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Online reflections : a constructivist tool?

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ONLINE REFLECTIONS: A CONSTRUCTIVIST TOOL?

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Abstract

The purpose of this study was to determine whether or not online reflections are effective in facilitating student learning, as measured by achievement on unit exams and instructional planning as reported by the instructor. This study followed an alternating-treatments design. The achievement of 22 students randomly divided into two groups of 11 students each (Group 1 and Group 2) was compared. The first group of students followed an A-B-A-B design and the second group of students from the same Biology class followed a B-A-B-A design. A refers to the condition where students completed higher order online reflections and B refers to the lower order word search condition. The word search condition in this study serves as a proxy control condition in this study. Achievement on unit exams was determined and compared for each student under treatment condition A and treatment condition B. Correlations between the average length of students' responses, the number of reflections and word searches completed and students' final marks were conducted to identify the degree of association between these variables. 5-10 minutes of class time was provided to students to complete their online reflections or word searches. Analysis of variance was used to compare the effect completing online reflections and word searches had on student achievement as measured by unit-exams marks. No significant differences in achievement were found between the two conditions. The number and average length of online reflections were positively and significantly correlated with a student's final mark (Pearson correlation = 0.556, $p = 0.007$; 0.463, $p = 0.03$). 50% (10/20) of students felt that online reflections helped them study. 45% (9/20) felt that they clarified their understanding of scientific concepts. Students identified the following benefits of online reflections: it helps you remember,

improves understanding and helps you think. The most common suggestion made by students for improvement was to change the questions with each lesson so that they were more relevant. The instructor felt the questions asked by students in the online reflections were important as they provided insight into what students know and don't know. As a result of online reflections the instructor now incorporates regular and in depth reviews into his teaching. According to the instructor online reflections helped him and his class meet 8 technology outcomes (i.e. Students will compose, revise and edit text). Future studies should control for the Hawthorne effect by changing the reflection questions on a daily basis and control for the different academic abilities of students.

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Chapter I

Introduction

As a science educator in Alberta I am interested in utilizing teaching/learning strategies that assist students in developing conceptions consistent with current scientific theory and that promote technological literacy. I believe online reflections—a series of questions that ask students to recall and reflect on what happened in class—to be one such strategy. Student responses are keyboarded in and submitted electronically to a database that the student, instructor and researcher can re-access as desired.

Online reflections are best defined as a combination of what Cobine (1995) calls dialogue journals—journals that encourage and develop communication skills and content area journals—journals that assist students in determining which subject areas, terms or concepts they are having difficulty with. Given the nature and intent of the online reflection questions it is assumed that in this study online reflections and journals are synonymous with one another.

Online reflections provide an observable shared record in which students can construct their own meanings of the day's events. The reflection questions in this study were designed to assist students in making their own connections between prior knowledge and the day's experiences.

Online reflections also meet Parker's (1999) criteria for what technology must be "technology must empower students to construct and reconstruct knowledge as a result of these interactions (between student and instructor)... Additionally, the interaction provided by current technologies must encourage students to be self reflective and self corrective (p. 13)."

Finally, online reflections present teachers with a valuable source of information about students' pre and post lesson conceptions. This information can be used to plan future corrective and enrichment instruction.

There is much research explaining how tools such as this qualify under a constructivist philosophy of education, how this philosophy should be reflected in classroom practice, as well as much qualitative research describing the benefits of using journals in the classroom. There is, however, little quantitative research examining the impact of reflection on student learning as measured by achievement on exams.

Thus, the purpose of this project was to determine whether or not online reflections are effective in facilitating student learning, as measured by achievement on exams and instructional planning. Five research questions provided a framework for this study:

- 1) Is the achievement of students as measured by unit exams greater for those students who complete online reflections than those who do not?
- 2) Is there a significant and positive relationship between the length of an online response and student achievement?
- 3) Do students perceive online reflections as valuable?
- 4) Are student responses used to guide future instruction?
- 5) Are online reflections effective in facilitating student learning and instructional planning?

Chapter II

Review of Literature

Before going into depth about online reflections it is necessary to develop the context in which online reflections are intended to operate, as well as recount the theoretical climate from which they emerged. Consequently, this review of literature begins with an introduction to the impact of technology outcomes on teaching from the perspective of this science teacher and how online reflections may be used to meet this challenge. Student learning from the theoretical perspective of constructivism and the tradition from which online reflections emerge follows. Research investigating the existence, nature and theorized causes of student misconceptions in science and the need to rethink our approach to science education are presented next to better understand how online reflections can be used as a tool to assist teachers in dealing with the dilemma of student misconceptions. The role of reflection in minimizing and aiding in self-awareness of misconceptions is then explored. Finally, literature extolling the reflective benefits of both paper and pencil and electronic journals is reviewed and examined under the lens of online reflections.

The Technology Outcomes

In September, 2000 Alberta's schoolteachers faced a unique educational challenge. They were responsible for ensuring that students learn two curriculums simultaneously. Not only do students have to meet the usual subject learning outcomes as before; they now have to meet the Communication and Technology Outcomes mandated by the Alberta government (Alberta Learning, 2000).

The outcomes, a series of technology related knowledge, skills, and attitudes increase in complexity across the divisions. For example, one general outcome that students in all four divisions are expected to meet is “students will compose, revise and edit text” (Alberta Learning, 2000, p. 17). The specific outcomes are different for each division. In division four it is expected that students will continue to demonstrate the learner outcomes achieved in prior grades and course subjects including the skills of “creating original text ...to communicate...”, “editing and formatting text to clarify and enhance meaning”... and “using appropriate communication technology to elicit feedback from others” (Alberta Learning, 2000, p. 17).

A three-year timeline for implementation of this dual curriculum has been established. Schools were expected to prepare and begin implementation of a technology plan by the end of September 2000. Full implementation of the technology program is expected to occur in the 2002/2003 school year (Alberta Learning, 1999).

Teaching two curriculums at once presents educators with many challenges. The challenges of this system may be greatest for science educators, as research on conceptual change and development indicates that students often hold and develop conceptions or understandings of scientific phenomena in a different manner than that intended by the science teacher. Furthermore, many of these misconceptions are often found to be resistant to traditional forms of corrective instruction.

One theory that has provided valuable insight into the nature, possible causes, and extent of student misconceptions in science is that of constructivism.

Constructivism and Learning

Constructivism is a theory concerned with the nature of reality and how people understand and learn about the world around them (Colburn, 1998). Constructivists believe “learning is an active process occurring within and influenced by the learner as much as by the instructor and the school” (Yager, 1991, p. 55). Learning is the result of an interaction between the information presented and how the student processes this information within their existing mental framework. It is the replacement of some ideas with others. It occurs when new information is connected, adapted to or modified within an existing framework of knowledge.

Past experiences and beliefs play a significant role in shaping what a student learns and understands (Southwest Educational Development Laboratory, 1995). Each student has his/her own worldview, knowledge and understanding that he/she brings to the classroom. Students develop different interpretations of common evidence, because they possess different perspectives and lived experiences that they draw upon to construct meaning (Lorsbach & Tobin, 1997). Through the interaction of prior learning, new information, and a willingness to learn, individuals choose what new information to assimilate and accommodate into their present cognitive framework (Southwest Educational Development Laboratory, 1995). Indeed, Colburn (1998) states, “What each student holds to be true will be based on ... what makes sense to them within their conceptual framework-what Von Glaserfeld (1992) refers to as viability” (pp. 10-11). In other words, individuals accept ideas according to their own sense of viability.

Student's Misconceptions

Because students typically have a smaller knowledge base and fewer experiences with scientific phenomena, the personal beliefs that they hold are intuitive and often uninformed. This is especially true when compared to a scientifically accepted theory (Colburn, 1998). These uninformed constructs are what Henriques (1997) calls child science. She states "... in an effort to understand the world around them, they organize, interpret, and explain it to themselves. Out of this process comes a body of ideas, beliefs and theories that one could call child physics or biology" (p. 146).

If we accept that learning is an active, individualized process influenced by prior knowledge and previous experiences then we should find evidence showing students' understandings of scientific phenomena are different from those espoused by the scientific community.

Research conducted in the nineteen seventies and early eighties which focussed on the formulation of ideas pertaining to scientific phenomena in children provides such evidence. Russell (1980, as cited in Osborne & Wittrock, 1985), studied children's conceptions of circuits and electric currents. Stead and Osbourne (1981a, as cited in Osborne & Wittrock, 1985) studied friction. Gunstone and White (1981 as cited in Osborne & Wittrock, 1985) investigated children's conceptions of gravity. All of these research teams found that students had great difficulty connecting what was learned in class with actual equipment or events involving these concepts. Osborne and Wittrock (1985) reported that elementary students also hold significant misconceptions about force, temperature, heat, light and what it means to be an animal.

Research suggests that the child science described by Henriques (1990) emerges prior to formal science education in school and persists in the face of contrary instruction (Osborne & Wittrock, 1985). For example Bell (1981, as cited in Osborne & Wittrock, 1985), found that many students did not consider a worm to be an animal. Bell observed the number of students categorizing worms and spiders as animals dropped significantly from the ages of 5 to 11. Stead & Osborne (1981b, as cited in Osborne & Wittrock, 1985) observed that many students believed “gravity requires the presence of air” and Osbourne (1981a as cited in Osborne & Wittrock, 1985), noted that some students believed that light bulbs use up electric current. In addition, Osborne (1981b, as cited in Osborne & Wittrock, 1985) found that the number of students holding a view on mechanics similar to that of the early Greeks increased between the ages of 13 to 15.

Osborne and Freyburg (1985) report that children often unknowingly misrepresent their experiences in a classroom in order to ensure the ‘new’ information is consistent with prior beliefs. These examples support the need for teachers to employ techniques and tools that assist them and their students in dealing with these challenges.

In order to devise a solution to a problem it helps to understand the root cause of the problem. Thus, before rushing in to see what can be done about minimizing the number of misconceptions students hold in science, every effort should be taken to identify plausible explanations for their existence.

Appleton (1993) provides insight into why students may misrepresent classroom instruction and experiences. After any lesson, where a new idea or concept is introduced different learning outcomes are possible. If the experience is in accord with present conceptions the new information will be assimilated and the students’ existing

conceptions will be reinforced. Alternatively, students will be in a state of discord if the new information is in conflict with their current conceptions. According to Appleton there are three possible outcomes stemming from this discord. The learner may recognize that current conceptions are inadequate and restructure to accommodate the new information. A student may simply wait for the teacher to present the right answer resulting in the student being able to recall this conception in a school setting but often being unable to apply the concept outside of a school context. A third potential outcome is that the student will recognize the limitations of his/her current conceptions but will not accommodate nor accept the authoritarian explanation. A fourth possibility, but one not identified by Appleton, is that a student may define the contradictory information as an anomaly and keep their original conceptions intact (M. Steed, personal communication, January 26, 2000).

Three of the identified learning outcomes support the creation or maintenance of misconceptions. This, coupled with the relatively small knowledge base possessed by most elementary students, accounts for the prevalence of misconceptions held by elementary students. The literature on student misconceptions in elementary science suggests there is a need for a teaching tool that can aid teachers and students in identifying student misconceptions. It would be foolhardy to assume that the literature on elementary students is applicable in the same manner to high school and university students. Consequently, there is a need to review the literature to see if high school and university students also hold misconceptions about science. If they do then the need for a tool that can aid teachers and students alike in identifying and minimizing the likelihood

of developing misconceptions becomes greater due to the increased complexity of the concepts studied.

Wandersee (1983) investigated the understanding of photosynthesis of grades 5, 8, 11, and college students. As may be expected an inverse relationship between students' grade levels and the number of misconceptions held was found. However, he also found that students from all grade levels had misconceptions about photosynthesis. For example student misconceptions, as paraphrased by this researcher, include 'the soil loses weight as the plants grow', 'plants are able to convert energy directly from the sun', 'plants release carbon dioxide as a waste product' and 'chlorophyll is unavailable in the fall and winter so plants do not get food during these times'. Many of these misconceptions were observed in students across all grade levels.

In order to understand the scope and possible implications of the problem at the level it will be dealt with in this study we have to look across science disciplines because students who take high school biology also encounter basic physics concepts (i.e. energy flow) and chemistry concepts (chemical equations).

Hesse and Anderson (1992) investigated the understandings of oxidation-reduction reactions of 100 high school chemistry students. Their results show that most students failed to use atoms and molecules as explanatory constructs, and many could not predict or explain the mass changes occurring in the reactions presented. These findings occurred despite the heavy instructional emphasis placed on these major chemical concepts. Hesse and Anderson attribute this to the fact that the "topic of chemical change is much more complex than ...currently acknowledged" (p. 292). They encourage teachers to use strategies that identify, address and remedy students' naïve conceptions.

Garnett and Treagust (1992) report that high school students also hold naïve conceptions about electrochemical and electrolytic cells.

Closely related to studies at the high school level a number of studies have found that undergraduate students also hold many misconceptions about scientific phenomena. Goldeberg and McDermott (1987) investigated undergraduate students' understanding of optics after the students completed a unit on optics. They found many students were unable to relate the concepts, principles and techniques taught in class to an actual lens, mirror or screen system. Furthermore students did not appear to understand the function of these component parts or the relationship between them. Based on these results and difficulties the students had in drawing ray diagrams they concluded that students' possessed an inadequate understanding of basic optic concepts.

Trowbridge and McDermott (1981) investigated University of Washington undergraduate physics students' understanding of acceleration. Subjects were asked questions about a series of simple motion demonstrations they had observed. Results indicate that many students in this study lacked even a qualitative understanding of acceleration as a ratio of velocity over time. According to Trowbridge and McDermott "at the end of instruction fewer than half of the students demonstrated sufficient qualitative understanding of acceleration as a ratio to be able to apply this concept in a real situation" (p. 253). As a result they recommend students receive active, varied, and lengthy intervention to overcome misconceptions and practice.

Halloun and Hestenes (1985) examined the impact of conventional instruction on over a thousand first year undergraduate physics students understanding of motion. A thirty three item multiple choice diagnostic test assessing understanding of mechanics

and motion was administered to students at the beginning and near the end of the course. Findings suggest that students' original conceptions about motion have a great effect on their learning physics, and that a lecture-recitation approach to teaching physics had little impact on students initial beliefs.

McCloskey, Caramazza and Green (1980) asked university students to draw the path of a moving object in a variety of situations. Over half of the 50 students participating in this study held varying misconceptions about the motion of objects. The most common misconception was that an object would move in a curved path even if no external forces were acting upon it. McCloskey et al believe that this implies that students were "basing their responses on a system of naïve beliefs about motion" (p. 1140).

McCloskey et al seem to speak for many of the researchers investigating misconceptions in science (i.e. Appleton, 1993; Hesse & Anderson, 1992; Goldberg & McDermott, 1987; Trowbridge & McDermott, 1981) in their statement "When a student's naïve beliefs are not addressed, instruction may only serve to provide the student ...with new terminology for expressing his erroneous beliefs" (p. 1141).

Science Teaching

Given the research on student misconceptions in science it is not surprising to find that there exists a movement to re-examine the goals, aims and practices of education.

According to Anderson and Smith (1987, p. 92) "science teaching must help students overcome naïve conceptions or habits of thought and replace them with scientific concepts and principles." They assert that "the problems with most presentations to students is that teachers fail to take students naïve conceptions into account" (p. 92). This is a crucial oversight as students' conceptions serve as the

framework for organizing new information. If a teacher does not address this in their teaching then the student will fail to comprehend the phenomena being taught or develop additional misconceptions.

Carr, Barker, Bell, Biddulph, Jones, Kirkwood, Pearson, and Symington (1994, p. 157) state:

If science is not a set of truths which exists independently of people, then in the construction of this structured complex of ideas there will often need to be changes made to ideas. This process of changing prior ideas is also the core activity of education so the issue of acceptance or rejection of a new idea is an important one both for science and for science education.

Online reflections may provide the instructor and student with the means of bringing about change and a permanent record of changes wrought.

Fosnot (1996) and Cobb (1994) advocate concept development as a major component of education. Fosnot (1996) states that "rather than behaviors or skills as the goal of instruction, concept development and deep understanding are the foci" (p. 10). Similarly, Cobb (1994) states that "the critical issue (in education) is not whether students are constructing but the nature or quality of these socially and culturally situated constructions" (p. 16).

Teaching science, then, should involve helping students understand how and why some conceptions explain and predict phenomena more accurately than others do. This is accomplished through the provision of experiences that encourage students to construct accurate, scientifically accepted knowledge (Colburn, 1998). Posner, Strike, Hewson and Gertzog (1982) recommend organizing instruction "so that ... a substantial portion of

(teacher's time is spent) ... diagnosing errors in student thinking and identifying defensive moves used by students to resist accommodation" (p.226). Any activity that takes into account the preconceptions students bring with them to class, and is based upon conceptual goals-class readings, discussions, labs/experiments, assignments and evaluative methods- will provide students with a series of building blocks from which they construct their own understandings of a concept (Appleton & Asoko, 1996). For conceptual change to occur both the teacher and student must be aware of misconceptions. Students must then become dissatisfied with their current conceptions and engage in activities that challenge prior knowledge and allow them to construct a new scientifically accepted understanding.

The Reflection Correction

One way for students to identify their misconceptions is to reflect on what they know and don't know. As Duckworth (1987) states "What you do know about what you don't know is, in the final analysis, what determines what you will ultimately know" (p. 64). Students who are aware of what it is they do not know should be more able to fill in their self-perceived gaps in understanding.

Duckworth is not the only constructivist to recognize the value of reflection for students. Indeed, Dewey (1933) also felt reflective thinking should be a major aim of education. He argued "Reflective thinking enables us to act in a deliberate and intentional fashion to attain future objects or to come into command of what is new, distant and lacking" (p. 17). Reflective thinking allows humans to act intelligently, improve our lives and invent. It is what enables us to evolve from a "brutish existence into a civilized one". Dewey defined reflective thinking as "intellectualization of the difficulty or perplexity

that has been felt or directly experienced into a problem to be solved, a question for which the answer must be sought”(p. 17).

Reflective thinking occurs when some event stimulates an idea and suggests that this idea may possibly be true, with steps being taken to determine if in fact the idea is true (Dewey, 1933). In this sense reflective thinking entails consideration, suggestion, verification and resolution (Marsh, 1998). According to Von Glaserfeld (1995) constructivist learning requires "self-regulation and the building of conceptual structures through reflection and abstraction" (p. 14). Hein (1991) contends that learners need to be able to revisit, ponder, try out, and play with new ideas for learning to occur. Wilson, Teslow, and Osman-Jouchoux (1995) also identify reflection as a key component of learning. Fosnot (1989) goes so far as to assert meaningful learning only occurs through reflection and resolution of cognitive conflict. Reflection, then, could be included as an essential component of learning.

Journals and Reflection

How can a teacher provide students with an opportunity to engage in and practice reflection? In the literature one learning tool consistently linked with reflection is the journal. Journals encourage reflection by requiring students to repeat material in their own words (Osborne & Wittrock, 1985). They also serve as a planning aid for educators as they provide information on student conceptions prior to and after instruction, and monitor what if any conceptual change is occurring in students (Mestre, 1994, Parsons, 1990).

Aside from the opportunities for reflection and identification of misconceptions student journals have been identified as an effective mode of learning in and of itself.

Emig (1977 as cited in Fulwiler, 1987) argues that writing is an effective tool for promoting learning because it activates and requires multiple approaches. To paraphrase - motor functioning is engaged as the pen moves across the page, sensory functioning is engaged as the eye reads what is written and the mind activates deep analytical processes as it creates and edits what is written. Jensen (1987) shares Emig's beliefs about writing as applied to more advanced cognitive levels reporting that journal writing is "useful for learning and cultivating thinking" with college level physics students (p. 335).

Parsons (1990) identifies many educational benefits associated with journals in addition to those already discussed. Journals allow students to explore and reflect on personal responses to experiences. They can serve as a source book for students to draw upon as needed, and they provide students with an alternative method for dialoguing with the teacher. Essentially journals allow students to shape, explore, clarify and develop their thinking in their own language. Articulating thinking gives students opportunities to connect what is being taught and learned to what is already known (Clarke, Waywood & Stephens, 1993).

In terms of relating journals to student achievement, math journals have been associated with improved student understanding and achievement on exams. Bell and Bell (1985) compared the achievement of two grade nine math classes. One class was taught to problem solve using conventional math techniques as well as an expository writing component. The other class was taught problem solving using traditional math methods. Both classes completed the same tests, quizzes and assignments. Students in the class combining traditional methods for problem solving with expository writing performed significantly better on a posttest than did the traditional problem solving class.

Students who wrote about their activities were more successful in problem solving than those who did not write were. Bell and Bell contend that writing serves to facilitate and foster communication between the student and teacher with respect to course material.

Similar to Bell and Bell (1985), Richards (1990) investigated the impact that writing had on students' understanding of math beyond the achievement measured by specific examinations. She found that the eleven-year-old children in her class benefited from writing as the process allowed them to "reflect on, clarify, record and demonstrate their learning processes and outcomes" (p. 18). She adds students' writings offer insight into "their thinking processes and understandings as well as how they have used resources and their skills and strategies" (p. 19). Richards asserts that journals provide students with opportunities to reflect on, clarify, record and demonstrate learning processes.

Henriques (1990) recounts the experiences of a grade two teacher named Jill who used journals. According to Jill, math journals allowed students to receive individualized instruction, and reflect on mathematical reasoning. They also provided her with a means for assessing student progress. Henriques states "By starting with the learner's assimilatory scheme, evident in the journal entry, Jill could tailor her probing questions to each child's needs and assess and plan her instruction via their understanding" (1990, p. 107).

Many of the advantages of journals reported by teachers for math students have been reported for science students as well. Shepardson and Britsch (1997) found that journals when used before, during or after an investigation as a basis for formal

communication, served to increase student learning. Journal writing after an investigation was found to be particularly effective after students had time to reflect on the lesson.

Colburn (1998) explains “writing helps students to articulate and understand their thoughts. Writing ideas in a student journal gives the student a basis for discussion, and listening to other student responses also helps students reflect on their own notions” (p. 24).

Roth (1992) investigated the role that writing and classroom discourse played in the scientific understanding of 22 fifth grade students. They reported that reading students journals helped them to better understand their students’ thinking and they used this information to guide future teaching. She found that the act of writing assisted students with clarifying and articulating their positions and ideas regarding various scientific concepts. The journal itself preserved students’ earlier images/beliefs that could be consulted and revised at a later date. Roth (1992) states “... for students, ... writing helped them elicit their ideas, contrast their ideas with others and helped them build onto and change their ideas” (p. 39).

Journals may also allow instructors to gain insight into student perceptions and conceptual understandings (Ammon & Ammon, 1990), provide students with a means to chart their progress over time (Marsh, 1998), and stimulate learning through the facilitation of interaction between students and their instructor (Abbas & Gilmer, 1997). Abbas and Gilmer found that by expressing their ideas, asking and answering questions and presenting the troubles experienced to their instructor, students’ science understandings were enhanced. Journals provide a forum where students and instructor to communicate through written discourse. They provide opportunities for students to

exchange, reflect upon and formulate their own understandings (Southwest Educational Development Laboratory, 1995). Lorschach and Tobin (1997) contend that knowledge can be supplemented through discourse with others.

Email journals and online reflections

Studies focussing on electronic journals have reported similar benefits to those reported for paper and pencil journals. Cooper (1996) used e-mail journals with her education students at Texas Tech University. Despite the difference in journal mediums, Cooper found she “gained a more expressive insight” into her students’ concerns and learning experiences from reading their e-mail journals. Cooper suggests one possible advantage of email journals over paper and pencil formats, in that she was able to provide more immediate feedback to her students than she could with more traditional paper and pencil journals.

Huitt (1997) used e-mail journals with his graduate and undergraduate educational psychology students. He found that these journals assisted undergraduate students in remembering and reflecting on the teacher/learner process. Huitt’s graduate students were able to connect the concepts covered during class to their experiences as educators through their journals. Huitt associates two advantages with e-mail journals. As a result of reading others’ experiences students have access to a greater depth and breadth of experiences not available with traditional journal writings. Huitt also noted increased sharing, discussion, communication and interaction among students.

Given the similarity in instructors’ perceptions regarding the value of electronic journals and reported benefits for students to those cited by instructors for paper and pencil journals this study operated under the assumption that despite the different written

mediums there are many similarities between paper and pencil and electronic journals. However, this does not mean that there may not be differences. Indeed, with a paper and pencil journal students typically engage in discourse only with their teacher. Online journals accessible by all provide additional benefits yet may require time for familiarity by students before these benefits can be accrued. Classmates can make sense of the views of others and compare personal meanings to those embedded within the theories of peers (Lorsbach & Tobin, 1997). In my experience for this exchange to occur classmates must develop an open, honest relationship with each other and with their teacher before free flowing sharing will result. Only when this happens is it possible for a student and his/her classmates to identify similarities and differences between one another's theories. Consideration and sharing of peers' ideas may lead to consensus allowing the entire class to develop conceptions more in accord with those of the scientific community.

A classroom teacher must be cognizant of students' past experiences when designing lessons and activities that best facilitate student learning. While constructivists believe learning is an active process, they in no way equate this with meaning that science should be only a series of activities (Mestre, 1994). Reflection time for students is required so that they can consider what transpired in the lesson, compare how this event or idea fits in with their current ideas on a topic and arrive at a 'new' understanding of the topic under consideration.

Clearly there have been many qualitative benefits associated with reflection. However little research has been conducted exploring the relationship between reflection and achievement. This study attempts to address this gap by investigating whether or not

online reflections are effective in facilitating student learning, as measured by achievement on unit exams and instructional planning as reported by the instructor.

Chapter III

Methodology

Participants

22 of 36 (61 %) students registered in Biology 20, in a Southern Alberta separate high school for the third quarter of the 1999-2000 school year agreed to participate in this project. Biology 20 students were chosen as subjects for this project because these students are expected to connect the recurring themes of diversity, energy, equilibrium, matter and systems throughout and across the four units of the course (Alberta Education, 1994). This integration presents numerous opportunities for misconceptions to develop. Given that the online reflections were established so that students were provided time and opportunity to identify what they know and don't know, and to consider events in terms of their current knowledge structure, this need to connect themes across different contexts seemed to make it an ideal choice for testing the value of online reflections.

Design and Procedure

One week into the Biology 20 course the purpose of the research project was explained to students. Consent letters (see Appendix A) were distributed to students for parents to sign. After all of the permission slips had been collected they were shuffled a number of times before slips were randomly selected for assignment of individuals to Group 1 or Group 2. At the end of this stratified random selection process (equal distribution of gender was the only variable monitored) 7 girls and 4 boys had been assigned to each group.

This study followed an alternating-treatments design (Christensen, 1988) where achievement on unit exams was compared across the two randomly constructed groups.

This is a single subject design whereby the sequences in which the online reflection and word search conditions are alternated to compare the relative impact of these two conditions on achievement. This design was the most practical given the setting of the study. Not only was the instructor able to assign work to all students at the end of the class regardless of the treatment condition a student was in, students not participating in the study could also be presented with a word minimizing the likelihood of non participating students disturbing their classmates. Furthermore, given the fact that word searches involve basic recall, low order tasks this condition served well as a ‘proxy ‘control condition for the purposes of this study.

The first group of students, Group 1, followed an A-B-A-B design. In treatment condition A students completed online reflections (see Appendix B). In addition to the biweekly reflections students also answered two review questions at the end of the course (see Appendix C). In condition B they completed word searches constructed using appropriate chapter vocabulary (see Appendix D). The second group of students, Group 2, from the same Biology class followed a B-A-B-A design. Achievement on unit exams was determined for each student under both the online reflection (A) and word search (B) conditions.

Students in condition A responded to four higher order questions online every two days for a period of two weeks. Each of the four questions was constructed for a different purpose. Each of these questions served a different purpose. The first question, ‘The three most important things covered in class were’, requires students to sift through everything covered in class and identify those topics that they felt were most important. This question also provides the instructor with information about whether or not students are

identifying those concepts that he feels are most important. If there is a discrepancy between the concepts the instructor feels are most important and those identified by his students then he will be able to address this next class. The second question, 'If I had to explain the most important topic covered in class to my best friend Pat I would tell Pat...'⁷ was included to provide students with an opportunity to describe concepts in their own everyday vernacular, thus presenting students with an opportunity to develop a deeper understanding of various concepts. The third question, 'Before we started today's class I didn't know much about _____ now I know _____', allows students to consider and identify any new information in light of what they already know. This question could also be used to identify any incomplete conceptions or misconceptions held by his students. For example if the class does a lab that expands upon concepts covered in earlier grades, and they don't indicate this in their response to this question it may be that they have held on to their original incomplete conception. Additional activities may be needed to remedy this. The fourth question, 'Questions that I have about today's class include', allows both students and the instructor to see what it is they do and do not know.

The teacher and students could view all reflections that were submitted in an anonymous fashion. When viewed by students and the instructor these reflections were free of any distinguishing characteristics that could allow for identification of the responder. The length of each student's online response was determined by using the Microsoft Word 98 word count tool. The word count value with spaces was determined for each question and then totaled for each student. The assumption underlying this measure is that longer responses require more time on behalf of the student and include

more detail and depth of thought. Thus, in this study word count serves as a crude measure of depth of thought.

Students completed reflective entries every 2 days in order to ensure that they could ask any questions about any/all chapters comprising a unit test. Students switched over from the online reflection condition to the word search condition every 2 weeks to coincide with the start of a new unit. This time frame was followed to provide students and their teacher enough time to become familiar with the process and content of the reflections. In order to stress the importance of online journal participation, the evaluative component of this course was modified for students participating in this study so that 5% of students' grades were awarded for completing their online reflections.

Between five and ten minutes of class time were provided for students to work on their reflections or word searches. This amount of time was based on the recommendation of Fulwiler (1987) that five to seven minutes of class time be provided for students to work on their journal entries.

A survey, consisting of both Likert and open-ended questions, was used to assess student perceptions of online reflections and their associated features at the end of the study (see Appendix E).

Originally bi-monthly interviews of the Biology 20 teacher were planned. However, there were complications involved with the latter stages of the instructor's wife's pregnancy, subsequent birth of the child and the mentoring requirements of his student teacher. These significantly reduced the amount of time that could be provided for interviews. Consequently, the instructor requested a more comprehensive final interview at the end of the semester, in addition to the interview completed earlier in this

study. The interview questions (see Appendix F) focussed on assessing the impact of student reflections on the teaching and student learning of Biology 20 from the teacher's perspective.

Chapter IV

Results

S.P.S.S. Version 9.0 was used to perform all statistical analyses including descriptive, frequency, bivariate correlations and ANOVAs. Findings are presented and discussed in terms of the research question to which they apply, as identified in the introduction on page 2. In this study significance was set at the 0.05 level in accord with standard research practice.

Research Question 1: Is the Achievement of Students as Measured by Unit Exams

Greater for Those Students who Complete Online Reflections than Those who do not?

According to the instructor, in the past, students have found Unit 2 Energy Flows and Cellular Matter most difficult, then Unit 3 Energy and Matter Exchange in Ecosystems, and Unit 4 entitled Energy and Matter Exchange by the Human Organism. Unit 1, the Biosphere, was reported as the easiest of the four units. A more detailed description of each of these four units taken from the Biology 20 program of studies is presented below to familiarize the reader with each of these units.

Unit 1 focuses on the dynamic *equilibria* that exist for *energy* and *matter* in the biosphere, and the *systems* that regulate those *equilibria*. In Unit 2, *energy* from the environment is traced through photosynthetic and cellular respiratory *systems* with the associated cycling of *matter* in the form of carbon. Unit 3 examines the *diversity* in characteristics of some of the *ecosystems* that make up the biosphere, and the interactions of the organisms mediating the flow of *energy* and *matter* through those *ecosystems*. The unit closes with a discussion of how organisms

evolve to fill available niches in *ecosystems*. The particular case of the human organism *system* and its *energy* and *matter* exchanges with the environment is examined in Unit 4, along with its biotic interactions with pathogenic organisms and the maintenance of *equilibrium* with its environment' (Alberta Education, pp. 11).

Despite introduction of the online reflection condition student marks continued to follow the pattern described by the course instructor. Regardless of the group they were in students performed best on unit exam 1 then unit exam 4, 2 and 3 (Group A: average marks 85.3, 83.9, 78.5 and 78; Group B: average marks 76.9, 75.1, 70.0, 66.0).

ANOVAs comparing the unit marks for groups A and B were conducted for all four unit exams. In an ANOVA or analysis of variance the variability in the means of the dependent variable across two or more groups is compared with the variability in scores within these groups, this comparison is the F ratio. When the variability across groups is considerably more than the variability within groups significance at the 0.05 level is achieved. In this study the variability in unit exam mark for the online group and the word search group was compared to the variability of scores within these two groups for each unit exam.

As observed in Table 1, on page 26, no significant differences between the groups were found for any of the unit exams. For the first unit exam the probability is 29.9 out of 100 that this result could be obtained by chance. This result is well beyond the level of 5 times out of 100 that is associated with significance, the impact submitting online reflections and completing word searches has on achievement is similar. Thus online reflections have no significant impact on achievement as measured in this study.

Table 1.

Analysis of Variance for Unit Tests for Groups A and B

Unit 1 (Group A reflections, Group B word search)	df	F ratio
Reflections/Word Search Condition	1	1.142
Subjects Within Groups	18	

p = 0.299

Unit 2 (Group A word search, Group B reflections)	Degrees of freedom	F ratio
Reflections/Word Search Condition	1	1.063
Subjects Within Groups	20	

p = 0.315

Unit 3 (Group A word search, Group B reflections)	Degrees of freedom	F ratio
Reflections/Word Search Condition	1	1.358
Subjects Within Groups	20	

p = 0.258

Unit 4 (Group B word search, Group A reflections)	Degrees of freedom	F ratio
Reflections/Word Search Condition	1	1.686
Subjects Within Groups	20	

p = 0.209

Research Question 2: Is There a Significant and Positive Relationship Between the Length of an Online Response and Student Achievement?

Three Pearson Product correlations were conducted to determine the degree of association between the average length of each student's reflection responses and his/her final mark; the total number of reflections completed by students and their final mark and the total number of word searches completed by students and their final course mark.

(Note: these values do not include student's responses to the two questions that everyone had to complete during the last week of the course as students did not write any exams during this period.) A Pearson Product correlation indicates the degree of association between one variable (i.e. number of online reflections completed) and another (i.e. overall course mark). A 2-tail test of significance was conducted because of the

uncertainty as to the direction of association between the variables. As was the case for ANOVA significance is set at the 0.05 level.

Significant 2-tailed correlations were found for average reflection length and overall course mark (Pearson correlation = 0.463, sig. 2-tailed = 0.03), and total number of reflections completed and overall course mark (Pearson correlation = 0.556, sig. 2-tailed = 0.007). No significant relationship was found for total number of word searches completed and a students' final marks (Pearson correlation = 0.193, sig. 2-tailed = 0.389). These findings suggest that a student who wrote longer reflection responses and submitted more reflections would have a have higher mark than a student who had submitted fewer and shorter responses would.

While not directly germane to this research question an observation regarding length of reflection response warrants mention. Average response length decreased markedly after the first week of reflections and tended to decline for the remainder of the project. For example at the beginning of this study average response length to the reflection questions was just over 102 words, by the end of the project the average response length was just under 43 words. This can be seen in the sample responses to question 1 presented below. These responses are from the same student at different times throughout the study. The date is provided as a reference point to illustrate this observation.

Well, we only really covered one topic today, which was biomes, and what they consist of. We started to prepare presentations on these, picking 5 and describing what made them what they are. I learned what biomes are: large scale ecosystems (ex: grasslands, tropical rainforests, taiga) They include both the

biotic and abiotic factors in an ecosystem, and countries can include many biomes. That is what makes our country so diverse. Canada consists of taiga, grasslands, and many more biomes. This accounts for the diverse vegetation and animal population that we have in Canada (Online Reflection, February, 7, 2000).

Just over a week later this student's reflections had decreased markedly in length. In fact on February 15, 2000, she submitted the following response: "We learned about the history of Charles Darwin, the Theory of Natural Selection, and the Main Types of Adaptations" (Online Reflection, February, 15, 2000). This response was considerably shorter than her first response. Later responses tended to fall in the 30 and 38 word range. For example "We did power point presentations on different diseases and conditions of the digestive system. Common ones are lactose intolerance, diarrhea, and hepatitis" (Online Reflection, March, 7, 2000). Similarly in her Online Reflection for March 21st she wrote "The different kinds of carbohydrates, lipids, and proteins. We also reviewed the functions of the heart and what it does in the body. And last but not least, the blood flow through the heart."

It is important to reiterate that while the length of response decreased over time for all students those who wrote longer responses and completed more reflections tended to obtain higher marks than those whose responses were shorter and more infrequent.

Research Question 3: Do Students Perceive Online Reflections as Valuable?

Near the end of the course students completed an Online Reflection Rating Form (see Appendix D). As shown in Table 2 the majority of students believed online

reflections made them think about the material covered in class. According to students reflections also clarified their understanding of various topics and they served as a study aid to some degree. Students did not perceive reflections as being especially able to stimulate their curiosity. Despite the fact that 22 students participated in this study only 20 completed the form because 2 were called away to an extracurricular event at the time when this form was administered.

Table 2

Mean, Count and Standard Deviations for the Online Reflections Rating Form

Question: Indicate the degree to which you felt the online reflections	N	Mean	S.D.
Q1A a. clarified your understanding of scientific topics	20	3.3	1.0
Q1B b. made you curious to learn more about the topics presented	20	2.8	1.1
Q1C made you think	20	4.1	1.2
Q1D helped you study	20	3.2	1.3

Note. A mean score of 1 corresponds to a not at all rating, a 3 refers to a rating of somewhat and a 5 corresponds to a rating of very.

Table 3

Frequency and Percentage of Online Reflection Rating Form Responses

Question: Indicate the degree to which you felt the online reflections	Frequency and percentage of responses				
	1 Not At All	2	3 Somewhat	4	5 Very
Q1A a. clarified your understanding of scientific topics	1 (5%)	3(15%)	7 (35%)	7 (35%)	2 (10%)
Q1B b. made you curious to learn more about the topics presented	3 (15%)	4 (20%)	9 (45%)	3(15%)	1 (5%)
Q1C made you think	1 (5%)	2 (10%)	2 (10%)	5 (25%)	10 (50%)
Q1D helped you study	3(15%)	3(15%)	4 (20%)	7(35%)	3(15%)

As indicated in Table 3, 16 of 20 or 80% of the students who completed the Online Reflection Rating Form stated the reflections served to clarify their understanding of topics covered in class somewhat or better. Two students, or 10 %, found the reflections very useful in clarifying their understanding, 7 students or 35% found them quite clarifying and 7 or 35% stated the reflections were somewhat clarifying. Three students or 15% felt the reflections were only a bit useful in clarifying their understanding and 1 student or 5% of the sample reported that online reflections did not clarify his/her understanding of the topics covered in class at all.

As reported in Table 3 1 student or 5% of the sample reported completing the reflections made him/her very curious about the topics presented in class. Three students or 15% of the sample stated the reflections made them quite curious and 9 students or 45% of the sample became somewhat more curious as a result of the online reflections.

Four students (20%) found that completing the reflections made them only a bit more curious, while 3 more or 15% of the sample reported the reflections did not increase their curiosity levels at all.

Ten students or 50% of the students who completed the rating form indicated the reflections were very helpful in making them think, 5 students or 25% indicated that the reflections were quite helpful in encouraging thinking. Two students or 10% of the sample found the reflections somewhat helpful in making them think about class material. Two students or 10% reported that the reflections made them think only a bit, and 1 respondent (5%) reported the reflections did not make him/her think at all about the topics presented in class.

When asked to indicate the degree to which online reflections ‘helped you study’ 3 students or 15% reported they were very helpful, 7 students or 35% of the sample reported they were quite effective, and 4 students or 20 % indicated the reflections were somewhat helpful as a study aid (see Table 3). Three students or 15% of the sample asserted the reflections were only a bit helpful as a study aid and 3 others did not find the reflections at all helpful as a study tool.

A split in responses to the question ‘ did the teacher address the concerns/questions brought forth in your reflections’ was observed. This result may in part be attributed to the presence of a student teacher for part of this course (the student teacher struggled somewhat in her placement and may not have always addressed student concerns). 1 student or 5% of the sample indicated that the teacher did not address his/her concerns/questions at all, 9 or 45% of the students responded N/A to this question and 10 students or 50% replied yes to this question.

The two groupings of answers to the open ended questions on the Online Reflection Rating Form suggests that there are two clearly identifiable camps of students, those that like the reflections and those who do not.

Key benefits of online reflections as reported by students and paraphrased by this researcher include reflections: 'helped them review or recall what they had learned in class for that day', 'helped them think', 'helped them understand things better' and 'assisted them in reflecting on the happenings of the day'. Other identified benefits include reflections helped 'with studying' and 'identifying the most important topic of the day', 'it got us on the computer', 'it helped clarify the answers', 'you can discuss (things) with others', 'it keeps 'the topics of the day fresh in your mind' and it 'took up time'. What is interesting is that all students identified some benefits associated with online reflections regardless of their level of like or dislike for them. This suggests that online reflections may facilitate student learning by helping students study, think and reflect on what was taught in class.

Students provided a variety of suggestions for improving the online reflections. The most common suggestion was to make the questions more specific and related to actual lessons. Other suggestions include providing more time to complete the reflections, varying the questions, having a shorter Uniform Resource Locator for the reflection website, reducing the number of questions asked, and acknowledging that not having the internet makes things inconvenient. One respondent indicated that they had no suggestions for improvement, another student stated that 'they were okay as is'.

Eleven or 55% of the students participating in this study felt reflections should become part of the Biology 20 course taught at their school, while 8 40 % felt the exact

opposite – they did not want reflections to become part of the Biology 20 course. One student reported he/she was unsure and 1 had no opinion. Reasons cited by students for incorporating reflections into the Biology 20 course include reflections helped them remember, improved their understanding, and helped them think. Additional reasons provided by students and paraphrased by this researcher include ‘you reflect on what’s learned’, and (reflections) ‘help you realize the most important topic of the day’. Two of the yes responses were conditional with a reminder that the questions needed to be varied on a day by day basis to make them more relevant.

Reasons provided by students (and paraphrased by this researcher) for not incorporating reflections into Biology 20 include ‘others did not know what they were talking about so reading their responses was not helpful’, ‘reflections took too much class time’, ‘they were not taken seriously’, ‘it was hard to summarize so much information’, ‘it made no real difference in understanding’, ‘they didn’t actually pinpoint whether or not a student is learning something’, ‘some don’t have a (home) computer’, and ‘doing the reflections was not enjoyable’. These comments are in contradiction with much of the benefits cited in Chapter 2 for reflection. This apparent contradiction will be revisited in the discussion section.

In response to the question would they encourage all science teachers to incorporate online reflections in to the courses they teach 9 students or 45% responded yes, 6 or 30% responded no, 3 or 15% left this question blank and 2 students or 10 % reported they were unsure. Reasons provided by students for a yes response were virtually identical to those provided for the question about incorporating reflections into the Biology 20 course. Paraphrased student responses include reflections ‘increase

marks', reflections 'show how much the students have learned', 'it is a good review'/helps with studying', they 'helped me think', 'you reflect on what's learned', 'it helps you realize the most important topic' and 'it is good if students are committed'.

Similarly, the reasons given by students for a no response were quite similar to those given for the question about incorporating reflections into the Biology 20 course. 'Others did not know what they were talking about so reading their responses was not helpful', 'they didn't really help', 'I'd rather have a recap at the end of the day', 'they were not taken seriously', 'they didn't actually pinpoint whether or not a student is learning something' and 'doing the reflections is not enjoyable' were the reasons given by students for not incorporating reflections into any science course.

One student who responded " maybe" felt that the reflections would have more impact if they were completed once a week as opposed to every second day.

Research Question 4: Are student responses used to guide future instruction?

As stated in the methodology section the instructor was interviewed twice to determine if reading the reflections helped him identify students' concerns, questions and confusion with material covered in class and what impact this knowledge had on his planning and teaching of science.

While similar questions were asked during both interviews, the list of questions for the second interview was expanded to address a number of additional queries. What technology outcomes do the reflections address; was it worth the time required to do reflections and would you recommend reflections to other instructors were added to the

second interview in addition to those questions asked during the first interview (see Appendix F).

The time required to read through the reflections, identify students' understandings and misconceptions decreased with practice. During the first interview, on February 16, 2000 the instructor reported he was spending approximately 45 minutes to read through student responses. By the time of the second interview on April 10, 2000 the time required had decreased to 20 minutes. This suggests that the instructor required time to become familiar with accessing and using the information contained within the reflections to guide his teaching.

The instructor felt that students' descriptions of the most important concepts covered during class were typically in accordance with his own. In the first interview he indicated any differences between his and his students' views came out in the questions. The instructor's response during the second interview suggests that as a result of increased familiarity he was able to identify not only student patterns in completing reflections but potential areas of difficulty in student learning. He stated: "For the most part yes they did identify the most important concepts. Typically when they had problems it was an activity-based lab" (instructor, second interview, April 10, 2000). When probed as to how he dealt with students' misunderstandings, he added he addressed them "through class discussion at the end of the day and/or follow up activities in the next lesson" (instructor, second interview, April 10, 2000).

When asked if there were any responses that surprised him, the instructor automatically focussed on the questions students asked. During both interviews he expressed the philosophy that all questions asked by students were valid and relevant.

Because his response in the second interview is more detailed than the response given during the first interview it is the one that is presented in the passage below.

All were relevant questions but with my student teacher sometime the timing was off. I was a bit surprised by the amount of help required by students to complete the final questions, perhaps I need to include some activities that show/stress the similarities in cell and biosphere processes (instructor, second interview, April 10, 2000).

When probed as to why he keyed in on the questions asked, the instructor stated “this is how I know what students get and don’t get - the students in this class are not shy about vocalizing their concerns/questions” (instructor, second interview, April 10, 2000).

The benefits of online reflections identified by the instructor were quite similar to those identified by his students. In the first interview he touched upon the importance of “self-reflection of own knowledge” (instructor, first interview, February 16, 2000). In the second interview he expanded on his earlier comment and added: “Yep, it helped them identify their own areas of concern. It became clear what students needed to know for their own success and what I had to help them with” (instructor, second interview, April 10, 2000).

When asked if students had shared their opinions about the reflections with him during the first interview the instructor stated: “Some students have indicated that they like it because it can help them do better” (instructor, first interview, February 16, 2000). During the second interview his comments, provided below, suggest that self-motivation may be an important factor to consider when adopting online reflections. “The more academically motivated students enjoyed the reflections most. The less academically

motivated students tended to view them as just extra homework so I don't think they enjoyed them no where near as much" (instructor, second interview, April 10, 2000). These observations appear to be in accord with both the split in student responses on the Online Reflections Rating Form – where it became clear some students enjoyed the reflections and some did not and the correlation between the number and length of student reflections submitted and students' overall mark. Students who are more academically motivated probably see more merit to completing the reflections, so they enjoy them more and are more likely to submit them. Future studies could investigate this common sense speculation.

Unlike the first interview where the instructor indicated he had no suggestions for improving online reflections, during the second interview the instructor offered suggestions quite similar to those offered by his students. His statement is provided below.

Change the variety of questions, have them do it every Monday and Friday- as it is easier for them to remember and if the questions cover the weekly activities it will provide more of a chance to track conceptual changes in students (instructor, second interview, April 10, 2000).

In both interviews the instructor indicated he modified his instruction, planning and approach in a variety of ways as a result of what he had read in the reflections. As indicated in the following quotes at the beginning of this study the instructor's main strategy for addressing students' concerns was discussion, by the end of this study the discussion had evolved into a more formal and structured review of the previous day's

lesson. This suggests that the online reflections did impact how the instructor planned and taught science.

I'd make sure I'd discuss with students the questions that they raised often we'd brainstorm answers to these questions as a class. If there were repetitive questions I'd take this as a sign that the concept needed to be re-taught and I'd try and go over the material in a different way (i.e. have students create a poster showing the main parts of digestion in humans) (instructor, first interview, February 16, 2000).

Yeah, I think I made sure even more so that I reviewed the previous lesson (than I did prior to doing reflections). I know I paid more attention to complicated topics on days of the reflections so that I could cut down on the number of questions I'd have to answer at the beginning of the next class. I guess you could say it impacted on my planning-which became more detailed and my instruction - I'd teach a difficult topic using more and varied strategies-although this was true if there were no reflections. But they sure made me plan more and I was very cognizant of potentially confusing areas for the students when planning (instructor, second interview, April 10, 2000).

Near the end of the second interview the instructor was asked if he would recommend on-line reflections to other instructors, he replied: "I would recommend this to instructors teaching more academic classes, because it requires some discipline. I'm not convinced it would work with Science 14 students" (instructor, second interview, April 10, 2000). His comment melds with the previously reported finding that the number and length of online reflections completed was significantly and positively correlated

with student's overall marks. Perhaps those students who are more 'academically motivated' are putting more in and getting more out of the reflections than those who are not so academically motivated are.

Finally, the instructor stated "I was surprised by this but it (online reflections) actually addressed a lot of the technology outcomes. Here's the list of technology outcomes that I think it met (hands me a list of the technology outcomes with stars by the one that it met)" (instructor, second interview, April 10, 2000). The list of technology outcomes that the Biology 20 instructor believes online reflections meet is provided below (see Appendix G for the complete list of general outcomes).

P1 Students will compose, revise and edit text, C1 Students will access, use and communicate information from a variety of technologies, C2 Students will seek alternative viewpoints, using information technologies, C5 Students will use technology to aid collaboration during inquiry, C6 Students will use technology to investigate and/or solve problems; C7 Students will use electronic research techniques to construct personal knowledge and meaning, F2 Students will understand the role technology as it applies to self, work and society, and F3 Students will demonstrate a moral and ethical approach to the use of technology.

The general outcome preceded with a P in the above passage refer to Processes for Productivity outcomes, those demarcated with a C fall under the Communicating, Inquiring, Decision Making and Problem Solving outcome category and those marked with an F are Foundational Operations, Knowledge and Concepts outcomes (refer to Appendix for a list of all general outcomes).

Aside from serving a planning function online reflections allow instructors and students to meet 1 of the 6 Processes for Productivity general outcomes, 5 of the 7 Communicating, Inquiring, Decision Making and Problem Solving outcomes and 2 of the 6 Foundational Operations, Knowledge and Concepts outcomes. Based on this instructor's responses online reflections appear to be a relatively easy way of meeting the technology outcomes while providing the instructor with information about students understandings of the day's lesson.

The last words go to the instructor who reports that the benefits associated with online reflections overrode his initial misgivings, when asked, at the end of the second interview, was it worth it? He states: "Yeah personally it's great to use technology daily, even though I'm not overly fond of it I realize that there's a lot of merit in self-reflection that will pay off and override any misgivings I may have" (instructor, second interview, April 10, 2000).

Research Question 5: Are online reflections effective in facilitating student learning and instructional planning?

During this project students generated over 28 pages of responses. Given that this study is one of the first of its kind it is hard to determine whether this volume of data is good or bad. However, my experience as a science teacher suggests that this is an impressive amount given the normal reticence exhibited by students when it comes to writing responses to short answer and essay questions in science. Future studies will have to address this issue. The responses for each question will be summarized according to theme and where appropriate the frequency of responses will be calculated. As well 1 - 2

sample comments will be presented to illustrate typical responses for each of the questions asked. Student's responses are presented as initially entered by the students. Consequently some of these responses may contain spelling and/or grammatical mistakes.

A more representative sample of student responses to all four of the reflection questions is provided in Appendix H. Sample responses were selected systematically, Where possible every 17th response was selected for inclusion, however if that individual already had a response selected for inclusion than the response immediately preceding/proceeding the original selection was chosen instead.

Online reflection results are discussed on a question by question basis.

Online reflection question 1.

The topics identified by students as being most important for February 7, 2000 through to March 27th are presented below in chronological order. The first series of online reflections identified biomes, their characteristics, importance and impact and student presentations as the most important topics covered; 2 days later the topics of the structure of lakes and ponds, seasonal variations and snow adaptations were identified.

On February 11th, it the test and gall bladder surgery video were identified by students as being most important. Darwin, fossils, natural selection, adaptations; peppered moth, plant and animal cells; microscope, organelles, abiogenesis were the important topics identified by students for February 15, 17, and 28th. Students in their March 1st reflections deemed the cell membrane, transport, and rat dissections important; on March 7th students mentioned enzymes, glycolosis, cellular respiration, and the Kreb

cycle as important topics. Organs, organ systems, and tissues were mentioned in the March 10th reflections; the digestion system and its associated components dominated the March 13th reflections.

Power point presentations on disease of digestive systems and carbohydrates, lipids, proteins; heart, blood flow and types were the topics identified by students as most important for classes held on March 16th, 21st and the 23rd respectively. The last series of reflections, submitted on March 27th, identified microscopes, blood cells, immunity, vaccines and allergies as the most important topics covered in class.

As shown in Table 4 the responses to reflections varied with course content but tended to be quite similar for any given day. In fact no topic had only one student who identified it as important suggesting that students tended to rate the importance of various topics in a similar light.

Table 4

Frequency of Topics Identified By Students as Most Important

Biomes	11
Student presentations	5
Structure of lakes and ponds	2
Seasonal variations	6
Snow adaptations	3
Test	11
Gall bladder surgery	6
Darwin	11
Fossils	2
Adaptations	6
Peppered moth	5
Plant and animal cells	14
Microscope	9
Organelles	4
Abiogenesis	3
The cell membrane	6
Transport	4
Rat dissections	8
Enzymes/substrates	5
Glycolysis	11
Cellular respiration	11
Kreb cycle	11
Organs	4
Organ systems	4
Tissues	2
Digestion system and its associated components	9
Carbohydrates, lipids, proteins	3
Heart	4
Blood flow	4
Blood types	6
Blood cells/parts	5
Immunity/vaccines	6
Allergies	3

Two sample responses, one from February 9 and the other from February 28th are presented to illustrate how students went about identifying the three important topics for various lessons. These samples also serve to illustrate some the variety inherent in students' reflection submissions.

The three concepts are: 1. The seasonal variations in lakes. 2. Adaptation for winter in animals. 3 types: - anatomical - physiological - behavioral3. The classification of animals based on the impact of snow on their behavior. – Chinophobe, - Chioneuphores – Chionophiles (Online Reflection, February 9, 2000)

1) We did a lab on microscopes. Learned how to make a wet slide. We looked at the different powers on the microscope and the difference between each. 2) We talked about the sceintists that dicovered the microscope and there different theories. 3) I drew the plant and animal cell and all about the different oraganelles and how they work and effect each cell. (Online Reflection, February 28, 2000)

The only time that there was not some consensus in students' responses to this question occurred when students did not submit reflections on the scheduled day and tried to do it later from memory. For example one student submitted a reflection for a class that had occurred 5 days previously, his responses were in line with those submitted by his classmates on March 21st but not for March 27th when he submitted his reflections. His response on the 27th of March to what were the three most important topics covered in today's class was: "all blood cells come from bone marrow, platelets create clotting, the different types of blood" (Online Reflection,

March 27, 2000) was quite similar to a classmate's submitted on the 21st of March. One of his classmates wrote "what human blood cells look like, what snake blood cells look like and blood cells are made from bone marrow" (Online Reflection, March 21, 2000).

Online reflection question 2.

Student responses to the second question: If I had to explain the most important topic covered in class to my best friend Pat I would tell Pat ... touched upon the topics identified in question one, but they also included details about class activities (i.e. today we made pamphlets, drew cell pictures, made PowerPoint presentations, registered for next year ...).

No where was it more noticeable that students differed greatly in their writing and communication styles, than in question 2. It is believed that this is the result of the intended audience for this question. This question was not being asked/answered for a teacher rather it was being done for one's friends – hence the more informal writing style and explanations. One student in particular had fun with this question telling Pat that she needed to 'get a life' and 'start coming to class'. Three examples of students' responses to this question are provided to illustrate the variation in length and style of student responses. For example one student wrote "That the cells of the body are very unique and they are responsible for carrying oxygen to all parts of the body" (Online Reflection, February 15, 2000). This response is considerably shorter than the two that follow.

Hey Pat, guess what we did in Bio class today? We go to dissect rats! It was pretty cool. I got to cut it open and see were it's heart was and the liver. We got to look

at all the organs in the rat. We tried to figure out if it was a girl or a boy and it was a girl it was really hard to tell. I also looked inside the heart and the stomach to see what it looked like inside it was really neat. To bad you weren't in my Bio class Pat it was a lot of fun today (Online Reflection, March 1, 2000).

Well Pat if you would have been paying attention in class today you would have learned that there is a plant and animal cell and they both have numerous different organelles. We learned how to draw them and what the function of each one of them was (Online Reflection, February 17, 2000).

Online reflection question 3.

Student responses to the question before today's class I didn't know much about ... now I know ... tended to follow a similar pattern throughout. Typically a student would identify one of the most important topics from question 1 as something they did not know a whole lot about, then they would then indicate specifically what it was that they had learned. This can clearly be seen in the samples provided below and in Appendix H.

His response on the 27th of March to what were the three most important topics covered in today's class was: "all blood cells come from bone marrow, platelets create clotting, the different types of blood" (Question 1 Online Reflection, March 27, 2000).

blood...there are 3 different parts to blood. Also that hemoglobin helps the red blood cells to hold more oxygen so that it can send more to the body (Question 1, Online Reflection, March 27, 2000).

As observed in Table 5, in the majority of cases the students tended to address the same topic in questions 1 and 3. The noticeable exception involved responses dealing with enzymes. 5 students indicated that enzymes were an important topic covered in class, in question 3, 11 students indicated that they didn't know much about enzymes to start with but they had learned lots about them in today's class. It is suspected that that this occurred because enzymes are not covered in great depth until biology 20. In order to confirm my suspicion I contacted the instructor and he indicated that enzymes are not really addressed until Biology 20 (instructor, personal communication, November 17, 2000).

Table 5

Frequency of Multiple Responses by Topic For Online Reflection Questions 1 and 3

Topic	Question 1	Question 3
Biomes	11	11
Snow Ecosystems	4	3
Layers of Lakes/Ponds	2	2
Seasonal Variation	4	4
Darwin's theory of evolution/laws	12	9
Gall bladder video	6	6
Plant and Animal cells	11	4
Rat Dissection	8	8
Kreb Cycle	11	3
Glycolosis	7	6
Cellular respiration	7	6
Enzymes	5	12
Red Blood cells	3	3

Online reflection question 4.

Students asked 75 different questions as they completed the following statement:

Questions I have about today's class include _____. 88 % or 65/75 of the questions asked were content related. Each question was unique to the individual who asked it. This

question is the only one where there was little overlap in student responses. This makes sense in light of the constructivist contention that knowledge (or lack thereof) is unique for every individual. 8 administrative queries regarding assignments/tests/labs and 2 comments on the fun/interesting class were made. Samples illustrating the variation in students' responses are provided below.

What does PGA do in forms of the Glycolysis cycle (Online Reflection, March 7, 2000)?

What can we expect to be on the exam tomorrow? How many questions are there? What diagrams do we need to know(Online Reflection, March 13, 2000)?

Why hasn't our science field of today developed a way to induce everyone to have this "better" blood type (Online Reflection, March 23, 2000)?

For the last week of the course the reflections were changed to ascertain students' understanding of the similarity in processes, structure and function between the cell and the biosphere. While most students successfully identified a few similarities in process and function between these two systems, a lot of them indicated that they experienced difficulty when attempting to answer this question.

When asked to explain how cell processes are similar to the processes that occur in the biosphere, one student replied: "Cell processes are similar because they have systems inside that work together to keep homeostasis and this is the same to the biosphere" (Online Reflection, April 4, 2000). A second response is provided below to illustrate the difference in length and style of responses submitted.

What kind of question is this? :-) Well, I thought that there was only going to be ONE question, but it looks like there's 2. Well, cell's each have distinct parts, as

does the biosphere. Each has cycles, the biosphere has the biogeochemical cycles, while cells have glycolysis, photosynthesis, cellular respiration, etc... I hope this is enough information I don't know how to write more without going into the details of each of these cycles (Online Reflection, April 4, 2000).

Similar variation in responses was obtained for the second question which asked students to explain how the systems of the body are similar to the parts/systems of the biosphere. Two student responses are presented below.

The biosphere is divided into different parts, each serving a different purpose, yet intricately connected. The body is the same way. We have many different organ systems, yet they are so closely related that without one, we could not function properly...so it is with the biosphere. Oh yeah, I think I know what you want me to say... (Online Reflection, April 4, 2000).

There are different systems for each of the different functions necessary for life. Circulatory, excretory and respiratory, while the environment has to have their Carbon, Nitrogen, Phosphorous and water cycles completely rejuvenate the necessary things needed for the environment to survive (Online Reflection, April 4, 2000).

It is interesting that so many students struggled with this question. This was surprising to both the instructor and myself and will undoubtedly influence how the Bio 20 course is taught next year. Indeed, in the words of the instructor:

“Students are not making all the connections between the units I’d hoped for. I’m going to have to ensure that I focus on these connections next year as it is important that students understand that there are basic system components,

structures and processes that transcend any individual system” (instructor, personal communication, April 12, 2000).

Chapter V

Discussion

Contrary to expectations, online reflections had no significant, measurable impact on student learning/achievement. It is possible that individuals in both groups regardless of the treatment condition they were in were mentally or on paper answering the online reflection questions (as a study aid) thereby confounding the results. In addition, everyone who participated in this study was aware of the purpose and nature of the study – consequently the results may have been confounded by a Hawthorne effect in which some subjects performed to their highest levels of ability regardless of the treatment condition they were in. Given the split in student ratings for online reflections and the relationship between the length and number of reflections submitted, that the Hawthorne effect may have been strongest for the academically motivated students and less likely to impact the less motivated students. With the random selection of students to groups A and B it is possible that the same number of academically motivated and unmotivated students were assigned to each group. Future research should be conducted to ascertain the effect reflections have on the achievement of motivated and unmotivated students.

It is also possible that the online reflection questions were simply a more complex recall activity than the word searches and they required no synthesis or evaluation on behalf of the student. It is also possible that completing the reflections did assist students in developing a deeper conceptual understanding of various topics (Roth et al, 1992; Shepardson & Britsch, 1997; Colburn, 1998), but these topics were not assessed in depth on the unit exams. Indeed Mestre (1994) argues that most tests administered in schools

only guarantee that what is taught closely reflects what is assessed. Teachers spend an inordinate amount of time teaching to the test, the result is that students are taught a collection of definitions and bits of isolated information ...rather than a cohesive corpus of knowledge.’’ Credence to this comment of Mestre’s comes from the observation that the students had difficulty synthesizing the different units of information covered in the course to formulate an answer to the end of the course reflection questions (where they had to compare processes and systems of the cell and biosphere).

Engaging in online reflections may have lead to a deeper understanding of the process side of science – including hypothesizing and interpreting, but because the unit exams focuses on content and definitions, unit exam marks may not be the most valid measure of deeper understanding. Since unit exams are snapshots of learning it may make more sense to define achievement within the reflections themselves, that is look for evidence of growth and development within the reflections as opposed on to a content focussed unit exam.

One other potentially confounding result is the number of students who responded N/A to the question the instructor addressed the concerns/questions raised in hr reflections. Only 50% of the students felt that this was done. This means that 50% did not receive the answer they were seeking. It may also mean that while they had identified a gap in their knowledge, but this gap was never filled to their satisfaction. Finally, with respect to learning it is possible that some students recognized the limitations of their current conceptions but did not accommodate nor accept the authoritarian explanation (Appleton, 1993). In addition, the student may have defined the contradictory information as an anomaly and kept his/her original conceptions intact (M. Steed, personal

communication, January 26, 2000). Future research is required to determine which of these explanations is most plausible.

Clearly, while online reflections may pinpoint the gaps in understanding other tools, activities, lessons are also required to remedy these misconceptions and allow students to arrive at the best possible outcome. The outcome Appleton (1993) describes as the learner recognizes that current conceptions are inadequate and restructure to accommodate the new information.

As expected the average length of reflections and the number of reflections completed were significantly and positively correlated with a student's overall course mark. Somewhat surprising was that no such relationship was found for the number of word searches completed and overall course mark. The explanation posited as to why is speculative at best. There is a sense that the more academic students felt that reflections were true homework and diligently worked on completing them, word searches however were seen by these students as time fillers and so they did not complete as many of them as did the less academically motivated students.

According to Mrazek and Steed (1999) differences in perceived worth of online tools is not uncommon. In fact they found that university students tended to question the value of online reflections but instructors were quite excited about this tool. This perception is somewhat different than that held by the Bio 20 instructor who felt online reflections would best serve only academically motivated students.

Mrazek and Steed (1999) found instructors tended to associate the following benefits with online reflections understanding student thought and encouraging student reflection. They contend it is how the tool is used that plays the biggest role in

determining its effectiveness. This statement is in accord with my observation that there were two groups of students those who seemed to enjoy and value the reflections and those who did not, clearly this would suggest that one group was putting more into the tool and consequently getting more out of it.

In apparent contradiction to the findings of Clarke et al (1993) that over time students usually progressed in their journal writing from an initial recount mode to a more complex dialogue mode, student responses in this study tended to decline in both detail and length over time. Whereas at the beginning of the project students would take time to explain/define terms by the end of the project students wrote jot points and did not include the detail that they did at the outset. It is suspected that the decline may be the result of students spending less time on formulating responses to the questions as they became increasingly bored with the same series of questions.

The majority of students do see some merit/value in the reflections, as they were, however there is a strong push for modifying them by alternating the questions and making them more lesson specific. This is not surprising, as it has been my experience as an educator that students with higher marks tend to put more into and complete more assignments than students with lower marks do.

While reflections did not have a significant quantitative impact on student achievement as measured in this study, this does not mean they do not have merit. Given that online reflections allow teachers to enhance student learning, improve the effectiveness of their instruction and meet some of the Communication and Technology Outcomes, they are a truly valuable instrument for educators struggling to meet the dual curriculum challenge. The value for students while not as unanimous still exists. Some

students reported benefit from online reflections through a review of course content and identification of gaps in their understanding while others perceived no such benefit. This does not mean that online reflections should be abandoned all together, rather it means that instructors need to use many different strategies and teaching tools to assist their students in arriving at the intended learning destination.

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Appendix A Consent Letter

Dear Parent/Guardian:

I am researching the effect of online reflections on teacher instruction and student understanding of biology. Online reflections are a series of higher-order questions that your child views and responds to online. After your child has entered his/her reflections the teacher and other students in the class can view them. All reflections will be handled in a confidential and professional manner and will not include any information that can be used to identify your child. Information identifying individual students, the teacher or school will **not** be included in any presentations, papers or reports. Participation in this study is voluntary and your child may withdraw from the study at any time without consequence.

The purpose of this project is to examine the effectiveness of online reflections as a tool for student learning and instructional planning. Online reflections benefit students by requiring that they review and re-examine the information covered during class, as well, they allow your child to meet specific learning outcomes from the new Communication and Technology curriculum.

If you choose to allow your child to participate in this study, please indicate your willingness by signing this letter in the space provided below, and returning the letter to the school with your child.

I thank you for your assistance with this study. If you have any questions please feel free to call me at 380-4674. Please feel free to contact the supervisor of my study, Dr. Rick Mrazek at 329-2452 and/or the chair of the Faculty of Education Human Subject Research Committee if you wish additional information. The chairperson of the committee, Dr. Richard Butt, can be reached at 329-2434.

Sincerely,

Lisa Halma
University of Lethbridge
380-4674

(Please detach and forward the signed portion)

NAME OF PROJECT: Online reflections: A constructivist tool.

I have read the above and I agree to allow my child, _____, to participate in this study.

NAME: _____ SIGNATURE: _____

DATE: _____

Appendix B Online Reflection Questions

The three most important things I learned in the last two classes were _____

If I had to explain today's most important topic to my best friend Pat I would tell
him/her...

Before we started I didn't know much about _____ now I know _____

Questions I have about today's class include ...

Appendix C Culminating Questions

In your own words explain how cell processes are similar to the processes that occur in the biosphere.

In your own words explain how the systems of the body are similar to the parts/systems of the biosphere.

Appendix D Sample Word Search

Photosynthesis Words – please be advised that the actual word searches used were considerably longer.

Photosynthesis	Cellular Respiration	Guard Cell	Glucose
Semipermeable	Oxygen	ADP	ATP
			AMP

z	q	H	S	B	D	Y	j	k	E	q	Z	w	H	C	i	q	R	I	X
q	i	R	O	x	y	g	e	n	z	V	z	c	A	e	j	S	t	d	z
e	f	r	w	N	r	x	i	x	I	Q	b	e	k	v	l	u	a	t	p
x	A	R	E	x	B	J	u	o	s	c	T	l	b	L	O	X	p	o	j
s	U	f	h	h	X	v	A	Q	N	U	G	l	f	w	F	F	j	c	I
e	n	o	i	t	u	l	l	o	p	p	g	u	n	s	V	B	r	m	d
m	J	a	d	p	y	k	O	T	E	h	V	l	Y	J	Y	i	V	A	G
i	d	O	S	D	E	b	P	J	q	o	f	a	u	X	y	A	q	j	r
p	l	L	F	Q	G	t	o	I	A	t	C	r	F	c	U	k	e	N	g
e	P	M	T	t	u	l	W	b	Y	o	O	r	u	D	o	r	j	m	u
r	c	h	l	o	r	o	p	l	a	s	t	e	z	N	h	s	q	H	a
m	H	l	Z	L	r	E	d	N	z	y	Y	s	z	r	z	k	e	j	r
e	w	N	S	L	V	Y	S	Z	h	n	g	p	d	s	y	H	U	R	d
a	b	G	c	W	O	R	j	s	K	t	v	i	R	n	F	z	e	w	c
b	J	r	W	m	P	u	X	X	h	h	d	r	C	g	b	l	U	o	e
l	a	F	z	F	t	a	u	r	w	e	k	a	b	q	M	c	V	U	l
e	M	z	z	P	K	q	Y	Y	h	s	a	t	R	L	G	w	O	B	l
K	l	k	I	n	G	p	P	n	O	i	h	i	h	L	T	c	T	V	N
U	h	C	K	p	o	q	V	j	C	s	B	o	G	w	r	R	U	H	G
B	d	k	A	F	n	H	Y	d	R	C	K	n	l	V	H	T	o	l	v

Appendix E Online Reflection Rating Form

1. On a scale of 1 to 5, where 1 corresponds to **not at all**, 3 **somewhat** and 5 **very**, indicate the degree to which you felt the online reflections:

Question	Not at all		Somewhat		Very
a. clarified your understanding of scientific topics	1	2	3	4	5
b. made you curious to learn more about the topics presented	1	2	3	4	5
c. made you think	1	2	3	4	5
d. improved your understanding	1	2	3	4	5
e. helped you study	1	2	3	4	5

2. In the space provided please list two benefits of online reflections.

3. What suggestions do you have for improving the online reflections?

4. Did the teacher address the concerns/questions you brought forth in your reflections?

No Not Applicable Yes

5. Do you think online reflections should become part of the Bio 20 course taught at CCH? Why or Why not?

6. Would you encourage science teachers to incorporate online reflections into the courses they teach? Why or Why not?

Appendix F Interview Questions

Please note these questions are starting points. As issues arise (from class observations and the teacher's responses) probing questions will be used to clarify responses.

How long did it take you to read through the online reflections?

Are students' descriptions of the most important concepts covered during class in accordance with your own?

Were there any responses that surprised you? Why or Why not?

Do you think students are gaining anything of value from engaging in this exercise?

Appendix G Information and Communication Technology, Kindergarten to Grade 12

General Outcomes

Communicating, Inquiring, Decision Making and Problem Solving

- C1. Students will access, use and communicate information from a variety of technologies.
- C2. Students will seek alternative viewpoints, using information technologies.
- C3. Students will critically assess information accessed through the use of a variety of technologies.
- C4. Students will use organizational processes and tools to manage inquiry.
- C5. Students will use technology to aid collaboration during inquiry.
- C6. Students will use technology to investigate and/or solve problems.
- C7. Students will use electronic research techniques to construct personal knowledge and meaning.

Foundational Operations, Knowledge and Concepts

- F1. Students will demonstrate an understanding of the nature of technology.
- F2. Students will understand the role of technology as it applies to self, work and society.
- F3. Students will demonstrate a moral and ethical approach to the use of technology.
- F4. Students will become discerning consumers of mass media and electronic information.
- F5. Students will practise the concepts of ergonomics and safety when using technology.
- F6. Students will demonstrate a basic understanding of the operating skills required in a variety of technologies.

Processes for Productivity

- P1. Students will compose, revise and edit text.
- P2. Students will organize and manipulate data.
- P3. Students will communicate through multimedia.
- P4. Students will integrate various applications.
- P5. Students will navigate and create hyperlinked resources.
- P6. Students will use communication technology to interact with others.

Appendix H Sample Responses

Question 1

2/9/2000 The three concepts are: 1. The seasonal variations in lakes. 2. Adaptation for winter in animals. 3 types: - anatomical - physiological - behavioral 3. The classification of animals based on the impact of snow on their behavior. –

Chinophobe, - Chioneuphores - Chionophiles

2/15/2000 Today we are just making puppets but yesterday we learned about islands and how animals get across, and about fossils, and how they were formed and preserved. today we got a hand out about charles Darwin and it talks about all his theories.

2/28/2000 1) We did a lab on microscopes. Learned how to make a wet slide. We looked at the different powers on the microscope and the difference between each. 2) We talked about the scientists that discovered the microscope and their different theories.

3) I drew the plant and animal cell and all about the different organelles and how they work and effect each cell.

3/7/2000 Cellular Respiration. Glycolysis Krebs Cycle

3/13/2000 NOTE: I am from group B but missed March 9th's entry. During thursday's class we studied for most of the first half before we had to go to a memorial service. I guess you could say I learned some things while I was studying but nothing substantial. In the second half of the class we wrote a test (A very hard test) which didn't involve a lot of learning.

3/22/2000 - the parts of the heart- the direction of blood flow in the heart. - the importance of capillaries.

(last thursdays) 3/27/2000 all blood cells come from bone marrow, platelets create clotting, the different types of blood

Question 2

2/9/2000 i would tell Pat that in the Hypolimnion there is no sunlight at all.

Subnivean means "beneath the snow" and Browsing is feeding on twigs and shrubs.

2/15/2000 I would tell Pat that if she wants to be put to sleep I guess I'll tell her, and since she is such a keener, she will want to know that Darwin was the one that came up with the theories of evolution, and I would outline them to her.

2/28/2000 today we learned about abiogenesis, that is the theory that fly's come from rotten meat.

3/1/2000 Hey Pat, guess what we did in Bio class today? We got to dissect rats! It was pretty cool. I got to cut it open and see where its heart was and the liver. We got to look at all the organs in the rat. We tried to figure out if it was a girl or a boy and it was a girl it was really hard to tell. I also looked inside the heart and the stomach to see what it looked like inside it was really neat. Too bad you weren't in my Bio class Pat it was a lot of fun today!

3/10/2000 Today I learned about how cells make up tissues and tissues make up organs and organs make up organ systems. I learned about all the systems of the body and the importance of these systems. I also learned how the body acts as a regulator to maintain the same temperature inside no matter of the external conditions.

3/22/2000 Well Pat the most important topic that we covered in class today was the direction that your blood flows and what parts do what functions.

3/28/2000 That the cells of the body are very unique and they are responsible for carrying oxygen to all parts of the body.

Question 3

2/9/2000 about the seasonal variations in lakes through the seasons, and why.

2/15/2000 Before today's class I didn't know much about gull bladder surgery but now I know that they are making improvements on the ways that this surgery can be performed.

2/28/2000 abiogenises-a lot about abiogenises and how it was introduced.

3/1/2000 What the inside of a rat looked like and the actual organ itself. I did know much about how a dissection was really like and now I know and it's neat.

3/13/2000 a lot of information about the digestive system and the various tasks and functions it performs.

3/22/2000 Circulation

(Last Tuesday) 3/27/2000 blood...there are 3 different parts to blood. Also that hemoglobin helps the red blood cells to hold more oxygen so that it can send more to the body.

Question 4

2/9/2000 what are some ways man affects these issues we have went over.

2/15/2000 I wonder if I will be told to differentiate between some of the types of adaptations, I'm not sure if I will be able to because I'm not all that clear on them.

2/28/2000 None

3/1/2000 I wonder if we will get another chance to dissect another organism and if the procedure is any different

3/8/2000 What does PGA do in forms of the Glycolysis cycle?

3/15/2000 What can we expect to be on the exam tomorrow? How many questions are there? What diagrams do we need to know?

3/16/2000 - Why is blood considered to be a tissue?

3/23/2000 What are the advantages to having a certain blood type over another?

Why hasn't our science field of today developed a way to induce everyone to have this "better" blood type?

3/27/2000 How does our body know how to put out all of these different things for different problems?