to the American Association of Community Colleges (2009), there are now 1,166 community colleges in the United States.

In 1963, the Alabama Legislature passed new taxes in education, creating public two-year colleges in the state. A single system governed by the State Board of Education was passed at the insistence of Governor George Wallace, the "Father of Alabama Community Colleges." By the end of 1964, the Alabama Community College program had expanded to 11 junior colleges and 24 trade schools (which were elevated to technical college status in the 1980s); by 1987, there were 41 publicly controlled two-year colleges under the direct governance of the Alabama State Board of Education (Katsinas, 1994). Over the years, a dual system of primarily African-American trade schools and primarily white junior and technical colleges merged into a single system. In 1982, the Alabama Legislature created the Department of Postsecondary Education, thus separating itself from the State Department of Education and creating the position of Chancellor. Today, Alabama's community college system includes 21 comprehensive community colleges and four technical colleges; Marion Military Institute, one of five junior military colleges in the nation; Athens State University, the system's only upper-division institution offering baccalaureate degrees; and extensive workforce development initiatives, including AIDT and the Alabama Technology Network (Alabama Community College System, 2009). The Alabama Community College System thrives because these institutions are centers of educational opportunity open to all seekers.

Community College Context: Social and Culture Role

Community colleges are committed to building communities of life-long learners. The community college must develop its mission and strategic goals based on the needs of the community (Harlacher & Gollattscheck, 1992). Community colleges focus not only on academics and workforce development, but also on social development. Harlacher and Gollattscheck (1992) suggested that community colleges should reaffirm, with pride and conviction, their determination to serve all ages and racial and ethnic groups through building learning communities. This reaffirmation does not mean merely enrolling students from different social, economic, cultural, and ethnic backgrounds, but empowering them to be responsive learners. Galbraith and James' (2002) study of social roles in community colleges supports the idea that these roles do influence student performance. Although this is not an absolute solution to community college instructional concerns, Galbraith and James' (2002) research favors the ideology that the higher the social engagement, the better that students perform academically.

Each community college has its own culture based on the community in which it is located and the students that it serves. Culture, as defined by Nieto (1999), is the ever-changing values, traditions, social and political relationships, and world view created, shared, and transformed by a group of people bound together by a combination of factors that can include a common history, geographic location, language, social class, and religion (p. 48). Masland's (1985) study focuses on the organizational culture of college campuses in higher education. Masland states that the organizational culture impacts values, beliefs, and ideologies of the students, as well as student life, administration, and curriculum, which strongly suggests that each institution (community college) is heavily influenced by the relative culture of its students. Lee's (2004) study of River Parishes Community College reveals that campus culture shapes and influences student success. Lee asserts that faculty and administration must work to shape a positive culture on community college campuses. The above assertion reflects that when students are a part of a community supporting academic learning and social development, the outcome reflects meaningful learning.

Community College Context: Scholarship and Pedagogy

Despite attention being placed on scholarship in community college, the majority of community college students are not interested in faculty scholarship; the students are concerned with obtaining credentials to help them qualify for a job or promotion, to upgrade their skills, or to transfer to a university (Kelly-Kleese, 2004). Many community college faculty members realize, however, that there is a need for scholarship in the community for several reasons: a) to raise the intellectual profile of two year faculty and teaching in higher education; b) to conduct research in integrative learning; and c) to build collaborative communities of practice (Kelly-Kleese, 2004; Sperling, 2003; Tinberg, Duggy, & Mino, 2007; Van Ast, 1999).

Traditionally, community colleges focus on teaching (Jenkins, 2003; O'Hara, 2001), with little or no emphasis on the pedagogical development of the faculty (Sperling, 2003). For instruction to be effective, it must be learner-centered, organized, and planned (Ennis-Cole & Lawhon, 2004). Sperling, who participated in the American Association of Higher Education's Carnegie Teaching Academy, questions the scholarship of teaching and learning in community college (2003). Sperling confirmed

> few community college teachers are accustomed to coming into teaching through a 'learning portal' like elementary or secondary education teaching colleagues, who are educated through schools of education. A few community college instructors are grounded in learning theory; most have never formally studied – or even read much about- cognition, learning styles, human development, moral development, or taxonomies of intellectual growth. (p. 596)

Unfortunately, Sperling also observed that community college faculty most often "back into" understanding of scholarship and pedagogy through a hit or miss fashion or practice and observation (p. 596).

Chickering and Gamson (1987) posed the question, "How can students and faculty members improve undergraduate education?" Together they offer seven principles based on research on good teaching and learning in colleges and universities. Chickering and Gamson suggested the following: 1) encourage contact between students and faculty; 2) develop reciprocity and cooperation among students; 3) use active learning techniques; 4) give prompt feedback; 5) emphasize time on task; 6) communicate high expectations; and 7) respect diverse talents and ways of learning (p. 3). In *What the Best College Teachers Do*, Bain (2004) presented six questions that college teachers should examine: 1) what do the best teachers know and understand; 2) how do they prepare to teach; 3) what do they expect of their students; 4) what do they do when they teach; 5) how do they treat students; and 6) how do they check their progress and evaluate their efforts?

Academic excellence through meaningful pedagogy preparation must be a commitment on the part of the college administration and faculty. For instance, The Miami-Dade Community College implemented the teaching/learning project in 1986. The administration observed the need to help faculty become effective in classroom instruction. Subsequently, the administration urged improvement in three areas: graduate level courses, new faculty orientation and mentoring, and a fully staffed teaching/ learning resource center on each campus (Wolverton, 1996). Projects such as the above, and a willingness by faculty to collaborate across disciplines, suggests Grubb (2000), are needed in community colleges to improve teaching. Learning communities, collaborative learning, other nonhierarchical and interdisciplinary approaches, self-directed learning, and institution wide efforts such as the Teaching/Learning Project are needed to help faculty teaching at community colleges (Van Ast, 1999; Outcalt, 2000). Administration and faculty must agree with the expectations for teaching and learning at their institutions. Professional development programs should be implemented in order to meet and improve teacher needs, student learning, and the culture that exists at that institution.

Community College Context: Faculty and Faculty Development

In the 1960s and 1970s, community college faculty was comprised of mostly K-12 teachers, who shifted to college teaching because of the flexibility of class schedule and ability to teach adult learners. Since the 1990s, a new group of community college faculty has emerged, a group who did not originally envision a career in education. Lail (2009) stated, "this new group of faculty prepared for other non-academic careers and came to the classroom as a second vocational opportunity, either by chance or as a result of self-actualization" (p. 30). According to the *Profile of Community College Faculty* published in Association for the Study of Higher Education (ASHE) Higher Education Report (2007), community college faculty is comprised of mostly part-time faculty having at least a master's degree. It is projected that a substantial percentage of full-time faculty will be retiring in the next few years (Haworth & Wilkin, 2004; Lail, 2009; Sprouse, Ebbers, & King, 2008). Due to the anticipation of retirees, Chicago area community colleges are addressing the anticipated retirements by implementing a Community College Learning and Teaching (CCLT) program to prepare future community college faculty (Haworth & Wilkin, 2004). Since the trend in community college faculty hiring reflects the fact that many new faculty have no or limited pedagogy background, new community college faculty will have to be trained or provided professional development to teach effectively, even though they know their discipline content.

Community colleges need to focus on several areas: teaching excellence, faculty development, and hiring and developing quality community college faculty. For instance, this philosophy supports Iowa Community Colleges' implementation of the Quality Faculty Plan in 2003. Data collected after the first year of implementation reveal how each college designed and implemented a faculty development plan. Each institution tailored a plan to fit the college's culture, and each faculty defined faculty development according to its own understanding. Sprouse et al. (2008) suggested that faculty members who participated in the Quality Faculty Plan believed that they developed a bridge between faculty members that improved teaching and learning in Iowa's community colleges.

Mentoring programs are often implemented in K-12 to assist the novice teacher in the first year of teaching. However, a limited amount of research about mentoring programs is used in community colleges in order to develop new faculty. The mentoring can be formal, informal, or a combination of both (Ennis-Cole & Lawhon, 2004). Due to the fact that community college professors are engaged in a multitude of tasks with various sub-roles in addition to teaching, it is essential to explore the elements of mentorship to improve instruction and the student learning process (Galbraith & James, 2004). Hopkins' (2005) study supported mentoring to enhance professional growth and career benefits. Mentors and mentees need to understand their respective roles and missions, desire the relationship, respect each other's individuality, and work in an equitable and collaborative manner (Ennis-Cole & Lawhon, 2004).

The mentoring program creates a greater need for professional development in community colleges (Stolzenberg, 2002; Watts & Hammons, 2002). Currently, most community colleges have "institutionalized" professional development, which means that the institution provides some type of professional development of the faculty. Taber (1997), who conducted a study of Alabama's two-year college faculty development needs and preferences, recommends a statewide system faculty and staff development program. He also recommends that this development program focus on the following: the needs of the employees, a reward and recognition system, and evaluation of professional development implemented. Based on Taber's recommendations, the Alabama College System (post secondary education) began providing state-wide professional development for faculty during the fall semester of the academic year. This professional development included a key note guest speaker and workshops presented by Alabama community college faculty.

Murray's (2001) national study revealed that there is "no evidence that faculty development at most community colleges is anything more than a randomly grouped collection of activities lacking intentional coordination with the mission of the college or the needs of faculty members" (p. 497). At the seven colleges included in this study, faculty development takes place in three venues: formal college wide programs, official department meetings and activities, and informal conversations among colleagues. The most frequently offered college wide programs are flex days, which are usually offered at the beginning of each academic year or semester. Colleges generally invite one or more speakers to address the faculty as a group, schedule time for departmental meetings, and allow faculty to participate in elective sessions on topics ranging from the use of technology to personal financial planning. Although substantial financial and human resources are invested in developing and offering these programs, instructors generally view them indifferently or negatively (Kozeracki, 2005).

Community of Practice within Science Instruction

Teaching Science in Higher Education

Many students in the United States complete their science requirements at a community college (Biermann, 1996). Most community college science faculty consider themselves “pure” science majors, which means having little or no pedagogy training. College faculty members make many assumptions about students. Yes, expectations are high; educators must remember that every student brings different perspectives, misconceptions, and prior knowledge to the science classroom. Studies (Goldston, Clement, & Spears, 2004; Van Dijak, Van Den Berg, &

Van Keulen, 2001) show that undergraduate science courses can be made interactive through inquiry rather than the traditional teacher centered lecture approach. Teaching science for understanding is strongly advised to uncover and address students' prior and alternative conceptions in science (Tanner & Allen, 2005).

In fact, meaningful learning can be achieved by assimilating new information rather than merely recalling text. Angelo (1997) recommended focusing on improving student learning rather than teaching. Teaching for learning moves the focus of the classroom (perhaps earning a certain grade or completing a set number of chapters) to self-awareness, self-assessment, and self-improvement for both teacher and student. Jones, Reichard, and Mokhtari (2003) suggested that learning styles are subject area sensitive, and a majority of students (community college) perceive that different disciplines require different learning strategies. These students are then better able to adapt or style-flex to meet the requirements of the learning task. When science teachers become reflective and collaborate, the result is effective teaching in a learning community in which students construct knowledge.

Meaningful professional development for science educators in community colleges is needed. This can be assumed since a study (Sunal, Hodges, Sunal, Whitaker, Freeman, Edwards, Johnston, & Odell, 2001) on university science teaching showed that professional development of science faculty in higher education was limited, and more effective science teaching is needed in higher education. Accordingly, Goldston (2004) stated that science faculty who teach undergraduates have the "knowledge and skills of the discipline," and science educators who have "specialized knowledge in pedagogy" should become co-participants in an effort to re-shape teaching science in postsecondary schools (p. 375). This collaborative partnership between these groups of science faculty could help to build a community of practice amongst community college science faculty.

The Teacher in the Classroom

This study was designed to allow the teacher to become more reflective in pedagogical practices to improve not only learning, but also teaching. The act of teachers learning to reflect upon their instructional practice is a step towards a more constructivist stance. This can be initiated by using visuals in science instruction, which in turn can be used to support students' learning within a constructivist classroom (Kinchin, 2001). Such constructivist teacher development is perceived by Kroll and LaBoskey (1996) to encourage teachers to see themselves

1. *As learners*: to reflect on themselves as learners as they learn to teach - seen as a lifelong construction process;
2. *As teachers*: to become passionately involved in their specialist content area; and
3. *As researchers*: to see their own teaching and learning and their students' learning as issues for inquiry.

Science educators should view teaching as a learning environment where the teacher is not only a learner, like the students, but a researcher in teaching and learning to promote change in pedagogy.

Building a Community of Practice in the Science Classroom

Communities of practice develop ways of maintaining connections with the rest of the world (Wenger, 1998). Educational communities of practice are beginning to develop and address such issues as teacher education, course revisions, or organizational changes in departments. The results of an ethnographic study (Olitsky, 2007) of an eighth grade urban magnet school science class suggest that successful interaction rituals can foster student engagement with topics that may not have previously held interest. This can ultimately contribute to student support of peer learning, thereby moving the classroom toward a community of practice model. Other studies (Goodnough, 2008; Howe & Stubbs, 2003; Sirum, Madigan, & Klionsky, 2009) have suggested that science teachers move from lecturing to more active learning instruction in an effort to develop communities of practice in science classrooms.

Higher education institutions are largely built on the assumption that learning is an individual process best encouraged by explicit teaching that is, on the whole, separated from social engagement with those outside the university community (Hodgkison-Williams, Slay, & Sieborger, 2008). However, the increasing demands of American higher education have encouraged academia to form collaborative teams, striving to work smarter to establish communities of practices (Carter, Park, & Reid-Griffin, 2004). Communities of practice have shifted from k-12 to higher education in science and science-related subjects. Higher education science faculty are attempting to facilitate collaborative groups among faculty and the science community (Carter et al., 2004; Hodgkison-Williams et al., 2008; Weaver, Pifer, & Colbeck, 2009). Higher education science faculty have found that case discussion of teaching dilemmas has fostered communities of practice with students as well (Glynn, Koballa, Coleman, & Brickman, 2006; Williams, 2008).

Literacy Context: Science Literacy Including Multiliteracies

Discourse about the goals and reform of science education is couched in terms of literacy. Science knowledge should be constructed, rather than rotely memorized. The construction of science concepts and knowledge promote meaningful learning. Novak (1998) stated that meaningful learning occurs when the learner chooses to relate new information to familiar ideas;

this in turn lends the new material conceptual richness. According to Novak (1998), meaningful learning has three requirements:

1. *Relevant prior knowledge.* The learner must know some information that relates to the new information to be learned in some nontrivial way;
2. *Meaningful material.* The knowledge to be learned must be relevant to other knowledge and must contain significant concepts and proportions; and
3. *The learner must choose to learn meaningfully*. The learner must consciously and deliberately choose to relate new knowledge to knowledge that the learner already knows in some nontrivial way.

Authentic construction of science knowledge involves application, manipulation, interpretation, or analysis of prior knowledge to solve a problem that cannot be solved simply by routine retrieval or reproduction (Newmann, Marks, & Gamoran, 1996). Faculty members should use active and collaborative teaching and learning practices that engage and challenge students in the classroom.

A New Literacy: Multiliteracies

With respect to literacy, this study does not examine functional literacy, which is defined as “a level of reading and writing sufficient for everyday life” (Harris & Hodges, 1995, p. 89). Rather, the study acknowledges that literacy has evolved to multiliteracies (Borsheim et al., 2008; The New London Group, 1996). The premise is that these multiliteracies represent a paradigm shift in the ways that research practitioners understand and enact literacy and learning (Cervetti, Damico, & Pearson, 2006). Multiliteracies refer to the range of literacies and literate practices used in all sectors of life and how these literate practices are similar and different (Anstey & Bull, 2006). It is being argued that science instruction should include various multiliteracies, e.g., visual illustrations as defined by Moline (2011), and multimedia, along with functional literacy practices of reading and writing.

The examining of multiliteracies is a social practice, which results in a myriad of ways to build a communicating (Tiernery et al., 2006) and learning community. Multiliteracies imply that there are different literacy genres and a variety of literacy situations that may be accompanied by a range of literacy practices (Paul & Wang, 2006). The concept of literacy as reading, writing, listening, and speaking is no longer a concept relating only to printed words on paper, but also digital technology, sound, music, words, and still and moving images (Anstey & Bull, 2006). Literacy practices will continue to change as literacy practices evolve. A greater range of literacy practices emerge (New London Group, 1996), engaging a student's scientific knowledge, critical thinking skills, processes, and behaviors more effectively than previous literacy practices.

According to Paul and Wang (2006), many students have difficulty accessing academic content information that traditionally has been presented in textbooks; such presentation does not give students the opportunity to develop the ability to reflect upon information, solve problems, and develop a higher level of critical thinking skills. Teachers reveal a repertoire of literacy practices when students are given the opportunity to explore images, sound tracks, and text that interconnect in multifaceted ways. These multiliteracies form new ways of knowing through communication, discovery, reflection, and critical thinking (Tierney et al., 2006). Multiliteracies offer students opportunities to access, evaluate, search, sort gather, and read information from a variety of multimedia and multimodal sources (Borsheim et al., 2008). When using multiliteracies in science classrooms, learning shifts from listening to science to actively learning about science through communication and various literary practices.

Using Multiliteracies in Science Pedagogy

Ideas in science are communicated through words, charts, diagrams, symbols, pictures, and mathematics (Wellington & Osborne, 2001, p. 82). Through multiliteracies, "different literacy genres and a variety of literacy situations accompanied by a range of literacy practices" (Paul & Wang, 2006, p. 305) serve several pedagogical functions. First, multiliteracies facilitates a constructivist model of learning; students can glean the meaning of science through authentic experiences (e.g., constructing graphics/visuals). Using multiliteracies in science pedagogy can support traditional literacy practices such as reading and writing through various engaging literacies such as digital text, multimedia, or animations, engaging students in literacy practices that incorporate audio, graphics, and images. Finally, multiliteracies extend beyond traditional literacy objectives to support and advance the development of future multiliteracies (Borsheim et al., 2008).

The traditional literacies of reading and writing print text are shifting to using digital, graphics, multimedia, and online discussion forms to engage students in literacy practices. Pedagogy that includes multiliteracies requires the teacher to identify characteristics of pedagogy that help students to become multiliterate (Anstey & Bull, 2006) through written, digital, and electronic formats of literacy. Anstey and Bull's (2006) definition of multiliterate is a person who "is flexible and strategic and can understand and use literacy and literate practices with a range of texts and technologies; in socially responsible ways; in a socially, culturally, and linguistically diverse world; and to fully participate in life as an active and informed citizen" (p.19). Using multiliteracies as an instructional strategy moves teaching and learning to a new and wider view of literacy, however, it must be understood that this does not mean using a LCD projector and producing or re-producing PowerPoint presentations. "Multiliteracies" implies that there are many forms of literacy that vary across time and communities – that literacy is a social practice, rather than a set of reading and writing skills to be acquired (Cervetti et al., 2006). Multiliteracies integrate students' everyday literacy practices, such as animations, multimedia, Wikis, and blogs, into classroom instruction.

Changes in literacy practices are created by rapidly evolving, online technologies that influence how teaching and learning take place in classrooms (Williams, 2008). Teachers have to understand the millennial student language and incorporate instructional strategies that will engage them in learning. Several studies (Chandler-Olcott & Mahar, 2003; Kervin, 2009; Kitson, Fletcher, & Kearney, 2007; Tan & Guo, 2009) noted success with the use of multiliteracies such as media text and interactive whiteboard to teach students. The researchers agree that 'new literacy' affects the students' learning positively. Using multiliteracies in pedagogy is not achieved simply by applying guiding principles to identify content and contexts for learning (Anstey & Bull, 2006). Rather, the teacher must learn how to use multiliteracies as a pedagogy practice. Multiliteracies help students connect "new literacies" simultaneously with traditional learning for real world application (Borsheim et al., 2008). This pedagogical approach allows students to collaborate in a real and virtual space by helping them to understand how to move between and across various modes of media (e.g., written, visual, and digital text) to become multiliterate.

Scientific Literacy versus Science Literacy

Although teaching science with diverse learners can be a difficult task, the goal is that each student can describe, explain, and express science in various ways. The National Science Education Standards stated

> 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. (National Research Council, 1998, p. 22)

Hobson (2000) suggested the following to re-design college science pedagogy to enhance science literacy learning for all students:

> First, make it (instruction) nontechnical, that is, conceptual. Second, teach in an interactive, inquiry-oriented way. Third, include plenty of the modern science that defines today's scientific world view. The finally strategy: make it (instruction) socially relevant by connecting science with the current world. (p. 136)

This can be difficult because not all students enter a science class with the same experiences and prior science knowledge. It is important to reach all students with the types of educational experiences and opportunities that will encourage and foster a growing understanding of and appreciation for the processes and the products of science (Mickikas, Bybee, & Hanych, 1995, p. 115).

Science literacy is an awareness of general science concepts, facts, and theories and a person's ability to construct and understand science concepts. Science literacy includes the unifying concepts of science, the nature of science, the relationships among science, technology, society and environment, the procedures of science, and the social relevance of science. For instance, Yore et al. (2003) suggested

> Language is an integral part of science and science literacy – language is a means to doing science and to constructing science understanding; language is also an end in that it is used to communicate about inquiries, procedures, and science understandings to other people so that they can make informed decisions and take informed action. (p. 691)

Science instruction should include more than functional literacy, "a level of reading and writing sufficient for everyday life" (Harris & Hodges, 1995, p. 89), with a movement to using new "literacies" in science. Thus, science literacy incorporates all types of literacy practices for understanding and constructing science learning.

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 (National Research Council, Principles and Definitions, 1996). Holbrook and Rannikmae (2009) argue that scientific literacy is based on two points of view: those that a) advocate a central role for the knowledge of science, and b) those that see scientific literacy referring to society usefulness (p. 278). *Framework for K-12 Science Education* (2012) views scientific literacy as education in the sciences and engineering in which students, over multiple years of schooling, actively engage in scientific and engineering practices and apply crosscutting concepts to deepen their understanding of the core ideas in STEM (science, technology, engineering, and mathematics) fields. Different from science literacy, scientific literacy focuses on "doers" of science in the context these individuals apply science daily in a STEM field.

In conclusion, scientific and science literacy may seem interchangeable terms, their meanings however represent subtle differences of language and meaning. In short, science literacy could be seen through one's ability to talk about conventional science knowledge, whereas scientific knowledge is one's capacity to talk and think in ways that resonate with the formalized practices of scientists. The understanding and practicing of science is a central interest to this study in the specific context of community college science education. Specifically, viewing using visuals such as concept maps and multiliteracies such as multimedia and animations to help students develop an understanding and application of science concepts.

The Language of Science

"Science" is not simply a body of knowledge to be transmitted; rather, science education is a sociocultural and a sociohistorical meaning-making experience (Fusco, 2001; Traianou, 2006b). "Science education involves a range of ways of communicating (visual, verbal, graphical, symbolic, tactile) which can be exploited to engage with different learning styles or abilities and to provide a variety of teaching approaches" (Wellington & Osborne, 2001, p. 8). This does not mean that science contains an inner hierarchy, but merely that each conversation in any given scientific domain builds on previous conversations. Thus, science progresses in a fundamental way that most other disciplines do not. The consequence is that the discourse of science increasingly deviates from that of other discourses (Osborne, 2002).

Wellington and Osborne (2001) believe that there is a body of research over the past 30 years that shows that one of the major difficulties in learning science is learning the language of science. Therefore, Wellington and Osborne suggested

> Learning science is as much about learning the language of science as it is about learning its substantive content… students must have an opportunity to practice its use through structured activities that require them to talk about science, to use scientific words, and to share and construct their own meanings of these words. (p. 84)

Wellington and Osborne (2001) assert that more effective teaching of language within the science classroom requires both the recognition and the development of practices that support and scaffold the development of reading, writing, and the exploration of meaning.

Using Visuals in Science Teaching

Multiliteracies captures the intersection of literacy as meaning between teaching and learning (Tiernery et al., 2006), using visuals as a pedagogical practice extends the basic premise of literacy to include visual literacy. Visual literacy is the "ability to interpret and communicate with respect to visual symbols in media other than print" (Harris & Hodges, 1995, p. 274). According to Coleman and Goldston (2011), visual literacy and science inquiry go hand in hand. By questioning visual information, students can develop visual literacy skills that enable them to critically interpret and communicate information observed through science experiences (p. 47).

Empirical Studies in Visual Literacy

One of the great advantages of visual texts such as maps and diagrams is that most of the information they provide is readily accessible to all readers (Moline, 1995, p. 1). With the change in literacy, visual texts have become multi-layered texts that include diagrams, graphs, maps, and tables, as well as multimedia like the Internet, CD-ROM, animations, and videos. Moline (1995) states that visual literacy is needed to function in today's society.

Visual literacy studies (Schnotz & Bannert, 2003; Stern, Aprea, & Ebner, 2003) show that active "visual illustrations of verbal statements" (Jones et al., 1988/89, p. 20) aid in the transfer and learning of concepts. Students today live in an age of technology that uses visual images to convey information. This means that it is essential that today's students develop the general visual literacy skills required for dealing with scientific graphs, but they must also learn about particular types of scientific pictures that actually form part of the content of a specific field of scientific or technological study (Lowe, 2000).

Several studies (Bruning et al., 2004; Mayer, 2002; Mayer, Heiser, & Lonn, 2001) reveal that the use of visual images in college instruction creates a meaningful learning experience for the student. The use of a visual image to illuminate relationships in data helps students not only to comprehend the text, but also to see patterns that are not clearly evident from reading the text alone (Thomas, Place, & Hillyard, 2008). According to Robinson and Kiewra (1995), graphic representations such as graphics, charts, and diagrams are more efficient than outlines because a visual format demonstrates relationships between and among concepts.

Starr and Kracjik (1990) stated that many college biology programs are implementing concept mapping to provide an aid for course conceptualization and development. Several research studies (Cliburn, 1986; Okebukola, 1990; Schmid & Telaro, 1990) suggested that concept mapping has a positive impact on learning used in biology instruction. In addition to these researchers, Mintzes, Wandersee, and Novak (2001) also stated that using concept maps encourages meaningful learning and conceptual understanding in the biological sciences.

Kinchin (2001) believes that teachers should have a positive attitude towards being equipped for the role of ‘empowered learners’ when using concept maps, which he claims enhance student learning. A teacher in his study, however, expresses concern with the way concept mapping could relate to teaching. The teacher views concept mapping as the first step towards adopting a more “meaningful learning approach.” The teacher states the following:

> To be very useful, the teacher’s then got to do something with it. You can’t just say ‘oh, I’ve done a concept map!’ ‘Oh good, let’s pat you on the back!’ It’s a can of worms. If you open it, you’ve got to do something with it. Otherwise you’ve got the danger of reinforcing mixed messages and confused concept. (Kinchin, 2001, p. 1262)

Hyerle (1995) states that “if the teacher is more interested in ‘‘correcting’’ or editing ideas to fit a lesson, the whole point [of mapping] has been lost” (p. 45) because the point is to allow students to construct the concept visually from prior knowledge.

Defining Visual Information

The use of visual information or visual text is not a new concept in science. The use of visual information should be relevant to students’ understanding that science includes more than reading and writing; literacy includes how information is communicated. Moline (2011) explains that communicating with words also includes visual elements such as diagrams, graphs, maps, and tables (see Appendix A). Visual images represent a well-founded form of data that can be used in a variety of ways. They are another instructional tool that teachers can utilize to gain a deeper understanding of the perceptions that students (PK-16) hold of science (Finson & Pederson, 2011, p. 79). Moline (2011) further stated that visual literacy cannot replace the traditional literacy of words and sentences. Visual literacy is rather a complementary skill.

Graphics are strong where words are weak; words are strong where graphics are weak. Visual texts tend to be a more concise, vivid, and therefore a more memorable way to organize information (p. 10).

Instructional Practices Involving Visual Information

Research by Ausebel (1963) and Novak (2001; 2003) suggested that the mind arranges and stores information in an orderly fashion. When important information is isolated, students can see how concepts are connected and make the concepts more understandable (Irwin-DeVitis, Modlo, & Bromley, 1995). Teachers now realize that visual illustrations help students to organize their knowledge, encourage divergent thinking, and stimulate higher order thinking (Gil-Garcia & Villegas, 2003). In a case study (Gil-Garcia & Villegas, 2003) of higher education faculty, the undergraduate and graduate students' opinions of visual images connect visual language with verbal language to stimulate active learning. This active learning reflects the idea that students using visuals such as concept maps are able to recall information from previous knowledge, which helps with learning and relating new information. Faculty members assert that visuals help with pedagogical value when introducing conceptual frameworks and offer students opportunity to represent knowledge. Ultimately, this asset strengthens students' critical thinking skills.

Visual images help learners to develop a visual framework of a concept. When students construct visual images of text, they better understand which ideas are important, how they relate, and what points are unclear (Jones et al., 1988/89). Graphic images can be used to show cause-and-effect relationships, to compare and contrast ideas, to represent the chronological sequence of objects or events, to group terms, and to answer problems or questions. Because of the visual nature, processing graphical images into memory requires fewer cognitive transformations. This way of processing information is easier than reading text for the learner because inferences are being drawn from graphical elements (Vekiri, 2002).

Larkin and Simon (1987) suggested that visual illustrations are computationally efficient because they enable the viewers to make "perceptual inferences." "When they (students) construct graphic representations of text they read, students better understand which ideas in the text are important, how they relate, and what points are unclear" (Jones et al., 1988/89, p. 20). Visual images can play a critical role in several cognitive tasks. Rather than simply providing information, graphical representations can stimulate the mind through visual displays, which can influence the nature of cognitive activity and operate as "external cognition" in various tasks (Scaife & Rogers, 1996). Interactive instruction takes place. Teachers can facilitate students in transferring written text to graphical images that can be used to assess learning. Students begin to construct rather than listen to science.

Summary

Pedagogy should be a collaborative and reflective practice that teachers use to improve and develop strong instruction in the classroom. Too often, science classrooms are dominated by lectures and dependency on textbooks. Science should be presented to students in a constructivist approach that allows students to construct ideas of what science is and then apply those observations to real world experiences.

This study focuses on a teacher learning to use visual tools as a means for enacting multiliteracies inside her classroom to enhance science learning. The study has as a secondary highlight the exploration of professional development and how it affects community college science instructors.

CHAPTER III:

METHODOLOGY

This is a qualitative case study of a community college science instructor's pedagogical and professional development practices. The researcher undertook the study as beginning steps to enhance science teaching involving visuals through collaboration at this community college. This chapter outlines the methodological rationale, method of study, critique of the study, and a brief summary of the chapter. Approval for the study was obtained through the governing university's Internal Review Board (IRB) (see Appendix B).

Research Methodological Rationale

This study took place at a community college, South State Community College[1](SSCC), located in the southern region of the United States of America. Since teaching and not research is the focus of community colleges (Jenkins, 2003; O'Hara 2001), this study was viewed as a springboard to connect teaching and research to improve pedagogical practices in community college science instruction. This inquiry was inspired by Fazio's (2009) study involving secondary science teachers in collaborative action research--an experience that not only enhanced their understanding of scientific inquiry and the nature of science, but also encouraged the faculty to evolve into a *community* of teachers and learners. Pedagogical use of visuals provided a common point of interest to bring the researcher and faculty member together for the study.

[1] Pseudonyms are used for all persons and places throughout this study.

The study's focus on one participant, N=1, was purposefully small to allow an "in-depth information-rich case" (Patton, 2005, p. 1634) examining issues of science pedagogy and faculty professional development in this particular community college setting. Yin (1994) defined a case study as "an empirical inquiry that investigates contemporary phenomenon within its real life context, especially when the boundaries between phenomena and context are clearly asking the question how or why" (p. 13). Stake's (1995) definition of case study is a study "of the particularity and complexity of a single case, coming to understand its activity within important circumstances" (xi). Case study methodology allowed the researcher to be reflective and gain understanding of the phenomenon of the case.

Methods of the Study

This section describes research methods of this case study, including background and role of the researcher, selection of the study participant, descriptions about the study setting, and data generation, analysis, and re-presentation.

Study Setting

The study was conducted at South State Community College (SSCC), a comprehensive, public, two-year, multi-campus located in a large urban setting. The study spanned a fourteen-week period including initial background interview, pre- and post-classroom interviews, two classroom observations each week over ten weeks (because of the timing of IRB approval the classroom observations begin in the spring), and debriefing interview. The mission of this community college is to provide accessible quality educational opportunities, promote economic growth, and enhance the quality of life for people in its service area. Also, the community college is dedicated to providing affordable and accessible lifelong learning opportunities in order to prepare students for employment or career advancement, enable students to transfer to senior colleges and universities, and provide customized training needs for business and industry.

In 2005, this institution was merged with a technical college retaining its historically black college/university (HBCU) status. Since the merger, the current trends in enrollment and ethnic background are approximately 65% female enrollment versus 35% male enrollment. Ethnic categories are approximately 80% Black; 12% white; and 8% other; enrollment ranges from 2,400 – 4,000. The average age range of students is 18 – 65 years, with about 40% of incoming freshman testing in one or more developmental courses (English, mathematics, or reading).

The study participant, Ann, and I work at SSCC within the Department of Natural Sciences. This department has primary responsibilities for science instruction for science majors and non-science majors. As stated in the 2008 Community College's Institutional Effectiveness Plan, the mission of the Natural Science Department is

> to provide quality science courses and programs to equip students with skills for employment or career advancement or to enable students' to transfer to senior colleges and universities with an adequate science background to be successful at those institutions and to enhance students' science literacy in an increasingly technologically sophisticated society. (South State Community College Institutional Effectiveness Unit Plan, 2008, p. 1)

The department's mission, as stated in the 2008 Community College's Biology Degree Program Student learning Outcomes, is " to support student learning using various teaching methods and strategies to encourage and motivate all students to achieve their maximum intellectual capability in the pursuit [of] their academic and professional goals" (South State Community College Biology Degree Program Student Learning Outcomes, 2008, p. 1).

The Natural Science Department is composed of five full-time female faculty members. Three of the five faculty members have doctoral degrees; two possess PhD degrees in biology and one has a PhD in secondary science education. The experience of the science faculty varies. Two of the five instructors in the department have prior experience teaching in public high school, whereas the other faculty members might be regarded as ‘real’ science faculty because of their biology degrees and biological research experiences prior to being employed as instructors at this community college.

Background and Role of the Researcher

Prior to being employed at SSCC in 2000, I taught biology for five years at a high school located across the city from the college campus. I was recruited to teach at SSCC by an administrator who previously was my principal at the high school. The opportunity to work as a teacher in higher education was compelling. The students at SSCC are there by choice, looking for an institution of higher education that can provide them better career options, particularly in the allied health professions.

My desire to keep current with trends in science education led me to pursue my doctoral degree in Science Education. During my studies at the university, I became interested in the use of graphic organizers, more specifically “graphical representations” (Coleman, 2006; Moline, 1995) in science teaching. Simultaneously, I was looking for collegial support, as I was literally thrown into the community college classroom without any orientation or preparation to teach in higher education. When I was hired, SSCC classes were already in session. The department chairperson handed me a copy of the course syllabi to use as a template and a copy of the recommended textbook for the course. Over time, I had the opportunity to see what and how other faculty in my department taught their courses and realized that I did not want to be an instructor who depended solely on the textbook and lecture.

Around my seventh year of teaching, a new adjunct, Ann, was hired. I noticed that she often arrived at least an hour before her classes, looking for supplies and other teaching resources. Although I tried very hard to be an observer of Ann's teaching, I was quickly drawn into the study as an active participant because of my working relationship with Ann stemming back to when she was an adjunct.

Selection of the Case Study Participant

The participant, Ann, is an African-American female and post-secondary biology instructor. She received her BS and master's degrees in biology from a historically Black university in the South. Her early work experience was in biological research, but her interests shifted when she did substitute teaching while completing her master's degree. Working as a substitute teacher led her to pursue teaching science. For three years, she was employed at a four-year institution, where she taught embryology, cell biology, zoology, and anatomy. For the past five years, she has been teaching *Principles of Biology I* and *Anatomy and Physiology I* at SSCC.

I have known Ann for about five years. We have developed a close working relationship because she knows that she can come to me when she needs assistance. I know when she needs help because she always knocks on my office door, inquiring "Can I ask you something?" She enters wearing her signature lab coat and notepad in hand. Once the question is asked, she writes detailed notes. Ann displays a hunger for learning how to better teach the students enrolled in her classes and that is why she was selected to collaborate with me for this study.

The original intent was to observe Ann, the participant, using graphical representations as an instructional tool with students. Upon interviewing Ann, I realized that the scope of the study had to change because she was not familiar with graphical representations or how to use them in science instruction. Although my desire was to be an observer of Ann, I was drawn into the study, advising Ann on how to better understand graphical representations in the form of concept mapping.

Starting on a smaller scale using concept maps rather than focusing the use of various graphical representations such as diagrams, maps, and time lines (Moline, 2011) as a whole. Therefore, the assumption that Ann would use graphical representations in teaching was premature. The study rather focused on her use of one visual tool, concept maps, to assist with students learning science.

Data Generation, Analysis, and Re-presentation

This section describes processes of data generation, data analysis, and data re-presentation used in this study. The phrase "data generation" was chosen over "data collection" to emphasize my role as the designer, interpreter, and participant within this study. Also, since I am the interpreter, making sense of Ann's experiences during the study, the research results are re-presentations of insights that I gained through classroom observations and interviews. Accordingly, I describe use of narrative as the approach used to re-present the study findings in Chapter IV.

Data Generation

Data generation for this case study took 14 weeks, involving an hour-long initial interview, one hour pre-classroom observation interview reviewing lecture materials to be used during the week, one hour post-classroom interview reflecting upon the concept introduced during the week, classroom observations twice a week for an hour, and a hour debriefing interview, totaling nearly 45-50 hours for interviews and class observations. No personally identifiable information was collected or recorded through the interviews, instructional materials, or field notes. This study primarily involved three types of qualitative data sources: (a) interview transcripts; (b) field notes from classrooms observations; and (c) documents obtained from Ann and those available to the public from the college. As the researcher, I started as an observer and listener of Ann's activities and dialogues, but, as the study progressed, I became an active participant in the study as she used visuals in science instruction.

Patton's (2005) recommendations for conducting qualitative research provide useful protocols for generating varied and particular types of data sources. Patton recommends the use of interviews to elicit direct quotations from people about their experiences, opinions, feelings, and knowledge. Observations by the researcher feature "detailed descriptions of people's activities, behaviors, actions, and the full range of interpersonal interactions and organizational processes that are part of observable human experience" (p. 1). Analysis of written documents may include studying excerpts, quotations, or passages from written records, such as "memoranda and correspondence; official publications and reports; personal diaries; and open ended written responses to questionnaires and surveys" (p. 1). This study, which utilizes these three types of data collection, resembles previous studies and narrative re-presentation studies in educational research (e.g., Arellano et al., 2001; Harris, 2007; Miles, 2008; Mitchell & Rosiek, 2006; Sconiers & Rosiek, 2000). The following sections provide specific details of data generation for this study.

Interviews. Throughout the study, interviewing shifted from being fairly unstructured or open ended to a more structured approach towards the end, when interviews were used to verify information. The study formally began as an initial one hour session, which was conducted to gain Ann's IRB informed consent form (see Appendix B), followed by an open ended interview to obtain general background information about Ann and her current teaching practices. Prior to classroom observations, I conducted a one-hour interview with Ann on the day before the class concerning her planned lecture (see Appendix C). This was done each week during the classroom observations. Following each class observation in the afternoon, Ann and I met for another one-hour interview reflecting on her science instruction (see Appendix C). A de-briefing interview (see Appendix E) was conducted for one hour once the class observations were completed to allow Ann an opportunity to express ideas about her learning through participation in this study.

Observations. In qualitative research, the researcher makes firsthand observations of activities and interactions, sometimes engaging personally in those activities as a 'participant observer' (Patton, 2005). Class observations were performed twice a week for an hour over a ten week period. Typically, I entered the classroom from the rear and sat in the back of the classroom prior to Ann beginning the class. As Ann taught, I took field notes of the activities that were taking place in the classroom. On a few occasions, Ann and I conversed while students were doing a quiz, or I assisted in a class activity of concept mapping.

Written Documents. Patton (1999) stated that written documents give a "rich menu of alternative possibilities within qualitative research" (p. 65). During the structured pre- and post-classroom observation interviews, Ann often shared artifacts that she regarded as important to her teaching practices, including lecture notes, PowerPoint, and exams (see Appendix D). Relevant documents provided through the college information system were also obtained, including those available online (e.g., SSCC Natural Sciences Department Biology Mission Statement).

Data Analysis

Qualitative methods are often used because they tell a story by capturing and communicating the participants' stories. They tell what happened when, to whom, and with what consequences. Analysis of data in qualitative research can be complex. The purpose of such studies is to gather information and generate useful findings (Patton, 2005). Stake (1995) stated that data analysis in a case study comes from reading and rereading the case accounts to gather a deeper understanding. The interview transcripts and field notes were examined several times, resulting in follow up interviews with Ann to gain further insight to her experiences during the study. Bogan and Biklen (1982) further described qualitative data analysis as "working with data, organizing it, synthesizing it, searching for patterns, discovering what is important and what is to be learned, and deciding what you will tell others" (p. 145). For this study, data analysis was conducted in conjugation with data generation.

Prior to and following each classroom observation, Ann was interviewed. These interviews were transcribed and coded to identify common patterns or themes. As these patterns were identified, Ann was questioned further to reveal additional thoughts on graphical representations and science pedagogy. These engagements encouraged Ann to share her personal instructional artifacts such as PowerPoint slides used in lecture, lecture notes/comments made on PowerPoint, study hints given to students, and exams administered. These documents were instrumental in composing narratives about her experience during the study.

Field notes were taken during each classroom observation. The field notes were analyzed after each observation and prior to the post observation interviews with Ann. Field notes analysis gave a better view of Ann's understanding or lack of science pedagogy and graphical representation. These observations are presented as science concepts taught during the study.

After the formal classroom observations were completed and debriefing and other interviews with Ann were conducted, the formal study of pre- and post-interviews and class observation was complete. Further analysis of data sources was done through triangulation to search for patterns in the data sources. Patton (1999) stated

> The logic of triangulation is based on the premise that no single method ever adequately solves the problem of rival explanations. Because each method reveals different aspects of empirical reality, multiple methods of data collection and analysis provide more grist for the research mill. (p. 1192)

Triangulation is used in qualitative research because the combination of interview transcripts, observation field notes, and document analysis provides validity to the study.

With the interview transcripts, field notes, and documents at hand, the task of organizing the data according to identified patterns/themes began. After several examinations and re-examinations of the data, they were interpreted to begin to tell Ann's experience. The collaboration with Ann was used to gain a deeper understanding of graphical representation pedagogy in conjugation with multiliteracies in community college science instruction. In addition, the study was used to examine the professional development provided to science instructors in community college. Findings were used to springboard professional development to develop a community of practice among community college science educators.

Data Re-presentation as Narrative Insights

Given my interest in engaging in collaborative professional development with Ann, the study is presented as a narrative of our collaboration of community college science instruction and professional development.

Narratives are used to tell Ann's story of using visual teaching tools and her professional development issues. Narratives make meaning of personal experiences through a process of reflection in which storytelling is the element (Clandinin & Connelly, 1990). Narratives reflect the participant's voice so that readers can understand the story or experience being examined (Holley & Colyar, 2009). According to Rosiek (1994), narrative accounts are one of the best research methods to produce accounts of classroom experiences to improve pedagogy.

As the researcher, this re-presentation of experiences is a *bricolage*- the sense of research activity as "a pieced-together, close knit set of practices that provide solutions to a problem in a concrete situation" (Geelan, 2007, p. 35). Thinking narratively, according to Clandinin and Connelly (1990), is practical because it draws not only on classroom observation, but also on personal experience in the form of stories, interviews, rules, principles, images, and metaphors.

Study Critique as Qualitative Credibility

To establish credibility in a qualitative study means representing truth in the findings. Since qualitative research is based upon the belief that there is no singular universal truth (Cutcliffe, 1999), the researcher describes, interprets, and understands the meaning of the study to gain credibility. The data must be "believable" by presenting real life situations, settings, and circumstances. Being a novice qualitative researcher, one may question the credibility of this study. Lincoln and Guba (1985) present the following techniques for enhancing credibility in qualitative research: prolonged engagement, persistent observation, triangulation, peer debriefing, negative case analysis, and member checking.

Prolonged engagement was a particularly strong element of the study design, given my professional relationship with Ann of nearly five years and our shared interest to learn more about better ways to teach science. I did multiple observations in Ann's classroom, and had many formal and informal interactions; however, the study timeframe was brief and did not allow for consistent observation and negative case analysis. Multiple qualitative data sources were used to enable triangulation; however, the study may have yielded greater insight if interviews with other faculty members and students had been conducted. Peer debriefing was not a strong part of the study design; however, I consulted my dissertation chair, who guided my final interview and observation sessions, in the last three weeks of the study. Field notes from concept mapping classroom observation and additional interviews with Ann discussing specific use of concept mapping were re-examined. Member checking seemed second nature, as interviews typically reflected on our previous experiences and spring-boarded our interests and actions as Ann moved into subsequent teaching sessions.

Trustworthiness, according to Lincoln and Guba (1985), is “how can an inquirer persuade his or her audience that research findings of an inquiry are worth paying attention to?” (p. 290). A subject of one, N of 1, gave me the opportunity to do a deep inquiry of Ann’s science pedagogy to gain insight on how science education at this community college could be improved. There is “no benchmark by which one can take repeated measures and establish reliability in the traditional sense” (Merriam, 1988, p. 170), but trustworthiness in the findings of this study provide a foundation for science pedagogy in community colleges.

Summary

This chapter described the qualitative methods of the study. The methodology selected was instrumental in reflecting the participant’s experience as she collaborated with the researcher in using visuals in the form of concept mapping in science teaching.

Chapter IV presents the study insights through narratives relevant to the research questions. Chapter V brings closure to the study, connecting the research questions that guided the study. The chapter also presents a discussion connecting the study to larger teaching and research implications, as well as a concluding critique of the study and future research possibilities.

CHAPTER IV:

NARRATIVE INSIGHTS

The purpose of the study was to examine a science instructor's use of visuals in community college science teaching and professional development available for community college science faculty. This chapter presents the participant's educational background, early science learning, and reasons for becoming a teacher. The chapter concludes with the participant's understanding of multiliteracies, the experience collaborating with the researcher using visuals and multiliteracies in instruction, and an examination of the professional development she was provided.

Why Science?

I begin with a prologue of the initial interview with Ann as she expresses her educational background, early science learning, and teaching method.

Ann's Prologue

I have a Bachelor of Science and Master's of Science in Biology, both from State University. I relocated to the state in 1999 to clinical studies research. In 2002, I made a career change in which I began teaching at a private, four-year, historically Black college, where I taught the following disciplines: Embryology, Cell Biology, Zoology, and Anatomy. While teaching at the private four-year college, I also worked part-time at South State Community College (SSCC). Once a full time position became available at SSCC, I applied and was hired in 2005. Although most of my time was spent in the private sector, making the transition into college science teaching was easy, and it has also been rewarding.

My initial exposure to science/biology was my freshman year in high school with Mr. Mums. He made the course fun, interesting, exciting, and I was very motivated to learn and look[ed] forward to attending his class. This experience sparked my interest in science and made an impact on me obtaining a degree in biology. Although I did not initially start my career as a science teacher, I knew it would be something I would pursue at some point in my life.

I decided to become a science teacher because of its flexibility and also for the mere fact [that] I wanted to give back to my community/society by enhancing the lives of young and old, male and female, and all races in a positive way. However, I have come to the realization [that] this profession comes with a challenge. Twenty-first century students have different learning styles, and teachers must adapt their learning methods accordingly in order for their students to become better learners.

My most commonly used teaching style, which is also my favorite, is demonstration or modeling. This is an effective approach in my labs where demonstrations are often needed. I act as a coach to assist students in applying the knowledge. Students are then given the opportunity to collaborate in lab groups or with their peers in an effort to problem solve. My responsibility [as] an instructor is also that of a formal authority in which I control the flow of the content in order for students to get a thorough understanding of the information.

I like to relate the labs to the lecture to connect what is going on in the textbook to lab. The experience in lab should translate to the lecture or what's in the textbook. But sometimes, students can't connect the labs to the lecture. So, sometimes I step in and ask questions, like "Remember when we talked about this in lecture?" So, sometimes the lab becomes a lecture as well [as]… hands-on because I want them to be able to connect the concepts from lab to lecture to critically think, which this is difficult for a lot of students.

Ann believes that her instructional strategy is student friendly but challenges students to relate scientific knowledge to real world applications through writing and hands-on experiences. She describes literacy as “students being able to read, write, listen, and speak at a level adequate for communication in the real world.” Ann associates literacy used in science instruction with being able to read, understand, and communicate science knowledge using print and written materials.

The Beginning of Becoming Collaborative Professional Learners

Ann and I casually talked about instruction often. In late November 2010, I entered Ann’s office and asked her to allow me to enter her classroom for observation and to turn our casual conservations to formal structure interviews exploring her notions of science literacy and multiliteracies, her pedagogical practices using visual tools, and her experience engaging in collaborative teaching learning as professional development. She replied yes without hesitation.

Ann’s excitement and willingness to collaborate with me may have come from our long working relationship stemming back to when she was an adjunct instructor. I remember that initial meeting: she was walking down the hall with a confused look on her face, carrying a box and a book bag over her one shoulder. I remember my first day at SSCC with no one to guide or assist me; it was assumed that since you had a science degree that you knew how to teach science. I stopped and asked her if she needed help. “Yes” was her reply, with a smile and a look of relief. That casual question and response led to examining her teaching practices.

The following sections portray Ann’s experiences during the study, with “the beginning” showing the early stages of her learning and understanding what and how to use visual tools in instruction. In addition, some changes that Ann made during the study included enrolling in graduate science education courses, beginning to understand how visual illustrations can be used in science teaching, and allowing students to use visuals to express science understanding (see Appendix G). Ann was selected to participate in this study because from our first meeting when she was an adjunct instructor, she was always inquiring about how to make her science teaching better. Although she lacks formal pedagogy training, her drive to be a better science instructor drew me to collaborate with her for the study.

Exploring Ann's Views of Multiliteracies

Walking into Ann's office for the initial interview, I noticed different elements of her that I never observed before, like the tidiness of her office, where she was waiting for me in her white lab coat.

> *Researcher: What is your definition or understanding of literacy?*
>
> *Ann: My definition of literacy is one's ability to read and write. I am not sure about the term.*
>
> *Researcher: Do you know different visuals that could be used in instruction, such as graphical representations? Explain.*
>
> *Ann: (puzzled look on her face, almost frowning)"No."*
>
> *Researcher: Graphical representations are a type of visual literacy that can include flowcharts, figures, diagrams, concept maps, and Venn diagrams. Have you used or are you currently using any type of visual tool (diagrams, illustrations, graphs, charts) in your instruction?*
>
> *Ann: I reference to diagrams and figures in my textbook during lectures. I also use animations.*
>
> *Researcher: The examples you gave are multiliteracies that can be used in science instruction. Multiliteracies expand the definition of literacy. Using multiliteracies is a way to present information or concepts to students in several different formats like animations, PowerPoint, and graphical representations.*

As I asked the questions and she replied, I realized that Ann considered herself a true scientist who became a science teacher, so her teaching is based totally on science knowledge.

Her approach to teaching is centered on her giving or referencing science concepts without engaging students in the learning process.

On a typical day at SSCC, one would see students moving through the hallway to class and instructors casually glancing at each other as they hurried to lectures. This day was different because I noticed something that was not typical of Ann. I walked into the classroom to give her a tentative schedule for the next semester, and Ann's students were handing in concept maps. I smiled and Ann smiled back, obviously pleased at their shared success. She had allowed students to express and experience science learning in a different way. I felt in that moment that Ann had connected the dots between teaching and learning science through using visuals as an instructional tool.

Ann's Views of Professional Development

Every fall and spring semester at SSCC begins in the same manner. Faculty members enter the auditorium, sit, and listen to information about the upcoming semester. Like many of the students, the faculty is often distracted. When asked to think about how faculty is provided professional development at this community college, Ann shared the following about her professional development experience:

> *Researcher: While working in the community college setting, do you feel that you have received adequate professional development to teach millennial students? Explain.*
>
> *Ann: No (laughing). The institution-wide professional development at the beginning of each semester is a waste of time because it doesn't address the teaching needs of science faculty. We sit in the auditorium and listen to pass/fail rates, what courses are not populating, and other things.*
>
> *Researcher: Have you participated in any professional development in teaching and learning? If so, what and when?*
>
> *Ann: Not addressing teaching learning. No one addresses instructional strategies to help us become a better instructor. The only professional development I attend or receive is at the beginning of the fall and spring semesters and it doesn't address my instructional*

needs as a science teacher. The professional development is general and addresses the concerns of the institution as a whole.

Researcher: What do you mean by general and institution concerns?

Ann: Mostly, finances, which is the lack of funds that the state is currently experiencing. And the institution's QEP (Quality Enhancement Plan), [which] is addressing the freshman experience, [and] is supposed to equip, engage, and empower students. I have heard that so much over the past year.

Based on this initial interview on professional development, Ann expressed the idea that professional development at SSCC centers on talking at faculty about the financial state of the college and institution's QEP (Quality Enhancement Plan), which is implemented over a five-year period. I wanted to know more about Ann's view of professional development. A follow up interview was done.

Researcher: I want to revisit your view of professional development. I want you to reflect back to the beginning of this semester and professional development that you received.

Ann: (Laughing) I really wouldn't call it professional development. It was over two days. I felt it was a waste of time.

Researcher: Explain what you mean about a waste of time.

Ann: Well, the first day, we heard from the President, which was his welcome back speech for another academic year. Next, individuals from student services talked about registration, financial aid, requisition and travel procedure… all this information could have been emailed to us. [This was] followed by administrators in academic affairs telling us to be creative in instruction, help students, and advise students.

Researcher: So, this took all day.

Ann: No, that was the morning session prior to lunch break, but we were given a morning break as well.

Researcher: You stated that faculty was told to be creative, help, and advise students. Were any strategies shared or any collaborative training activities done with faculty to accomplish this?

Ann: No, not really. After lunch there were several work sessions given on using Blackboard, Tegrity, planning for retirement, new employee orientation with human *resources, and a couple more which I can't recall. But, most of the sessions are given every semester and I feel I have mastered Blackboard and Tegrity.*

Researcher: That was day one. What did day two include?

Ann: Committee meetings, Departmental and Unit planning.

Researcher: Does the Department provide the professional development needed to improve science instruction?

Ann: Nothing against the department chair, but he is wearing two hats: chair of the department and Associate Dean. So, the answer would be no. Science faculty members are not provided that type of professional development through the department to improve science instruction. That's why I enrolled in a graduate science education course.

Researcher: You took it upon yourself to take graduate courses. Does the institution provide any financial assistance?

Ann: Yes, they do some tuition reimbursement for graduate school, as well as providing some funds for travel to conferences.

Researcher: Have you taken advantage of the funds to attend conferences?

Ann: Yes, I have attended the regional science teacher association conference before, but it has been awhile since I've attended a conference.

Based on Ann's responses, SSCC provides institution wide meetings, departmental meetings, and work sessions in areas that do not relate or benefit her as a science teacher. Ann's responses during the professional development interviews suggested that she feels unprepared to teach. That is why she chose to take graduate courses: to become a better science educator.

Ann's Science Classroom

Classroom observations were done twice weekly for an hour in a *Principles of Biology I* class over ten weeks. This biology course covers physical, chemical, and biological principles of all organisms. The course is designed to explain cell structure and function, cellular respiration, basic biochemistry, cell energetics, the process of photosynthesis, and Mendelian and molecular genetics. The course also includes discussion of the scientific method, basic principles of evolution, and an overview of the diversity of life with emphasis on viruses, prokaryotes, and protist.

The following section narrates the ten weeks of observing Ann's classroom as she lectured on several science concepts - What is Biology, Life's Chemical Basis, Molecules of Life, Cell Structure and Function, Cell Membrane and Transport, Metabolism Equals Energy and Cellular Respiration. These classroom observations give insight into Ann's teaching practices. Ann never had any formal pedagogical training, but, while participating in the study, she was enrolled in two graduate science education courses. Prior to the study, she did not view our relationship as collaborative, but as colleagues dialoguing about ideas and issues with teaching.

Week 1- Day 1

Ann walked into the classroom wearing a white lab coat and stood at the wooden podium for the first day of class. Her lips curled into a smile, and she said, "Welcome to Biology 103." As she called roll, she exhibited no emotion and ignored students who were entering the classroom late. She began reviewing the syllabus, being very detailed about her expectations, assignments, and evaluation of students in the course. "These areas are just as important as the material that will be covered over the semester," she expressed to the students. Although Ann seemed very stern in the overview of the class, a sense of wanting students to learn science was projected. "Are there any questions?" She paused. "No questions. Let's begin with learning biology. Chapter 1." Ann began asking general questions to students. Observing her, I felt that she was trying to get a feel for what students brought from their high school science learning experience. She dismissed class.

What is Biology?

Week 1 - Day 2. Wearing her lab coat, Ann entered the classroom. Students sat patiently, almost nervously, for the words of science to leave her mouth, but Ann began class differently. "I would like everyone to participate in the discussion. Look in your textbook at the diagram illustrating the domains." Ann told students that she records each lecture in Tegrity- lecture capture software -as she uploaded the lectures in Blackboard. She informed students that they could listen to the lectures over and over again as a resource to prepare for exams. Ann also informed students that along with listening to the Tegrity sessions, they should print the study hints (study guide) placed in Blackboard.

Ann began with a continuation of lecture material from the previous class meeting. Using PowerPoint to guide the lecture, Ann explained the diagram of the domains projected on the board. She began asking students about kingdoms, directing them to look at Table 1.3. She completed the lecture on kingdoms and domains and instructed students to go to lab in room B121 so that lab groups could be organized.

Week 2 – Day 1. Ann began class by asking review questions. Following the review, Ann began a discussion of the scientific method. Ann asked the students to form a hypothesis. One student formed the hypothesis, "If you eat snacks like potato chips, you can develop high cholesterol." As a class, Ann guided the class through the scientific method using the hypothesis formed by the student. To tie all the pieces together, Ann explained that the lab for the week would test the scientific method. Directing the students to another diagram and illustration in the textbook, Ann gave real world examples to tie the textbook images to the students' everyday lives. Ann continued the lecture on why students should learn science and the scientific method.

Before dismissing class, Ann reminded students to view the Tegrity sessions and to bring the study hints to class.

Week 2 - Day 2. Ann started class with the opening statement: "Again, I want everyone to actively participate in class. Be prepared for class when you enter. I call on students to get feedback. I'm not picking or singling any student out. I just want to know if you understand what is going on in class." Ann began asking students questions from the "study hints" (study guide) provided through Blackboard. As Ann asked the questions and students answered, she directed them to figures and diagrams in the textbook. "Please bring your textbook to class because I will be referring to photos, charts, and diagrams during the lecture. You need a textbook so you will be able to follow me during the lecture."

Ann spent the majority of the lecture re-capping key concepts from Chapter one. She went over lab instructions before directing students to move downstairs to lab B121.

Life's Chemical Basis

Week 3- Day 1. As students walked into class, Ann was drawing a diagram of an atom on the board. Ann turned around and said, "Clear your desk and take out a sheet of paper. You have 10 minutes to complete this quiz on the scientific method." Ann motioned for me to come to the front of the room.

Ann: Will you work with me to develop a concept map?

Researcher: Sure.

Ann: We will talk later about it. I just wanted to ask while it was on my mind.

Following the quiz, Ann began Chapter 2 by explaining the diagram of the atom that she had drawn on the board. She directed students to the textbook to view similar diagrams of different atoms.

Ann projected any diagram referred to in the textbook on the board. She continued to explain atoms and energy levels. “Take out another sheet of paper. I am going to write some elements on the board using the periodic table in the appendix of your textbook. I want you to draw the atom for each. I will return the quiz so you can see what you missed. You need to know this information because it will be on your first exam.”

Week 3- Day 2. As students walked into the classroom, Ann was writing an outline of the day’s lecture on the board: “As well as writing assignment instructions for ‘Acidosis and Alkalosis,’ write a group summary of the article provided to you in Blackboard and turn it in during our next class meeting.” Ann began class with asking questions from the “study hint.” Students responded well and seemed prepared for class. “Good, I see some of you are reading and preparing for class.”

Ann continued the discussion on the chemistry of life by drawing an illustration on the board. She explained the diagram and related it to the textbook. “Always review the figures in the textbook. They reinforce what the textbook is explaining.”

Ann: Young man in the back, explain Figure 2.1 to the class.

Student: Figure 2.1 shows a hydrogen bond between two water molecules. Oxygen is red and bonding to one of the hydrogen’s which is white. The single line between them is the hydrogen bond.

Ann: Very good

Following the student’s explanation, Ann directed students to the textbook to review another figure, which she explained. She further illustrated bonding by showing two animations in class. “Do you understand bonding better after viewing this animation?” The class responded, “Yes.” She responded, “I will place the animations in Blackboard so you can view them again.”

Ann often stopped during the lecture to ask questions about the concept being discussed. Before dismissing class, she reminded students that the date for exam #1 was approaching.

Week 4 – Day 1. Ann entered the classroom and returned quiz papers. "I'm impressed. You all did well on the quiz when you drew that atom's orbital; but [on] the written quiz on Chapter 1, as a class you didn't do as well." She continued passing back quiz papers. "I need for you all to sit with your lab groups. You are going to do a group quiz on Chapters 1 and 2. This quiz is a collaborative effort. Everyone should participate. One person should not answer all the questions. I only need one answer sheet per group so write everyone's name on the sheet." Ann gave the class 10 minutes to answer 10 questions. Ann handed me a copy to look over while students were working. She walked around the room listening to the groups discuss their answers.

Following the quiz, the students re-arranged their desks. "Take out your study hints sheet." Ann began to review all the concepts, figures, and diagrams that were presented in class. Ann paused periodically, asking students if they had any questions. All the figures or diagrams listed on the study hint sheet were projected on the board and explained. Ann would administer the Chapters 1 and 2 exam during the following class meeting.

Week 4 - Day 2. Ann administered the first exam for the semester. Following the exam, students were instructed to read Chapter 3 before going to lab.

Week 5 - That Teachable Moment. The question that Ann asked about concept mapping had me curious. As I walked in, I noticed that she was still in science mode, sitting at her desk with her lab coat on, reading over notes for the Anatomy and Physiology class that she also teaches.

> *Researcher: Are you free? I am curious about what you want to know about concept mapping.*

Ann: Yes. I am taking a graduate science education course this semester and my professor has assigned a concept map. I am confused.

Researcher: Can I read the instructions?

Ann: I don't where to begin. I don't know what he wants. I have emailed him but I haven't gotten a response. That's why I asked you.

Researcher: It seems he assumes that everyone has used concept mapping before so he didn't explain it to the class. He just gives the concepts he wants mapped.

As I looked up from the paper, I noticed the frustrated and confused look on Ann's face. So, I began to explain as simply as possible what a concept map is and how they are used. Once I finished, she seemed a little more comfortable with the assignment. I realized that Ann probably felt like our students do when we throw science jargon at them.

Researcher: When you finish with it, I can look over it if you like.

Ann: Ok, thanks.

Researcher: Once you master concept mapping, you can use this with your students.

Ann: Smile turns to frown. I don't know about that. They (students) probably won't get it.

Researcher: Try it. Explain why and what they will be doing before assigning the concept maps.

Ann: Hesitating. What chapter do you think?

Researcher: The chapter on molecules of life would be good to use for concept mapping. You should allow students to do a concept map in class in groups at first. You let them do a group quiz. You can give them a prepared template. Each group can have a different concept to map from the chapter.

Ann: Once I get it (concept mapping) down, I probably will.

Molecules of Life

Week 5 - Day 1. "Today's lecture will focus on the molecules of life. I asked you to read the chapter before coming to class." Ann began asking questions about the chapter. "I'm changing how I'm asking the questions so you can think critically about the answer. I will no longer ask questions exactly like they appear on the study hint sheet." After making that statement, Ann referred students to page 41 in the textbook as she projected the diagram of different carbohydrates. "This is the same figure that is in your textbook." She began explaining the different types of carbohydrates: monosaccharide, disaccharides, and polysaccharides, giving examples of each.

Ann began to discuss condensation reaction. "Young man in the back, explain condensation reaction." The student struggled to explain it. "Use Figure 3.7 that is in your textbook to help, or your notes." Once the student viewed the figure, he began explaining the reaction. "You have to know this concept. If you saw a figure similar to this on your exam, could you answer the question?" No response from the students. Ann seemed frustrated because there was no response. Sensing that the students were frustrated too, she dismissed class.

The frustration that I observed from Ann and the students prompted me to review teaching material that I had used when I taught the class. Later that day, I met with Ann and shared an illustration of condensation reaction different from the one in the textbook. We discussed her use of the illustration in class so she could get a better understanding of what students "get" or "do not get" about condensation reaction and hydrolysis. She decided to let the students explain the illustration in groups rather than individually. I also shared a concept map template that she could use with students for organic molecules (molecules of life).

Researcher: Remember when I explained concept mapping to you for your graduate class? You said once you got it you would probably use concept mapping with your students. Do you want to try concept mapping using this template?

Ann: In groups, right?

Researcher: If that's how you want to use concept mapping, yes.

Week 5- Day 2. As I sat in my usual spot in the back of the classroom, Ann began class. "You have to know the classes of organic molecules and be able to identify them on your next exam. Ok, look at the illustration of lipids in your textbook." Ann began to explain the structure of lipids using the diagram. "Look at Figure 3.11. What type of reaction is being illustrated?"

Student: Dehydration.

Ann: Explain the diagram of the fatty acids.

Student explained.

Ann: Why are they considered fatty acids?

Student: Because of the structure of the tails.

Ann pointed at the projected image. "These are double bonds. Do you see that? You may see this diagram on your exam." "We are going to stop here today. Before going to lab, I want to get your perspective as a student about something. Do not put your name on the survey." Ann began handing out a survey that she developed concerning the usage of PowerPoint in class. She informed students that she wanted to know if the PowerPoint slides were helpful in their learning. "When you turn in you survey, you can leave and go to lab."

Week 6 – Day 1. Ann began the next class meeting by asking questions about the chapter. She referred students to Figure 3.11 of a triglyceride molecule. She explained the figure, which was projected on the board, while students looked in the textbook. "Know the difference between saturated and unsaturated fats. Look as Figure 3.10," she said, pointing to the board, "is the figure saturated or unsaturated?" Student: "Figure 3.10 is an unsaturated fat because of the double bond."

Ann continued the discussion, asking students to look at Figure 3.14. "What is the functional group in the figure to the right?" Student: "Hydroxyl group." "Correct." Ann continued projecting different figures on the board. "Proteins are a very important organic molecule." She showed an animation on proteins. "Do you think the animation helps you understand proteins?" A loud "Yes" was voiced in the room from the students.

Ann showed another animation illustrating protein structures and how they form. Following the animations, Ann asked the class to view Figure 3.16. "These are the different structures of proteins that were shown in the animation." Ann continued the discussion of proteins by asking questions and projecting the figures on the board to reinforce the lecture.

Looking at her watch, she said, "We are going to stop here today because I want to try something different. Close your books, notes, or any other material about what we have been discussing. Get in your lab groups. I'm going to give you a sheet [with] a figure on it. As a group, I want you to explain what reaction is taking place and why. You can work together. Do not be afraid; this is not for a grade. I just want to see what you know or do not know." Ann began to move through the rolls of desks, passing out the sheets. "Also, guys, make sure you look over/study the organic molecules because we are going to do something at the beginning of class on Thursday, and you need to understand carbohydrates, lipids, and proteins. Also, guys, exam #2 is coming up soon."

While students were working on the illustration, Ann and I discussed the concept map that would be presented in class Thursday.

Ann: I'm nervous about what they are going to put on the concept map.

Researcher: Why? You want to see what they know or don't know. It will give you a better understanding of what they don't understand or what they do.

Ann: Will you introduce or examine the concept map first? I don't feel comfortable with that yet.

Researcher: Yes. I'll develop a concept map on the topic. It can be projected on the board while I explain what a concept map is and why they are doing it to the class.

Ann: Ok.

Week 6 – Day 2. Next class meeting, Ann and I were at the front of the class. She seemed nervous and students had confused looks on their faces as they walked in. Looking at her watch, she began calling roll. She introduced me to the class and stated that I would be introducing concept maps to them because they would be completing one in groups this morning. I explained what concept maps are and how they can be used to visually express what they understand about proteins, lipids, and carbohydrates. When I finished, Ann asked the students to sit with their groups, and she handed out the prepared concept map template. Each group was given a different organic molecule to map: lipid, carbohydrate, or protein. As the groups were working, Ann walked around listening to their discussions, giving additional instructions to help students when needed. She gave them about 15 minutes to complete the concept map.

After the activity, Ann concluded the chapter by explaining nucleic acids. She projected the structures of DNA and RNA on the board as she explained the similarities and differences between the molecules. She directed students to lab.

In our follow-up interview of the concept mapping activity class, Ann and I reviewed the maps. As we examined each map, she noticed that some groups understood more than she had thought, but other groups were struggling with this topic.

Researcher: What do you think about concept mapping after using it in class?

Ann: As I walked around and listened, they made some good points and said things that I didn't realized they knew about organic molecules. Also, I know which groups don't understand. This…will help me when we do the lab on organic molecules. I know what to stress when we test them in lab.

Researcher: I notice you use groups a lot in lecture. Why do you have students work in groups?

Ann: I think working in groups allow students to share ideas, knowledge and skills pertaining to various concepts. Also I believe that students tend to learn better from each other as opposed to the instructor. It also gives those individuals that may be introverts an opportunity to open up. Group work also plays a vital role in enhancing or developing certain skills that are important in the real world (e.g., social, cognitive/mental, interactive skills, teamwork, etc.)

After the post observation interview, I began to see a new Ann evolving. She was more open and willing to give up some of the control of the classroom to students to learn science. At the onset of the study during observations, she was an instructor who liked to control everything in the classroom and was very structured, never deviating from the classroom norm of lecture. In the initial interview she described her teaching to me as "student friendly but challenges students," meaning that students sat and listened to the teacher talk science to them. She was beginning to take baby steps to allow students to "do" science in class, not just in a lab setting.

Cell Structure and Function

Week 7 – Day 1. The Chapter 4 PowerPoint was already projected on the whiteboard. Students were sitting and waiting. Wearing her lab coat, Ann walked in without a good morning and stated: "Chapter 4 is a very important chapter because you have to understand the parts of the plant and animal cell and their functions. So, we are going to begin a discussion of the organelles." Ann began going through the PowerPoint, associating shape with function of each organelles. In usual fashion, Ann directed students to the textbook to view figures and diagrams that reinforced what she was explaining. "Read the chapter and print the study hints for the chapter so you will be prepared for class. Exam #2 will be next Tuesday. I will see everyone on Thursday." After class, I met her in the hallway.

Researcher: You seemed distracted this morning.

Ann: I am tired. Working and taking graduate classes is beginning to take a toll. I am ready for spring break.

Researcher: Ok, get some rest this evening.

Week 7 – Day 2. The next class meeting Ann seemed herself. She continued with the lecture on organelles with asking questions from the study hints. She asked students to look on page 67 of the textbook at the figure while explaining the same figure projected on the whiteboard. She turned to the class and stated: "I feel you are getting too dependent on the PowerPoint and not reading the textbook. The PowerPoint is a guide for me during the lecture. You have to read the text as well. What can I do to help you remember this information?" The class looked at her blankly. With no response from the class, Ann turned and began to draw on the board.

Ann: This is similar to the figure on page 67; tell me what you know about this structure.

Student: It's the mitochondria.

Ann: What else?

Student: It's the powerhouse.

Ann: What else?

Student: Makes ATP.

Ann: Good, but we are going to expand this knowledge of the mitochondria.

Ann showed the class another diagram of the mitochondria and referred them to page 68 of the textbook. After completing the lecture, Ann asked the class to take out their study hints. She began going down each row asking each student a question.

I sensed Ann seemed concerned about students learning this concept because she stopped in the middle of the lecture to address her concerns about their dependence on the PowerPoint, asking what she could do to help them learn.

Week 8 – Day 1. I sat in the back of the room as Ann handed out scantrons and instructed students to sit every other row. She gave students a few minutes to review their notes. Some students discussed questions with each other. Finally Ann said, “Clear your desk of everything but a pencil.” She began passing out the exam. “When you finish, you can leave. Read Chapter 5.”

Cell Membrane and Transport

Week 8 – Day 2. Ann began the discussion on the cell membrane by asking questions that pulled from prior knowledge because this structure was discussed in a previous chapter. As students responded to the questions, Ann drew the plasma membrane on the board.

> *Ann: What is this?*
>
> *Student: Fatty acid tail inside and the head is on the outside.*
>
> *Ann: Which [is] hydrophobic? Which is hydrophilic?*
>
> *Student: The head is hydrophilic and the tails are hydrophobic.*
>
> *Ann: Good. Now look at Figure 5.2. This is the phospholipids bilayer. This is the main part of the cell membrane.*

Ann began talking about cystic fibrosis to explain the movement of molecules across the plasma membrane. “Now you can apply what the cell membrane does to real life.”

The lecture continued with Ann asking students to look at Figure 5.3 again. She explained the Fluid Mosaic Model and what structures make up the model. She asked the class to look at Figure 5.5 and began explaining this illustration of the plasma membrane as well. To really stress the importance of the cell membrane, Ann drew her own illustration of the plasma membrane on the board, emphasizing the proteins that are embedded in the plasma membrane to explain movement of molecules in and out the cell.

Ann had a beaker of water and an agar plate on the demonstration table. She asked the class to look at the beaker as she poured food coloring into it. Then, she dropped methylene blue on the agar plate. She explained that the movement of molecules or particles from high to low concentration is diffusion. She explained that the molecules diffused quicker through the liquid than the solid.

Ann: Look at page 83, Figure 5.8, which illustrates what I just demonstrated. Someone explain Figure 5.8b.

Student: It's moving across the bilayer.

Ann: Which way are they moving?

Student: Moving from high to low.

Ann: This is passive transport. Someone explain letter C in the figure.

Student: Moving from low to high.

Ann: You are right. This is active transport. Someone explain letter A.

Student: Move across freely.

Ann: Correct, no energy is needed.

Ann continued with the discussion of transports across the cell membrane by explaining the figures and diagrams that were in the textbook. Ann showed two animations comparing diffusion and osmosis; afterwards, she asked students questions about the two processes. Ending the lecture, Ann gave instructions for the diffusion and osmosis lab. "Go to B121. When you finish lab today, you can began your spring break. Be safe and enjoy."

Week 9 – Day 1. Ann entered the class. "I hope everyone enjoyed spring break, but it is time to get back in the swing of things. Let's start with a quick review of what we discussed prior to the break." Ann began asking questions about diffusion and osmosis. Ann asked a student to voluntarily come to the front of the classroom, and a male student walked to the front of the class. There were two beakers of water with a slice of potato in each.

> *Ann: One beaker has salt water and the other has just water. Remove the potato from each beaker.*
>
> *The student removed the potato slices.*
>
> *Ann: Tell me how they feel.*
>
> *Student: This one feels hard, really stiff. This is one soft and floppy (shaking the potato wedge up and down).*
>
> *Ann: This demonstrate illustrates osmosis. Osmosis is the movement of water. Remember you did a lab similar to this before spring break.*
>
> *Students: (a low mumble) Yes.*

Ann continued re-teaching Chapter 5, directing students to look at various diagrams in the textbook. She played an animation illustrating how osmotic pressure affects red blood cells. Following the animation, Ann asked questions from the study hints from Chapter 5. She dismissed the class and students filed out of the classroom in slow motion.

Metabolism Equals Energy

Week 9 - Day 2. As students walked into class, Ann was drawing a reaction on the board. The reaction illustrated reactants, products, and energy in and out. Ann explained her drawing on the board and directed the students to look at Figures 6.6 and 6.7 in their textbooks to reinforce what she had drawn and explained. Ann paused and began asking questions from previous concepts to relate to the concept being discussed. She projected an illustration of ATP, ADP, and AMP, explaining the difference between each. "We have talked about ATP previously. This animation is showing how ATP is formed from ADP and AMP." As the animation played, Ann using a pointer to refer to key points in the animation.

When the animation concluded, Ann asked students to look at page 98 in the textbook. "This figure explains how enzymes fit substrates. Enzymes can be used over and over again. They do not run out." She directed the students' attention to her drawing on the board, which was similar to the figure explained in the textbook. Ann called on students to explain each part of her drawing. I noticed some students drawing Ann's illustration from the board and not listening to what was being said about the illustration. Before dismissing the class to go to lab, Ann gave a quiz.

Cellular Respiration

Week 10 – Day 1. Ann entered the classroom and then made general announcements. "Exam #3 will be given Thursday. First, I will do a quick review for the exam and begin Chapter 8 on Cellular Respiration. We will not cover Chapter 7 on Photosynthesis."

Ann asked students questions from the study hints. Some students asked for more instruction or explanation on enzyme-substrate and how it worked. "Remember you can view the Tegrity session on these chapters to help you prepare for the exam. Are there any more questions?" No one replied. Ann directed students to page 135 in the textbook and began introducing the concept of cellular respiration. Ann drew an illustration on the board. "This chapter will compare aerobic and anaerobic respiration. Both processes start with glucose being broken down, but aerobic respiration requires oxygen and anaerobic respiration does not. We are going to spend about three or four class meetings discussing cellular respiration. This is a very important concept in biology."

Ann projected and explained a flowchart illustrating cellular respiration. She followed the explanation of the flowchart with playing an animation of the process. Ann directed students to

Figure 8.7 in the textbook and asked for a volunteer to explain. No one responded. Looking around the room, Ann called on a student.

Ann: Young lady, explain Figure 8.7.

Student: (looking down at the textbook) It's like the video.

Ann: How?

Student: You know…sugar breaking down and forming energy.

Ann: Can you give more details than just sugar breaking down?

Student: looks at Ann, but gives no response.

Ann explained the figure and asked students if they had any questions. When no one responded, she dismissed the class. As students rushed out, she called "Remember the exam at the beginning of class Thursday."

Week 10 - Day 2. Ann walked in and addressed her students. "Clear your desk except for a pencil." She passed out the scantrons followed by the exam. Students completed the exam in about 30 minutes.

"Since you finished the exam so quickly, we will continue with Chapter 8." Ann started with projecting a flowchart of cellular respiration ATP production. She explained the flowchart. "Let's do something different. Get in your lab groups." As students moved, Ann wrote three questions on the board. "You can't use your textbooks or notes to answer these questions, but you are working together as a group. I only want one sheet per group. When you finish, turn your papers in, go to the computer lab, and complete the virtual lab for cellular respiration."

The next section brings closure to the formal study that was conducted with Ann. Her epilogue reflects Ann's experience participating in the study.

Ann's Epilogue

I feel participating in this study benefited me more professionally than personally because it gave me new ideas to use such as using concept map, flowcharts, and animations in class. I am not very creative, so working together helped me develop new strategies to use in the classroom. To be honest, when I agreed to participate in the study, I thought, "I'm just being watched while I'm teaching. I am not going to change what I am doing," but I did change a little, not dramatically. [I began] to let students do concept mapping, which is just a small step that will lead to bigger ones. The ideas that you (the researcher) shared with me, I will use in the future because I do want to use more activities in my instruction rather than just lecturing for an hour. I think students today want more hands-on activities rather than lecture.

I guess I was using graphical representations but didn't realize it because I didn't know there was a term associated with what I was using. I just used the prepared graphical representations that came with the textbook. As I reflect on my teaching, I realize that I referred to the pictures, diagrams, illustrations, and played the animations in class. I placed graphics on my exams. I feel that students today are more visual learners. Using visuals and multiliteracies does give students a visual picture of what I am teaching. I didn't realize how beneficial the visuals were until I gave the class a survey (see Appendix F). Based on their responses on the survey, students preferred the visual instead of just me lecturing to them for an hour. I think I will continue to develop simple surveys like that one to get feedback from students about how I am teaching.

I really want to incorporate my own graphics in instruction rather than the ones provided with the textbook. Some textbook graphics are very complex and difficult for students to understand, and I have to really probe students to see if they understand the concept.

While participating in the study, I started graduate school. I was taking a science education course and I found myself reading articles that addressed different instructional strategies in science. One (article) about using animations and short videos to introduce concepts really caught my attention. I realized that I am doing this is strategy in class now and I realize that animations and videos are types of multiliteracies. Now, I can answer that question that I was asked at the beginning of the study: Do you know what multiliteracies are? Yes, I do.

I like the idea of using graphical representations, but it is going to be time consuming and require a lot of preparation. It worked well during the study because we (researcher and participant) met, shared, and talked at least two or three times a week, sometimes more. So, it made it easier to incorporate the two graphical representations that I used in the instruction during the study; now I know what I am using. I loved collaborating; it was like a strategy I read about, "think, pair, and share." It really helped me.

Everyone has their own skill[s] to teaching, but we still need professional development, either individually or as a department. The current approach to professional development at my institution does not benefit me as a science instructor. As a whole, we (instructors) experience lack of motivation, poor attendance and such, but science faculty need a different type of professional development that addresses science teaching and learning. I would prefer professional development as a department. It would allow use to share ideas on teaching that would help students learn.

Prior to participating in the study, I enrolled in a graduate science education program. My goal was to equip and prepare my students in hopes of them being successful at a four-year institution of higher learning, the work force, and to be well-rounded and/or diverse in a global economic society based on what was developed as the Department's mission. That goal has since *changed. I have learned so many ideas on how to approach certain science concepts, and the classroom observations kept me on my toes and challenged me to reflect on my teaching. Participation in the study provided time and space for collaboration on science teaching and helped me gain a lot of insight on becoming a science educator, rather than just someone teaching science.*

Analysis of Research Questions

Multiliteracies in Community College

What are the teacher's understanding of multiliteracies that could be used in a community college science teaching? At the beginning of the study, Ann thought that literacy and science literacy meant reading and writing. She presented science to students through lecture and hands-on activities (i.e., weekly laboratories) because that was the way she learned science, but she did direct students to visuals (e.g., illustrations, diagrams, flowcharts) in the textbook and used animations and multimedia. Ann did not have a clear understanding of the term multiliteracies and how this form of literacy expands to a functional notion of literacy of reading and writing. She believed that students should be able to apply those concepts in real world application, but presentation of science really did not matter because students should be able to learn. As the study progressed, she realized that science literacy includes all literacy types that can help in the presentation of science so students can learn.

Through trial and error, Ann used visuals (figures, diagrams, flowcharts) and multiliteracies (animations and multimedia) that came with the textbook adopted for the course. Because of her lack of pedagogical training, she did not know the instructional strategy being used.

> *Ann: I haven't taken any education courses until recently, when I enrolled in a graduate science education course. I have been doing a lot of the strategies that we discuss in class, but I just didn't know what I was doing. Literacy and science literacy is more than just reading and writing.*

I gathered from observing and interviewing Ann that participating in the study helped her to understand the different types of literacy--science literacy and multiliteracies. By the end of the study, I inferred that Ann realized that multiliteracies include not only science knowledge but also the presentation of the science using different literacy practices – visuals and multimedia. In follow-up interviews, I did learn that Ann was directing students to look at the visuals provided in the textbook, but she was allowing them to develop concept maps in class individually. I again concluded that she had some idea that multiliteracies, in addition to reading and writing, could aid in presenting science to students.

Visual Illustrations and Multiliteracies

How might visual illustrations and multiliteracies help both the science instructor and researcher learn about science instruction? At my initial interview with Ann, she did not understand my references to graphical representations or multiliteracies, so our talks focused on her use of "visual illustrations" in her teaching. Through participating in the study and taking a graduate science education course simultaneously, she realized that "science literacy" actually addresses multiple dimensions of literacy learning, and her pedagogy should include various visuals, multimedia, and written text to address these many ways of learning. She used prepared visuals that came with the textbook, but was reluctant to develop and use her own visuals (e.g., concept maps) in class. She definitely did not feel comfortable enough to let students prepare their own graphics or visual images.

> *Ann: I don't know if students can do graphics on their own. I think I will waste a lot of time explaining what to do and their graphics may be wrong.*

Throughout the ten weeks of classroom observations, Ann referred to prepared graphs, diagrams, and figures in the textbook. She sometimes drew her own illustrations on the whiteboard and frequently showed animations to reinforce the textbook. Based on the lecture materials (see Appendix D) and exam (see Appendix H) she shared with me, she used different visuals, for example, figures and diagrams in the textbook, in her instruction and on exams.

Ann was reluctant to give up instructional time to allow students to explore graphical representations through discussion or creation. She was more concerned with students getting the graphics correct rather than using visuals to see what misconceptions students might have had about a science concept. Ann considered students creating visuals to be an assessment tool rather than an instructional, student collaborative learning tool. As we collaborated more, she used two visuals (see Appendix G) in class with students.

Through this study experience, Ann became more comfortable using visuals and collaborating with me.

> *Ann: If you help me, I will start to use a concept map in class. You are going to be in the class to assist me if I need help giving instructions.*

She did not feel comfortable enough to use this pedagogy alone as an instructor, but she was assigned a concept map to complete in a graduate science education course that she was taking.

> *Ann: I have to do a concept map in my science education course I am taking. I am going to have to learn concept mapping now (laughing).*

After the classroom observations were concluded, I did notice Ann using concept maps without assistance in class. Her comfort level had increased, which was a big step in her improving her teaching practices, given her reluctance at the onset of the study. Ann increasingly used visuals and recognized issues of multiliteracies in association with her lectures.

Collaboration and Professional Development

How might the collaborative teacher-learning in this study provide useful insights for re-thinking professional development practices in the community college science context? We (participant and researcher) learned a lot from each other during the study. Outside of our scheduled interview and classroom observations, Ann came to my office to share strategies and articles with me. She definitely felt that institutional wide professional development does not benefit her as a science faculty member.

> *Ann: As a whole, we (instructors) experience lack of motivation, poor attendance, and such, but science faculty need a different type of professional development that addresses science teaching and learning. If we did professional development as a department, it would provide some cohesiveness in the department because we would be on the same page.*

The type of professional development that Ann talked about would build a community of practice amongst science faculty. With professional development, as faculty, we feel like students; we are disengaged rather than engaged during so-called professional development because our instructional needs are not being met.

Although we talked frequently about teaching, Ann realized through participating in the study that she worked in isolation, like must faculty in community college, when preparing for class. Collaboration done during the study allowed her time and space to reflect on teaching, and it provided an opportunity to ask questions and share teaching strategies.

> *Ann: I liked collaborating with you this semester. We shared a lot of ideas and activities that I can use. So, I would love to collaborate with other faculty members that teach the same courses that I do.*

The collaboration done during the study supported Ann's statement of more cohesiveness within the department. Departmental professional development that focuses on addressing concerns about teaching can lead to a community of practice that could improve science pedagogy in community colleges. Professional development –institutional or departmental- should not be confused with weekly or monthly departmental meetings or semester faculty meetings that address schedules, student learning outcomes, and budgets.

Summary

Science teaching presents both a challenge and an opportunity that involves a range of ways of communicating (visual, verbal, graphical, symbolic, tactile) science that can be exploited to engage different learning styles, abilities, or educational levels and provide a variety of teaching approaches (Wellington & Osborne, 2001). This study focus was on Ann’s experience learning and understanding visual illustrations and multiliteracies to engage students in the learning process. A second focus was Ann’s professional development experience in community college to prepare her to teach science.

The study showed that collaboration allows faculty to become reflective in their teaching and helps them to incorporate new ways to communicate science. The study also reflected that a very small community of practice was developed between the researcher and participant. Science education in community college should move from lectures and isolated class preparation to one of collaborative communities of practice.

Learning institutions must address the needs of faculty members in teaching and learning to continuously improve higher education instruction. Institution wide professional development involves communication between administration and faculty, which leads to collaboration within departments, extending cross disciplines to develop communities of practices.

CHAPTER V:

CONCLUSION

While reflecting on the interviews and observations with Ann, I asked myself some of the same questions that I had asked her in our initial interview. When did I realize I loved science? Why did I decide to teach science? I thought back, and it came to me as if it was the first day of fifth grade, when I walked into Mrs. Wilson's science class. That is when I fell in love with science. Mrs. Wilson's classroom represented science in every aspect- models, diagrams, and pictures hanging from the ceiling, animals in aquariums. This classroom exhibited life and inquiry. Those images sparked my curiosity to discover everything about this subject–science.

In the rationale of the study, I asked these questions:

1. Why is it so difficult for students to understand and learn science at the post-secondary level, and specifically in our community college setting;
2. How can we, as science teachers, change students' ways of learning science to enhance their science literacies- or multiliteracies; and
3. What instructional approaches should be taken to address these student learning concerns?

Upon deeper reflection and analysis, the collaboration between Ann and I brought me to the conclusion that students learn science when the pedagogy is engaging and challenges students to think beyond the science textbook to express their science knowledge. Teaching science is more than throwing science jargon at students during an hour long lecture. This chapter draws on the study to discuss issues of multiliteracies in community college science education, using visual illustrations in science instruction, and professional development in community college. The chapter concludes with a discussion of the limitations and benefits of the study and future possibilities for teaching and research.

Multiliteracies in Community College Science Education

The twenty-first century marked a change in global communication that extended into the classroom. When the New London Group (1996) coined the term "multiliteracies," literacy and literacy pedagogy shifted to encompass all forms of text. Multiliteracies resulted in learning communities that allow students to engage in peer-group activities, collaboration, and transmission of knowledge using a 'new form of literacy' (Mills, 2006).

In studies (Hennessy, Deaney, & Ruthven, 2006; Mills, 2006), teachers using multiliteracies as a pedagogical approach developed collaborative interaction and a community of learning. Multiliteracies provide a variety of media and technologies that can be used in teaching. Multiliteracies facilitates a constructivist model of learning, utilizes students' home and community language, and moves literacy practices beyond the traditional literacies of just reading and writing (Borsheiem et al., 2008; Cervetti et al., 2006; Williams, 2008) changing traditional instruction to multimodal in which written linguistic modes of meaning interface with visual, aural, gestural, and spatial patterns of meaning (Kalantzis, Cope, & Harvey, 2003). Using multiliteracies extends the classroom beyond the traditional classroom space and changes how science concepts are communicated. Ann was using multimedia, animations, and lecture capture software (Tegrity) in her instruction. She was using these forms of multiliteracies but did not understand that is was a type of pedagogy. Although Ann was in the early stages of using this type of instructional strategy, she was interested in engaging students in their science learning. She was open to learning how to improve her pedagogy practices.

Reflection upon the first interview, Ann stated she had no idea what multiliteracies were but during classroom observations, I observed Ann devoting some instructional time to showing animations and multimedia in order to explain a science concept. Confirming the use of multiliteracies by Ann without fully understanding the practice being used through continued to collaborate with me to improve our science teaching Ann was interested in using other literacy practices. The following is an example: an e-mail was sent out to all faculty members at SSCC announcing training on a SMART podium (interactive whiteboard) for instructors. Ann approached me the day that the e-mail was sent to all faculty members with an urgent but excited look. "Which SMART podium training session are you going to? We need to go together," she said. While Ann and I sat in a cross discipline training session, the trainer demonstrated all the interactive activities. She inserted shapes, images, and multimedia. Ann turned to me with a big smile on her face and said, "This is will be great for students to draw concept maps in class." At that moment, I thought, "Ann gets it." "New literacy" -multiliteracies - is an inclusive pedagogy that she can practice to help her and her students practically link ideas to their life experiences and interests.

Using Visuals in Science Education

Effective science pedagogy in community college science education can begin with science educators viewing science teaching differently. At the same time, science educators must realize that not every student in the class will be a scientist or enter a science-related career. With that said, science pedagogy should engage students to "know, do, and value" science (Mickikas et al., 1995, p. 114). This study examined a science instructor beginning to explore the use of visual illustrations, beginning with concept maps, to better address the diverse literacies of her students. Ann, like the elementary teachers surveyed in Coleman's (2006) study of graphical representations in science teaching, not only used a limited range of visual tools, but also restricted her practices by merely pointing or directing students to look at graphics such as diagrams, flowcharts, and charts in the textbook. Initially, in the study, Ann did not engage students in creating their own visuals to express their science knowledge. As the study progressed, Ann became more comfortable using concept maps, allowing students to work in groups to complete concept maps, extending her approaches to assessment, and enabling students to prepare social contributions during class sessions.

The benefit of using visual tools such as maps, graphs, pictures, or charts to represent a science concept (Coleman, 2006; Moline, 1995; 2011) can be two-fold. First, this allows students a different way to process and understand the concept being presented beyond passive reading of a textbook and/or listening to lecture. Second, instructors shift from being transmitters of facts to being facilitators of science understanding. This gives the instructor immediate feedback of student misconceptions. This pedagogical approach makes the science classroom a learning community for both instructor and student.

Consistent with Novak's (2003) encouragement for using visuals such as concept maps, "The teacher can influence the choice to learn meaningfully by the kind and organization of information presented, how it is sequenced, and instructional strategies employed" (p. 124). In turn, the students engaged in using multiliteracies are compelling as "literacy shifts to communicating, discovering, reflecting, and critiquing knowledge through multiliteracies" (Tierney et al., 2006).

Ultimately, I feel highly encouraged to continue our collaborative professional learning and research of using visuals in community college science teaching. We have much to learn, as Unsworth (2001) notes:

> What students learn about multiliteracies is intertwined with the how of their learning. Although the nature of classroom practices cannot be realistically decontextualized from this complexity of influences, pedagogic frameworks for managing multiliteracies development that optimize learning and teaching need to be identified. (2001, p. 8-9).

That spark that was ignited in me by Mrs. Wilson in the fifth grade; Ann has it now. This study has shown both Ann and me that visuals are powerful tools that can be easily implemented in instruction to examine student thinking and learning (Struble, 2007).

Professional Development in Community College

The significance of this study not only affected teaching and learning in the classroom, but it also created possibilities to enhance our professional learning and my research insights. Professional development involves more than monthly departmental meetings, two faculty meetings a year, or institutional wide gatherings at the beginning of each semester discussing the politics and economics of education. Some community colleges have recognized the need to plan and implement change through professional development (Watts & Hammons, 2002, p. 5). Watts (2002) described professional development as it emerged three decades ago as "loose connections of activities" that "when strung together looked fairly impressive" (p. 1). Successful professional development programs become "permanent fixtures" typically when someone champions the cause, facilitating the way for support among a senior-level administrator who allocates the funds and assigns staff responsibility for program administration (Watts & Hammons, 2002). Reflecting on this experience of working together to help Ann learn new science pedagogy, I envision professional development in science education for community college science faculty being collaborative. The collaboration between myself and Ann has fostered a close working relationship and friendship that will continue because we both have a desire to be effective science educators.

This case study provides insights regarding science teaching and learning at community college and improving professional development for science faculty. Whereas the faculty of universities typically remain current researchers of science, community college faculty members, like as this case study of Ann illustrates, the community college science instructors are not provided professional pedagogical training nor retained as a viable science researcher. Ann resembled more a science teacher of secondary science—expected to deliver instruction about science, yet provided little to no professional development. At the end of the day, when a science teacher/instructor/professor leaves the classroom, he or she should feel that each student has been provided effective science pedagogy. Based the findings of the study, I feel professional development for science faculty in community college should be more reflective, collaborative. Working together as a department to address the issues in science teaching in community college and developing individual professional plans should based on the pedagogical needs of each faculty member in the science department.

Back to the question I asked myself prior to conducting this study, "Why are students struggling in science classes?" If given the time to truly collaborate with other science faculty in the Department, this question can be addressed and answered. Professional development for science faculty should focus on teaching and learning. This involves creating a new learning environment and opportunities for science faculty. This can be accomplished by doing the following, as recommended by Loucks-Horsley, Bybee, and Wild (1996):

1) Learning science by doing science. This means replacing traditional lecture/laboratory experiences with inquiry, investigative activities, and appropriate multimedia;

2) Learning to teach science by integrating knowledge of learning, pedagogy, and science. This means teachers not only have to know science but how to teach it effectively. Thus, teachers need some pedagogical knowledge; and

3) Becoming a life-long learner. The body of science knowledge is growing rapidly; therefore, science teachers must become lifer-long learners to help students with new discoveries in science (pp. 132-133).

Professional development should encourage and support science faculty to adopt a more constructivist or student view of learning science (Borko & Putnam, 1995). The experience of meeting and discussing science instruction allowed Ann and me to engage in our own professional development to inquiry and learn a new instructional strategy. Professional development should focus on faculty teaching practices that address the learning needs of their students (Lail, 2009):

> Just as their (community college faculty) four-year faculty colleagues are seeking tenure through publishing, teaching, and serving, community college faculty must also find professional equilibrium by maintaining proficiency in their disciplines, persisting in their institutional-service commitments, and staying engaged in mastering their teaching vocations. (p. 37)

The study provided a great opportunity to experience collaboration with a faculty member examining an instructional strategy, rather than working in isolation as many instructors do when preparing lessons. As Ann stated in her debriefing interview: "*It would be great if faculty could collaborate as a part of professional development, rather than sitting [in] all day meetings that do not benefit our (faculty) teaching and learning.*"

Collaborating on Ann's use of visuals developed a small community of practice between researcher and participant and helped Ann with her professional development needs in the classroom. "Peer collaboration can provide a means of exchanging resources, experiences, and ideas related to teaching and learning, which may be particularly helpful for instructors with less pedagogy knowledge and expertise than their peers" (Weaver et al., 2009, p. 307). A community of practice provides a platform for individuals to communicate and collaborate on topics of importance (Weaver et al., 2009). Members of a community could give a positive meaning to 'teaching,' so that it is something that is desirable to do and undertake enthusiastically and something that should involve professional development (Laksov, Mann, & Dahlgren, 2008, p. 123). According to Wenger (1998), a successful community of practice should be based on a) mutual engagement – the way members engage with and respond to each other's actions and establish relationships based on this engagement; b) joint enterprise – how participants in the community understand, contribute to, and take responsibility for the development of the community of practice; and c) shared repertoire – the ability to make the range of resources employed into something that is used. The community of practice that Ann and I developed during the study should be expanded to include more science faculty.

Limitations of the Study

With any study there are positives and negatives; this study was no different. When reviewing the literature, I found a growing research literature base regarding visual literacy and multiliteracies as it applied to elementary and middle grade science instruction, but limited research on visual literacy and multiliteracies being used as an instructional strategy in post secondary science instruction. This lack of applicable literature limited me in addressing science teaching practices in our post secondary science teaching context. My limited research experience with qualitative research, combined with working full-time and simultaneously trying to teach the teacher who was the focus of the study, made it difficult to systematically focus on data collection. Some may challenge the validity of a case study that uses only one subject to examine the pedagogical practices of science faculty in community college. The primary reasons I decided to engage an N=1 study are fundamental: I, the researcher, was just learning how to conduct qualitative research, and my participant, Ann, was in the beginning stages of learning graphical representations, taking the initial steps to learn concept mapping. We shared a similar position of being limited within the study, relating and supporting each other in our moments of risk-taking and novice co-learning.

Benefits of the Study

This study was needed to examine the pedagogical practices of science instruction in a community college to improve pedagogy and help students to understand science better. Thinking that a science instructor can walk into the classroom and lecture science at students is an ineffective pedagogical approach, but also an inaccurate representation of the nature of science ---how science is learned. Science is the search to describe a reality that is becoming more and more accurate. Multiple interpretations of an experience or data set are likely, but these interpretations must be submitted to public judgment using the evidence extracted from nature and established science (Yore et al., 2003). The pedagogy practices in higher education reflect that teaching and pedagogy excellence are debatable and problematic issues (McAlpine, Maguire, & Lee, 2005) because post secondary instructors often disengage rather than engage students in the learning process. Jones, Riechard and Mokhtari (2003) note most community college students require different instructional approaches that enable them to learn. Students should be engaged in teaching and learning, not merely lectured. Students should feel that same excitement when entering a science class because they know they are ready to learn rather than passively hear science. Science instruction should incorporate a “new literacy”- multiliteracies -

so that teachers and students can experience science through various modes of sense making, not just print-based resources.

Ann felt that the professional development at this institution did not benefit or support improvement in teaching and learning science. The study also reflected that pedagogical practice can change and empower science faculty to collaborate and develop a community of practice. This can only be achieved if the institutions support and allow time and space for faculty to dialogue freely. Then meaningful professional development that encourages and promotes effective teaching and learning pedagogy takes place.

Future Study Possibilities for Teaching and Research

As a science educator, I would like to continue to conduct collaborative research to address the issues that science faculty face in teaching and learning in community college. That could be problematic in this type of academic setting; faculty members are at different levels in their pedagogy abilities and training, there is often a large adjunct population, and many community colleges have multiple campuses. A larger issue concerns the question: "Are community college faculty interested in conducting research on their teaching practices?"

The community college setting is an untapped arena in educational research in the area of science education. For future research possibilities, I would like to begin with mini action research studies addressing the teaching concerns of the science faculty. I think that community college science faculty conducting action research would help to provide the best science pedagogy for students enrolled in science courses in community colleges.

I would like to expand this study by introducing the pedagogical practices of visual literacy and multiliteracies in science instruction by mentoring new science faculty members and collaborating with current science faculty members. This could be difficult with different class schedules, multiple campuses, and outside commitments and employment. Administration should work with faculty members to provide space and time. Hopefully, this would lead to a professional development unique to science faculty that could expand across disciplines.

Finally, I would like to get students' perceptions of visual literacy and multiliteracies learning, in a manner similar to that of Coleman (2006), beginning with an elementary science teacher administering a survey as a springboard for this research. Student feedback would indicate if this approach to teaching science in community college is effective. In addition, survey data could assist in improving science pedagogy. Such an approach would begin with a survey and narrow to working with smaller groups of students through focus groups and interviews to obtain a deeper understanding of the students' perceptions.

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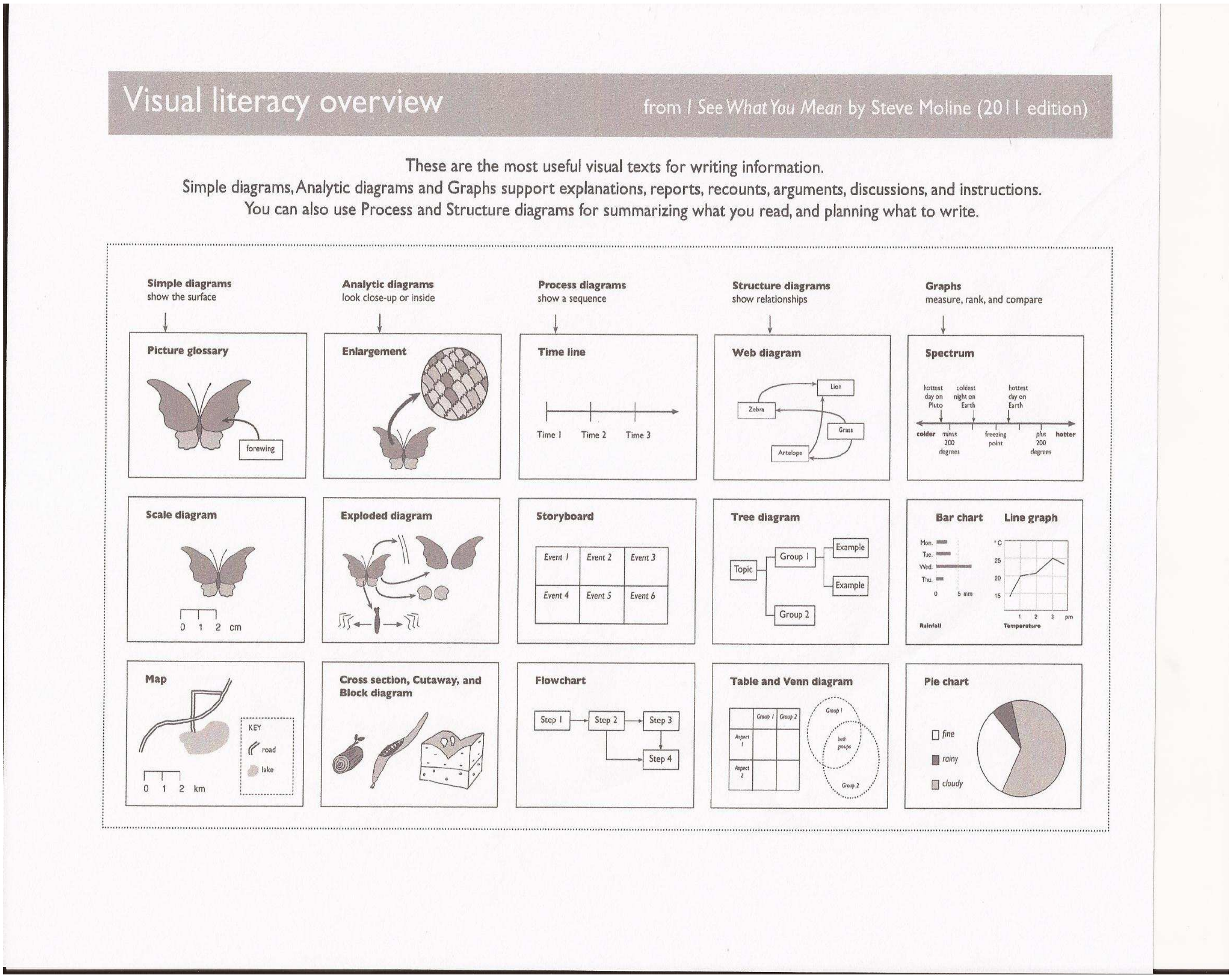
APPENDICES

Appendix A

Graphical Representations – Visual Samples



Appendix B

IRB Approval

October 8, 2010

Office for Research

Institutional Review Board for the
Protection of Human Subjects

Chantae Calhoun
Department of Curriculum & Instruction
College of Education
The University of Alabama

THE UNIVERSITY OF
ALABAMA
RESEARCH

Re: IRB # 10-OR-304 "What Do You See? A Case Study of Community College Science Pedagogy"

Dear Ms. Calhoun:

The University of Alabama Institutional Review Board has granted approval for your proposed research

Your application has been given expedited approval according to 45 CFR part 46. Approval has been given under expedited review category 7 as outlined below:

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

Your application will expire on October 6, 2011. If your research will continue beyond this date, complete the relevant portions of Continuing Review and Closure From. If you wish to modify the application, complete the Modification of an Approved Protocol Form. <u>When the study closes, complete the appropriate portions of FORM: Continuing Review and Closure.</u>

Please use reproductions of the IRB approved informed consent form to obtain consent from your participants.

Should you need to submit any further correspondence regarding this proposal, please include the above application number.

Good luck with your research.

Sincerely,

Carpantato T. Myles, MSM, CIM
Director & Research Compliance Officer
Office for Research Compliance
The University of Alabama

152 Rose Administration Building
Box 870117
Tuscaloosa, Alabama 35487-0117
(205) 348-8461
FAX (205) 348-8882
TOLL FREE (877) 820-3066

Appendix B

Invitation Letter and Consent Form

Dear Miss Smith:

I am writing to request your participation in a study. I am a doctoral student in the Secondary Science Curriculum and Instruction program at the University of Alabama who is conducting a study regarding science pedagogy in community college.

Your participation in this study is extremely important and will help gain insight of science teaching in community college. As part of this study, I am seeking information about the professional development that is provided for science faculty in community college.

This study will require you to participate in several interview sessions over 12 weeks. Each interview will take approximately an hour to complete. In addition to this letter, I have enclosed two copies of a consent form which gives details of the study and a self addressed stamped envelope. If you decide to participate in this study, please return a signed copy of the consent form to me in the self addressed stamped envelope I have provided.

Your participation in this study is completely voluntary, and interview transcripts will be kept confidential. All collected data will be kept in a secure location, at the principal investigator's home. In addition, as the data is collected, there will be no personally identifiable information associated with you. There are no costs or known dangers for participating in this study.

Thank you for taking the time to read this letter and for considering participation in the study. I realize this study will require you to take some time away from your normal daily duties; however, research and scholarship are important to improving science instruction in higher education.

If you have questions or problems related to this study, please contact the principal investigator, Chantae Calhoun at calho002@crimson.ua.edu or 205-944-1098. You may also contact Dr. Sherry Nichols at snichols@bamaed.ua.edu or 205-348-5246. If you have any questions about your rights as a research participant you may contact Ms. Tanta Myles, The University of Alabama Research Compliance Officer, at 205-348-5152.

Sincerely,

[redacted]

Chantae Calhoun

UNIVERSITY OF ALABAMA
Informed Consent for Community College Science Pedagogy

You are being asked to participate in a study of community college science pedagogy. This study is being conducted by Chantae M. Calhoun, a doctoral student in the Secondary Science Curriculum and Instruction program at the University of Alabama and is being supervised by Sharon E. Nicholas, Ph.D., who is an associate professor in Secondary Science Education within the College of Education at the University of Alabama.

STUDY PURPPOSE: The purpose of the study is to examine a community college science instructor's use of graphical representations to enhance science pedagogy in the classroom. In addition, the study will explore community college professional development for science faculty.

IMPORTANCE OF STUDY: The information gained from this study will provide a better understanding of graphical representation pedagogy use in science instruction in community college.

PARTICIPANT(S) IN THE STUDY: You have been asked to participate in this study because you are a community college science faculty. Your experience in science instruction in community college is important to examine graphical representation pedagogy.

PROCEDURE FOR THE STUDY: If you agree to participate in this study, there will be an hour interview to gain general background information and teaching experience data, followed by hour pre and post classroom observation interview sessions. Class observations will be done twice a week for an hour for ten weeks. As well as, an hour debriefing interview at the end of the ten week classroom observations and interviews. If you agree to participate in this study, there will be no cost to you except for your time.

BENEFITS OF TAKING PART IN THE STUDY: The benefits to participation include assisting the principal investigator to better understand the use of graphical representation pedagogy in community college science instruction and professional development for science faculty.

RISKS OF TAKING PART IN THE STUDY: While being observed and interviewed, it is possible that you may be uncomfortable sharing your experiences in science instruction. In order to minimize risk, no unnecessary questions will be asked. There is no risk associated with taking part in this study. Although the interview questions do require sharing your personal experiences, all transcripts from the interviews and any instructional materials shared will be confidential and will be kept in a secure location accessible only to the principal investigator. In addition, there will be no legal or disciplinary consequences for you for participating in the study.

CONFIDENTIALITY: A pseudonym will be used to protect the participant's identity. In addition, names will be removed or blackened from shared instructional materials. All collected data will be kept in a secure location, at the principal investigator's home. At the end, audio tapes will be erased and interview transcripts will be shredded.

VOLUNTARY NATURE OF THE STUDY: Participation in this study is completely voluntary. You may choose not to participate or may withdraw from the study at any time. Leaving the study will not result in any consequences.

CONTACT INFORMATION: If you have questions or problems related to this study, please contact the principal investigator, Chantae Calhoun at calho002@crimson.ua.edu or 205-944-1098. You may also contact Dr. Sharon E. Nichols at snichols@bamaed.ua.edu or 205-348-5246. If you have any questions about your rights as a research participant you may contact Ms. Tanta Myles, The University of Alabama Research Compliance Officer, at 205-348-5152.

By signing this consent form, you are acknowledging that you have read and understand the guidelines set forth in this document.

[redacted] 1-3-11

Signature of Research Participant Date

[redacted] 1-6-11

Principal Investigator Date

Appendix C

Interview Protocol Questions

Background Interview Protocol

1. Tell me about your educational background, undergraduate and graduate.

2. Tell me about your work experience.

3. Take a moment and reflect on your early science learning experience(s). This could be elementary, middle or high school, college, or a combination of all of them. Now, tell me about the moment you realized you had an interest in science.

3b. Do you have a negative experience in learning science that you would like to share?

4. Why did you become a science teacher?

5. Describe your teaching style currently used in the classroom.

6. What do you think you could do to enhance your teaching?

7. What is your definition or understanding of literacy?

8. Do you know what graphical representations are? Explain.

9. Have you used or are you currently using any type of graphical representations in your instruction?

10. While working in the community college setting, do you feel that you have received adequate professional development to teach millennial students? Explain.

11. Have you participated in any professional development in teaching and learning? If so, what and when?

Pre Classroom Observation Interview Protocol

1. What is the concept or topic of focus for this week's lecture?
2. What form(s) of instruction will be used this week?
3. Will graphical representations be used? If so, what type?
4. How will you incorporate graphical representations in the lecture?
5. How much time did it take to prepare the instructional materials for this week?
6. Can I review the materials that you will use in class?
7. Does the assigned textbook for this course incorporate graphical representations for student and instructor use? If yes, do you refer to them or use them during class?
8. Do you allow time in class for students to develop or use graphical representations? If yes, is this done individually or in groups?
9. Are students encouraged to develop graphical representations to organize or re-present text for studying?
10. When preparing for class, do you collaborate with other faculty members or work in isolation?
11. Do you reflect upon your teaching methods? After each lesson? Weekly, at the mid-point of the semester, at the end of the semester?
12. Was any professional development provided (institution or department) to help develop or improve teaching this topic or concept?

Post Classroom Observation Interview Protocol

1. Why is this lesson or topic important to understanding science? Prompts: real world application or scientific knowledge

2. When you developed this lesson, what goal did you have in mind for students?

3. What difficulties did you encounter presenting this lesson to students?

4. Do you feel the graphical representations were beneficial? Why or Why not?

5. What adjustments, if any, need to be made to this lesson?

6. Were any adjustments made after the first day of lecture for the second lecture on the topic?

7. What were the strengths of this lesson? Weaknesses or shortcomings of this lesson?

8. Did anything happen during the presentation of the lesson that surprised you? Prompts: student questions, comments from students

9. At any point in the lesson (day one or two), did you feel students “got” the science (understood the concept being presented)? If yes, give an example.

10. At any point in the lesson (day one or two), did you feel students didn’t understand the science (the concept being presented)? If yes, give an example.

11. Do you feel you need to change your instructional strategy or method in preparing for next week’s lesson? Why or why not?

Appendix D

Instructor's Artifacts

Small amts of transfats occur naturally in red meats and dairy products

6/1/2009

- Hydr veg oil is a part of our diets, cakes, cookies, pies, doughnuts, fries, choco

• Require 1 TBSP of fat/day to remain healthy

Molecules of Life

Chapter 3 Part 1

Impacts, Issues:
Fear of Frying

artificial fat product

Δ's liquids into solids

- Trans fats in hydrogenated vegetable oil raise levels of cholesterol in our blood more than any other fat, and directly alter blood vessel function

Hardening of arteries

arterisclerosis
atherosclerosis

• high fat foods ↑ one's risk for many diseases (atherosclerosis, heart attacks, diabetes)

• double bond straightens the molecule

• We are made up of mainly C, H, O. Hydrogen & Oxygen are in the form of H_2O

Organic Molecules

- All molecules of life are built with carbon atoms
- We can use different models to highlight different aspects of the same molecule

3.1 Carbon – The Stuff of Life

macromolecules are organic due to them consisting of C and H

↓ hydrocarbon (T)

- Organic molecules are complex molecules of life, built on a framework of carbon atoms
  - Carbohydrates
  - Lipids
  - Proteins
  - Nucleic acids

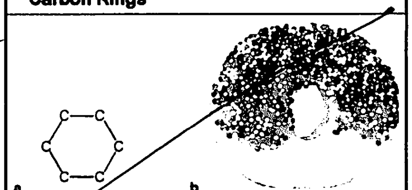
Carbon – The Stuff of Life

Carbon has a versatile bonding behavior

- Carbon atoms can be assembled and remodeled into many organic compounds
  - Can bond with one, two, three, or four atoms
  - Can form polar or nonpolar bonds
  - Can form chains or rings

Carbon backbone - a chain of carbon atoms to which other atoms attach; mainly H

Carbon Rings

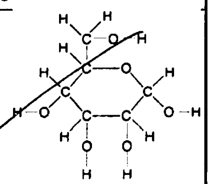


found in many sugars, starches and fats

1

Representing Structures of Organic Molecules

- Structural model of an organic molecule
  - Each line is a covalent bond; two lines are double bonds; three lines are triple bonds

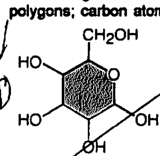


glucose

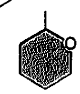
Representing Structures of Organic Molecules

- Carbon ring structures are represented as polygons; carbon atoms are implied

many sides



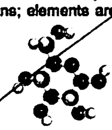
glucose



glucose

Representing Structures of Organic Molecules

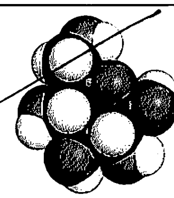
- Ball-and-stick models show positions of atoms in three dimensions; elements are coded by color



glucose

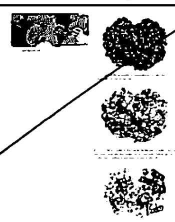
Representing Structures of Organic Molecules

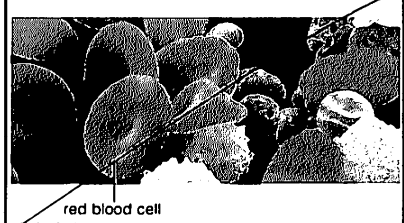
- Space-filling models show how atoms sharing electrons overlap



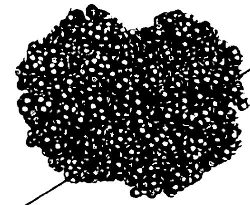
glucose

Three Models of a Hemoglobin Molecule



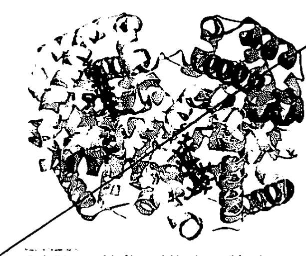


red blood cell



A A space-filling model of hemoglobin shows the complexity of the molecule.

B A surface model of the same molecule reveals crevices and folds that are important for its function. Heme groups, in red, are cradled in pockets of the molecule.



C A ribbon model of hemoglobin shows all four heme groups, also in red, held in place by the molecule's coils.

3.2 From Structure to Function

- The function of organic molecules in biological systems begins with their structure
- The building blocks of carbohydrates, lipids, proteins, and nucleic acids bond together in different arrangements to form different kinds of complex molecules

simple

Poly

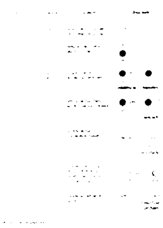
or CHO - sugars or monosaccharides
lipids - fatty Acids
Proteins - Amino acids
nucleic acids - nucleotides

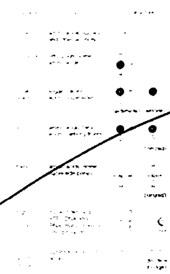
Functional Groups

- **Hydrocarbon**
  - An organic molecule that consists only of hydrogen and carbon atoms ; hydrophobic
- Most biological molecules have at least one functional group — determines the type of reaction the mm will undergo
  - A cluster of atoms that imparts specific chemical properties to a molecule (polarity, acidity) — bonded to carbon

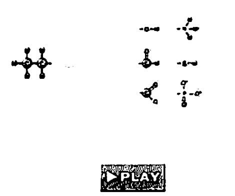
OH (A.A. sugar, alcohols)
CH_3 (methyl)
COOH amino acids, fatty acids
COO-
NH_2
PO_4 (ATP, DNA, RNA
C = O carbonyl (fats, carbs)
SH Proteins

Common Functional Groups in Biological Molecules



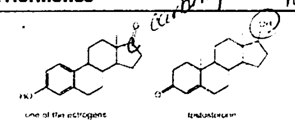


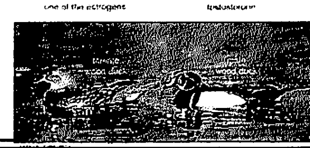
Animation: Functional group

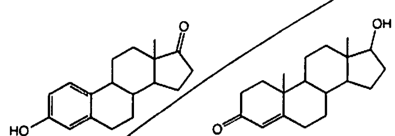


Effects of Functional Groups: Sex Hormones

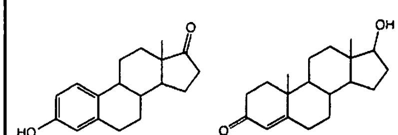
carbonyl hydroxyl







one of the estrogens testosterone



one of the estrogens **testosterone**

4

What Cells Do to Organic Compounds

Condensation

Rearrange - convert one organic Compound to another

- **Metabolism** –
  - Activities by which cells acquire and use energy to construct, rearrange, and split organic molecules (cleavage)
  - Allows cells to live, grow, and reproduce
  - Requires enzymes (proteins that increase the speed of reactions) · in order for a rxn to occur - monomers

Sum-total of all chemical reactions

must be activated before they will react

What Cells Do to Organic Compounds

- **Condensation** AKA dehydration synthesis
  - Covalent bonding of two molecules to form a larger molecule
  - (Water forms as a product) Ex Starch
- **Hydrolysis**
  - The reverse of condensation
  - Cleavage reactions split larger molecules into smaller ones
  - (Water is split) Ex food digestion

H_2O is used to break the bond holding subunits together

What Cells Do to Organic Compounds

Simple - Simple - Simple = carb

- **Monomers**
  - Molecules used as subunits to build larger molecules (polymers) gl
- **Polymers**
  - Larger molecules that are chains of monomers
  - May be split and used for energy

broken down lipids carbohydrates

What Cells Do to Organic Compounds

Table 3.1 What Cells Do to Organic Compounds

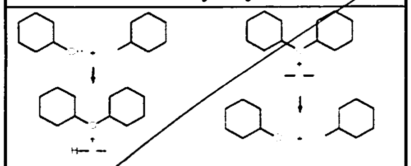
Type of Reaction	What Happens
Condensation	[illegible]
Cleavage	[illegible]
Functional group transfer	[illegible]
Electron transfer	[illegible]
Rearrangement	[illegible]

a) valine - leucine - tryptophan - glutamate = serine - aspartate = Protein

b) glucose - glucose - glucose = ~~Complex carb~~ polysaccharide

5

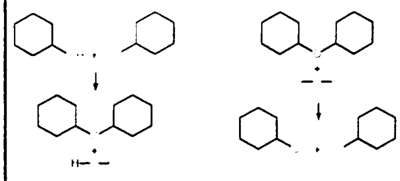
Condensation and Hydrolysis



A Condensation An —OH group from one molecule combines with an H atom from another. Water forms as the two molecules bond covalently

B Hydrolysis A molecule splits, then an —OH group and an H atom from a water molecule become attached to sites exposed by the reaction

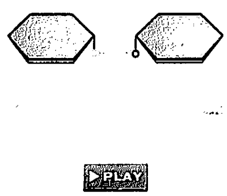
---



A) Condensation. An —OH group from one molecule combines with an H atom from another. Water forms as the two molecules bond covalently.

B) Hydrolysis. A molecule splits, then an —OH group and an H atom from a water molecule become attached to sites exposed by the reaction.

Animation: Condensation and hydrolysis



3.1-3.2 Key Concepts: Structure Dictates Function

- *We define cells partly by their capacity to build complex carbohydrates and lipids, proteins, and nucleic acids*
- *All of these organic compounds have functional groups attached to a backbone of carbon atoms*

3.3 Carbohydrates

- **Carbohydrates are the most plentiful biological molecules in the biosphere**
- **Cells use some carbohydrates as structural materials; others for stored or instant energy**

↓
cellulose keeps plants erect
Shell on Crab is chitin
peptidoglycan found in cell walls of bacteria

Carbohydrates

- **Carbohydrates**
  - **Organic molecules that consist of carbon, hydrogen, and oxygen in a 1:2:1 ratio**
- **Three types of carbohydrates in living systems**
  - **Monosaccharides** one
  - **Oligosaccharides** few
  - **Polysaccharides** many

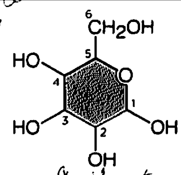
Saccharide means Sugar

Ex. lactose, sucrose

Simple Sugars

cellulose!

- Monosaccharides (one sugar unit) are the simplest carbohydrates
  - Used as an energy source or structural material
  - Backbones of 5 or 6 carbons
  - *Example:* glucose



$C_6H_{12}C_6$
glucose
molecular formula

Hexagon

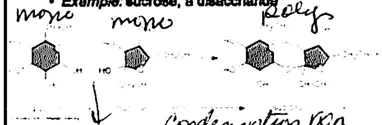
Pentose pentagon 5 carbons
DNA/RNA
Ribose
deoxyribose

Short-Chain Carbohydrates

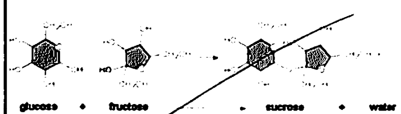
- Oligosaccharides
  - Short chains of monosaccharides
  - *Example:* sucrose, a disaccharide

maltose lactose glucose + galactose

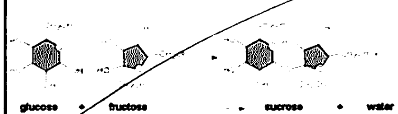
mono mono poly



condensation rxn
water formed



6 C's 5 C's



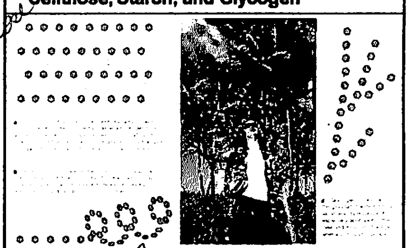
Complex Carbohydrates

storage molecules
not as soluble in H_2O

- Polysaccharides – Polymers of monosaccharides
  - Straight or branched chains of many sugar monomers
- The most common polysaccharides are cellulose, starch, and glycogen
  - All consist of glucose monomers
  - Each has a different pattern of covalent bonding and different chemical properties

Cellulose, Starch, and Glycogen

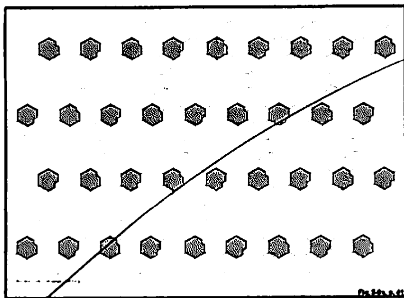
straight cellulose branched

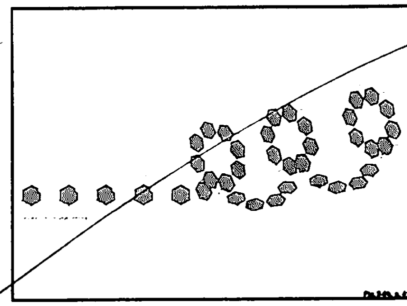


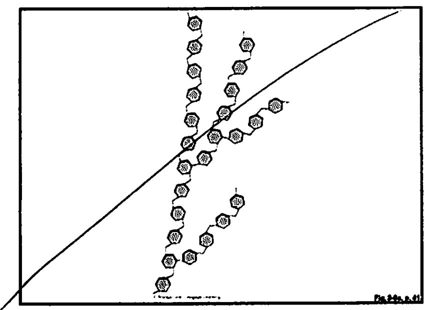
starch coils

- Cellulose - difficult to digest, cell walls of plants
- Starch - sugar storage in plants - resists hydrolysis (can not dissolve in H_2O)
- glycogen - sugar storage in animals
  liver - liver converts glycogen → glucose when sugar level falls
  muscle -

7

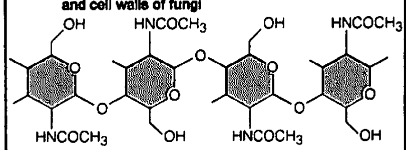






Chitin – exoskeleton – ticks, lobsters, various insects

- **Chitin**
  - **A nitrogen-containing polysaccharide that strengthens hard parts of animals such as crabs, and cell walls of fungi**



3.3 Key Concepts:
Carbohydrates

- ***Carbohydrates are the most abundant biological molecules***
- ***They function as energy reservoirs and structural materials***
- ***Different types of complex carbohydrates are built from the same subunits of simple sugars, bonded in different patterns***

We are familiar with fats and oils ~~because we used them as foods~~ + for cooking

3.4 Greasy, Oily – Must Be Lipids

- **Lipids function as the body's major energy reservoir, and as the structural foundation of cell membranes**
- **Lipids**
  - **Fatty, oily, or waxy organic compounds that are insoluble in water**

nonpolar hydrocarbons

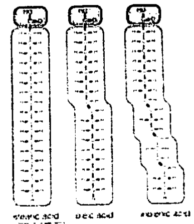
Adipose tissue – fat is stored
good insulator
cushions

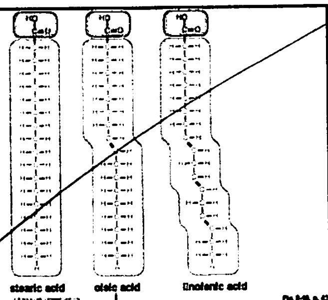
Fatty Acids

- Many lipids incorporate **fatty acids**
  - Simple organic compounds with a carboxyl group joined to a backbone of 4 to 36 carbon atoms
- **Essential fatty acids** are not made by the body and must come from food
  - Omega-3 and omega-6 fatty acids

Fatty Acids

- Saturated, monounsaturated, polyunsaturated





double bond forms a kink or bend in the tail

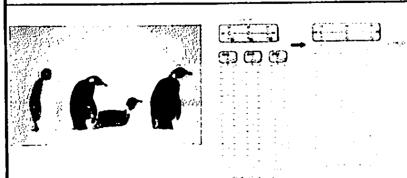
Fats

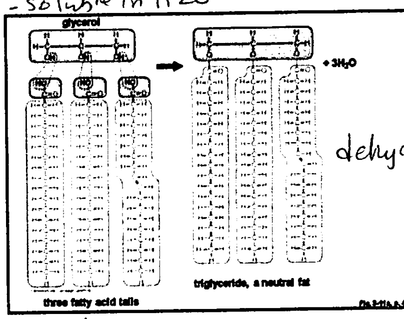
- **Fats**
  - Lipids with one, two, or three fatty acids "tails" attached to glycerol
- **Triglycerides**
  - Neutral fats with three fatty acids attached to glycerol
  - The most abundant energy source in vertebrates
  - Concentrated in adipose tissues (for insulation and cushioning)

Fat below the skin is called "spare tire"

Glycerol
- has 3 OH groups
- polar
- soluble in H_2O

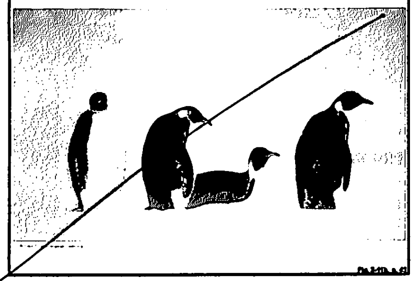
Triglycerides



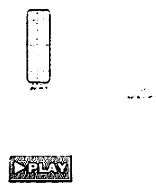


dehydration reaction

glycerol = alcohol



Animation: Triglyceride formation



Saturated and Unsaturated Fats

Trans fat

- Saturated fats (animal fats) →
  - Fatty acids with only single covalent bonds
  - Pack tightly; solid at room temperature
- Unsaturated fats (vegetable oils)
  - Fatty acids with one or more double bonds
  - Kinked; liquid at room temperature

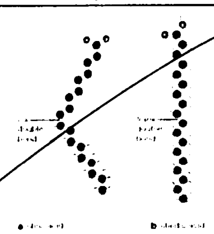
fatty acid tails are

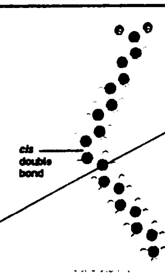
keeps them from packing tightly

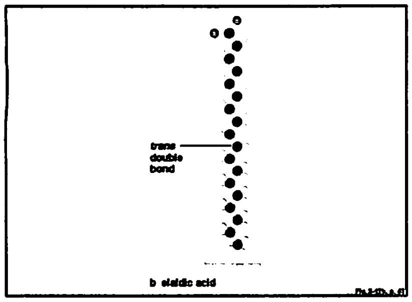
Trans Fats unsaturated

- Trans fats
  - Partially hydrogenated vegetable oils formed by a chemical hydrogenation process
  - Double bond straightens the molecule (trans fats)
  - Pack tightly; solid at room temperature

Cis and *Trans* Fatty Acids







b elaidic acid

Phospholipids

- **Phospholipids**
  - Molecules with a polar head containing a phosphate and two nonpolar fatty acid tails
  - Heads are hydrophilic, tails are hydrophobic
  - The most abundant lipid in cell membranes

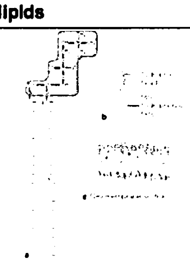
aqueous

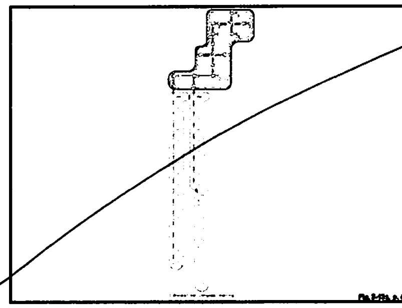
cell's exterior

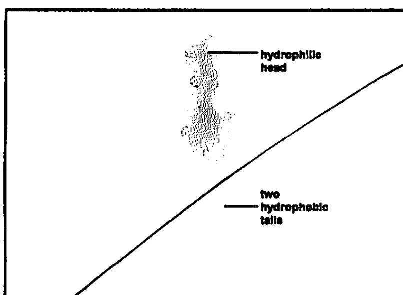
cell's interior

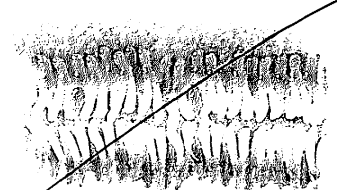
aqueous

Phospholipids








c Cell membrane section

Waxes - beeswax, car wax, ear wax, fruits

- **Waxes**
  - Complex mixtures with long fatty-acid tails bonded to long-chain alcohols or carbon rings
  - Protective, water-repellant covering

Protects, lubricates, skin and hair

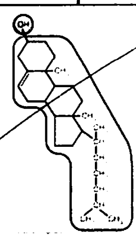
* soften

Cholesterol and Other Steroids

- **Steroids**
  - Lipids with a rigid backbone of four carbon rings and no fatty-acid tails (simple lipid)
- **Cholesterol** - the most common
  - Component of eukaryotic cell membranes
  - Remodeled into bile salts, vitamin D, and steroid hormones (estrogens and testosterone)

· Cholesterol is a precursor to hormones

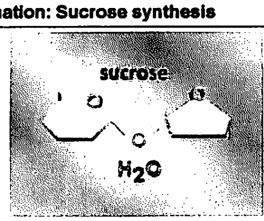
Cholesterol - Simple lipid



3.4 Key Concepts: Lipids

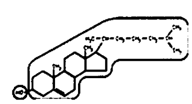
- *Lipids function as energy reservoirs and waterproofing or lubricating substances*
- *Some are remodeled into other substances*
- *Lipids are the main structural components of cell membranes*

Animation: Sucrose synthesis



PLAY

Animation: Cholesterol



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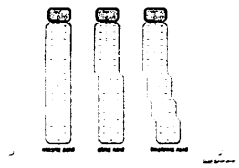
Animation: Fatty acids

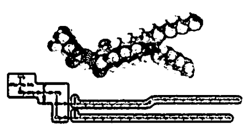


PLAY

Animation: Molecular models of the protein hemoglobin

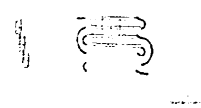
PLAY

Animation: Phospholipid structure



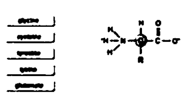
PLAY

Animation: Secondary and tertiary structure



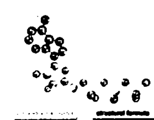
PLAY

Animation: Structure of an amino acid



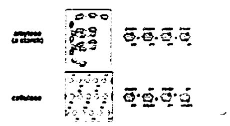
PLAY

Animation: Structure of ATP



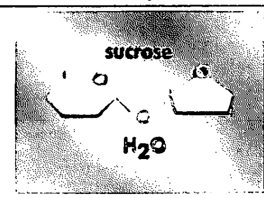
PLAY

Animation: Structure of starch and cellulose



PLAY

Animation: Sucrose synthesis



PLAY

Biology 103 Study Hints

Chapters 5 and 6

1. Study Figure 5.2 (phospholipid molecule)
2. How can you differentiate between a single bond and a double bond in a hydrophobic tail.
3. Why is the phospholipid bilayer called the fluid mosaic model (Chapter 5)
4. What is the role of cholesterol in the phospholipid bilayer
5. What macromolecule carries out most of the functions of the plasma membrane
6. State the difference between a receptor and recognition protein. Support your response with an example.
7. Be able to identify/name the membrane proteins on pages 80-81
8. What is meant by concentration gradient and when does it cease to exist?
9. What is meant by simple diffusion and what factors affect the rate of diffusion
10. How does carbon dioxide and oxygen cross the plasma membrane (diffusion, osmosis, active or passive transport)
11. Study figure 5.8 (diffusion, passive and active transport, endocytosis and exocytosis)
12. Know the difference between passive and active transport (which requires energy, the direction the molecules move, examples)
13. Know the difference between isotonic, hypertonic, and hypotonic and what will happen to a cell when placed in these solutions
14. What will happen to a plant cell when placed in a hypotonic /hypertonic solution
15. Read Impacts, Issues (Binge drinking) – two questions taken from here
16. Know the difference between kinetic energy, potential energy, first law of thermodynamics, and the second law of thermodynamics
17. Pg. 96 – Know what is meant by an endergonic reaction. Support your response with an example
18. – Know important facts about ATP – The Cell's Energy Currency
19. Study Figure 5.10 (Calcium Pump)
20. Pg. 98 – What are enzymes, what is an active site – a groove or crevice of the enzyme complementary to substrate (Reactant)
21. Study figure 6.11 (reactants, products, activation energy with and without enzyme) – min. amt of energy needed for a reaction to proceed on its own
22. page 98 – Know what is meant by induced fit model.
23. Figure 6.9 A structure of ATP (page 97)
24. Phago and Pinocytosis

Appendix E

Debriefing Protocol Questions

Debriefing Interview Protocol

1. Were there aspects of this study you felt benefited you either personally or professionally?

2. Did any aspects of your teaching change during this study? If yes, what changed?

3. Do you think that using graphical representations improved your teaching? Student learning? Why or why not?

4. What challenges did you encounter using graphical representation pedagogy?

5. Would you continue to use this type of pedagogy in science instruction?

6. If given the opportunity to collaborate with other science faculty on teaching and learning, would you take advantage of it?

7. Do you feel more collaboration is needed to improve teaching and learning in community college? Why?

8. Do you feel more professional development is needed in community college science faculty? What type of professional development - system wide, each institution, by department, or individual?

9. What are your thoughts about the study?

10. Are there any questions about the study that you would like to ask at this time?

Appendix F

Class Survey

The Effectiveness of PowerPoints – Survey

1. Did you download the PowerPoints for Chapters 1 and 2?
   a. Yes
   b. No

2. Were the PowerPoints helpful in preparing you for your exam?
   a. Yes
   b. No

3. How helpful were the PowerPoints?

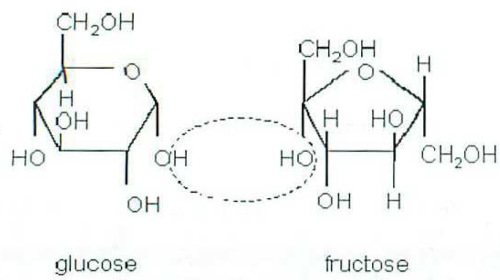
4. Do you think you would have passed your exam without your PowerPoints?

5. Those of you that successfully passed your exam, would you attribute it to PowerPoints or the study guide?

6. Which carried the most weight in you passing your exam?
   a. PowerPoints
   b. Study hints
   c. Textbook
   d. Two of the above; if so, which two
   e. All of the above

Appendix G

Visual Samples

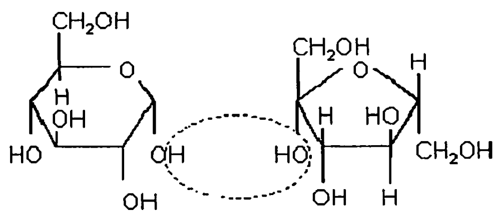


Explain this diagram. Each person the group must write an idea/concept that explains the diagram in sequence. Write your name by your idea/concept.

1. ____
____
2. ____
____
3. ____
____
4. ____
____
5. ____
____
6. ____
____

[redacted]

Sample Figure; use diagram projected on the board for your explantation.



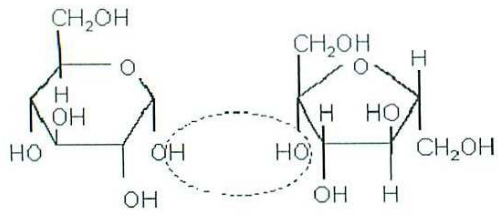
glucose (monomer) fructose (monomer) →

Explain this diagram. Each person in the group must write an idea/concept that explains the diagram in sequence. Write your name by your idea/concept.

1. This diagram shows the condensation process between two monomers to create a polymer (sucrose). [redacted]
In the carboxyl group in the diagram it shows how it releases
2. water which is a condensation reaction - [redacted]
This diagram is explaining how condensation transfer from one group to the next. [redacted]
3.
4.
5.
6.

[redacted]

Sample Figure; use diagram projected on the board for your explantation.



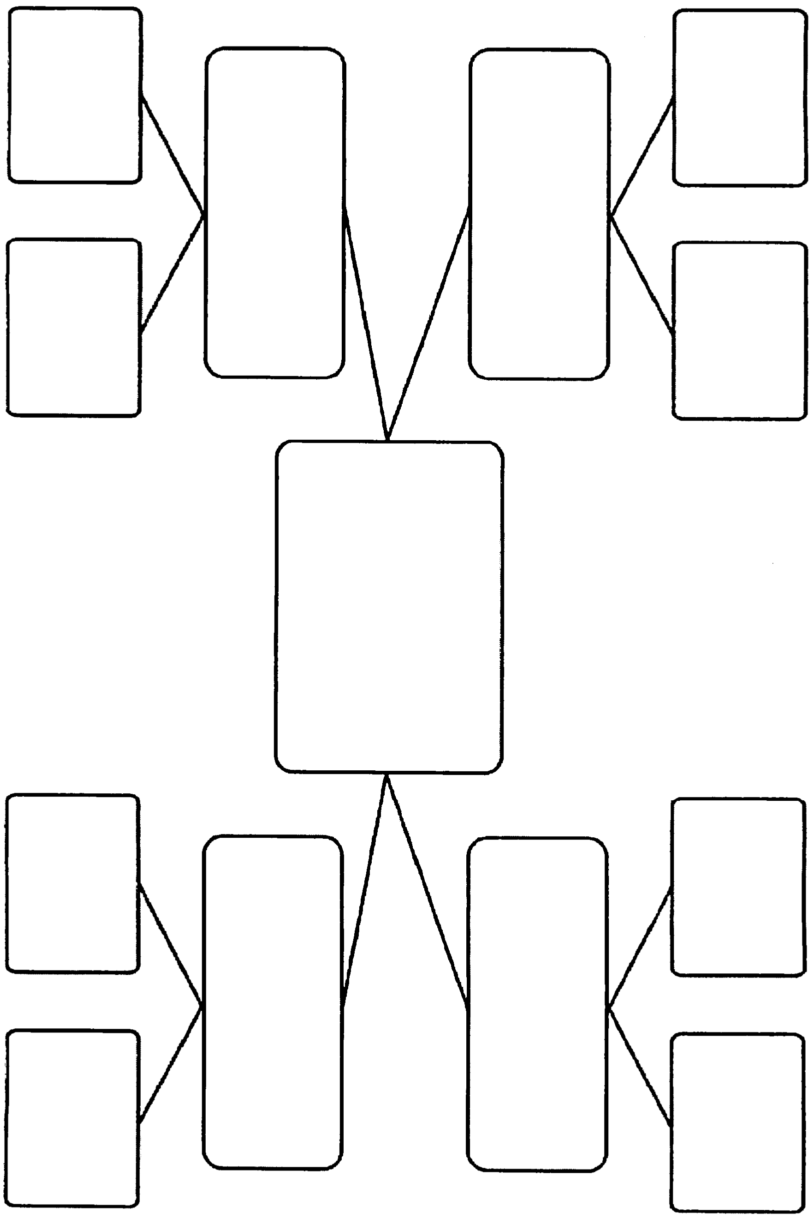
glucose fructose

→ Sucrose + H_2O

Explain this diagram. Each person in the group must write an idea/concept that explains the diagram in sequence. Write your name by your idea/concept.

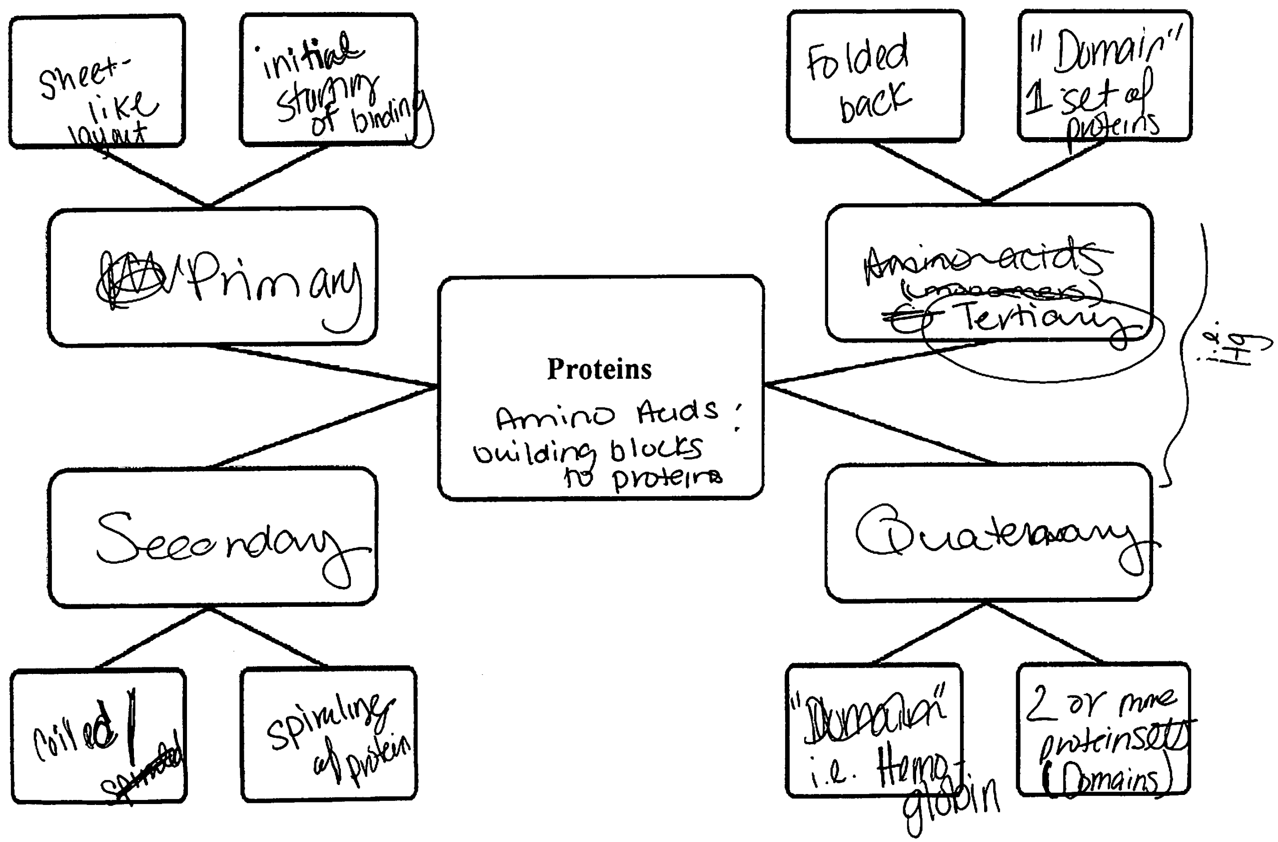
1. Glucose and fructose are Simple sugars also called Monosacchandes. On this diagram, When this two Sugars combine they form Sucrose
2. and water is also formed. Sucrose is a disacchanide, plentiful sugars.
3. This Process is called Condensation, an OH group from a glocose Molecule which is (a monomer) Combines with a fructose H atom, a (monomer)
4. and the two bond covelently, to form Sucrose - (polymer) + Water is formed.
5.
6.

NAME:



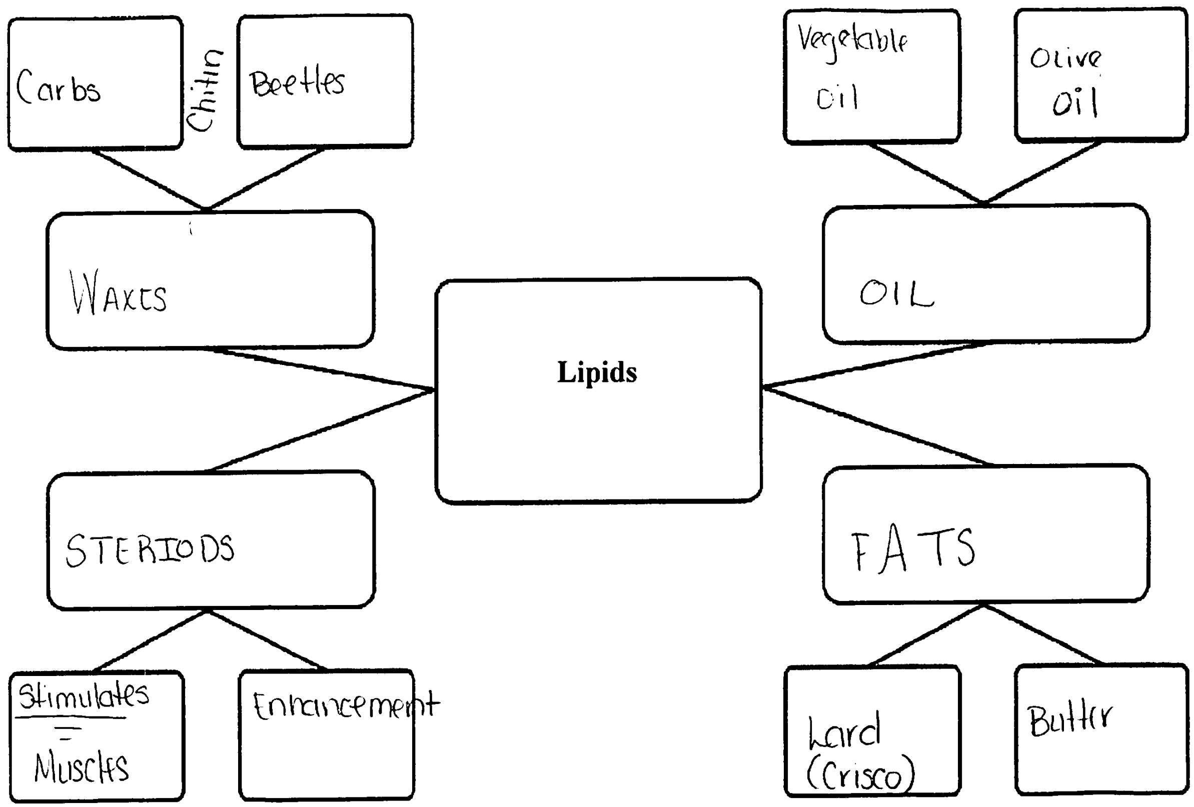
Group 1:

NAME: [redacted]

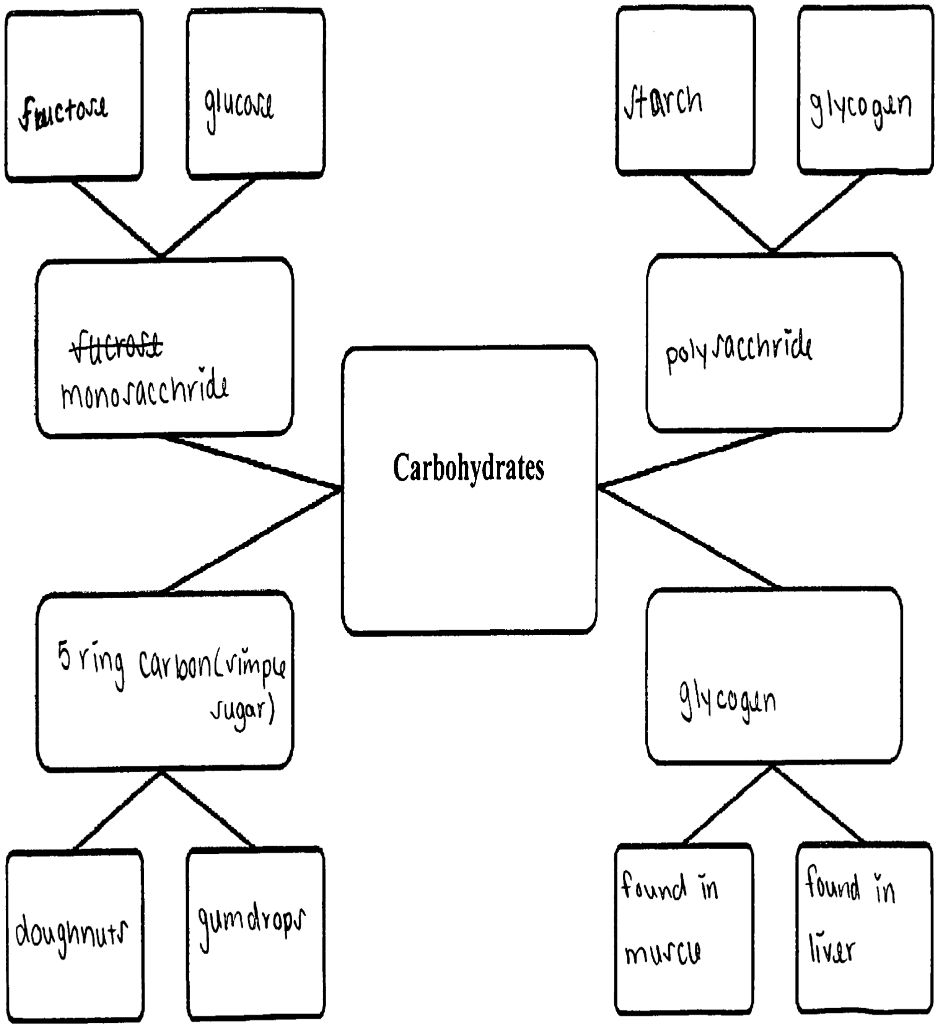


NAME: [redacted]

(Group 5)



NAME: Group 6 2/17/11



Appendix H

Exam

Name: ________________________ **ID: A**

____ 3. In an attempt to visualize the fluid mosaic model of a membrane, we could describe the ____ as floating in a sea of ____.
a. lipid; protein.
b. phospholipids; carbohydrate.
c. proteins; lipid.
d. fats; water.
e. glycolipids; sterols.

____ 4. Cholesterol
a. is not found in plant membranes.
b. is a phospholipid.
c. at high concentrations tends to make fatty-acid tails stick together.
d. renders membranes more fluid in cold temperature.
e. has all of these attributes.

____ 5. Most of the functions of plasma membranes are carried out by
a. cholesterol.
b. proteins.
c. hydrophilic heads.
d. hydrophobic tails.
e. carbohydrates.

____ 6. A water-soluble hormone would most likely bind to which of the following membrane proteins?
a. adhesion
b. recognition
c. receptor
d. communication
e. transport

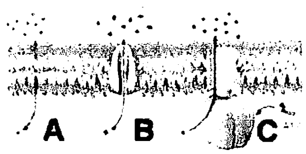
____ 7. Which of the following proteins is not necessarily associated with the plasma membrane?
a. recognition protein
b. plasma protein
c. receptor protein
d. channel protein
e. adhesion protein

____ 8. A concentration gradient ceases to exist when
a. all the molecules have moved from high concentration to low.
b. the membrane pores close.
c. the temperature drops.
d. there is no net movement.
e. bulk flow intervenes.

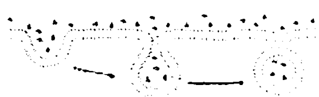
Name: ______________________ ID: A

____ 9. In simple diffusion,
a. the rate of movement of molecules is influenced by temperature and pressure.
b. the movement of individual molecules is random.
c. the movement of molecules of one substance is independent of the movement of any other substance.
d. the net movement is away from the region of highest concentration.
e. all of these happen.

____ 10. Oxygen, carbon dioxide, and other small nonpolar molecules cross the plasma membrane through the process(es) of
a. osmosis.
b. diffusion.
c. endocytosis and exocytosis.
d. active transport.
e. facilitated diffusion.



____ 11. Which of these three mechanisms illustrates facilitated diffusion?
a. A
b. B
c. C
d. both A and B
e. none of these



____ 12. This illustration shows the mechanism of
a. simple diffusion.
b. bulk flow.
c. endocytosis.
d. facilitated diffusion.
e. an active transporter.

____ 13. The method of movement that requires the expenditure of ATP molecules is
a. simple diffusion.
b. facilitated diffusion.
c. osmosis.
d. active transport.
e. bulk flow.

____ 14. The glucose transport mechanism is an example of
a. simple diffusion.
b. facilitated diffusion.
c. osmosis.
d. active transport.
e. bulk flow.

____ 15. A single-cell freshwater organism, such as a protistan, is transferred to saltwater. Which of the following is likely to happen?
a. The cell bursts.
b. Salt is pumped out of the cell.
c. The cell shrinks.
d. Enzymes flow out of the cell.
e. All of these happen.

____ 16. Which statement is true?
a. A cell placed in an isotonic solution will swell.
b. A cell placed in a hypotonic solution will swell.
c. A cell placed in a hypotonic solution will shrink.
d. A cell placed in a hypertonic solution will remain the same size.
e. A cell placed in a hypotonic solution will remain the same size.

____ 17. A red blood cell will burst when placed in which of the following kinds of solution?
a. hypotonic
b. hypertonic
c. isotonic
d. any of these
e. none of these

____ 18. If a plant cell is placed in a hypotonic solution, the
a. entire cell will not swell or shrink.
b. entire cell will shrink.
c. turgor pressure will increase.
d. cell wall prevents the cell from exploding.
e. turgor pressure will increase, but the cell wall prevents the cell from exploding.

____ 19. White blood cells use ____ to get rid of foreign particles in the blood.
a. simple diffusion
b. bulk flow
c. osmosis
d. phagocytosis
e. facilitated diffusion

Name: ______________________ ID: A

Selecting the Exception

____ 20. Four of the five outcomes listed below result when a cell is placed in a hypertonic solution. Select the exception.
a. wilting
b. plasmolysis
c. turgidity
d. limpness
e. shriveling

____ 21. Which of the following quantities of alcoholic beverages have the least damaging effect on the liver?
a. 12 ounces of beer
b. 5 ounces of wine
c. 1.5 ounces of vodka
d. either 12 ounces of beer or 5 ounces of wine
e. all have the same amount of ethanol and therefore have similar effects on the liver

____ 22. Currently, the most serious drug problem on campuses is
a. methamphetamine addiction.
b. cocaine addiction.
c. marijuana addiction.
d. codeine addiction.
e. binge drinking.

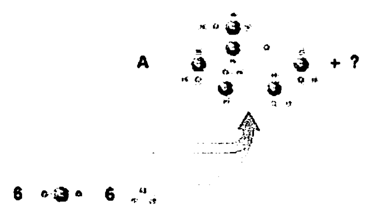
____ 23. When skydivers jump from an airplane, which of the following statements concerning energy is false?
a. Potential energy is converted to kinetic energy.
b. ATP in muscle cells gives up some potential energy to muscle contractile units.
c. The contraction of muscle cells increases the potential energy of the cells.
d. The thermal energy of the surroundings is decreased.
e. Chemical energy is converted to kinetic energy.

____ 24. The second law of thermodynamics holds that
a. matter can be neither created nor destroyed.
b. energy can be neither created nor destroyed.
c. energy of one form is converted to a less concentrated form whenever energy is transformed or transferred.
d. entropy decreases with time.
e. none of these is true.

____ 25. Essentially, the first law of thermodynamics says that
a. one form of energy cannot be converted into another.
b. entropy is increasing in the universe.
c. energy can be neither created nor destroyed.
d. energy cannot be converted into matter or matter into energy.
e. all of these are true.

Name: ______________________ ID: A

____ 26. The activation energy of a reaction refers to the minimum amount of energy
a. released by the reaction.
b. in the reactants.
c. in the products.
d. necessary to cause it to proceed on its own.
e. difference between the energy of the reactants and the energy of the products.



The following questions refer to the figure above.

____ 27. The reaction illustrated in the figure
a. is endergonic.
b. represents a decrease in cellular entropy.
c. is usually driven by sunlight energy.
d. has reactants that are more stable than the products.
e. is all of these.

____ 28. ATP
a. easily gives up phosphate groups.
b. primes stable molecules to react.
c. is the energy currency in the cell's economy.
d. is made by all cells.
e. is/does all of these.

Name: ______________________ **ID: A**

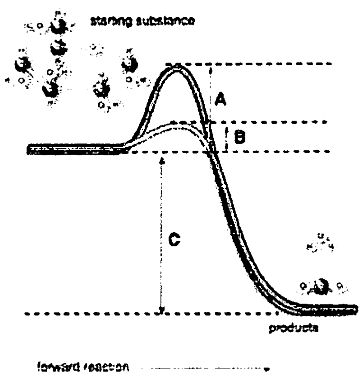
The following questions refer to the figure above illustrating the active transport of calcium ions.

____ 29. Which statement below is true concerning the movement of calcium ions as shown in the figure?
- a. The net movement of calcium ions is from inside the cell to outside the cell.
- b. The net movement of calcium ions is from outside the cell to inside the cell.
- c. Ultimately, there will be more calcium ions inside the cell.
- d. Cellular energy is required to move the calcium ions to the inside of the cell.
- e. Ultimately, there will be an equal number of calcium ions on either side of the membrane.

____ 30. Which molecule provides the energy for the process illustrated in the figure?
- a. A
- b. B
- c. C
- d. Ca^{2+}
- e. All of these

____ 31. Enzymes
- a. are very specific.
- b. act as catalysts.
- c. are organic molecules.
- d. have special shapes that control their activities.
- e. are all of these.

____ 32. The active site of an enzyme
- a. is where the coenzyme is located.
- b. is a specific bulge or protuberance on an enzyme.
- c. is a groove or crevice in the structure of the enzyme complementary to the substrate.
- d. will react with only one substrate no matter how many molecules may resemble the shape of the substrate.
- e. rigidly resists any alteration of its shape.



The following questions refer to the figure above illustrating an energy diagram for the breakdown of glucose.

____ 33. The products in the figure
a. are less stable than the reactant.
b. have more energy than the reactant.
c. have the same amount of energy as the reactant.
d. release energy in the reaction.
e. none of these.

____ 34. The amount of energy required to initiate the reaction when an enzyme catalyzes it is represented by
a. A.
b. B.
c. C.
d. C plus A.
e. A minus B.

____ 35. An enzyme is thought to optimize the fit between substrates by restraining and stretching or squeezing them into certain shapes and moving them to the transition state as described by the ____ model of enzyme activity.
a. lock and key
b. induced-fit
c. template
d. activation
e. conformational