Using a "Primer Unit" in an Introductory Biology Course: "A Soft Landing"

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Abstract: This study aimed to facilitate students' entrance to an introductory cell biology course for biology majors. The most prominent difficulty in this introductory course, is students' poor background-knowledge, such as a lack of understanding of very basic concepts and terms, and the huge differences in students' background knowledge. In order to bring all the students to a common and adequate level of comprehension and familiarity of basic terms, thus giving a fair chance to all attending the introductory cell biology course, the chief instructor decided to build a "primer unit". The unit provided an overview of the subject matter of the course, and it was placed on the course website before the beginning of the course. The findings show that students who consulted the primer unit came to the course better prepared. The primer helped to reduce the gap between students who studied advanced biology in high school and those who did not. Even though the differences between students who went over the primer and those who did not was not sustained after formal learning, students reported that due to the primer they started the course less intimidated and with a better idea about what to expect.

Keywords: Higher education, introductory course, cell biology, primer unit

Introduction

This paper is part of a longitudinal study which aimed to improve the instruction in introductory biology courses. Our choice to focus on the introductory cell biology course was due to two main reasons. One was students' statements, such as: "This course [introductory cell biology] sometimes feels like a shower of new concepts threatening to drown me out." The other was the course instructor's view that a major cause for students' difficulties in the course was a lack of background knowledge in science and in biology in particular.

Our university offers some programs that are designed to help students enrich their background knowledge prior to undergraduate biology studies. For example, it is highly recommended for candidates who have not completed high-level mathematics and chemistry to attend preparatory courses. However, no such preparatory courses exist for biology related topics, despite the fact that the students' backgrounds differ greatly, especially due to the fact that about 40% of the freshmen have not studied advanced biology in high school (Marbach-Ad, 2004).

We believe that the students' experience in the first year of their studies is a very important element in their decision to stay in or leave their field of study. Tobias (1990) claimed that introductory science courses are responsible for driving away many students who began majoring in science programs. In the mid- to late 1980s, concerns about the number of freshmen entering and remaining in math and science-based majors surfaced. Not only was there a striking decline in entering-freshmen interested in science and in math (Green, 1989), but the number of students who subsequently moved out of science, math, and engineering majors by their senior year was substantial and ranged from 20% in math and physical sciences to 40% and 50% in the life sciences and engineering (Astin, 1993; Astin & Astin, 1993). Moreover, the losses were from a pool of highly capable students (Green, 1989; White, 1992).

One of the major reasons that Seymour (1995) indicates for drop-out relate to the course curriculum, especially the amount of material that students have to learn in a short time. Such complaints were mainly raised regarding the introductory courses. Belzer, et al. (2003), discussing students' difficulties in introductory courses, refer to the poor background knowledge and lack of learning

and reasoning skills that students bring to college along with their insufficient preparation for classes.

Views regarding the importance of prior knowledge have been present for several years in the science education literature, largely in terms of Ausubel's (Ausubel, et al., 1978) assimilation theory of meaningful reception learning. These authors implied that meaningful learning depends on the ability of the teacher to instruct the subject matter at hand in a well-organized way that connects the new knowledge with the learner's cognitive structure (Ausubel, 1968). Novak (1977, 1990) believed that learners acquire a hierarchically organized framework of specific concepts, each of which permits them to make sense out of new experiences. If these prior concepts are lacking, no new concepts can be acquired.

Cose

The introductory cell biology course is one of the corner stones for life sciences majors in their first year of their undergraduate studies. This course exposes students to many new concepts and ideas in molecular biology. In order to reduce the gap between students' background knowledge and give a fair chance to all the students in the introductory cell biology course, the chief instructor decided to build a "primer unit" and placed it on the course website before the beginning of the Spring 2003 course. The primer was available to students starting at the end of the Fall 2002 semester. Thus students could review the primer during the vacation between semesters. The primer was a Power-Point presentation which contained text and pictures, mostly taken from the course textbooks. It provided an overview of the subject matter that was presented in the first six lectures of the course, which emphasized major concepts and ideas. Students, who did not study biology in high school or those who did but felt weak in this subject, could go over the material before the beginning of the semester.

During the present study, students answered three questionnaires. The first questionnaire was handed out before exposure to the primer unit and examined students' background knowledge in the subject. The second questionnaire was intended to yield a profile of the students who chose to use the primer and to examine the impact of the primer on students' achievement at the beginning of the semester. The third questionnaire was handed out to the students after the first six class sessions and examined the impact of the primer after the subject-matter was taught in class. We focused our study on the following three research questions:

1. What was the profile of students who used the primer unit?
2. What was the impact of using a primer unit on students' preparedness for the course and on students' conceptual understanding after the material was taught in class?
3. What was the students' attitude towards the use of the primer unit?

Method

Course Description

The introductory cell biology course for freshmen is a four-credit, one-semester class (28 lectures - two hours, twice a week). Three instructors from the department of cell research and immunology teach the course in rotation, each of them specializing in specific topics. The instructors cooperate and build the curriculum as a successive unit. The course rationale is to teach the central cellular processes from both a functional and a structural viewpoint, emphasizing basic cellular ***mechanisms***, while paying relatively less attention to cell ***morphology***. The first six lectures serve as an introduction chapter to the course and provide a systemic overview of the macromolecules (carbohydrates, phospholipids, nucleic acids, and proteins) that build the cell and are involved in the life cycle processes. The instructor emphasizes similarities in macromolecular structures by presenting each one of them as a complex compound or polymer chain consisting of monomer building blocks.

This study was conducted in the Spring of 2003. Four hundred and fifty students, majoring in biology, were enrolled in this class. Prior to the course, in the one-month vacation between the Fall and the Spring semesters, the chief instructor of the course placed the primer unit on the course web site. The instructor encouraged students to review the primer unit at their own time and pace. The primer included 32 Power-Point color slides and represented the main issues of the first six lectures of the course. The main primer topics were the macromolecules of the cell (sugars, proteins, lipids and nucleic acids), their compounds, and their functions in the cell.

Research Instruments and Sample

Written questionnaires were handed out to the students during the following occasions:

1. The first questionnaire was handed out in the last week of the Fall 2002 semester (see Appendix A). This questionnaire examined the student's background knowledge in cell biology prior to the cell biology course. One hundred and sixty eight students completed the questionnaire. From this questionnaire, we collected student characteristics, such as: gender, age, advanced courses taken in high school, and psychometric scores. In addition, students

were asked to answer seven open-ended questions including "What are the main functions of nucleotides?", "What is a monomer?" and "What is a polymer?" There were also five multiple-choice questions (e.g., "Phospholipids are made of: a. sugar units; b. lipids; c. proteins") and one fill-in the blank question.

2. The second questionnaire was distributed during the first week of the course. This time, 261 students responded. The questionnaire included content questions similar to those in the first questionnaire, as well as questions about the primer (e.g., "Was the primer clear?" "Do you think it would be a good idea to use this type of a primer in other courses?")

3. The third questionnaire was administered in the sixth class session (the third week of the course). This questionnaire included the same content questions as the second questionnaire, as well as two questions about the primer. One hundred and seven students completed and returned the third questionnaire.

Data Analysis

To evaluate students' responses, we referred to the scientific literature (Nelson & Cox, 2000; Suzuki, et al., 1999). An example of a response that was considered a complete answer to the question, "What do nucleotides consists of?" was "A nucleotide consists of a nitrogenous base, a five-carbon sugar, and one or more phosphate group(s)." We ranked each response (An example for the open-ended questions' evaluation coding, see Appendix B) and then created a score (between 0 and 100) for each student.

In order to validate the grading scheme, each of the authors (two science educators and the instructor) built his/her own grading scheme. In addition, a sample from the students' questionnaires was given to a researcher in science education, who was not connected to this study, and to a high school biology teacher. Each independently graded the questionnaires they received according to the approved grading scheme, and their grades were found to be similar to those given by the authors. For each questionnaire, we calculated a total score, and this enabled us to examine correlations between students' scores on each occasion and compare differences in achievement among subgroups (i.e., students who used the primer and students who did not, or students who studied high school advanced biology and those who did not). The attitude questions about the primer were analyzed qualitatively by building categories of similar responses. In order to analyze the questionnaires and compare among subgroups, we used an independent *t*-test. To examine the similarity of demographic characteristics between these groups we used chi-square tests.

Results

About 45% of the students who completed the questionnaires (147 out of 317) indicated that they consulted the primer. Table 1 shows that the demographic distribution in the group of students who used the primer (female – 69%; advanced biology – 60% and the average score on a psychometric exam - 676.3) was similar to the demographic distribution of the students that answered to the questionnaires (female-67%; students who took advanced biology at high school-55%, psychometric exam mean scores-679.3). Chi square analysis showed that there were no significant differences between these groups.

Students' profile	Students who consulted the primer N=147	Students who answered the questionnaire N=317
Age		
18-20	10%	11%
21-25	84%	81%
26-32	6%	8%
Gender		
female	69%	67%
male	31%	33%
Advanced biology in high school	60%	55%
Advanced chemistry in high school	54%	48%
Advanced physics in high school	28%	23%
Advanced math in high school	94.6%	92%
Average psychometric test scores	676.3	679.3

Table 1. Profile of students who consulted the primer in comparison with their proportion in class

Students' explanations for not using the primer were mainly procedural, including "I did not see the note about the primer on the web site", "The Power Point file was too heavy to print at home." Other explanations were mainly of the type: "The vacation between semesters is already overloaded with tests and assignments; therefore, I didn't have time to look at the primer." "I don't think that it's important to go over the primer, since we will go over these topics in the beginning of the course."

Questionnaire	Did not use the primer	Used the primer	Sig.
First (N=168)	**17.4**±0.17	**18.8**±0.16	NS
Second (N=261)	**26.6**±0.23	**35.7**±0.23	p < .001
Third (N=107)	**69.0**±0.17	**75.2**±0.24	NS

Table 2. Students' mean scores* in the content questionnaires (*means score are calculated out of 100)

Table 2 summarizes the findings concerning students' mean scores on the content questions in the three questionnaires. The first questionnaire reflects the background knowledge of the students in cell biology prior to the course. The mean scores in this questionnaire, both of students who ultimately used the primer (primer 18.8) and of those who did not (no primer 17.4), were very low and with no significant difference, which suggests that these two groups were comparable in background knowledge.

In the second questionnaire, both groups gained higher scores. This could be a result of having to complete the general test twice or the fact that they had studied for the other exams, of the first semester (e.g., introductory course in evolution) where some

of the subject matter may have been relevant. However, the fact remains that the mean score of the group that used the primer (35.7) was significantly higher than the mean score of the group that did not use the primer (26.6). These results suggest that the primer helped the students who used it to embark on the course with better background knowledge than students who did not use it. In the third questionnaire, handed out after six class sessions, students from both groups achieved markedly better scores, yet those using the primer did better than those who did not (75.2 as compared to 69.0); this difference was not statistically significant.

Questionnaire	Did not study advanced biology	Studied advanced biology	Sig.
First (N=168)	**15.3**±0.17	**19.5**±0.15	$p < .05$
Second (N=261)	**30.7**±0.21	**35.5**±0.23	NS
Third (N=107)	**70.6**±0.15	**74.7**±0.18	NS

Table 3 Students' mean scores* in the content questionnaires: comparison between students who study advanced biology in high school and those who did not (*mean scores are calculated out of 100)

Interesting results emerged when we compared the achievements of students who studied advanced biology in high-school and students who did not (Table 3). In the first questionnaire, as was expected, students who studied advanced biology scored better (19.5) than students who did not (15.3); however, in the second questionnaire these differences disappeared. This might suggest that students who did not study advanced biology in high school might have enriched their background knowledge by using the primer.

Although differences in scores were sometimes marginal, the students' attitude toward the primer was very positive, which was indicated by the fact that more than 85% of those who used the primer thought it would be useful in other courses. Some of the statements were: "The primer helped me to prepare for the course, it reduced my anxieties about the course;" "When I came to the first class I was less intimidated since I new what to expect from the course;" and "I don't have a strong background in biology, and the primer helped me to catch up with other students before the hectic period of the semester." Some of the criticism about the primer was the issue that it was in English (while the vast majority of the students' mother-tongue was Hebrew). It is noteworthy that the instructor of the course intentionally used English as the language of the primer, since this is the language of the main text. The primer was intended to introduce the students to the need to cope with English as well as to deal with the specific subject matter.

Discussion and Conclusions

This study describes an attempt to reduce the burden of new concepts at the beginning of an introductory course, without compromising the high standards and wide curriculum coverage of the course. For this, a primer unit was provided to the students prior the beginning of the course.

The findings show that students who used the primer came to the course better prepared. In addition, it seems that the primer helped to reduce the gap between students who studied advanced biology in high school and those who did not. Interestingly, the differences between students who used the primer and those who did not were not sustained after the formal learning of the subject. These results are similar to the findings of Papp, et al. (1987), who reported that in a cell biology course, in the Virginia School of Medicine, prior knowledge did not predict the final exam scores. They explained that since many factors influence the students in the course of their studies, background knowledge becomes less significant towards the end of the course. Nevertheless, we did find that the primer helped students to come to the course better prepared at a relatively low expenditure of effort. Students who referred to the primer reported they came to the course less intimidated and with a better idea about what was expected of them.

Although the primer alone did not measure real academic improvement for long term achievement, we believe that the greatest impact was to provide a psychological advantage for the students. We armed the student with a greater sense of confidence and a feeling that the teachers care and have attempted to

ensure a "soft landing".

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Appendix A: The first questionnaire

Name: **I.D.:**

Advanced learning at high school: Biology ___ Chemistry ___ Physics ___ Math ___

Age: ____ Gender: _____

Answer the following questions:

1. Explain what is a monomer and what is a polymer:

_____

_____

2. Fill in the table:

Polymer	Monomer
DNA	
	Amino acid
RNA	
	Glucose

3. What is a carboxyl group?

_____
_____

4. Which molecule contains carboxyl group?

a. sugar

b. nitrogen base

c. fatty acid

d. I don't know

5. Phospholipids contain:

a. sugars

b. lipids

c. proteins

d. I don't know

6. A peptide bond occurs commonly between:

a. two amino acids

b. two nucleic acids

c. two fatty acids

d. do not know

7. What are the main functions of nucleotides in the cell?

_____
_____
_____

8. What is the meaning of “deoxyribose?” Name a molecule that contains deoxyribose.

_____
_____
_____

9.What are the differences between RNA and DNA, and what are the similarities between them?

_____
_____
_____
_____

10. What is the meaning of the phrase "ATP is an energy coin"?

_____
_____
_____

11. What is the relationship between nucleic acids and amino acids?

_____
_____
_____

12. Nitrogen base G is paired with nitrogen base:

a. A

b. B

c. C

d. T

d. I don't know

13. Glycogen is a polymer of:

a. sugars

b. lipids

c. amino acids

d. I don't know

Thank you for your cooperation!

Appendix B: The coding of the open-ended question 7: "What are the main functions of the nucleotides in the cell?" The answer should refer to the genetic function (building blocks of the DNA) and to the energetic function (The nucleotides' phosphate groups are common energy currency in all cells).

Categories of answers	**Score**
An answer that includes the genetic and the energetic aspect: Example: *"building block of DNA and maintain available energy to the activity of the cell."*	3 points
An answer that refer to one function only: Example: *"they are components of the nucleic acids (DNA and RNA) and they carry the genetic information that translated to proteins."*	2 points
An answer that refers to the structure only: Example: *"they are components of the DNA and the RNA."*	1 points
* Incorrect answers like: *"Monomers of amino acids."* * "I don't know" or "I don't remember" * No response.	0 points