IR Applications
Using Advanced Tools, Techniques, and Methodologies

Volume 14, October 19, 2007

Association for Institutional Research
Enhancing knowledge. Expanding networks.
Professional Development, Informational Resources & Networking

How to Determine Course Prerequisites: An IR Perspective on What to Do and What Not to Do

Frank Abou-Sayf, Kapiolani Community College
Samir Miari, Chicago State University

Abstract

One of the most valued approaches to identify course prerequisites relies on statistical techniques, typically requiring institutional-research support. Yet these techniques are often inadequate for prerequisite-identification purposes. A discussion of the reasons for the inappropriateness of these techniques is presented. A review of common practices used to identify prerequisites is also presented, and some basic notions related to the concept of prerequisites are discussed. A tool conceived by one of the authors' institutional-research offices for the purpose of identifying prerequisites is presented and demonstrated.

Introduction and Problem

Few approaches are used to identify and assign course prerequisites. However, the two which seem to be used most often are a quantitative approach, based on statistical techniques such as tests of means, correlation and regression studies, and a qualitative approach, based on selecting prerequisite courses by comparing the skills and competencies they cover with the skills and competencies that are needed in the target course. The quantitative approach may require the assistance of institutional-research offices, while the qualitative approach is usually carried out by the instructors teaching the target courses.

The quantitative determination of a course prerequisite is usually based on comparing performance on the target course between students who did and who did not take the prerequisite course. Higher performance on the target course by students who took the prerequisite course would typically validate the need for the prerequisite (Borden, 2002, Cohen et al. 1990). As shown below, these techniques can often lead to erroneous conclusions.

The qualitative determination of a course prerequisite can be accomplished in a multitude of ways, some more structured than others. The general principle consists of comparing the required entry skills of the target course with the exit skills of the prerequisite course.

The Current Practice

In the two institutions discussed here, the current practice consists of identifying the prerequisite course in a document to be submitted by the instructor to the Curriculum Committee in one institution and to the Academic Standards Committee in the other. The instructor is required to justify the prerequisite in one or two lines, and the department chair signs off on the form. Presumably, the prerequisite determination is done through consultation among the faculty teaching the course and the department chair. Rarely, if ever, has a prerequisite request been turned down. In one of the institutions, a large-scale statistical analysis undertaken in the 1990s led to the establishment of the majority of the prerequisite courses that exist in Arts and Sciences today.

At the other institution, things are changing piecemeal. Faculty offering courses identify, based on professional determination, the background a student must minimally have to perform effectively in the class. Courses at

the 200 or 300 level are generally expected to have prerequisites.

An approach worth noting, if not for its merit then simply by virtue of its magnitude, is the one used at the California Community College (CCC) system, comprised of 109 colleges. State legislation, called Title 5, defines the process of identifying prerequisites rather rigorously. The intent of Title 5 seems to be to prevent colleges from establishing unnecessary prerequisites. In this process, a number of options are available to justify the use of a prerequisite course (Curriculum Committee, 2001):

- Option A: Use of the "Content Review Correlation List Form," which is composed of two lists, one enumerating the desired entrance skills for the target course and one enumerating the existing matching skills in the proposed prerequisite course. An example of this form is presented in Figure 1.

Figure 1:
Sample CCC Content Review Correlation List Form

Desired Entrance Skills for _____

1. operate a scientific calculator, including +, -, x, - exponential notation, log and antilog (base 10 and base e), 1/x, square root of x, x^y;
2. find a root of power of any number;
3. add, subtract, multiply, and divide numbers in exponential notation;
4. take the log and antilog of any number in either base 10 or base e;
5. perform chain calculations knowing the hierarchy of functions;
6. add, subtract, multiply, and divide fractions;
7. solve an algebraic equation for an unknown, including both first and second order equations (quadratic solution);
8. give a linear equation with two variables, recognize direct and inverse proportionalities

Course Exit Skills for _____

A. operate a scientific calculator, including +, -, x, - exponential notation, log and antilog (base 10 and base e), 1/x, square root of x, x^y;
B. find a root of power of any number;
C. add, subtract, multiply, and divide numbers in exponential notation;
D. take the log and antilog of any number in either base 10 or base e;
E. perform chain calculations knowing the hierarchy of functions;
F. add, subtract, multiply, and divide fractions;
G. solve an algebraic equation for an unknown, including both first and second order equations (quadratic solution);
H. give a linear equation with two variables, recognize direct and inverse proportionalities

Note: Use one **Content Review Correlation List** for each advisory/prerequisite/corequisite course that is to be set (copy page as needed).

- Option B: Use of the "Content Review Matrix'" where one dimension shows the desired entrance skills for the target course, and the other shows the course exit skills for the suggested prerequisite course. A check mark is placed into the cell that intersects a required skill that is present in the prerequisite course skill. An example of this matrix is presented in Figure 2.

Figure 2:
Sample CCC Content Review Matrix

		Desired Entrance Skills for _____						
		1. find a root of power of any number	2. add, subtract, multiply, and divide numbers in exponential notation	3. take the log and antilog of any number in either base 10 or base e	4. add, subtract, multiply, and divide fractions	5. give a set of data involving two variables, plot a graph of that data	6. give a straight-line graph, calculate the slope of the line	7. perform chain calculations knowing the hierarchy of functions
Course Exit Skills for _____	1. find a root of power of any number	X						
	2. take the log and antilog of any number in either base 10 or base e			X				
	3. give a set of data involving two variables, plot a graph of that data					X		
	4. add, subtract, multiply, and divide numbers in exponential notation		X					
	5. add, subtract, multiply, and divide fractions				X			
	6. perform chain calculations knowing the hierarchy of functions							X
	7. give a straight-line graph, calculate the slope of the line						X	

Note: Use one **Content Review Correlation List** for each advisory/prerequisite/corequisite course that is to be set (copy page as needed).

Source: Curriculum Committee, 2001

In addition, the legislation identifies different levels of scrutiny. The simplest is considered to be a basic content review with no supporting evidence. The middle level is the filled-out content review form, and the highest level of scrutiny is considered to be data collection and statistical analysis. The qualitative approach is usually carried out by the instructors teaching the target courses. Faculty are encouraged to use as high a level of scrutiny as possible.

A refreshing feature at the CCC system is the fact that the form used to justify a prerequisite course is different and separate from that used to request the introduction of a new course: a prerequisite request can be denied while the new course is accepted.

Data Collection and Analysis to Determine Prerequisites

Quantitative approaches are considered by many institutions, including the CCC system, to be the "highest level of scrutiny." Abou-Sayf (1999a and 1999b) has, however, shown that statistical analysis can be misleading in the determination of prerequisites for several reasons:

1. Spuriousness of relationships. Good students tend to perform well on most courses while poor students tend to perform poorly on most courses. A high correlation between grades on a prerequisite course and a target

course is as likely to be an artifact of this phenomenon as it is a benefit of completing the prerequisite course.

2. The persistence factor. Students who take one or more prerequisite courses before the target course will tend to do better than students who do not, partly because completing the prerequisite course often requires spending one additional term in school. Because students who persist tend to perform better than students who drop out, it follows that those who take the same course after one semester of college (needed to complete the prerequisite) are likely to perform better on that course because they have persisted and hence are better students. This improved performance may be erroneously attributed to the benevolent impact of the prerequisite course. To complicate matters further, quantitative corrections for this phenomenon are not easy to find. For example, Tobit analysis (Tobit, 1958) and Heckman's two-stage estimator (Heckman, 1979), two recognized approaches to correct for restriction of ranges and data censoring, do not apply to this situation, as these do not address the impact of persistence on performance. The impact of persistence (students who persist do better) introduces a new component that does not permit the valid use of these corrections. Restriction of range can be corrected only when the group which is restricted has the same characteristics as the groups on which measurement is done. This is no longer applicable because of the persistence factor.

3. Correlation and Causation. With prerequisites, causality is prone to be erroneously attributed where only correlation exists. Furthermore, when instructors waive prerequisites for the stronger students – a practice that some faculty and counselors use – correlation analysis may indicate that students who took the prerequisite course did worse in the course.

Unfortunately, a great number of studies and institutions rely on statistical techniques to identify and establish prerequisite courses (see, for example, Arismendi-Pardi, 1997; Armstrong, 1998; Cohen et. al., 1990; Gramer and Liberty, 1981; Wilson, 1994; and Yuba Community College, 1996).

A Correlation Study

To check the validity of these concerns, a correlation study was carried out on the performance of 536 students in a Speech course at one of the authors' institution. The correlation coefficient between each of the two courses, English 22 and English 100, both candidates for prerequisites for the Speech course, and grades on the Speech course were calculated. Subgroups of varying sizes within the cohort of 536 students yielded correlation coefficients of 0.2588 and 0.3250 respectively, none of them being statistically significant. These results indicate that neither course should improve performance in the Speech course. The same calculations were carried out with a course that would not be considered a prerequisite for Speech – Food Service 30. The correlation coefficient in this case was 0.5244, higher than the previous two and the only one that was statistically significant. The results are shown in Table 1.

Table 1:
Performance in a Speech Course as A Function of Various Prerequisites

Correlation coefficients	English 22	English 100	Food Service
Speech	0.3250	0.2588	0.5244*

*p < 0.01

Based on these statistical considerations alone, one could erroneously conclude that the Food Service course is a more relevant prerequisite for the Speech course than either of the English language courses.

Valid Approaches in Determining Prerequisites

One quantitative approach that allows the determination of prerequisites without the drawbacks of correlation studies consists of eliminating the prerequisite on a trial basis for one or more terms and comparing the course outcomes with and without the prerequisites. This is no easy feat, requiring controlling for extraneous variables such as the instructor, the course content, grading standards and the qualifications of the students.

On the other hand, qualitative approaches rely on the principle that instructors are the most qualified individuals to identify prerequisites for the courses they teach. In some instances, instructors have a predetermined opinion about which prerequisite their course needs. In the absence of a carefully designed approach to encourage an objective selection, these instructors may be influenced by the power of their own suggestion. Thus, in the CCC system, filling of the Content Review Matrix (figure 2) may be involuntarily influenced by the instructor's desire to include a certain prerequisite course, leading to the checking of more cells than is necessary to support the instructor's initial decision.

This discussion suggests that an ideal approach would be one that empowers instructors to make prerequisite-selection decisions while promoting their objectivity during the selection process.

A Tool for the Determination of Prerequisites

An innovative Web-based tool to determine prerequisites was prepared for this purpose. The tool identifies only Math and English prerequisite courses for non-sequential courses, that is, for target courses other than Math or English. The tool, as it currently stands, is at:

http://iro.kcc.hawaii.edu/competency

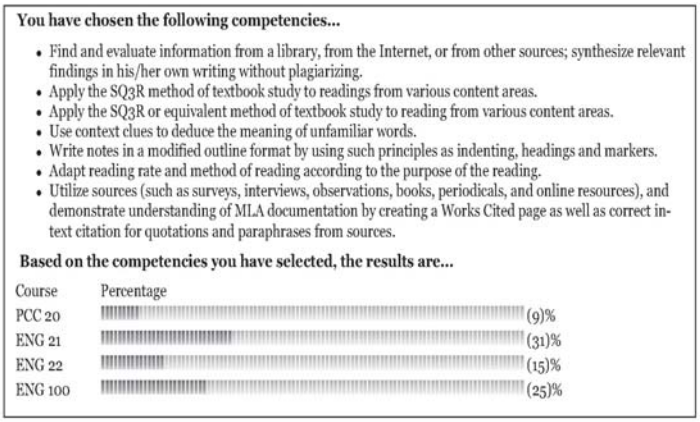
The tool was conceived, designed and constructed by IR personnel. It was used at one of the author's institution on a trial basis during Fall 2005. The tool was constructed to ensure that instructors select prerequisites with the greatest measure of objectivity. It can be seen from the features described below that promoting users' objectivity was of utmost concern to the tool designers.

Features

- The tool is Web-based. This feature ensures accessibility, immediate results, and minimizes the likelihood of the process being tampered with.
- As it currently stands, the tool was built to look like a game. The reason is that, at this institution, all faculty members were encouraged to use it on a trial basis, and the game features were an attempt to make it attractive.
- The tool is comprised of two sections: one for English and one for Math competencies. Math and English were selected because these are the most common prerequisites for courses
- The tool was built to identify English and Math competencies (or student-learning outcomes) only for non-sequential courses. It was not designed to determine, for example, whether Chemistry 100 should be a prerequisite for Chemistry 200, but rather to determine, for example, whether Math 100 should be a prerequisite for Chemistry 100.
- For each of the two sections, all the competencies for all courses starting with the lowest remedial level and ending with the 100-level course (English 100 and Math 100) are included.
- Information about the course from which each competency was derived is not available to the user.
- The competencies are listed in random order.
- The order of the competencies is randomly generated every time the tool is recalled, making it very unlikely to view the same order more than once.
- A limit was set on the number of times the same instructor is allowed to access the tool, after which this user is locked out and will need to contact the Web administrator for further use. Currently, this number is set at four.
- For each competency, a weight is given that is equal to the time it takes to cover this skill in class. Using time as weight allows the construction and synthesis of courses from and into their specific competencies, and leads to the generation of the graphs shown in the bottom of the output (Figure 2).

The instructor is asked to select, from the menu of competencies provided, those that are needed for the target course. Completing the selection generates an output comprised of a series of bar graphs indicating the percent of each course that is needed as the prerequisite for the target course. An example of the result page is shown in Figure 3.

Figure 3
Sample Tool Output for an English-Course Prerequisites



Findings

The most striking finding that resulted from the use of the tool is one that, in retrospect, appears trivial: almost no single course requires a complete course as a prerequisite. As Figure 3 shows, the decision maker is faced with parts of several prerequisite courses to contend with, ranging from 10% of the lowest-level course (PCC20) to 35% of the college-level course (English 100) in this example. The initial unsettling feeling that these results have generated is slowly giving way to a healthy debate about the entire concept of prerequisites at the college. What is clear to everyone is that use of the tool leads to a significantly more accurate identification of prerequisites than the current practice of selecting a course and justifying the selection in a few lines.

Uses

The college is currently in the process of requiring that a copy of the output, similar to that shown in Figure 3, accompany the Course Outline Form, as evidence of the need for a prerequisite course.

Ramifications

Debate at the college is centering on what to do with the results that the tool generates. A number of related questions remain unanswered: Should the department set a percentage threshold of competencies above which a certain course covering these competencies would be acceptable as a prerequisite? If so, what should this percentage be, and how should it be determined? What to do with the other competencies that are covered in other courses with less than the percentage threshold?

While these issues are being debated, some prerequisite alternatives to entire courses are emerging, most of them resulting in the desirable outcome of shortening graduation time. These are:

- Offer entrance exams in lieu of the prerequisite course to allow students with a certain level of competencies to be admitted, all the while modifying the target course slightly to teach some lacking competencies, likely at the beginning of the course.
- Rather than use a current course as a prerequisite, tailor a specific, perhaps shorter, prerequisite course for some highly populated target courses.
- Offer a short intensive course covering only the competencies desired as a requirement for acceptance to the target course. This course could either be Web-based or offered on a crash basis over a few days.
- Offer non-credit self-taught modules online that would be capped with a controlled final exam. Performance on this exam will determine whether the student will be accepted in the target course or be required to take the module over again or to take one or the other prerequisite courses as indicated by the student's performance on the competencies tested. Self-taught modules also help cut the cost of education (Carol Twigg, n.d.)

Summary and Conclusion

Prerequisites should be set for only two reasons: to increase significantly the likelihood of student success, or for health or safety. The proliferation of prerequisite courses is a phenomenon that should be carefully monitored because of the detrimental effect that unnecessary prerequisites can have on student progress. Prerequisite courses tend to prolong the period of study, thus increasing the attrition rate and delaying the release of the graduate into the workforce. Adding prerequisites also leads to an undesirable drop in target-class occupancy rates. It is not surprising that accreditation bodies tend to frown upon the proliferation of prerequisites. Furthermore, where competition for student enrollment exists among institutions, those that exercise insufficient care in controlling the establishment of prerequisites will lose some of their competitive edge.

Rather than succumb to the pressure by faculty and decision-makers to use only statistical analyses to make prerequisite determinations, IR professionals should inform the institution's community of the shortcomings of these analyses. At one of the authors' institutions, the IR director was considered by the Faculty Senate Chair to be in dereliction of his duties when he tried to explain why statistical analysis could not be validly used to identify prerequisites. What IR professionals need to do is to encourage the empowerment of instructors to make prerequisite decisions, while ensuring their objectivity. The tool used in this study is one way to promote objectivity. The institution and its students could significantly benefit from practices such as a careful and recurring reviews of prerequisite courses. The study's finding that no target course requires a complete course as a prerequisite will hopefully encourage the search for shorter alternatives to entire courses. IR offices should assume leading roles in these initiatives.

Editor's Notes

IR Applications is delighted to have this example of how to meld together the human judgment of content area experts on the faculty with the pragmatic skill of IR. First, most, if not all, of our institutions have prerequisites. These prerequisites are grounded in faculty discussions and beliefs that certain skills are necessary to advance in knowledge and ability. The prerequisites are then thought to provide the needed skills and the foundations for the required knowledge. Using software such as People Soft and SCT Banner, many institutions have the ability to implement prerequisite rules or to issue warnings when the rules are being violated. This IR Applications gives several examples of how these prerequisites can be discussed and proposed.

Part of the prerequisites issue is that they have a resource aspect as well as an intellectual aspect. In an institution where faculty resources are allocated based on student credit hours taught, the ability to get a course identified as a prerequisite may well equate to additional faculty resources. From the faculty perspective, students who do not have the required skills for a course will either slow the other students down, place an additional strain on the faculty, or meet an untimely and unfortunate outcome in the class. From the student's perspective, unnecessary prerequisites are an additional expense and slow the ability to complete a program in a timely manner. Institutions, students and faculty are asking about the issue of prerequisites. How are prerequisites handled at your institution? On the likelihood that the modal response is a strong "It depends" this article gives a methodological look at the issues and the options.

The authors' solution is an innovative concept where faculty are asked to identify the skills needed from a prerequisite course. The relevance of a skill in a prerequisite course is estimated based on the time spent on the skill in the course. Using a Web-based tool, the person proposing a course can see the degree to which the various possible prerequisites are likely to be appropriate. Will this eliminate, lessen, or exacerbate the discussions of prerequisites? What challenges do you anticipate if this were part of the prerequisites discussion at your institution?

It is unlikely that any methodology will ultimately resolve the prerequisites debate, but this tool will add an informative and interesting capability. It is also enjoyable to use.

References

Abou-Sayf, F. K. (a) (April 1999). How Not To Determine Prerequisite Courses. Paper presented at the Excellence in Education Conference, Honolulu, Hawaii, U.S.A.

Abou-Sayf, F. K. (b) (1999). Prerequisite courses: Statistical considerations. Community Colleges, University of Hawaii, Vol. 34, No. 4, 11.

Arismendi-Pardi, E. J. (1997). Comparison of Final Grades of Students in Calculus for Business, Management, and Social Sciences with and Without a Prior College Algebra Course. Ed.D. Practicum, Orange Coast College, CA, ERIC # ED405924.

Armstrong, W. B. (1998). Mandatory Skill Level Prerequisites: How Are Student Outcomes Affected? A Student Equity Approach, San Diego, CA, San Diego Community College District, CA.

Borden, R. (January 2002). Validation of English 1A as a prerequisite for Psychology 1A. Santa Cruz, CA, Cabrillo College.

Cohen, E., Friedlander, J., Kelemen-Lohnas, E., & Elmore, R. (April 1990). Method for Determining Valid Course Placements and Prerequisites, Findings & Recommendations from a Study of California Community Colleges. Paper presented at the 70th Annual AACJC Convention, Seattle Washington.

Cramer, R. & Liberty, S. (1981). A Plan for improving Instruction and Services for Development Skills Students at Fresno City College. Fresno City, CA, Fresno City College

Establishing Prerequisites and Corequisites, A Guide for Departments (January 2001). Curriculum Committee, Prerequisite Subcommittee Chabot College, CA,

Heckman, J. J. (1979). Sample selection bias as a specification error. Econometrica, 47, 153-161..

Tobin, J. (1958). Estimation of relationships for limited dependent variables. Econometrica, 26, 24-36.

Twigg, C. (no date). What is the most important thing that we have learned about quality and cost?

http://www.usmd.edu/usm/academicaffairs/courseredesign/kickoffslides.html, Retreived April, 2007.

Wilson, C. E. (1994). Comparison of Final Grades in Introductory College Chemistry With or Without Math Prerequisites. Ed.D. Practicum, Donnelly College, Kansas City, Kansas, ERIC # ED392507.

Prerequisite Handbook. Revised Edition: Approved CC. (December 1996). Yuba Community College District, Marysville, CA.

IR Applications is an AIR refereed publication that publishes articles focused on the application of advanced and specialized methodologies. The articles address applying qualitative and quantitative techniques to the processes used to support higher education management.

Editor:
Dr. Gerald W. McLaughlin
Director of Planning and
Institutional Research
DePaul University
1 East Jackson, Suite 1501
Chicago, IL 60604-2216
Phone: 312/362-8403
Fax: 312/362-5918
gmclaugh@depaul.edu

Associate Editor:
Ms. Debbie Dailey
Associate Director of Planning and
Institutional Research
Georgetown University
303 Maguire Hall, 37th & O St NW
Washington, DC 20057
Phone: 202/687-7717
Fax: 202/687-3935
daileyd@georgetown.edu

Managing Editor:
Dr. Terrence R. Russell
Executive Director
Association for Institutional Research
1435 E. Piedmont Drive
Suite 211
Tallahassee, FL 32308
Phone: 850/385-4155
Fax: 850/385-5180
air@airweb2.org

Authors can submit contributions from various sources such as a Forum presentation or an individual article. The articles should be 10-15 double-spaced pages, and include an abstract and references. Reviewers will rate the quality of an article as well as indicate the appropriateness for the alternatives. For articles accepted for *IR Applications*, the author and reviewers may be asked for comments and considerations on the application of the methodologies the articles discuss.

Articles accepted for *IR Applications* will be published on the AIR Web site and will be available for download by AIR members as a PDF document. Because of the characteristics of Web-publishing, articles will be published upon availability providing members timely access to the material.

Please send manuscripts and/or inquiries regarding *IR Applications* to Dr. Gerald McLaughlin.