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An Improved Database System for Program Assessment

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Abstract

This research paper presents a database management system for tracking course assessment data and reporting related outcomes for program assessment. It improves on a database system previously presented by the authors and in use for two years. The database system presented is specific to assessment for ABET (Accreditation Board for Engineering and Technology) accreditation effort of a CIS (Computer Information Systems) department, but could be easily adapted to any program assessment. The relevance of tracking course assessment data and its role in reporting the outcomes for assessment is discussed. Issues of consistency, efficiency, flexibility, and reusability are discussed and sample data and reports are presented. This paper concludes with a discussion of the merits of the database management system as a tool in program assessment.

Keywords: program assessment, ABET accreditation, course assessment, database system

1. INTRODUCTION

Program assessment has become one of the highest priorities in higher education and a key component of accreditation efforts for any academic program. Program review and accreditation efforts for organizations such as ABET and AACSB require the tracking of data from

such sources as questionnaires from alumni and feedback from advisory boards. Another key ingredient for assessing program outcomes is the performance of students in the required coursework in the program. Outcomes of any

instrument used to evaluate student performance, such as homework, projects, presentations, course exams, and national exams, can be used for course or program assessment. Course objectives can be evaluated using objective measures and this data can be aggregated to assess the program outcomes. To support the gathering and analysis of this data, a relational database was designed and implemented in Microsoft Access. This paper describes the mapping of course learning objectives for a CIS department's courses to both the program outcomes and ABET outcomes, the development of a relational

database to support the assessment of courses, and an ongoing evolution of that database system.

2. LITERATURE REVIEW

A review of the literature shows that while there is a wealth of research on the general topic of program assessment, there has been a relatively limited number of efforts to develop tools and software to help streamline the time-consuming and burdensome process of data collection and analysis for program assessment.

Spurlin reports on the development of a database for collection and analysis of data of an engineering program for ABET accreditation (Spurlin, Rajala, Lavelle, & Hoskins, 2002). However, it is not clear if the system allows for easy input of data from exams and projects and easy generation of assessment reports. Harding (2005) reports on the development of a prototype web-based assessment system for an ABET accredited engineering program. The author indicates that the student developed prototype had a number of problems but provides a good base to build upon.

Poger describes a web-based system developed for online evaluation of courses for a Computer Science department (Poger, Kamari, Chuah, & Ricardo, 2005). The system is used to compile data from student prerequisite skills surveys, course objective student surveys, faculty course objectives assessment, and student exit surveys.

Booth proposes a database template that, among other things, provides a mechanism to map program outcomes and course objectives to ABET outcomes (Booth, Preston, & Qu, 2007a). Booth also proposes requiring students to submit assignments via the Web and a method for extracting assessment metadata from these assignments. Booth presents a prototype of the implementation of the template in a second paper (Booth, Preston, & Qu, 2007b).

Urban-Lurain proposes a database system that includes a newly defined extensible Educational Metadata Language- EdML(Urban-Lurain, Ebert-May, Momsen, McFall, Jones, Leinfelder, & Sticklen, 2009). EdML enables assessments to be tagged based on taxonomies, psychometrics, and other data to facilitate analysis.

Segall presents a database driven system for IS Curriculum Assessment using the national ISA exam (Segall, Ghosh, & Morrell, 2009). The system provides for two-step mapping from ISA exam questions to course objectives via the 2002 IS Model curriculum Learning Units (LU).

Essa (2010) proposes the ABET Course Assessment Tool (ACAT) as his Masters thesis. ACAT is a web-based tool that allows Faculty to input assessment data and generate a report in pdf format. This work appears to take a similar approach to the database design taken by Morrell (Morrell, Morris, & Haga, 2009).

3. BACKGROUND

The CIS Department faculty at Metropolitan State College of Denver debated for months before finally agreeing on a set of program outcomes prior to the initial pursuit of ABET accreditation. The final result was a set of 10 program outcomes, which are listed in Table 1. Subsequently, many additional months were spent mapping: 1) CIS course learning objectives to these CIS Department outcomes; and 2) CIS course learning objectives to the 10 ABET outcomes. The ABET outcomes are listed in Table 2.

This work was performed by a CIS Department taskforce. During these meetings, a faculty member came up with the idea of developing a database management system to record and analyze assessment data for courses. A collaborative process lead to the design of this relational database.

The goals for this database design were as follows:

a) The design must be sufficiently flexible to allow tracking of any instrument used in evaluating students while allowing the faculty to determine the scale and level of the items measured.

b) The design must provide for a control of consistency of the data captured.

c) The design must provide a mechanism for mapping the course evaluations to program and ABET outcomes.

d) The design must be portable and reusable for subsequent accrediting efforts.

e) The data entry for the system must be sufficiently utilitarian to be acceptable by faculty and staff.

4. DBMS DEVELOPMENT

Initial Database Design and Implementation

The initial database design was previously presented by Morrell at the Northeast American Society of Engineering Education (Morrell, 2009).

The Entity Relationship Diagram (ERD) for the improved database design is shown in Figure 1*.* The database entities are explained in Table 3. Looking at the design we can see the tables that relate to the two mapping processes described above. The mapping of CIS course objectives to the CIS Program Outcomes is handled by the *CourseObjective*, *Po_Co*, and *Program_Outcomes* tables. The mapping of CIS course objectives to the ABET Outcomes is addressed by the *Course_Objective*, *Ao_Co*, and *Abet_Outcomes* tables. The basic *Course*, *Faculty*, and *Class* data was imported from the college scheduling system.

The assessment instruments, such as exams, quizzes, assignments, and projects were entered into the Eval_Instrument table. To facilitate access for faculty and staff, the database is stored on a network shared folder. Faculty have access to this folder and the Information Technology department configured access for an administrative assistant. Faculty can enter the data themselves or record the data on a paper form. The data from the latter can then be entered by an administrative assistant.

After the assessment instruments are entered, faculty can enter evaluation items for each instrument. In terms of tracking students' success, a faculty member can choose one multiple choice question, a group of multiple choice questions, a short answer question, a whole project or part of one. In other words, the faculty member has total control over the granularity they use.

Before any data is captured the Department must set up guidelines for entering the results of any item on any instrument. An example would be the *countright* attribute in the database – see Figure 1. If the instrument is an exam and the item is a subjective question, then the department must decide what "*countright*" means. The department agreed that a passing grade means that the student scored a seventy percent on that item. For multiple choice questions, the determination of passing is clear,

but for subjective items, the seventy percent measure is used.

The class entity includes time attributes, which will allow for periodic review, analysis, and comparisons over any number of semesters/years. The database could also be easily modified to track curriculum changes and their effect on student outcome scores.

Sample Database Form and Report

A data entry form (see Figure 2) is used to facilitate data entry of the detailed assessment data. It also promotes consistency and accuracy.

This form allows users to enter assessment data for each evaluation item (e.g. question 11) for each evaluation instrument (e.g. an exam). Therefore this form corresponds to the Eval_Instrument and Eval_Outcome tables (see Figure 1). The user first selects a class ID (CRN) from a drop-down box and information about this class is displayed so the user knows they are entering data for the correct class. They then enter the data for exams/projects as well as how many students were successful on the chosen questions.

The data entry form emphasizes the granularity possible with this design. Looking at the bottom part of the form a faculty member can enter an Eval_ID of *E1* for Exam 1 and then enter every question on that exam as an evaluation item. Entering each question as an evaluation item would only make sense if these questions can be mapped to the course and ABET objectives. Alternatively they could group five questions that pertain to one course objective and enter this as one row in the form.

The *CIS Assessment Data by ABET Outcomes* report (see Figure 3) displays the detailed assessment data grouped by ABET outcomes a–h. Each outcome has a list of all courses, evaluation instruments, as well as the success rate for each evaluation item that pertains to that outcome. The *Percent* column indicates the percentage of students in a class who got a question correct.

Second Database Design and Implementation

The initial database system was used for one year and the information generated was used in the creation of the Self-Study report for ABET accreditation. After having had a year's

experience with the database management system, faculty expressed a few concerns:

  a) Regardless of whether an assessment item was a multiple choice question, an essay question, a minor homework assignment, or even a major project there was no way to "weight" the item – so for example a multiple choice questions was being counted as equal to a major project.

  b) There was no distinction between a lower level objective such as "Identify the components of a LAN" and a higher level objective such as design a LAN/WAN network.

  c) Faculty had trouble remembering what the assessment items were when reviewing reports later.

This lead to the following modifications to the database:

Weight is added to the Eval_Outcome table. This allows a professor to distinguish between the various types of exam questions (true/false, multiple choice, fill-in the blank, short answer, essay, program, coding, design problems, etc) and the various types of homework assignments (research papers, programming assignments, minor projects, major projects, etc). For example in the case of a database course, it is clear that a multiple choice question on an exam should not be weighted the same as a problem that requires students to create an ERD from a set of several business rules. The ERD should have a much higher weight than the multiple choice question when it comes to determining if the course objective, and therefore a program outcome, is met. An example of weighting for such a class, a multiple choice question could be assigned a weight of 1, a short answer question a weight of 3, and ERD a weight of 5 and a major project a weight of 10.

BloomLevel is added to both the Course_Objective and Eval_Outcome tables. When developing/modifying course learning objectives, faculty frequently use the Bloom levels. In fact, the college-wide Curriculum Committee for this college checks these objectives using Bloom levels. Adding the attribute to the Eval_Outcome table allows faculty to match evaluation items with the learning objectives in the course syllabus. It could also be used by the course coordinator and/or curriculum committee when reviewing

assessment to identify possible problem areas (i.e. Faculty trying to measure higher level objectives with all multiple choice questions).

ItemType is added to the Eval_Outcome table. It allows faculty to indicate the type of evaluations item, such as multiple choice question, short answer question, assignment, etc. This is helpful when reviewing the assessment data at the end of a semester.

ItemDesc is added to the Eval_Outcome table. It allows faculty to indicate the concept/skill covered by the evaluations item. Using the database class example again, while *ItemType* could indicate a multiple choice question, *ItemDesc* for example could tell us that it was a question related to foreign keys. This is helpful when reviewing the assessment data at the end of a semester. Otherwise the faculty member has to go back to the evaluation instrument, say an exam, and find the question to which this item pertains.

5. DISCUSSION

The initial database design in this paper was adopted by the authors' CIS Department and has now been used for 4 semesters.

Dr. Janos Fustos, Chair of the department's ABET committee, provides the following evaluation of the database system:

> Being charged to coordinate the CIS program's ABET activities, I appreciate your work that provides us with this important tool. As accreditation agencies have moved to an outcome oriented program assessment it is vital for us to have a data source that records all the assessment activities and data that we can use to evaluate how far our program meets the aimed goals and criteria proposed by accreditation requirements. The database system that you've created allows us to capture the necessary data, generate reports at different granularity levels, and supports all of our documentation requirements including course revisions, curriculum modifications, annual analysis, regional and professional accreditation, and periodical program reviews.

Course coordinators are required to, and responsible for, entering assessment data for their courses in the database each semester. The database system and its results, along with specific ways the system help to improve courses, was presented to the ABET Visiting Team in the Fall of 2009. The team responded

with very positive feedback. In addition, other departments seeking accreditation at the college have expressed a desire to have access to the database system. The reaccreditation process was successful. In fact, the department received an Assessment Achievement Award for its diligence in identifying course-embedded sources of evidence, articulating targets for student scores on program outcomes data, and engagement of the faculty. The award was accompanied by a monetary prize. Therefore the authors believe this bottom-up approach of assessing student performance in CIS courses played an important role in successful reaccreditation. This information was used in the creation of the ABET Self-Study Report. However, the system is much more flexible and adaptable than just this particular application. Indeed these are key characteristics of the design. The system could be used not just for ABET accreditation but also any other academic accreditation effort such as AACSB. In addition it could be used by any non-academic organization that captures numeric data for assessment

Another strength of the design is that the expert, say a course coordinator, is in control of the chosen granularity. They can choose whether they want to track individual multiple choice questions, a group of multiple choice questions, a complete project, or a part thereof. In addition to the choice of granularity, an organization can choose which attributes to use. For example, they could initially choose to ignore *Weight* and *BloomLevel*. If necessary they could start capturing these items in later time periods. This flexibility reduces the barriers for the adoption and use of an assessment tracking system.

The organization also decides how to handle such issues as what percentage constitutes passing a subjective evaluation item such as a short answer question. This department uses greater than or equal to 70% as a passing score and then counts the number of students that got this score. Another organization could choose a different value.

How can the information from the generated reports be used? An example from a LAN/WAN class illustrates the potential. The faculty member noted from the reports that students answered a question about routing and autonomous systems poorly. More emphasis was given to this material in the following semester with a resulting improvement in

student results. Thus one key application of the system is to identify weaknesses in the coverage of the subject matter and to be able to address these issues in subsequent semesters.

Another example of the use of the information captured by the system is the identification of anomalies. For example, a course may have a certain Bloom level but there are no evaluation items at this Bloom's level. The department could then evaluate how to improve assessing the students in this course. This illustrates the potential of the system to be used for addressing continuous improvement.

In conclusion, the database design allows the tracking of course results at any level of granularity. If a department is in doubt about the level of detail required, the database can store all the items of all instruments used to determine course or program results. This is important to programs that undergo accrediting for multiple agencies such as ABET and AACSB. The mantra for this system is "If the data is sufficiently captured and organized, any reporting requirement on program results can be met". Hence the Department must invest the time and effort in developing the requirements for collecting the data.

6. SUMMARY AND cONCLUSION

Program assessment is now one of the highest priorities in higher education and has a vital role in program accreditation. Course assessment, which is an important focus in program assessment, is centered on collecting and reporting data related to course outcomes. Although there are various approaches to the latter task, this paper presents a system which is DBMS centered to accomplish this task. The system described in this paper is one that addresses the issues of consistency, flexibility, reliability, and reusability. The discussions above make a case that the system is technically and operationally feasible and that it meets criteria developed by the department for program assessment. The discussion of the evolution of the systems reveals the critical element of involvement of program constituents and the flexibility and utility of the system. Although the system was developed for a specific program for accreditation, it has the potential to be used by any similar organization (program or department) undergoing assessment for any purpose such as accreditation by agencies including ABET or AACSB. While the system is designed to be used primarily for tracking class assessment

data, it can be modified or adopted for tracking any quantitative metric used in assessment of an organization by an agency. The overall goal of such a system is to simplify, standardize, and organize the capture of data to provide a rich repository to support current and future assessment efforts. The system described in this paper meets that goal.

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Appendix

Table 1 - CIS Program Outcomes

The program enables students to achieve (by the time of graduation) the following outcomes within the framework of professionally accepted Information Systems practices:

SO1:	Knowledge of basic information systems theory and concepts and the skills to apply this knowledge to the functional areas of business
SO2:	Knowledge of project management tools and techniques as they apply to Information Systems projects
SO3:	Knowledge of programming processes including planning, writing, testing, executing and debugging
SO4:	Knowledge of database design, development and management
SO5:	Knowledge of telecommunications and networking systems
SO6:	Knowledge of web-based systems
SO7:	Knowledge of operating systems
SO8:	Knowledge of how to create and utilize team approaches to problem solving
SO9:	Advanced knowledge in an IS area
SO10:	Ability to support the delivery and management of information systems

Table 2 - ABET Outcomes

The program enables students to achieve, by the time of graduation:

:	An ability to apply knowledge of computing and mathematics appropriate to the discipline;
:	An ability to analyze a problem, and identify and define the computing requirements appropriate to its solution;
:	An ability to design, implement and evaluate a computer-based system, process, component, or program to meet desired needs;
:	An ability to function effectively on teams to accomplish a common goal;
:	An understanding of professional, ethical, legal, security, and social issues and responsibilities;
:	An ability to communicate effectively with a range of audiences;
:	An ability to analyze the local and global impact of computing on individuals, organizations and society;
:	Recognition of the need for, and an ability to engage in, continuing professional development;
:	An ability to use current techniques, skills, and tools necessary for computing practices.
:	An understanding of processes that support the delivery and management of information systems within a specific application environment.

Figure 1 – Database Design
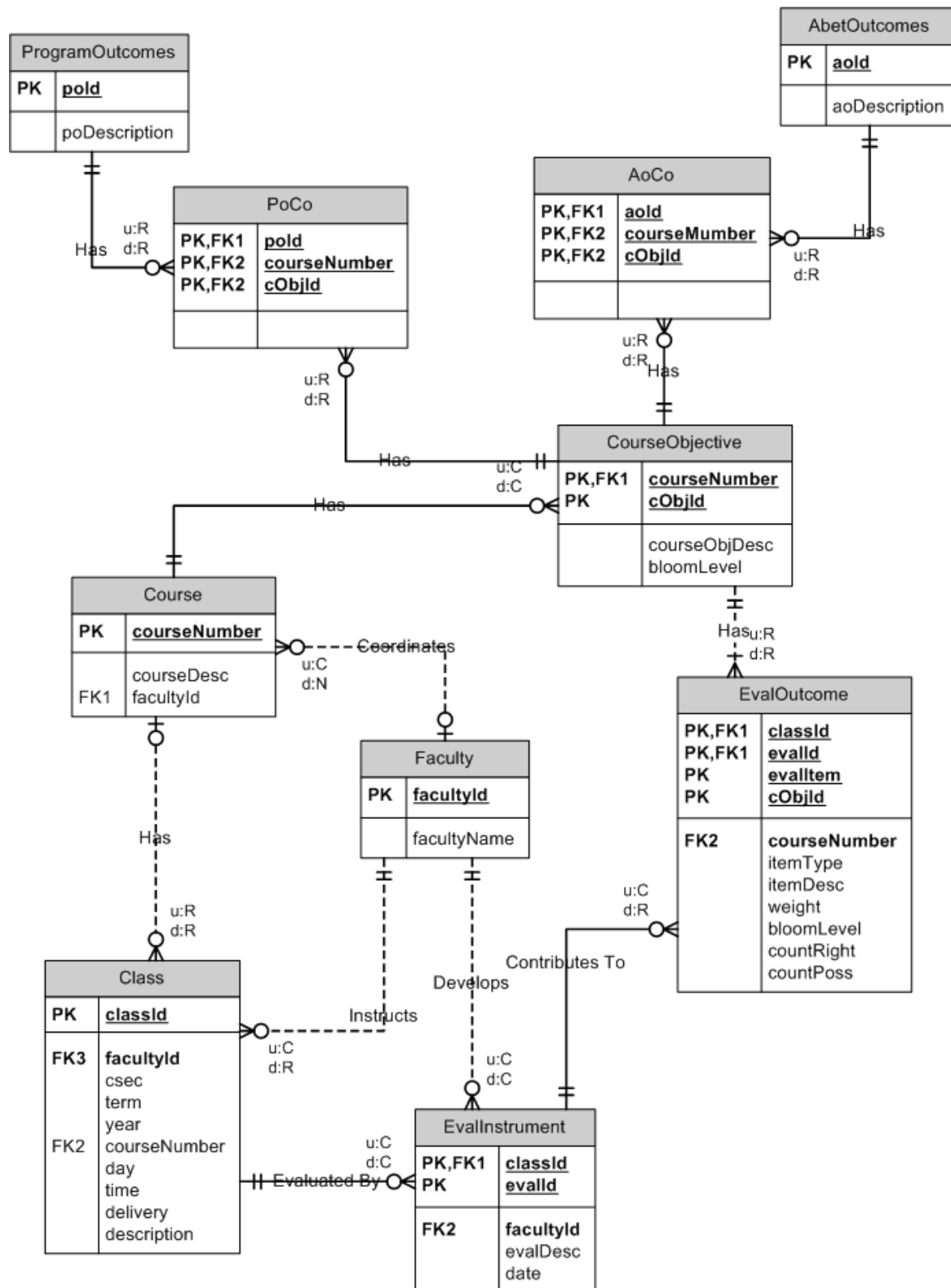
Table 3 – Database Entities

Entities	Description
ABET_OUTCOMES	All ABET outcomes.
AO_CO	Maps course objectives to ABET outcomes.
CLASS	Specific information for a given section offering of a course
COURSE	General information about each Course
COURSE_OBJECTIVE	All course objectives for a course
EVAL_OUTCOME	Individual items from a specific evaluation instrument
EVALUATION_INSTRUMENT	General information about a specific assessment
FACULTY	General information about the faculty member.
PO_CO	Maps course objectives to program outcomes.
PROGRAM_OUTCOMES	All program outcomes for the CIS degree.

Figure 2 – Data Entry Form

Figure 3 – Reporting Assessment Data by ABET Outcome

			CIS Assessment Data by ABET Outcomes		
ABET Outcome	Course Number	Course Objective #	Course Objective	Evaluation Item	Percent
a	An ability to apply knowledge of computing and mathematics appropriate to the discipline;				
	3030	6	Search for and use Web development resources	Discuss2	75.00%
	3030	6	Search for and use Web development resources	Topic2	80.00%
	3030	6	Search for and use Web development resources	Topic1	85.00%
	3030	6	Search for and use Web development resources	Search	90.00%
b	An ability to analyze a problem, and identify and define the computing requirements appropriate to its solution;				
	3030	2	Develop Web site specifications for any kind of Web site from a set of requirements	q39	94.74%
	3030	2	Develop Web site specifications for any kind of Web site from a set of requirements	q15	95.00%
	3030	2	Develop Web site specifications for any kind of Web site from a set of requirements	q50	100.00%
	3030	2	Develop Web site specifications for any kind of Web site from a set of requirements	q49	94.74%
	3030	2	Develop Web site specifications for any kind of Web site from a set of	q48	84.21%