Student Learning Outcomes Assessment Summary

Biological Sciences, BS

College of Natural Science and Mathematics

2016-17 and 2017-18

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Background

The biological sciences degree programs seek to provide students with the disciplinary knowledge and skills necessary to succeed in the job market or advanced or additional study. The biological sciences BS is a large program, with >300 majors as of fall 2017. The majority of our BS students report that they plan to pursue an advanced or additional degree in biology or health science (Fig. 1a). Over one-third of majors plan to work in the field of human or animal health. The remaining two-thirds of major report a wide range of career plans, including biological research, conservation, wildlife management, environmental assessment, and education (Fig. 1b).

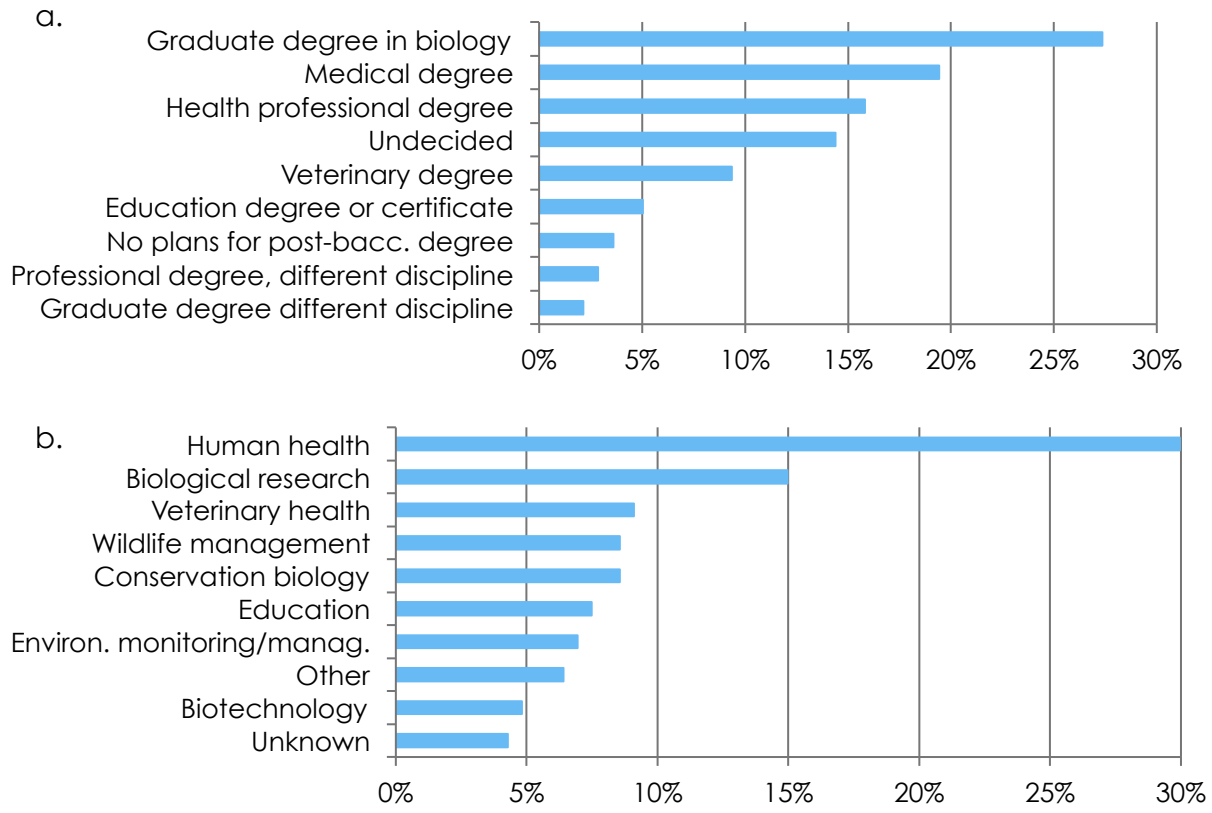

Fig. 1. Plans for post-baccalaureate education (a) and employment (b) reported by BS biological sciences majors from Fall 2016 to Spring 2018 (n = 87). Data were collected using a departmental survey of seniors in a required senior-level course.

1. Assessment information collected

1.1. Knowledge

Graduates of the Biological Sciences program should possess knowledge of core biological concepts, including evolution, inheritance and the expression of genes, cellular and organismal structure and function, and biologically-relevant pathways and transformations of energy. The Biology & Wildlife Department assesses knowledge acquisition using the Educational Testing Service's Biology Major Field Test (Biology MFT) (https://www.ets.org/mft/about/content/biology), which consists of 150 multiple-choice questions covering the four major biology subject areas. The test has been administered every semester since 2010 to majors enrolled in a required, senior-level course, Principles of Evolution (BIOL F481). Our aim is to rank above the 50th percentile of participating institutions across all major subject areas.

1.2. Communication and Information Literacy

Graduates of the Biological Sciences program are expected to communicate clearly and accurately about biological science in both oral and written form. In particular, the department aims to produce graduates who can read and interpret the published biological literature, argue convincingly from evidence, and write a report describing the findings of a biological study in the format of a scientific paper.

Teaching and learning about science communication takes place in the required courses: BIOL F115X and 116X Fundamentals of Biology I and II, BIOL F260 Principles of Genetics, and BIOL F481 Principles of Evolution. These courses assign oral and written reports and provide feedback for improvement. Additionally, students are required to take a minimum number of elective upper division biology courses, many of which are communication-intensive.

We assess our students' ability to use the scientific literature and communicate science in the required capstone project, which is described in more detail in section 1.5. Briefly, all students are required to perform an original research project and communicate the results to specialists and the public.

1.3. Quantitative Skills

Biological Sciences majors must be able to apply quantitative approaches to problem solving in biology. Like biological knowledge, the quantitative proficiency of Biological Sciences majors is assessed using the Biology MFT. Approximately 25% of the exam's 150 questions provide information on a student's analytical skills. Content covered by the test includes: experimental design; inductive reasoning; application of data to problem solving; units of measure; probability theory and statistics; and interpretation of graphs, tables, and statistical analyses.

The ability to successfully apply quantitative analysis to a particular scientific problem is assessed as part of the capstone project. Analysis and interpretation of data is a

required component of the capstone project and is formally assessed as part of the standard evaluation (Table 1, assessment point 5).

1.4. Technical Skills and Collaboration

Biological Sciences majors are expected to be competent in basic laboratory skills and techniques. Instruction on the use of essential biological tools and practices is integrated into the laboratory exercises of three required lower division courses: Fundamentals of Biology I and II (BIOL F115X and F116X) and Principles of Genetics (BIOL F260). The instructors and TAs in these courses provide informal, formative assessment of technical proficiency. The only aspect of technical skill that is currently subject to summative assessment is biochemical lab work by within Principles of Genetics students, which is assessed in lab assignments, quizzes, and exams.

Biological Sciences majors are expected to collaborate effectively, leading to a productive outcome. Training in effective collaboration begins in the Fundamentals of Biology series (BIOL F115X and F116X) and continues in Principles of Genetics BIOL 260. Within BIOL 115X and 116X, students complete a total of three collaborative research projects. For each, students develop a group contract as part of their project plan in which they formalize their expectations. TAs review the plan, track the collaborative skills of the students, and provide formative assessment in the form of feedback. At the end of the project, students enforce their group contracts and have the option to impose penalties on group members who did not collaborate effectively, adding a summative component to the assessment. In Principles of Genetics, students conduct two major collaborative projects, one of which culminates in an oral presentation within which the quality of collaboration is scored.

1.5. Synthesis: The Capstone Research Project

The best evidence that a biologist can integrate knowledge and skills gained in coursework to solve problems using critical and creative thinking is the successful completion of a research project. The capstone research project is a required element of the program. The capstone project is an original, faculty-mentored research project chosen by the student and communicated through three assignments: a formal written report in the format of a scientific paper, a non-technical summary written for the public, and an oral presentation. All aspects of the project must be evaluated as "adequate" or better in order to pass. Students receive feedback from the instructor on all aspects of the assignment and may revise their work. Student projects are assessed with a standard rubric (see forms on the capstone website). Evaluation criteria for the final written report are listed in Table 1.

Table 1. Evaluation criteria for capstone projects in the biological sciences. All twelve elements must be evaluated "adequate" or better in order to pass the capstone project.

	Final paper rubric
1.	Is the capstone project the product of data collection and/or analysis by the student?
2.	Does the capstone paper make a compelling argument for the significance of the student's research within the context of the current literature?
3.	Does the capstone paper clearly articulate the student's research goals?
4.	Are the methods appropriate given the student's research agenda?
5.	Is the data analysis appropriate and accurate?
6.	Does the author interpret the results skillfully and accurately?
7.	Are the tables and figures clear, effective and informative?
8.	Is there a compelling discussion of the implications of findings?
9.	Is the literature review appropriate and complete?*
10.	Are the citations presented consistently and professionally throughout the text and i list of works cited?
11.	Is the writing appropriate for the target audience?
12.	Is the paper clearly communicated and free of language errors?

2. Conclusions drawn from the information summarized above

2.1. Knowledge

Between fall 2016 and spring 2018, 91 biological science majors in the BS program took the Biology MFT. Relative to students at >300 domestic institutions taking the exam during the same period, UAF student scored very well (Fig. 3; total institutional percentile was 91% in 2017-18 and 75% in 2017-18), well exceeding our 50% benchmark for total performance during both years.

Fig. 3 shows the institutional percentile for biological sciences BS students in major subject areas of biology. Students scored well in cell biology, organismal biology, ecology, and evolution, and somewhat lower in molecular biology and genetics (63% in both years), relative to other institutions (Fig. 3).

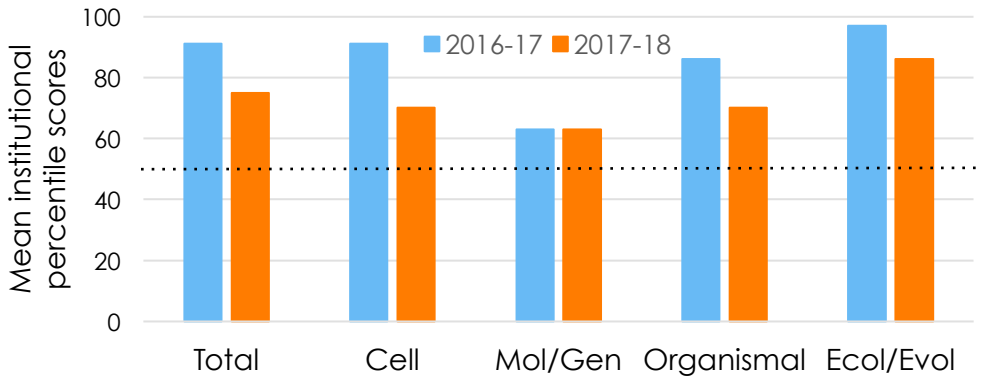

Fig. 3. Biology MFT institutional percentiles for the total score and each of the four major subject areas during the 2016-17 (17 n = 40) and 2017-18 (n = 51) academic years. The dotted line shows the department's minimum benchmark for success.

The biological sciences curriculum changed in fall 2013 to include optional concentrations, provide more flexibility in the choice of junior and senior coursework, and require a capstone research project. Examination of test performance since 2010 suggests that these curricular changes have had little impact the overall performance of student, as measured by our institutional percentiles (Fig. 4).

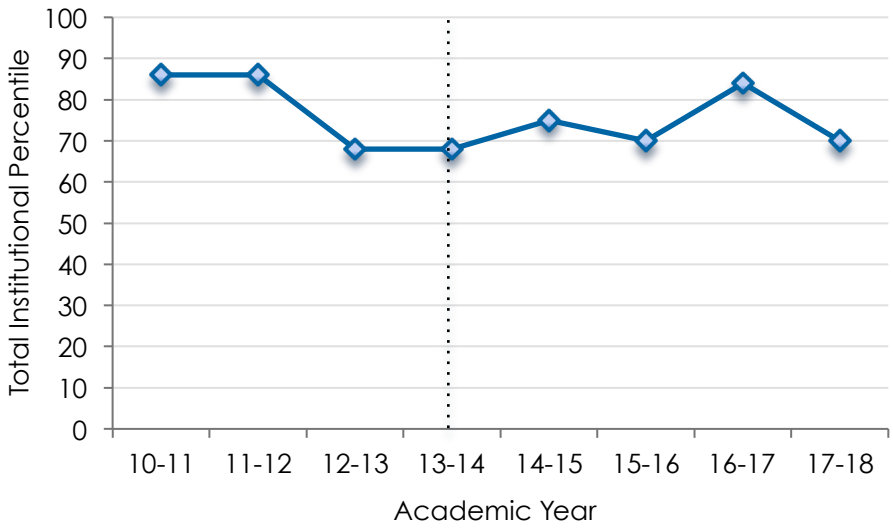

Fig. 4. Biology MFT institutional percentiles for total score across the eight years UAF has required the exam. The dotted line marks the year our curriculum changed.

Students in the BS program now have the option of concentrating study on a particular disciplinary area of biology. A possible negative outcome of this programmatic change is that our students' knowledge of biology will become overly narrow. To examine whether there were trade-offs between proficiency in the concentration area and other areas of study, we compared the performance of student with different concentrations on the four major subject areas of the Biology MFT. The data suggest there are differences in overall performance among the concentration groups, with students concentrating in cell and molecular biology (CMB) tending to score higher than other groups on all aspects of the exam (Fig. 5). Strong evidence of a tradeoff between specialized knowledge and breadth was not evident among students concentrating in CMB or physiology. However, students concentrating in ecology and evolutionary biology performed somewhat more poorly on the molecular biology and organismal portions of the exam relative to other groups.

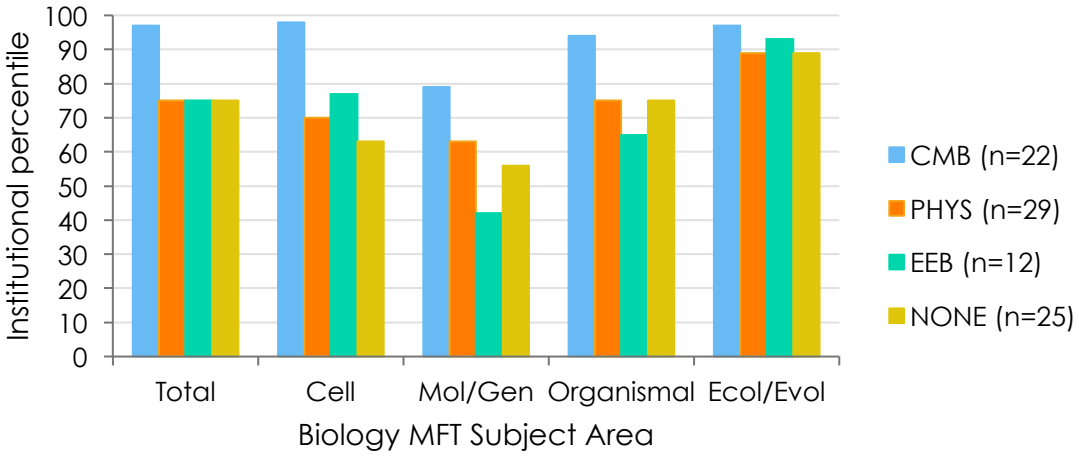

Fig. 5. Biology MFT institutional percentiles for 2016 - 2018 combined for students with different concentrations within the biological sciences BS degree. Concentrations: blue - cell and molecular biology (CMB); orange - physiology (PHYS); green - ecology and evolution (EEB); yellow - no concentration.

Overall, knowledge acquisition by students in the BS program continues to meet or exceed our expectations.

2.2. Communication

On the whole it appears that seniors in the BS biological sciences program can communicate science effectively. Instructors report wide variation in basic writing skills among students, which slows completion of the capstone for some students. Most students revise their project reports several times in response to feedback from the

mentor or instructor, which provides an opportunity for learning. A possible shortcoming of our current approach is that the research instructor alone evaluates the project, and therefore differences in expectations among instructors may affect the assessment.

Students in the BS program are completing the requirement for an oral presentation of their research project in a variety of ways, including class presentations, poster presentations at UAF Research Day, and presentations at regional and national meetings. The latter provide important opportunities for students to perform in a professional context and make contacts that may help them advance in their careers.

2.3. Quantitative skills

Students scored well on the analytical skills portion of the Biology MFT. Institutional percentiles for the analytical skills portion of the Biology MFT indicate very good performance by UAF students relative to those at other institution in both years: 89% in 2016-17 and 80% in 2017-18. This level of performance is similar to the previous reporting period. Fine-scale indicators of performance on the Biology MFT such as analytical skills are not provided in a form that allows us to separate BS from BA students. However, the vast majority (88%) of test-takers were enrolled in the BS program and therefore the scores largely represent the performance of BS students. We conclude that UAF students in the biological sciences have a very good command of analytical issues such as experimental design, probability theory, problem solving, graphical interpretation, and statistics relative to other institutions administering the exam.

2.4. Technical skills and collaboration

Instructors of Fundamentals of Biology I and II and Principles of Genetics report that students master the basic technical tools of biology within required lab classes. Summative assignment grades relating to biochemistry techniques within Principles of Genetics indicate that most students master that aspect of the course.

With regard to collaboration, coursework in required courses indicates that Biological Sciences majors are collaborating effectively on the whole. In Fundamentals of Biology I and II, student and TA evaluations of student group work indicate that students are generally successful collaborators. Students were able to identify what led to a successful or problematic collaboration, indicating the ability to identify successful collaboration and, in general, to achieve it. Over the past 3-4 years, >98% of students reported successful collaborative experiences. Rarely, collaborations were less than successful due to an individual student's disengagement from the course and failure to meet his or her obligations to the group, increasing the workload for others. In Principles of Genetics, the instructor reports that collaborative projects have also been generally successful, albeit occasional problems caused - again - by the disengagement of an individual within a group.

2.5. Synthesis: The Capstone Research Project

Between fall 2016 and spring 2018, more than 70 students in the BS program completed capstone projects. Approximately 70% of students completed their projects within a designated capstone course, while 30% worked individually with faculty mentors. A list of capstone project titles is linked on the capstone website.

The capstone research project is proving to be an effective way to engage students in biology and assess their knowledge and skills in a synthetic way. Informally, students report that the project is a source of pride and accomplishment. We intend for the project to enhance our students' preparedness for graduate studies and professional positions in the discipline. However, we currently do not have the resources to track the professional fates of our undergraduates.

3. Curricular changes resulting from conclusions drawn above

On the whole, biological sciences BS students are performing well and no extensive changes are planned based on the information presented above.

Of the major areas tested by the biology MFT, molecular biology and genetics continues to show lower performance than the other areas. One contributing factor may be early placement of Principles of Genetics (BIOL 260) and Cell and Molecular Biology (BIOL 360) in the curriculum; relative to courses taken in the senior year, the lessons of genetics and molecular biology may be remote by the time students are tested. Another contributing factor may be specialization on a broader level of biological organization by students concentrating on ecology and evolutionary biology. The most recent results of the Biology MFT will be discussed with the faculty in fall 2018 with the aim of increasing these scores.

The capstone research project appears to be effective. However, the departmental Teaching Advisory Committee will conduct a review of completed capstone projects during 2018-19 in order to assess consistency in project complexity and assessment across instructors.

4. Identify the faculty members involved in reaching the conclusions drawn above and agreeing upon the curricular changes resulting

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