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ABSTRACT

This study examines how the Biology 101 curriculum at The Ohio State University, a non-major's course, was changing with regard to recommendations expressed in the National Science Education Standards (NSES) and Benchmarks for Science Literacy. The Bio 101 course was observed to compare the content topics identified in the syllabus with topics recommended in the NSES and Benchmarks to determine the extent to which the course was similar to and different from content recommended for grades 9-12. An interview was conducted with the professor to further understand why these changes were being made within the program he directed. This paper concludes that there was significant improvement in the Bio 101 curriculum compared to the past one on teaching pedagogy, assessment style, and how standards are influencing teaching in this course. The appendix includes a Biology 101 syllabus for Autumn 2001. (KHR)

The Changing Face of Biology 101

with Regard to the Nation's Science Standards

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The Changing Face of Biology 101 with Regard to the Nation's Science Standards

Introduction

To a great extent, the quality of life today has been shaped by advances in scientific knowledge that form the foundation for the increasingly technological world in which we all live. In the next century, global competition among nations will continue to expand as scientific knowledge increases. It is unlikely that the current rate of progress in science and technology can occur without increased achievement in science education by all students. This argument was put forward in Science for All Americans (1990) as: "the life-enhancing potential of science and technology cannot be realized unless the public in general comes to understand science, mathematics, and technology and to acquire scientific habits of mind. Without a science-literate population, the outlook for a better world is not promising"(p.xiv-xv). The Glenn Report (Before It's Too Late, 2000) reiterates this notion and then goes on to describe why scientifically literate citizens are such a sensitive issue among educators: "From mathematics and the sciences will come the products, services, standards of living, and economic and the military security that will sustain us at home and around the world. From them will come the technological creativity American companies need to compete effectively in the global market place" (p.4).

Moreover, the expectation that scientifically literate people in the 21st. Century need to transfer their scientific thinking into their daily lives rather than to only have knowledge of scientific advances is widespread. Thus, today, the content of a curriculum in science content courses should include the acquisition of scientific thinking skills in addition to knowledge about specific science content. Since introductory science courses offer the last formal opportunity for the next generation of college educated citizens to attain this goal, the role of these courses in a students' curriculum have increasingly become the focus for producing scientifically literate members of our society.

Concerns about what should be done to improve the quality of science education among academics and policy makers began almost two decades ago. Reform documents such as Science for all Americans (AAAS, 1989), the Benchmarks for Science Literacy (AAAS, 1993), the National Science Education Standards (NRC, 1996), and the Atlas of Science Literacy (AAAS & NSTA, 2001) all point to the need to address what and how science is taught K-12. Collectively, these documents establish criteria for what all students should know and be able to do as a result of their K-12 science education. Furthermore, these documents contain recommended guidelines for integrated curricula and pedagogical practices. Although similar standards for college science teaching and learning became available after we began to work on the project reported here (Siebert & McIntosh, 2001), the existing standards for K-12 level should, to some extent, inform, influence and direct changes in what and how science is taught in college. Articulation between the end of high school and matriculation into post-secondary education is especially critical because freshmen students today are coming to college with science learning experiences that have been influenced by K-12 teachers who are, in some cases, meeting the current standards for change in science curriculum.

In this regard, the purpose of our study is to examine how the Biology 101 curriculum at The Ohio State University, a non-major's course, was changing with respect to recommendations expressed in the National Science Education Standards (NSES) and Benchmarks for Science Literacy. The curriculum for the Bio 101 course we observed was quite different from the curriculum offered at the beginning of 1990's (see Appendix A) and was changed in light of the reform documents mentioned above. The previous curriculum was organized around traditional content topics with no mention of the process skills that are so common in contemporary reform documents or of the pedagogy by which students would be taught. Both of these are explicitly addressed in the current version of Bio 101. Our analysis of the current course follows a few descriptive comments regarding the course immediately below.

Course Structure

Non-majors Biology 101 was first taught in the autumn of 1990 at The Ohio State University as one course in the Introductory Biology Program (IBP). The IBP is responsible for teaching all introductory Biology courses for majors and non-majors through the College of Biological Sciences. Virtually every student enrolled at Ohio State will take at least one IBP course before graduation. However, since the IBP is not a department per se, faculty from various departments within the College of Biological Sciences and their graduate teaching assistants assume the teaching of non-majors Bio 101 as a college responsibility. In the past, this has lead to inconsistencies in the content of the course depending on the interests of an individual instructor assigned to Bio 101 that term. Bio 101 is a laboratory-based course with multiple sections, as many as 35 sections including 25 students/section. The weekly format for the course includes three hours spent in lecture delivered by a professor and three hours spent as a combination of recitation and laboratory experience under the direction of a graduate student.

Student demographic Information

Bio 101 has the largest enrollment of any course at The Ohio State University. The number of students enrolled in Bio 101 for Autumn 2001 was roughly 1400. Similar enrollments occur in the Winter and Spring Quarters as well. Across the four quarters in each academic year at The Ohio State University, more than 4000 students take Bio 101 to meet their science content General Education Course requirements for a variety of majors. Bio 101 is likely to be the last opportunity to acquaint non-science majors with scientific knowledge and process skills before they leave their undergraduate education.

The majority of students enrolled in Bio 101 are female with academic majors from all departments and programs throughout the university. The distribution of students with regard to their majors in Autumn 2001 was: 31% Business, 14% Social & Behavioral Sciences, 8% Education, 8% Human Ecology, 7% Journalism/Communication, 5 % Art, 3% Social Work, 2% Engineering, 1% Math & Physical Sciences, 1% Music, and 20% Others. Education as used here refers to those students pursuing degrees leading to preschool or lower elementary school teaching – not students who would teach secondary science exclusively.

Methods

To determine the extent to which the Bio 101 curriculum was aligned with the NSES and Benchmarks for Science Literacy, we randomly chose a syllabus from one of the four instructors teaching this course in Autumn 2001 (see Appendix B). In addition, lecture notes made available to students by the same instructor were obtained from a commercial source. We compared the content topics identified in the syllabus for this instructor with topics recommended in the NSES and Benchmarks to determine the extent to which the Bio 101 courses was similar to and different from content recommended for grades 9-12.

It is well- known that NSES as well as other reform documents emphasize teaching and assessment methods that are alternative to traditional didactic approaches. To identify pedagogical practices advocated for Bio 101 students in terms of teaching and assessment we interviewed Dr. Steve Rissing, Director of the IBP. Dr. Rissing was a major influence on changes that have and are occurring for all IBP courses and he is responsible for choosing instructors from the College of Biological Sciences to teach the curriculum he was attempting to establish for this course. Quotes from our interview with Dr. Rissing are presented below as a means of establishing the pedagogy through which Bio 101 was to be presented to students regardless of the instructor. The interview protocol is included in Appendix C.

Benchmarks for Science Literacy (http://www.project2061.org/tools/benchol/bolframe.htm)

A benchmark "specifies how students should progress toward science literacy, recommending what they should know and be able to do by the time they reach certain grade levels."(p.xi) Furthermore, "it describes levels of understanding and ability that ***all*** students are expected to reach on the way to becoming science-literate." (p.xiii) In point of fact, Benchmarks are not the curriculum per se but they guide the design of curriculum. The Benchmarks document consists of twelve chapters that elaborate on individual benchmarks but "chapter order is unrelated to the relative importance of the benchmarks." (p.xiii)

National Science Education Standards (http://books.nap.edu/html/nses/html/index.html)

"National Science Education Standards provide criteria to judge progress toward a national vision of learning and teaching science in a system that promotes *excellence*."(p.12) NSES provides a framework not only regarding the quality of what students should know and are able to do, but also the criteria by which whole systems such as science programs, science teaching; assessment practices and policies could be evaluated. NSES contains eight chapters, only one of that deals with content. The other chapters are related to functions of the education system.

Atlas of Science Literacy (http://www.project2061.org/tools/atlas/default.htm)

The Atlas of Science literacy is kind of map for educators to follow as they try to integrate knowledge from several disciplines for students. This reference contains 49 strand-maps, each of which focuses on topics that are crucial for literacy in math, science and/or technology. Each map illustrates how K–12 learning objectives for a specific topic are connected to each other and how knowledge in each grade band is fundamental to building coherent knowledge of science and scientific processes across the grade bands. The syllabus and lecture notes for Bio 101 were evaluated in the light of these three documents -NSES, Benchmarks for Science Literacy and Atlas of Science Literacy and are shown below in Table 1 and Table 2.

Table 1: National Science Education Standards and Bio 101 topics

BIO 101 TOPICS / NSES STANDARDS	Liv. Thi.& Nat. Sci.	Biodiversity	Life on Earth	Evolution I	Evolution II	Cell Cycle I	Cell Cycle II	Inheritance	Mol. Basis of Heredity	Gene Exp.& Re.	Biotechnology	Cell Str. & function	Membrane	Flow of Energy I	Flow of Energy II
The Cell						4				3		1, 4, 5	1, 4	2	5
Molecular Basis of Heredity							2	2	1, 3	1					
Biological Evolution		4, 5	2	3, 4											
The interdependence of organisms					3										4
Matter, Energy, and Organization in Living System														1, 3, 6	2

Relevant topics from Science Content Standard C- for grades 9-12.

Table 2: Benchmarks for Science Literacy and Bio 101 Topics

BIO 101 TOPICS / BENCHMARKS	Liv. Thi.& Nat. Sci.	Biodiversity	Life on Earth	Evolution I	Evolution II	Cell Cycle I	Cell Cycle II	Inheritance	Mol. Basis of Heredity	Gene Exp.& Re.	Biotechnology	Cell Str. & function	Membrane	Flow of Energy I	Flow of Energy II
The Nature of Science	**1A/3** **1B/2** **1B/4**														
The physical Setting			**4A/2** **4B/1**												
The Living Environment		5A/1 **5A/2**	**5F/1** 5F/8 5F/9		5F/3 5F/4 5F/6 5F/7	**5B/3** **5C/4**	**5B/2** **5B/3** **5C/4**		**5B/4** **5B/5** **5F/5**	**5C/3** **5C/4**		**5C/1** **5C/2**	**5C/2**	**5E/3**	**5E/2** **5E/3**
The Human Organism											6B/4 **6E/2** **6E/3**				
Historical Perspectives				10H/1 10H/2 10H/3 10H/4	10H/3 10H/4			10H/5							

Statement numbers indicated in bold in Table 2 are also included in the Atlas of Science Literacy

Analysis of Bio 101 documents

The content for Bio 101 was compared topic-by-topic to Science Content Standard C from the NSES (e.g., the cell, molecular basis of heredity, biological evolution, interdependence of organisms, matter, energy and organization in living systems, and behavior of organisms). In producing the tables above statements in the course syllabus or class notes that related to each of these topics were taken as evidence that a topic was covered in the course although the total number of statements related to a topic is not indicated. This is to say that our analysis of the syllabus and class notes does not indicate the depth to which each topic was covered. With this in mind, Bio 101 does covers the breadth of topics that are NSES believes are necessary for students to be scientifically literate.

One of the pedagogical approaches Dr. Rissing favored for addressing these topics was reading and critiquing articles from daily newspapers. We interpreted this as an explicit attempt to link the content of each topic to the daily lives of these non-major students. However, the large numbers of topics covered in the Bio 101 still left the impression that this was a survey of many topics rather that in-depth study of a few.

The Benchmarks for Science Literacy are divided into 12 chapters related to the content of science and the integration of science with related subjects. For this reason topics in Benchmark's version of Life Science are sometimes included in more than one chapter. For example, the Bio 101 topic "Biodiversity" is relevant to both "The Living Environment" and "Historical Perspectives" regarding the organization in Benchmarks for science literacy. Therefore, topics common to Benchmarks and the Bio 101 course may be tallied more than once in Table 2.

Two topics on the Bio 101 syllabus, "Living Things and Nature of Science" and "Evolution II", correspond to none of the NSES standards. Based upon class notes, although Living Things and Nature of Science were taught in the same class period, the main objective for this lesson was to acquire knowledge of scientific inquiry and general knowledge about living things. Since this topic is one of the most fundamental concepts in biology, it is actually taught throughout the years from K-8 grade levels, therefore, we thought that this might be one of the reasons why this topic was covered superficially in Bio 101. Biotechnology, on the other hand, is of great interest in most field of biology and is college level subject matter rather than K-12 level. Moreover, it requires advanced knowledge and specialized equipment to present the content of biotechnology in high school classes. Therefore, this could be the reason why no standard statement matched with the content of the biotechnology topic in NSES.

Even though Life on Earth was studied in detail in Bio 101 it matched with one Content Standard C of the NSES - Biological Evolution. Similarly to the situation with Benchmarks, this topic is expressed in more than one standard - Content Standard D -Earth and Space Science (9-12) under the subtopics of Origin and Evolution of the Earth System and also Origin and Evolution of the Universe.

The subject matter of cell cycle consisted of mitosis and meiosis, which were included as Cell Cycle I and Cell Cycle II in the Bio 101 syllabus respectively. These are merely two subtopics covered under the broader topic The Cell. Therefore, they match with only three Benchmarks statements (5B/2, 5B/3, 5C/4) in "Heredity" and "Cells" sections in Chapter 5 "The Living Environment".

The topic of inheritance was one of the main focus areas in biology and it is very broad topic that includes Mendelian genetics, chromosomes, and genes. However, it was limited to Mendelian genetics in the Bio 101 curriculum, which is just introduction to inheritance. Thus, this subject matter covers just a few NSES and Benchmarks standards.

Flow of Energy (I, II) deals with glycolysis, cellular respiration, and photosynthesis respectively. In the NSES there is a section under Content Standard C namely "Matter, Energy, and Organization" in living systems. However, since process related to energy take place in the cell as well, the cell section also includes some statements about energy.

Comments on changes to of curriculum

Our analysis now shifts to excerpts from Dr. Rissing's comments on changes to the Bio 101 curriculum, his preferred teaching pedagogy for instructors teaching the course, and assessment practices related to the new curriculum to get an insight about why these changes were being made for Bio 101.

Dr. Rissing: "Committees are not the best way to change a curriculum. I believe that university professors are very strong in academic freedom. I do not intend to have anybody tell me I must teach my class in a certain way. There is obviously a limit to do that, so, the whole concept of academic freedom does rest on an assumption of fairly normal behavior."

Druger (1999) expressed the same idea that "college science teaching seems to be a highly individualistic endeavor."(p.154). Instructors have their own styles and beliefs about student learning to guide their teaching. In this respect, the existing National Science Education Standards and Benchmarks are typically seem as restrictive on academic freedom by higher education faculty when in reality, they should be seen as beneficial to college instructors who are interested in improving or changing their curricula to be consistent with their students' prior experiences.

Comments on how much NSES influence on Bio 101 curriculum

Dr. Rissing: "I began to worry about what is going to happen [to introductory university science courses] when K-12 teachers do what they do and we get students coming out of high school and into Biology with those [NSES and Benchmark] standards behind them. The whole point of the NSES was to get individual states to institute their own science standards, and the kind of unwritten expectation was that you need to spend time to develop your own. I like to think of the day when people will come to the university having done everything within the science education standards. Our survey of IBP students indicates that we are long way away from having that happens. Students do not come in with that kind of background yet."

As Fox (1998) reported, "many postsecondary faculty and academic departments across the United States have recognized the need to change their courses and programs and are taking seriously the challenge to do so." Druger has argued that it is necessary to design national standards for college science teaching, especially for introductory courses. He believes that "developing national standards does not, by itself, raise the level of achievement," and that "raising the bar does not necessarily make the student jump higher."(p.154). Even though NSES is structured with high expectations in terms of raising achievement there are still great concerns about the ability of students to be successful in science. The Glenn Report's (2000) recommendation is consistent with this assertion that "in an age driven by relentless necessity of scientific and technological advance, the current preparation that students receive in mathematics and science is, in a word, unacceptable." (p. 7) Even if there is some contradiction between intentions and real results about achieving the best in science with national standards, but it should be taken into consideration that no such a long period passed after releasing of standards. More time is needed for this kind of projects to make judgment about its significant impacts on science education.

Comments on Teaching Pedagogy

Dr. Rissing: "I think that the NSES have had a greater impact on my own thinking and I have tried to bring them into Bio 101. It is the overarching emphasis on what we are trying to accomplish in the science classes. All those pages in NSES that say, we should replace the emphasis on memorization with an emphasis on thinking skills, we should replace lectures with lab exercises. What is good enough for K-12 education is probably pretty good for college education, especially for non-majors. I am trying to encourage my colleagues in the College of Biological Sciences to embrace the spirit that is in NSES. What do our students need to know and does our current curriculum meet those standards?"

" In my opinion, NSES had a tremendous impact on what we are doing. I do think we have to model how to think, how to teach, how to learn. One other thing that NSES says is that we should show people the process of learning and thinking, how to learn. I asked myself constantly 'how am I doing that?'. Our labs in Bio 101 include student discovery, they are guided, student-designed experiments. I had already been using for some time my own form of a learning cycle and I certainly try to do more of that now. Things are introduced in the lab and than we talk about them in the lecture. I made explicit reference to why I am doing that at the end of the each learning cycle in my teaching – "Look! That was a learning cycle you just did as students!" In the current Bio 101 curriculum topics are introduced in the lab and than we talk about them in the lecture. I made explicit reference to this pedagogy - why I am doing that at the end of the each learning cycle. For example, last week in the lab you worked with dialysis tubing, watching them swell up and shrink down depending upon what your group elected to put on inside of them and outside of them. Then we have talked about how the nephron in the kidney works. I have tried to draw attention to the similarity between reactions of the dialysis tubing in the lab done last week and reactions of the nephron. What we saw in the lab was applied to what we discussed in lecture. So, if the students has done this right as they study it, they recognize that you are comfortable with what was going on in lab last week and you can apply that information from last week into the new problem that we developed this week. That ability to take information out of one context to apply it to a new context is the definition of learning."

Similarly, Spillane & Callahan (2000) pointed out that people should be able to apply science knowledge to their life rather than memorize the content of science. Lord (1994) supports this position in the following: "the present way we teach undergraduate science at colleges and universities almost everywhere simply does not stimulate active learning," Although traditional teaching methods are still widely used, this does not mean that no effort is spending to improve the teaching and learning of science in colleges.

Comments on assessment

Dr Rissing: "To be more honest we have difficulty to start to establish some new assessment techniques. Way before the NSES came out; I was already sensitive to that issue. Way before the standards came out, I was already de-emphasizing memorization and recall. I was just more emboldened to do the same once the Standards came out. The other thing that I think is more crucial very difficult and very scary is the non-grade assessment. You are accomplishing what you want with your students. I have been working and trying to press those kinds of assessments for at least 10 years."

"I don't think I do it particularly well yet. We are getting better and getting Michael's help and assistance in this area. I like to think that a lot of changes that we have been working on were already well in place before NSES came out and all we did was make it easier for us to pull it off. They came out in the same time that everybody else was issuing their report, for example AAAS had a national project 2061, the National Science Foundation Report Shaping the Future came out in 1996. It was just one of the bunch of things moving. The most basic one is the Glenn's Commission Report and in some ways it is the least provocative in terms of telling you what you ought to be doing and thinking about other than wherever we came up with we ought to be surely continue in the future. That scares me a little bit. So, that particular NSES you know cause me and a lot of my colleagues to go: "Well, I have never thought about that before?" It was part of the movement that was going strongly at the time and had many of us both contributing to that movement as well as already learning from them. But certainly many of us were concerned about these things."

A fundamental philosophy under girding the NSES is the understanding of concepts in science rather than memorization of facts. As Kahle, Meece & Scantlebury (2001) summarized, "NSES recommended that assessments be embedded in instruction and that students be provided with multiple ways to demonstrate content understanding and process skills, such as portfolios, exhibitions, and performance tasks."(p.1020) In that case, it is inevitable that assessment and instruction should be in the same context to make the understanding meaningful, because the purpose of the teaching and learning as implied in national science education standards is to acquire higher-order thinking skills to the students to have them perceive concepts in a broad spectrum rather than give meaningless discrete knowledge. In this case, it seems that as part of the ongoing change in Bio 101 course with regard to national standards at the Ohio State University have some impact on assessment strategies also, which is an anticipated improvement in this framework.

Conclusion

The purpose of the present study was to describe changes to the Bio 101 curriculum at The Ohio State University in light of the NSES and Benchmarks. The NSES and Benchmarks were used as a reference in the topic-by-topic analysis of the Bio 101 course syllabus and class notes. In addition, an interview was conducted with Dr. Steve Rissing to further understand why these changes were being made within the IBP program he directs. Our analysis concluded that there is significant improvement in the Bio 101 curriculum compared to the past. Dr. Rissing's comments on teaching pedagogy, assessment style and how standards are influencing his teaching in this course also indicated that he is knowledgeable about and responding to NSES recommendations for effective teaching and learning of science. In this respect, changes to the Bio 101 course should have impacts on students to enhance their scientific literacy.

There are some limitations in the present study. First, the data were restricted to documents and instructor comments about changes in Bio 101. In the future, observations of the enacted curriculum could be used to identify how students perceived planned instruction. It would also be fruitful to extend the study to other universities in the USA and to compare the differences and similarities in changes in introductory biology courses in terms of curriculum, teaching pedagogy, and assessment practices.

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APPENDIX A

BIOLOGY 101
WINTER 1999

WEEK	DATE	LECTURE	LECTURE TITLE	LABORATORY	QUIZ
1	1-4 1-6 1-8	1 2 3	What you're in for: Biology 101 Life: Survey of living things Exploring the world of the cell: The cell	No laboratory	None
2	1-11 1-13 1-15	4 5 6	The makings of life: Carbohydrates The makings of life: Lipids & Protein The dance of life: Mitosis	Five kingdoms	None
3	1-18 1-20 1-22	 7 8	HOLIDAY - Martin Luther King Jr. Day The central dogma: DNA, RNA protein The language of life: DNA & protein syn.	The cell and mitosis	Quiz 1 Lecture 4,5 & 6
4	1-25 1-27 1-29	9 10 11	Here, there, everywhere: Energy Green magic I: Photosynthesis & light Green magic II: Photosynthesis & CO_2	Protein synthesis	Quiz 2 Lecture 7 & 8
5	2-1 2-3 2-5	12 13	The breath of life: Respiration The cell: Review for midterm MIDTERM EXAMINATION	Invertebrate animals	Quiz 3 Lecture 9,10&11
6	2-8 2-10 2-12	14 15 16	The monks peas: Mendelian genetics All together now: Linked genes & Meiosis Modern alchemy: Modern genetics	Mendelian genetics	None
7	2-15 2-17 2-19	17 18 19	You and your genes: Human genetics Onward & upward: Evolution Darwin & Mendel: Population genetics	Animal behavior	Quiz 4 Lecture 14,15&16
8	2-22 2-24 2-26	20 21 22	Bigger & better: Micro & macro evolution The big apple: Ecology Around & around it goes: Energy & minerals	Plant form and function	Quiz 5 Lecture 17,18&19
9	3-1 3-3 3-5	23 24 25	The wee ones: Viruses & bacteria The good, the bad, the deadly: Protista & fungi Up, up & away: Plants	Ecology	Quiz 6 Lecture 20,21&22
10	3-8 3-10 3-12	26 27 28	Lords of them all: Animals I Lords of them all: Animals II Review for final	Lab exam	
	3-17		FINAL EXAMINATION Wednesday 3-17-98 3:30pm - 5:18pm		

APPENDIX B
Biology 101 Syllabus
Autumn 2001

LECTURE SCHEDULE AND ASSIGNMENTS

(note: schedule subject to change)

Date		Topic	Chapter(s)	Lab
Wed	Sept. 19	Introduction-Living Things	1	None
Mon	Sept 24	The Nature of Science	1	Biodiversity
Wed	Sept 26	Video: Prisoners of Silence		
Mon	Oct 1	Biodiversity	16	Natural Selection
Wed	Oct 3	Life on Earth	15	
Mon	Oct 8	Evolution I	13	Body Plans
Wed	Oct 10	Evolution II	14	
Mon	**Oct 15**	**Midterm 1**		Cell Growth
Wed	Oct 17	Cell Cycle I	10	
Mon	Oct 22	Cell Cycle II	10	DNA Structure and Replication
Wed	Oct 24	Inheritance	11	
Mon	Oct 29	Molecular Basis of Inheritance	8	DNA to Protein
Wed	Oct 31	Gene Expression and Regulation	9	
Mon	Nov. 5	Biotechnology	12	Membrane Dynamics
Wed	Nov 7	Video- Cracking the Code of Life		
Mon	Nov 12	Holiday		Energy
Wed	**Nov 14**	**Midterm 2**		
Mon	Nov 19	Cell Structure and Function	5	none
Wed	Nov 21	Membranes	4	
Mon	Nov 26	Flow of Energy I	3&7	Insect Navigation
Wed	Nov 28	Flow of Energy II	6	
Mon	**Dec 3**	**Final Exam 3:30 - 5:18**		

APPENDIX C
Interview Protocol

1) How many students do you have in Bio101 course?

2) What do you think about new freshmen's knowledge in basic biology concept? Do they enough basic knowledge when they started to the course?

3) Have you realized any differences among students who come from different states?

4) How do you select the content of 101, how do you order the topics in syllabus, what is your reference while you are choosing the textbooks?

5) Is the content of Bio101 more advanced compare to K-12 level? Or Is it just a repetition of high school biology content?

6) What do you think about NSES (National Science Education Standards)?

7) After application of NSES in K-12 level, did you realize any improvement in freshmen's biology knowledge?

8) Have you changed your course and lab content after releasing of NSES?

9) When you are planning your course and lab, do you consider NSES?

10) After releasing NSES, are there any changes in your teaching, assessment strategies in Bio101?

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