

What Should Life-Science Students Acquire In Their BSc Studies? Faculty and Student Perspectives

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ABSTRACT: What should an undergraduate student in a specific discipline gain in the course of his/her studies? All too often, the answer to this question is not formally defined, and answers differ, sometimes largely, even between members of the same academic faculty. In our study we focused on the life sciences faculty and explored both undergraduate students' and faculty members' perspectives regarding this question. Eighty-two faculty members and 124 sophomores responded to a written questionnaire. In response to the question: "What do you think a graduated student should gain during his/her years of study?" they were asked to rate on a scale from 1 to 4 (1= not important at all...4=most important) eight factors: knowledge, lab experience, scientific writing, research skills, understanding the dynamic nature of science, science applicability to everyday life, historic viewpoint and motivation to continue in the field. Twenty-one faculty members of the 82 who responded to the written questionnaire were also individually interviewed. The findings show that there was a consensus, between both populations, on the importance of providing basic knowledge during undergraduate studies. Significant differences ($P < 0.01$) existed regarding the importance of lab experience, research skills, scientific writing and understanding of the dynamic nature of science.

KEYWORDS: higher education, life sciences, undergraduate studies

INTRODUCTION

In the last decade there has been a general tendency to define the goals of university teaching from the point of the instructors. Trice and Dey (1997) described a longitudinal study, which examined changes in teaching goals over the past two decades. They reviewed data on trends in teaching goals obtained from national surveys of faculty conducted from 1968 to 1992, and they found that the goals that aim to *develop the ability to think clearly, prepare students for employment after college, prepare students for graduate studies, and provide for students'*

emotional development were fairly stable over the 24 years covered by the surveys. Goals were also stable over time when compared by institutional type, although support for preparing students for employment after college grew at liberal arts and comprehensive institutions in the late 1980s and fell at research and two-year institutions. Interestingly, the results indicate a growing divergence between the relatively stable goals of faculty and the changing goals of students, who are placing more emphasis on practical training and job preparation.

Hativa (1995) surveyed 113 instructors from different disciplines (Humanities, Social sciences, Math/Natural sciences and Engineering) at an Ivy League university. She listed 21 teaching goals, grouped under two categories: (a) promoting the knowledge needed for functioning in the academic domain and in daily life, and (b) promoting students' motivation, aptitudes, and skills in the subject domain and for self-learning. The results demonstrated very high agreement among the respondents on 13 of the 21 goals. The goals perceived as important or very important by at least two thirds of the faculty belonged in the first category: *helping students gain the basic body of knowledge and tools of the domain, and promoting students' ability to apply methods and principles and to gain other working and thinking habits typical of the domain.* For the second category, the most highly agreed-upon goals were: *promoting students' independent, objective, critical, original, and creative thinking; advancing their interest and motivation to continue studying in the domain; enhancing skills for oral and written expression; fostering openness to different points of view; and facilitating the ability for self-study.* Thus, the main goals in teaching include the cognitive aspects of gaining knowledge and understanding, the affective aspects of promoting motivation, and the skills for learning and functioning in the workplace and in social life.

In a recent study, Stark (2000), surveying 2105 colleges' and universities' instructors of introductory courses, found that almost all teachers perceived *planning the promotion of students' effective thinking* as their most important goal. She found that the type of teachers' goals differed substantially by discipline. For example, biology teachers were most likely to emphasize knowledge acquisition, while teachers of English composition and literature emphasized personal and intellectual development. Stark also focused on teachers' views about their academic discipline and found that biology teachers "view the academic field concurrently as a group of individuals exploring common related interests and values, as a set of phenomena these individuals are trying to explain, and as a mode of inquiry" (Stark, 2000, p. 418). Other researchers (Angelo & Cross, 1993; Franklin & Theall, 1992; Hativa, 1993) also suggested that there are significant differences among disciplines concerning course goals and attitudes of faculty towards instruction, and that good teaching reflects the distinctive characteristics of a discipline.

In light of the suggestion that different fields of study operate according to different rules, which might in turn differentially affect instruction in these fields (Hativa, 1993), in our study we decided to focus on one discipline (biology). The major research question that we asked the life-science instructors and students, was: What should life-science undergraduates acquire

during their studies? The in-depth interview (which took about an hour) with each instructor enabled us not only to view the instructors' declared goals, but also to understand the reasons behind their choices.

METHOD

The study was conducted at Tel-Aviv University's life-sciences facility. Tel-Aviv University, the largest university in Israel, is a public research university. It is a major center of teaching and research, comprising nine facilities, 106 departments, and 90 research institutes. The program for life-science undergraduates provides a thorough basic grounding in all fields of organismic and molecular biology. Students receive both theoretical and practical experience. Studies for the BSc include lectures, laboratory work, discussion sessions, and field trips. In 2002, there were 1100 undergraduates students (66% women), distributed over three years (ICBS, 2002).

The life-sciences faculty includes 141 members (18% women). Most of them (98) hold a professorial position, and have more than ten years of experience in teaching and research. The faculty members are grouped under seven departments: *Biochemistry* (19 members), *Molecular Microbiology and Biotechnology* (20 members), *Plant Sciences* (31 members), *Neurobiochemistry* (11 members), *Zoology* (36 members), *Cell Research and Immunology* (13 members) and *The Institute for Nature Conservation Research* (11 members).

In this study, we conducted in-depth personal interviews with 21 faculty members (between two and four instructors from each department). During the interviews, which lasted about an hour each, we asked participants the following question: What should life-science undergraduates acquire during their studies? We also urged them to elaborate on each aspect to which they referred, and to refer to issues such as their teaching approach, their attitude towards teaching and their course planning.

In addition, 82 faculty members (15% women) responded to a written questionnaire. In the written questionnaire the instructors were asked to rate, on a scale from 1 to 4 (1 = not important at all...4 = most important), eight factors answering to the question "What do you think an undergraduate student should gain during the years of his or her studies?" The eight factors were: knowledge, lab experience, scientific writing, research skills, understanding the dynamic nature of science, science applicability to everyday life, historic viewpoint and motivation to continue in the field. These factors had been suggested in the in-depth interviews, at an earlier stage of the study.

Since the learning process involves students as well, we also examined students' perspectives about the importance of these factors, and compared them to those of their teachers. Thus, we asked the sophomores to answer the same questionnaire, rating the eight

factors; 124 sophomores (72% women) answered the questionnaire.

The participants' responses to each of the eight factors were divided into two major categories: less important (Categories 1 and 2) and very important (Categories 3 and 4). We conducted χ^2 tests to examine differences between instructors' and students' responses.

FINDINGS

Faculty Perspectives

Below we elaborate on faculty responses to the question: What should life-science students acquire in their BSc studies? Our discussion will be based on the eight factors that were mentioned above. Table 1 shows the percentages of faculty members who marked each factor as either important or very important

Knowledge: Almost all the instructors believed that knowledge is one of the fundamental aspects that should be emphasized in the course of graduation. This aspect gained the highest rate of importance (Table 1). About 92% of the instructors chose to mark Categories 3 or 4 for this aspect. Interestingly, in the interviews the instructors raised the dilemma that while "knowledge" is necessary for any graduated student, independently of his/her future specialization, nowadays the available knowledge is so enormous, that it is difficult to agree what parts of it are necessary for a graduated student to master. Some of the instructors argued that it is more important for students to acquire the tools and skills to locate relevant knowledge rather

than trying to cover all the subject matter during the course of study. They mentioned their conflict about the topics that should be included in their course syllabus. As one instructor explained:

In the past, I thought that I knew exactly what knowledge in ecology a graduated student should master. Then one day a student told me: "Listen, at the Hebrew University in Jerusalem they don't teach this topic and they are becoming as good biologists as at Tel-Aviv University." And then I realized that I couldn't define the body of knowledge that students should acquire during their undergraduate studies. I try to give them a broad picture of the subject, and basic concepts as much as I can, but I know that they are only at the beginning of their studies, and that they will have to do the rest by themselves. So I also try to give them the skills and the tools to learn.

Only one instructor was very determined about the insignificance of providing a basic body of knowledge during first-degree studies:

The body of knowledge is changing from year to year so it is not important to teach facts or theories. We only need to equip the students with tools and skills that will enable them to get the information.

Table 1: Percentages of students and faculty members that chose each of the eight factors as important or very important, while answering to the question: What should life science Students acquire in their BSc studies?

FACTOR	Instructors N=82	Students N=124
Knowledge*	92%	99%
Lab experience*	67%	90%
Inquiry skills	81%	88%
Scientific writing	74%	63%
Dynamic nature of science*	89%	70%
Application of science to everyday life	70%	71%
Historical viewpoint	37%	37%
Motivation	84%	85%

* $P < .01$

Lab Experience: This aspect refers to the obligatory and optional lab courses in which students participate during their course of study. Two-thirds of the instructors thought that laboratory experience is very important for undergraduates to gain. Almost all the instructors emphasized this in their interviews. One instructor said, *It is very important that every life science undergraduate acquires manipulative skills, such as, how to hold a pipette, or how to prepare solutions.* Another instructor stated, *Biology is an*

experimental discipline, and so teaching biology without emphasis on the practical aspect is really a joke. The opposite point of view was expressed, *Since lab techniques are changing and what is relevant today will not necessarily be relevant tomorrow, and, anyway, since not all graduating students will go into research, we shouldn't invest too much time in lab experience during the first degree.* In fact, in the last few years, there has been a major decline in obligatory laboratory courses required for the BSc. A main

reason for this decline is due to budget problems, especially due to the three-fold growth in student enrollment. Some instructors argued about the importance of acquiring lab skills during the first degree. They claimed that undergraduate studies tend to be more general these days, and that the specialization in life sciences should occur only at the graduate level. It might hence be important to expose undergraduate students to lab work, but lab skills acquisition should be moved to MSc studies.

Inquiry Skills: More than 80% of the instructors thought that acquiring research skills is very important to the undergraduate student. One instructor said: *The aim of teaching in a research university is not just to transmit knowledge, but to “produce” people who think creatively and are able to analyze observable facts and events, since at the end of the road, we want them to be researchers.* Other instructors thought that involving students in field research could be postponed to MA studies.

At Tel-Aviv University, students have the opportunity to actively experience field research in their last BSc year as part of a project under the supervision of one of the faculty members. Participation in this activity is not obligatory, but most of the students (about 85%) are involved in such projects.

Scientific Writing: During first-degree studies there is no specific scientific writing course, which trains students in writing the results of their research studies. Students gain limited experience in scientific writing through their lab reports or in seminar papers. Seventy-four percent of the instructors rated this as an important component of BSc studies. In the interviews, all the instructors complained about students' poor writing skills. One instructor said: *Israelis are good students, but they don't know how to complete one single sentence. They don't know how to organize paragraphs in a fluent and logical way.* But while most of the instructors mentioned the importance of this skill, they also claimed they did not know how to teach it. They mentioned that in the past there had been a special course dedicated to scientific writing, but it was cancelled due to budget considerations.

Understanding the Dynamic Nature of Science: Nearly ninety percent of the instructors believed it is very important for students to understand that science is not based on definite facts, and that scientific theories are changing and developing all the time. One of the instructors mentioned that, *It is important to give the student the sense that this field is dynamic, changing and adjusting all the time, generating more questions than answers.*

Emphasizing the Applicability of Science to Everyday Life: A majority of the instructors (70%) rated this aspect as very important. It should be noted

that the instructors argued that, on one hand, it is important to relate science to everyday life in order to enhance its relevance and interest for the students; yet on the other hand students should also appreciate that pure scientific research is not necessarily applicable to everyday life.

Teaching science from an historic viewpoint: A relatively small proportion of instructors (37%) rated this aspect as very important. The interviews revealed that instructors' attitude toward teaching with an historical viewpoint depended a great deal on the specific topic that they taught. One instructor argued that teaching with an historical view greatly contributes to students' understanding of the dynamic nature of science, and that it is important that students who graduated in life science departments should recognize key characters in the history of science. In his words, *It is ridiculous that life science students do not know who Louis Pasteur was. Besides, I think that we owe them [scientists from the past] this recognition.*

Motivation to continue in the field: Most of the instructors (84%) viewed this as a very important factor. One of the instructors mentioned that, *It is important to develop a positive attitude towards the field among the students; this will motivate them to specialize in life science later on.* Another instructor said, *Their [the students'] motivation to stay in the field greatly depends on our teaching, so it is our responsibility to make the subject interesting and appealing to students.*

Students' Perspectives

Table 1 shows that, with the exception of the historic viewpoint, students rated all the other factors as important components of the BSc program. We found significant difference ($p < .01$) between instructors' and students' perspectives only in the case of three aspects: knowledge, lab experience and the dynamic nature of science.

Our findings show that students rated knowledge and lab experience as more important than did the instructors. This might be because many students who choose life sciences believe, as a result of the way they were taught at high school, that this is an experimental discipline, mainly built on facts (knowledge) and hypotheses that are tested in the lab. Moreover, unlike the instructors, they are probably unaware of budget-related constraints.

Concerning the dynamic nature of science, 90% of the instructors, compared to 70% of the students, rated this aspect as very important. We assume that students, in the second year of their BSc studies, do not fully understand the meaning of the “dynamic nature of science”, and even if they do, it may well be easier for them to be taught definite facts than to have to deal with uncertainty. For example: one instructor told us about one incident, during which a student became very upset and confused when the instructor tried to

explain that the theory that had been presented in class the previous day, was actually no longer valid. The student claimed that she had already put “yesterday’s theory” in her notes and she felt the teacher ought to provide only one valid theory.

DISCUSSION AND CONCLUSION

Decisions about curriculum and teaching approaches are made by the faculty’s academic staff. All too often, these decisions are not formally defined, and sometimes there are major differences among faculty members’ beliefs regarding what an undergraduate student in a specific discipline should gain during his/her studies. In our study we focused on the life sciences faculty, and explored both undergraduate students’ and faculty members’ perspectives regarding the above question.

The findings show that there was a consensus between both populations on the importance of providing a basic body of knowledge during first-degree studies. Disagreement mainly concerned the importance of developing scientific skills, such as lab experience, research skills and scientific writing.

In the interviews, faculty members expressed a range of opinions concerning the importance of providing such skills during first-degree studies. Arguments against providing these skills mainly involved budget considerations (lab courses, for example, demand more faculty staff and require expensive materials and instruments), or ideological issues, as one faculty explained:

I believe that our responsibility in teaching for the first degree in life

sciences is to provide the knowledge and tools that will enable students to go on acquiring knowledge independently... as for research skills, lab experience and scientific writing – these things are important, but could be postponed until advanced degrees, for students specializing in one of the biology fields. A life science undergraduate student could proceed to be, for example, a life-science expert in a law firm. He or she would not need lab skills...

But, there was a considerable percentage of faculty members who believed in the importance of developing research skills during first-degree studies; as one professor said, *It is a sad fact that undergraduates lack the ability to write scientifically, not to mention that they demonstrate poor writing abilities in general... These students might be the science teachers of our children.*

While the faculty members are those who determine the academic policies and teaching, we cannot ignore students’ opinions. For example, even though faculty did not express definite opinions concerning lab experience, students were quite consistent regarding its importance, as a main feature to be acquired during their BSc studies, alongside formal knowledge. We believe that an awareness of both the faculty and student perspectives and the relations between them, will lead to better decision making concerning curriculum planning and teaching strategies, and will improve student satisfaction with their studies.

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