# The Function of Course Prerequisites in Biology

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**articlehighlights**

*Based on a case study at the University of South Florida (USF):*

- *the faculty-driven model of the function of prerequisites yielded better course performance than the student-driven model*
- *both failure and withdrawal rates of students in Department of Biology courses at USF dropped markedly when prerequisites were enforced*

***Do prerequisites promote student success?***

Prerequisite courses are essential tools in many university curricula, but some educators have suggested that they may be detrimental if applied overzealously to exclude students from courses.[1] A true measure of the value of prerequisites is whether or not they promote student success. The strongest way to test the value of prerequisites is to compare the success rate of students with and without prerequisites in higher-level courses. Although such comparisons can be based on instructor assessment of preparedness or even on student self-assessment,[1] the most meaningful comparisons of student success are grades and withdrawal rates of students with and without prerequisites.

***We compared grades and withdrawal rates of students with and without prerequisites.***

Here, we present the results of a comparison of the success rates of students with and without prerequisites in higher-level biology courses at the University of South Florida.

- The University of South Florida (USF) is a large metropolitan research university, with a total enrollment exceeding 40,000 students.
- The Department of Biology has about 1,700 majors in two undergraduate degree programs, biology and microbiology.
- The department also contributes significant instructional effort to various preprofessional programs, as well as to the general education component of other majors.
- Overall, the department generates about 25,000 student credit hours per year.

Although most departmental courses have always had one or more other courses listed as prerequisites, the USF registration system did not prevent students from enrolling in courses for which they lacked the prerequisites. In effect, the university relied on the students' personal assessments of the need for prerequisites; so, many students simply ignored them.

***Faculty members were concerned about course quality.***

Faculty members within the Department of Biology have long suspected that allowing students to ignore prerequisites is not desirable. Their concerns are that unprepared students contribute to

- some combination of high drop rates and high failure rates in courses
- low retention rates and slow progression rates in majors
- a general dumbing down of the curriculum

***We decided on a strict enforcement policy.***

No doubt, many factors other than failure of the university to enforce prerequisites could contribute to the academic malaise that Department of Biology faculty members perceived in the students in their courses. Prerequisite enforcement seemed to the departmental administration to be a good place to start making improvements. The departmental administration decided to switch from a no-enforcement policy to strict enforcement of prerequisites. This switch presented the department with an opportunity to assess the relative merits of two models of the function of prerequisites:

1. **student-driven model** in which prerequisites are

suggestions that help students make informed decisions

*compared two models: student- and faculty-driven.*

2. **faculty-driven model** in which prerequisites are requirements that channel students along predetermined routes

### Procedures

Because recognition software had not been installed by USF to check for prerequisites, the Department of Biology, with the support of the dean of the College of Arts and Sciences, assumed the burden of manually checking student records for prerequisites during registration for the fall semester of 2002.

- The department advertised the switch from no enforcement to strict enforcement of prerequisites in the spring of 2002, before preregistration began, on bulletin boards, in classes and teaching laboratories—verbally and by way of handouts—and as a pop-up notice on the departmental web page.

*Prerequisites were then checked and enforced.*

- The department allowed students to register ad libitum as usual for its courses until the end of July 2002, at which time no further registrations were allowed without specific permits from the department.

- In the meantime, because the computer registration system used by the University was incapable of screening student records, the department staff manually checked the records of every student enrolled in every course for prerequisites.

- A list of students without appropriate prerequisites was prepared, and with the help of the registrar, these students were dropped from the courses. The registrar assisted the department in sending letters to the students informing them of the action that had been taken.

- A second round of manual checking, followed by dropping of students without prerequisites, was undertaken in August 2002, at the end of the registration period, to ensure that no students had managed to find a breach in the prerequisite checking

system.

## Outcomes

The number of students enrolled in courses for which they did not have the appropriate prerequisites came as a shock to administrators and faculty members.

***In some courses, unprepared students made up 40% of the total.***

- At the end of July, the cumulative total of students enrolled in the relevant undergraduate courses in the Department of Biology was 2001, of which 623 (31%) lacked prerequisites.
- In some courses, unprepared students comprised more than 40% of the total number enrolled. The level of unprepared students stretched from freshman to post-baccalaureate, and although most of these students were biology and various preprofessional majors, 41 different majors were represented.

All students who wished to contest being dropped were interviewed. They were required to show some proof—usually a transcript—showing they had successfully completed the prerequisites. A total of 127 of the dropped students were able to show such proof and were reinstated. Virtually all of these students suffered from missing records, so the error rate for the manual prerequisites checking was near zero. The department was able to place 253 of the dropped students into the prerequisite courses that they needed. Another 340 students who had appropriate prerequisites, but were blocked from enrolling in courses by the presence of students who lacked the prerequisites, were able to enroll when the unprepared students were dropped.

***The grades of unprepared students were compared to the overall average***

What would have happened if unprepared students had been allowed to continue in the courses for which they lacked the prerequisites? We answered this question by comparing the overall distribution of grades in junior-level courses for the 2001–2002 academic year with the distribution of grades received by students in the same courses who did not have the prerequisites. Many of the unprepared students who were dropped from courses during manual prerequisites checking were chronic offenders, so their grade reports were used to generate the latter distribution.

- Overall, students had almost an 80% chance of making a grade of C or higher.
- Unprepared students had only a 53% chance of making a grade of C or higher in the same courses ($chi^2$ = 47.4, p < 0.01; see Figure 1).
- The situation is even worse than it appears, however, because many of the grades of C or higher obtained by unprepared students were done so only upon a second or third attempt.
- If senior-level courses are included in the analysis (data not shown), the chance of unprepared students making a grade of C or higher in a course for which they did not have the prerequisites improves only marginally.

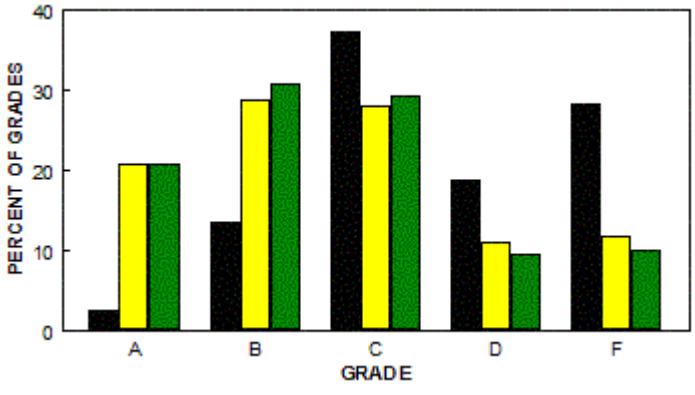


***Figure 1.***
*Cumulative grade distributions of students without prerequisites in junior-level biology courses (black bars, n = 202) and for all students in the same courses (yellow bars, n = 823). The grade distributions of all undergraduate courses offered at USF in spring 2001 (green bars, n is unknown) is included to illustrate that the grade distribution for all students in junior-level biology courses was not unusual.*

### *Failure and withdrawal rates before and after enforcement were compared.*

Did improvement in student performance warrant all of the effort that went into prerequisites checking? We answered this question by comparing grade distributions from two semesters in which prerequisites were not enforced, fall 2001 and spring 2002, with grade distributions from the first two semesters in which they were enforced, fall 2002 and spring 2003.

- The failure (D + F) rate declined by 18% in the fall semester ($chi^2$ = 4.6, $p$ = 0.03) and 15% in the spring semester ($chi^2$ = 3.0, p = 0.08).
- The withdrawal rate declined by 21% in the fall semester ($chi^2$ = 4.6, p = 0.03) and 31% in the spring semester ($chi^2$ = 13.3, p < 0.01).

These declines in failure and withdrawal rates followed modest increases over the previous several years. Improvements were more pronounced for junior-level courses than for senior-level courses. Anecdotal feedback from faculty members indicates that the atmosphere in the classroom also improved with prerequisites enforcement: faculty members said that both attendance and participation in their courses were greater than they had been in the recent past.

***The study focused on overall performance, not on individuals.***

The design of this study allows only assessment of overall improvement in grades and retention rates brought about by prerequisites enforcement. The design does not allow assessment of individual improvement, that is, whether or not student preparation for upper-level courses improved. The latter assessment would require the study to continue, to track the success of students who had high versus low grades in the prerequisite courses. The department lacks the resources to continue the study, but a previous analysis (unpublished data) bears on this issue:

- Students who received a grade of C, the minimum passing grade for biology and microbiology majors, in both of the prerequisite introductory biology courses had a substantially lower chance of passing the subsequent upper-level biology course than did students who received at least one grade of A or B.
- The difference in chance of success was similar in magnitude for students whether the introductory biology courses were taken at USF or at a community college.

In response to this analysis, the department has increased the GPA requirement in the introductory biology courses—and in the introductory chemistry and mathematics courses, as well—for admission into the biology and microbiology majors.

## Discussion

***The faculty-driven model yielded***

The faculty-driven model of the function of prerequisites yields better course performance than the student-driven model. Both failure and withdrawal rates of students in Department of Biology courses at USF dropped markedly when prerequisites were

enforced. In response to this success, the provost provided funding for software improvement, and USF now can check student records for prerequisites by computer when students attempt to register. Departments and programs at USF still have the option not to check for prerequisites at all or merely to warn students that they are enrolling in courses for which they lack prerequisites.

***The student-driven model was a recipe for failure for many students.***

Should other departments follow our lead and enforce prerequisites? We think so, but we do not categorically suggest that the faculty-driven model necessarily is better for every department at USF or for biology departments at other universities. The results of this study indicate that the student-driven model is a recipe for failure for many biology students at USF. Department and program personnel need to decide for themselves whether or not the apparent student-friendliness of the student-driven model actually is a façade masking a greater chance of failure for unprepared students. Worse still is the possibility that the student-driven model may affect the quantity and quality of instruction for prepared students, if courses have indeed been dumbed down to accommodate unprepared students, but our analysis does not address this possibility.

***Letting advisers guide students may substitute for the faculty-driven model.***

An intermediate model, the adviser-driven model, in which prerequisites are suggestions that, in conjunction with rigorous advising, help students make informed decisions, can substitute for the faculty-driven model. The adviser-driven model is an acceptable substitute only when student advising is mandatory and binding, however. Advising at USF is not mandatory after an initial orientation and never is binding. For the adviser-driven model to succeed, advisers need to adhere tightly to the minimum set of guidelines that prerequisites provide for the way in which faculty members think that students should progress through the curriculum. Substantial deviation from these guidelines does not appear to provide the best chance of success for many students; indeed, it may have a negative impact.

***Other studies confirm***

The results obtained in this study mirror other tests of the general value of prerequisites. For example, studies of the consequences of strict enforcement (lock-out mode) of prerequisites at some community colleges in California showed the following:[2–6]

***of prerequisites.***

- percentages of students lacking prerequisites often were high before strict enforcement
- efficient screening reduces the number of students that enroll in courses for which they are unprepared
- strict enforcement of prerequisites does not permanently affect enrollments
- strict enforcement improves student performance

***Re-evaluate prerequisites in light of advances and other changes affecting course content.***

Although tests of the general value of prerequisites tend to produce results like these, the specific value of poorly chosen or poor quality prerequisites may be negligible for particular courses,[1] particular disciplines,[6] or even particular institutions. Tests of the value of prerequisites for individual courses,[7] therefore, appear to be warranted, but such tests can be prone to small sample sizes and other methodological problems,[8] and, of course, are difficult to conduct once strict enforcement of prerequisites is in place. We suggest that, because the sciences build on principles and facts that must be learned hierarchically, validation of prerequisites on a course-by-course basis may be less important in the sciences than in some other disciplines, provided that prerequisites are re-evaluated periodically by the faculty in light of advances in the discipline, turnover of instructors, and other changes that might affect course content.



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This article on ActionBioscience.org by Brian R. Shmaefsky examines why it's important for educators to adequately prepare science students for a science career in industry.
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**American Institute of Biological Sciences on Careers in Biology**
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**Careers for Biology Majors**
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http://facweb.furman.edu/~jsnyder/careers/careers.html

**"Working in the Aquatic Sciences"**
The American Society of Limnology and Oceanography offers advice to students on how to prepare for careers in aquatic sciences, including basic higher education courses to take.
http://aslo.org/career/aquaticcareer.html

**"Preparing for College: Tips for Grades 9–12"**
Suggested steps to take in high school to prepare for a college career. Also check out the pdf file "College Planner for Seniors" at the end of the tips.
http://www.tusd.k12.az.us/contents/distinfo/tips/studentscollege.html

**"The 21 Things Every First Year College Student Should Do"**
Article outlining tips for first-year college students, including why you should learn about prerequisites and requirements.

http://www.thehighschoolgraduate.com/editorial/US21things.htm

**Conversations with biologists**
Excerpts from "Online Chat about Life Sciences" careers and studies on MyAngel.com in June 2000.
http://www.dbs.nus.edu.sg/outreach/career_in_biology.htm

**"The FAQs of Life"**
Questions and answers about studying and planning a career in biology.
http://artssciences.udayton.edu/Biology/careers.asp

**U.S. Bureau of Labor Statistics on Biology Careers**
Information on biological and medical careers, including nature of the work, working conditions, employment, training, other qualifications, job outlook, earnings, related occupations, and more.
http://www.stats.bls.gov/oco/ocos047.htm

**Read a book**
*Opportunities in Biological Science Careers*, by Charles A. Winter and Kathleen Belikoff, explores the latest information on bioscience fields, training and education requirements for each career, and much more (McGraw-Hill, rev. ed., 2004).

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http://www.aibs.org/student-chapters/

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