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# Competency-Based Educational Program Effectiveness Assessment

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**Abstract**

Colleges and Universities, like most businesses, need to regularly assess the effectiveness of their products and services. In fact, such analysis is usually required by accrediting bodies to ensure that educational institutions, and each of their departments, show continual improvement. This paper describes a competency-based approach to effectiveness assessment at the program level utilizing various feedback mechanisms. Also discussed is an approach to feedback analysis using curriculum-competency mapping that can suggest areas for program improvements. Finally, experiences in applying the competency-based assessment process for the Computer Information Systems program of a small college are described.

**Keywords:** Program assessment, competencies, curriculum evaluation, computer information systems, continual improvement

## 1. Introduction

Higher education is a business. It provides educational services to its students and provides a product, the educated student, to the job marketplace. As a business, an educational institution must be concerned about the effectiveness of its programs and the quality of its products and services (Mangan 1992). This is especially true for institutions seeking regional and other accreditation. In many ways, however, higher education is different from most businesses. It is, in some sense, like a regulatory body that specifies a series of steps (courses) that a student must successfully complete in order to obtain the right and qualification (a diploma) to participate in the job market. Courses are often loosely coordinated, their content being defined by selected textbooks and/or knowledge experts (professors) who present the courses and specify the requirements for successful completion. The fact that students achieve passing grades in courses is sometimes the only quality control mechanism in place.

The above dichotomy provides a unique challenge for higher education. How can an institution operate like a business with proper planning, coordination, and control, and yet maintain the academic freedom demanded by semi-independent professors who are responsible for its products? Faced with similar problems, elementary and secondary schools have had state mandated curriculum standards imposed on teachers. While this has not happened in higher education, there has been considerable work by scholars and researchers to define models for curriculum in specific areas. Especially important to this paper are efforts in the Information Systems arena that build a curriculum from knowledge units into suggested courses (Cougar et al. 1997).

The focus of this paper is on a coordinated, business quality control-like, approach to assessing educational program effectiveness. The approach is based on student attainment of a well-defined set of competencies (knowledge and skills) and on the ability to measure the attainment of these competencies by various feedback mechanisms in a manner that can directly suggest areas where program improvements are needed. Section 2 describes some of the current approaches used to measure program effectiveness. Section 3 then describes a competency-based assessment process that utilizes various feedback mechanisms such as surveys, projects, research papers, and examinations. The foundation of this process is a set of competencies, as mentioned previously, which have been defined to reflect the unique characteristics of an academic program and the needs of the customers that it serves.

The process of defining these competencies for the CIS Program of a small college and mapping them to the existing curriculum is then described. Once the competencies were defined for the program, the challenging process of establishing feedback mechanisms that measure the achievement of the competencies began. Having established this foundation, the next step was to implement the feedback mechanisms and utilize the results in an attempt to improve program effectiveness. An initial experiment at implementing several feedback mechanisms for the CIS Program is described and an analysis and discussion of the findings presented in Section 4. The paper concludes with summary comments, recommendations, and suggestions for further research.

## 2. Current Assessment Approaches

Assessing the academic progress of students has traditionally been the responsibility of the course instructor. Students complete various course objective-based work products such as textbook problems, papers, case analyses, projects, and examinations. Such assignments could be considered "work in process" quality control. More recently, accreditation efforts have begun to focus more on the "finished goods" level of quality assessment. Spurred by accreditation requirements, institutions have established institutional effectiveness organizations with responsibility for expanded assessment efforts. In addition, some academic programs have added a project-oriented capstone course to their curriculum in which specific assessments can be made.

Figure 1 below shows several of the feedback mechanisms that are utilized by these "end product" assessment approaches. Surveys are a big part of effectiveness evaluation. Whether from students, employers, or alumni, much data is collected by Institutional Effectiveness organizations on a regular basis.

Standardized testing by such organizations as Educational Testing Services (www.ets.org) are also widely used. This gives the added benefit of being able to benchmark an organization against its peers.

While these mechanisms do provide valuable information for analysis, it is often a matter of subjective evaluation to link their results to specific program areas for improvement. The following sections suggest an approach to strengthen these linkages.

## 3. Competency-Based Assessment

A competency is a requisite ability or quality of a student within an academic program, the achievement of which indicates the student's capability or qualification in the area of the competency. Most universities and colleges have students should possess. For the most part, however, academic programs have not formally enumerated their expected competencies (except as course descriptions) and few have actually utilized these competencies as a linkage between their curriculum and feedback assessment instruments. A notable exception to this is the competency-based approach being utilized by the Western Governors University (www.wgu.edu). Competencies may pertain to knowledge, skill, or a personal quality. Competencies may also be called behavioral objectives or learning outcomes. In any case, the attributes of a competency are its area, name, description, level of achievement required, importance, and its level of abstraction (see Table 2 below for a specific example).

Each competency should have an associated level of achievement. A simple example of levels of achievement could be beginning, intermediate, and advanced. Bloom (1956) and others (Cougar et al. 1997) have suggested more definitive taxonomies. The key point to be made about such levels is that different levels require different forms of assessment. A competency's description should follow a predefined standard to reflect its required level of achievement. The importance-attribute ranks each competency (e.g., high, medium, low). This ranking can be used later when designing feedback mechanisms and measuring achievement. The level of abstraction for a competency indicates its position on a decomposition hierarchy. The highest level in the hierarchy will generally correspond to the specific academic program that is defining the competencies. For the remainder of this paper, the discussion will focus on the CIS area.

### Establishing and Mapping Competencies

The process of defining competencies for an area can be difficult and time consuming, especially if there are many stakeholders whose consensus is required. One way to begin is for a small group, perhaps the program's curriculum committee, to develop a "strawman" for discussion and refinement. The major inputs into the development process are shown in Figure 2.

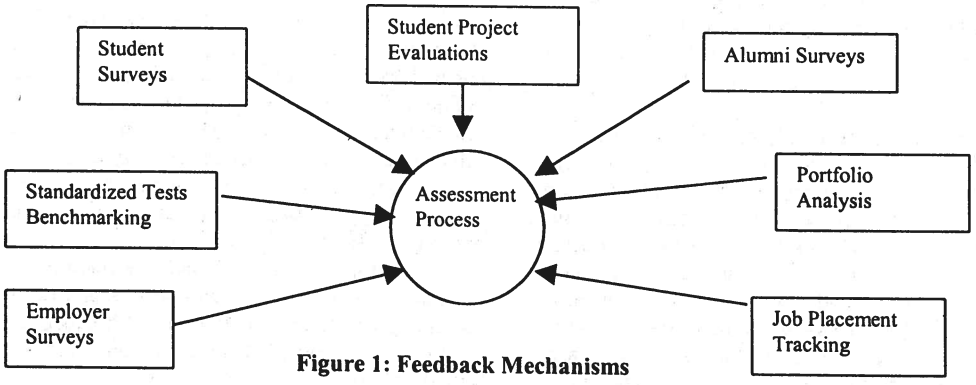


**Figure 1: Feedback Mechanisms**

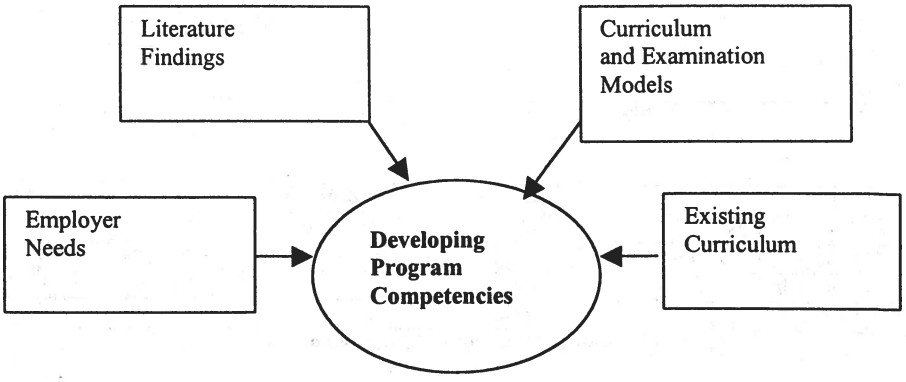


**Figure 2: Inputs to Competency Development**

| 1.0 Information Technology | 2.0 Organizational and Management Concepts | 3.0 Theory and Development of Systems |
|---|---|---|
| 1.1 Computer Architectures | 2.1 General Organization Theory | 3.1 Systems and Information Concepts |
| 1.2 Algorithms and Data Structures | 2.2 Information Systems Management | 3.2 Approaches to Systems Development |
| 1.3 Programming Languages | 2.3 Decision Theory | 3.3 Systems Development Concepts and Methodologies |
| 1.4 Operating Systems | 2.4 Organizational Behavior | 3.4 Systems Development Tools and Techniques |
| 1.5 Telecommunications | 2.7 Managing the Process of Change | 3.5 Application Planning |
| 1.6 Database | 2.8 Legal and Ethical Aspects of IS | 3.6 Risk Management |
| 1.7 Artificial Intelligence | 2.9 Professionalism | 3.7 Project Management |
| | 2.10 Interpersonal Skills | 3.8 Information and Business Analysis |
| | | 3.9 Information Systems Design |
| | | 3.10 Systems Implementation and Testing Strategies |
| | | 3.11 Systems Operation and Maintenance |
| | | 3.12 Systems Development for Specific Types of Information Systems |

**Table 1: IS Knowledge Areas and Sub Areas**

The process of developing competencies will differ from program to program. For those programs where curriculum changes have not kept pace with advances in information technology (IT), the exercise can provide opportunities for program review and possible reengineering. A thorough analysis of the current needs of local employers of program graduates is important along with a review of relevant literature. For example, VanSlyke, et al. (1998), in a skill requirements survey of central Florida IT employers, found basic technical skills and "soft skills" (e.g., writing and listening) more important that specialized technical skills. Mackowiak (1992) discussed skill requirements for various CIS positions. In a recent article, Doke and Williams (1999) studied the importance of their knowledge and skill taxonomy to CIS bachelor's degree graduates.

Probably the most extensive sources for defining competencies, however, are the knowledge hierarchies developed to support information systems (IS) curriculum models and standardized examinations. The effort to develop these models has been ongoing for many years, the most recent being the IS'97 Model (Cougar et al. 1997) and the IS2000 Model (Longenecker 1999). These models define courses in terms of learning-units that are built from knowledge units of the aforementioned knowledge hierarchies. Table 1 shows the major knowledge areas for information systems.

| Area | Abstr. Level | Name | Description | Achievement Level | Importance |
|---|---|---|---|---|---|
| CIS | 3.1 | Value of Informa-tion Systems | Describe the organizational value of information systems and list the critical success factors for obtaining value. | Beginning | High |

**Table 2: An Example Competency**

| Competency | Course | Level | Comment |
|---|---|---|---|
| 3.1 | Computer Apps. | Beginning | Value concept introduced |
| 3.1 | Business Info. Systems | Beginning | Organizational context and CSFs introduced |
| 3.1 | Business Info. Systems | Beginning | Value assessment methods introduced |
| 3.1 | Systems Analysis | Intermediate | Cost/Benefit analysis methods |

**Table 3: Example Curriculum-Competency Mapping**

Each of the knowledge sub areas is further decomposed into topics and sub topics. A somewhat differing view of the IS knowledge hierarchy can be found in the study guide for certification examinations such as the ICCP (Linkletter 1997) which forms the assessment foundation for the previously mentioned WGU's IT program.

The task, therefore, is to glean from these inputs a limited list of competencies that reflects the unique characteristics of an academic program. An example outline of such competencies for a CIS Associates Degree Program within a small college is shown in Appendix 1. Further details for one of the competencies is shown in Table 2 below. The competencies were developed with input from faculty and members of the CIS Advisory Board consisting of IT professionals in the community. The wording for each competency followed the guidelines suggested in IS'97 for the various achievement levels. Three achievement levels were chosen. These are shown in Table 4 along with their correspondence to the levels from the IS'97 document. It should be noted that these program competencies are an extension of the general, "soft-skill", competencies already established by the college.

With the program competencies established, the next step was to map each competency to the course(s) in the curriculum responsible for teaching the competency. This was accomplished by examining each course syllabus and textbook along with input provided by the faculty teaching each course. Table 3 gives an example of the mapping for the competency shown in Table 2.

The next step in the process then is to develop a set of feedback mechanisms to help measure the achievement of the competencies by the students.

**Competency Achievement Feedback Mechanisms**

Some of the feedback mechanisms currently utilized for assessing program effectiveness were discussed previously. These mechanisms do serve a useful purpose, however, unless the mechanisms have been designed to identify specific program areas needing improvement, their full potential may not be realized. The development of program competencies and associated curriculum mappings provides the opportunity to make this a reality. To make this happen, all feedback mechanisms must be defined to measure attainment of the competencies at specific levels.

As mentioned earlier, different types of feedback mechanisms are required for various competency levels. Table 4 below gives a suggested approach for the three competency levels utilized in the analysis of the CIS associates degree program.

It is clear that a single assessment mechanism will not suffice for evaluation. While examinations work well for assessing beginning competencies, more sophisticated mechanisms such as case analyses and application development projects are required for the higher achievement levels.

To implement the above process, the capstone course for the CIS associates degree program was utilized. A three-pronged approach was planned consisting of a multiple choice examination to measure level one competencies, a major case analysis to measure level two competencies, and a team-oriented application development project to measure the attainment of level three competencies. The remainder of this paper will focus on the first level, measuring the achievement of beginning level competencies by examination.

| Achievement Level | IS'97 Levels | Types of Assessment Mechanisms |
|---|---|---|
| 1 - Beginning | 1 - Awareness | Multiple choice and short answer exams |
| 2 - Intermediate | 2 - Literacy | Case analysis, Essay exams |
| 3 - Advanced | 3 - Concept / Use<br>4 - Application | Application Development Project, Research Paper, Portfolio Development |

**Table 4: Assessment Mechanisms for Competency Achievement Levels**

A multiple-choice examination was developed, in conjunction with faculty members, consisting of at least two questions for each competency. Additional questions were taken from sample certification exams found in study guides and on the Web. For example, the following questions from the exam pertain to competency 3.1 shown in Table 2:

Q1: The value of an IS to an organization depends on ___.
- a) the number of users
- b) the department served by the system
- c) the costs and benefits of the system
- d) the management level served by the system

Q2: A key Critical Success Factor for overall IS value is ___.
- a) the use of PCs by top management.
- b) end-user satisfaction
- c) a knowledgeable CIO reporting to top management
- d) the existence of numerous strategic information systems

The link from these questions to the courses mapped to the competency shown in Table 3 should be clear.

Departmental faculty members were asked to review the exam for clarity and ambiguities. The examination was then given to students as they entered the CIS program, as a pre-test, and again to students in their final semester capstone course prior to graduation. It should be noted that no coaching was given for the exam, nor were students given the opportunity to review or study specifically for the exam.

## 4. Findings and Discussion

Data from the CIS competency exams for two semesters were analyzed in an attempt to identify program areas for improvement. Eighteen pre-test students and eleven post-test students were included. The average pre-test score was 34.6% ± 8.7 and the average post-test score was 70.2% ± 9.9, showing a significant improvement of 30% on a t-test with alpha =.05. While no post-test student scored in the 90-100% range, all but one of them passed the exam.

Next, the data were analyzed to see if there were differences in the scores for the seven major competency areas. A two-factor ANOVA (alpha=.05) showed no differences between scores for the various competency areas (p=.5669), however, as expected, significant differences were found between students (p=.0098). Since all competency area results were passing scores and since there were no previous scores for benchmarking, it was concluded that no entire competency area could be singled out for improvement.

Following this, a more detailed analysis at the individual competency level was performed. This analysis focused on questions that were answered incorrectly by more than half of the students. In cases where most of the students chose the same wrong answer, it was assumed that the question needed to be improved. For the remaining frequently mis-answered questions the randomness in wrong answers suggested guessing. These questions, when traced back to their competency and course, did suggest several areas for improvement. For example, the competencies of microcomputer operating systems and networking were shown to be problem areas. Since these were both taught as part of the microcomputer hardware class with limited coverage, it was decided that a new course in computer networking was required.

One final analysis was done to see if there was a difference in the scores between the questions written by the faculty and those selected from more standardized certification exams. A t-test showed that the faculty composed questions had a significantly (alpha=.05) greater mean (74.1% ± 11.4) than those taken from the certification exams (62.6% ± 12.4).

Admittedly this analysis is only one step in the process of competency-based program evaluation. Similar analysis needs to be performed on the results of the student cases and projects as well as the other feedback mechanisms used by the program and the college.

## 5. Conclusion and Recommendations

This paper has described an approach to educational program effectiveness assessment. The research is specifically important to university departments, faculty, and program chairs seeking an approach to continual program improvements as part of their yearly planning cycle and for accreditation reviews. The main message of the work is that feedback mechanisms such as surveys, case, project and portfolio evaluations, and exit examinations need to be designed to measure the attainment of a set of program competencies that in turn are linked to the program's curriculum. A specific example utilizing a competency-based exit examination for the CIS Associates Degree Program of a small college was given. Results of the exam were statistically analyzed and the curriculum-competency mappings utilized to suggest program areas needing improvement.

The main recommendations to be gleaned from the paper are to:

1. Develop a list of student competencies, at specific levels of attainment, that reflect the goals of your program.
2. Develop a set of curriculum-competency mappings that link each competency to a course or a specific course unit in your program.
3. Develop a variety of feedback mechanism designed to measure the attainment of the program competencies. Different forms of feedback mechanisms are required for the various levels of competency achievement.
4. Analyze the results of the feedback mechanisms in the context of the curriculum-competency mappings to identify areas of the curriculum that could be improved.
5. Modify the curriculum in the areas suggested by the analysis and begin the cycle again.

As with any such exploratory work, numerous areas for further research are suggested. One area would be for the academic community to develop a set of questions based on

the knowledge areas of the IS'97 guidelines. Longenecker et al. (1999) suggest the beginning of such an effort. This would give the added benefit of standardization and validation while at the same time maintaining the program uniqueness suggested in this paper. In addition to this work on competency-based examinations, further research is required in the areas of competency-based surveys and competency-based evaluations of student projects, case analyses, and research papers. Finally, ways of making such competency-based assessments a part of the culture of an educational institution also need to be studied.

## 6. Appendix A: Example Competencies for a CIS Associates Degree Program

1. Computer Applications
   - 1.1 Word Processing
   - 1.2 Spreadsheets
   - 1.3 Database Management
   - 1.4 Presentation Graphics
   - 1.5 Internet & E-mail
   - 1.6 Desktop Publishing
2. Human and Organizational Frameworks
   - 2.1 Business Environment
   - 2.2 Management
   - 2.3 Project management
   - 2.4 Interpersonal Communication
   - 2.5 Professional Issues
3. Business Information Systems
   - 3.1 Value of Information Systems
   - 3.2 Business Applications
   - 3.3 Management Applications
   - 3.4 Business Information Systems Environment
4. Data Management
   - 4.1 Data Management Functions
   - 4.2 Data Analysis
   - 4.3 Database Design
   - 4.4 Database Management Systems
   - 4.5 Structure Query Language (SQL)
5. Microcomputers
   - 5.1 Architecture
   - 5.2 Operating Systems
   - 5.3 Troubleshooting
   - 5.4 Networking
6. Systems Development
   - 6.1 Life Cycle
   - 6.2 Systems Analysis
   - 6.3 Systems Design
   - 6.4 Systems Implementation
7. Visual Basic Programming
   - 7.1 VB Programming Interface
   - 7.2 User Interface Development
   - 7.3 Programming Process
   - 7.4 VB language

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## Author's Biography

**David W. Johnson** has an undergraduate degree in education and received his Ph.D in Information Systems from The University of Michigan. He has 25 years of industry experience and has been in academia for the past several years. He is currently a Visiting Professor at Florida Gulf Coast University. Prior to this he was the CIS Program Chair at International College. He is the co-founder and current president of the SW Florida Chapter of AITP. He can be reached at djohnson@fgcu.edu.


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