

AC 2009-1803: INTEGRATION OF ASSESSMENT AND CURRICULUM IN ENGINEERING, MATHEMATICS, AND PHYSICAL-SCIENCE PROGRAMS

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Integration of Assessment and Curriculum in Engineering, Mathematics and Physical Science Programs

Abstract

The development of the curriculum of a program normally includes academic considerations that promote knowledge acquisition of the student. In this paper the authors discuss how the Engineering, Mathematics and Physical Science programs at Texas A&M International University are also incorporating assessment tools to design specific target courses in their curriculum. The development of such strategy has followed a process that has involved all faculty members in the related disciplines. Every program has five outcomes, of which three are common to all programs. The department is also targeting specific courses in its programs to measure these outcomes, and is using the results of this assessment to rethink the way a course is being offered. This paper presents some results.

Introduction

In past years, academic choices were mostly dictated by purely academic considerations. Today that is not the case. Universities are paying more and more attention to assessment as part of the considerations that are taken into account when making academic decisions^{1,3}.

The Department of Mathematical and Physical Sciences at Texas A&M International University decided to begin a process in which assessment tools would be used to think and rethink the way courses are implemented. The department offered at the time this process began six major degrees, five of them in Mathematics (a Bachelor of Arts, a Bachelor of Science, as well as two teaching certificate degrees for 4th to 8th grade and from 8th to 12th grade, and a Master of Science in Mathematics), and one Bachelor of Arts with a Major in Physical Science. In summer 2008 the Bachelor of Science with a major in Systems Engineering degree was approved. Even though the main driving force of the department has been Mathematics, Engineering is emerging as the new driving force in the department.

This paper describes the process since its beginning in 2007, when the department hired a new chair. Since then the department has revised its Mission and Vision statements, agreed on Program Outcomes for all of its degrees, added Student Learning Outcomes to all syllabi, and used the assessment cycle to improve its programs. These jobs have been undertaken by the Assessment Committee of the department. The committee is composed by five members: one from Engineering, one from physics and three from Mathematics.

Beginning the Process: The Mission and Vision Statements

The beginning of this process dates back to 2007, when the University hired a new chair for the Department of Mathematical and Physical Sciences. One of the first tasks that the new chair assigned to the Assessment Committee was to revise the Mission and Vision statements that are displayed in our web page². The version that existed at the time did not include all fields represented in the teaching and research of the department. For example, neither Engineering nor Computer Science were mentioned in the statement. Other fields, with the exception of Mathematics, were included under the umbrella of being *physical sciences*. This label, however, was not enough to include the emerging Engineering discipline in the department. As a result the Mission and Vision statements of the department were rewritten to include Engineering and other disciplines explicitly.

The process of revising the Mission and Vision statements itself was short. It took about two meetings in

two weeks, and a few e-mail exchanges, for faculty to agree on their new *job description*. The Assessment Committee started the process by modifying the document to include all disciplines in the department. Most faculty did not feel comfortable in modifying the document past that, because they felt that the current Mission and Vision Statements already reflected well the current activities in the Department. The activities, as listed in the Mission statement, are very generic, and therefore are easy for faculty to agree on.

Developing Program Outcomes

During the spring semester of 2008, University Administration required departments to develop program outcomes. This would be general objectives for each program that would be assessed each year. This represents a paradigm shift in assessment, since in previous cycles, assessed outcomes were directly linked to the university strategic plan, and now assessed outcomes are linked to the needs of a program. Each program must develop a list of three to five program outcomes and choose one to three of these, to be assessed each year. At the time of this task the department offered six degree programs, so potentially there could be thirty program outcomes and eighteen of them to be assessed each year. Therefore, in order to simplify the job of assessing program outcomes, the Assessment Committee decided that all programs in the department would have at least three common outcomes.

In order to start the process, the Assessment Committee created a list of outcomes that would be proposed as the starting point of the discussion. Giving this list is important since it speeds the process, creates less confusion among faculty about what is required and helps faculty to brainstorm new ideas.

The meeting to decide what the program outcomes would be occurred during a University retreat on a Friday afternoon. It began with a presentation by the Department chair, who explained in detail how program outcomes fit into the bigger picture of program design. The decision that the first three outcomes would be common to all programs, had the positive effect of engaging all faculty in the discussion, but it also meant that many of them questioned the presence, or use of specific words in the writing of each outcome.

Although the main point of discussion was program outcomes, many faculty members turned the discussion into the problem of assessing the proposed outcome. The result was that some faculty opposed desirable outcomes for a program, fearing that assessment for that outcome would be either too complex or simply impossible. A specific example was a discussion about if students graduating with a Mathematics degree should have a working knowledge of software tools. In this instance, the issue under discussion was not if this was an important issue, but if the department was able or ready to do this. It was explained that the main consideration was not what the department could do at the time, but if faculty agreed that this was an important outcome for a program. If faculty agreed, then the department would find a way to implement it, which includes redesigning courses, training faculty or adding supplies to a computer lab.

The adopted common outcomes were

- Outcome 1:* Students will be able to communicate effectively in written and oral forms, work successfully in teams, and understand ethical responsibilities.
- Outcome 2:* Students will be able to think critically and be prepared for life-long learning.
- Outcome 3:* Students will be able to continue graduate studies in their current major or related field.

One interesting aspect of the first outcome is that it mentions ethics. For engineers this is just part of their discipline, but for Mathematicians, this is not so. Ethical aspects are never touched in Mathematics since the ethics is very clear: if you can not prove your result, it is not accepted. However, there are many more

aspects to ethics other than developing theories, like exchanging favors, not reviewing papers promptly, etc. Most mathematicians do not talk about the ethical aspects of their discipline and many were surprised to see that a sentence like this would be included in the list of outcomes.

Other program outcomes were specifically designed to emphasize differences between outcomes of different programs in the department. Teaching certificate programs have different outcomes than a Bachelor of Science or a Bachelor of Arts program. These differences were taken into consideration in outcomes four and five of each program.

Unfortunately, one meeting was not enough to conclude the discussion, which continued the following week, after the Assessment Committee summarized the input from faculty. The next meeting, a week later, started where the first one ended. By that time, most of the ideas discussed in the first meeting had already been absorbed by faculty and the discussion flowed more easily, without much opposition or discussion of new ideas. After the second meeting the Assessment Committee had the task to summarize all the input and create a document that gathered all agreements reached there. The new documents were sent to the faculty, who were given a new opportunity to give feedback on it. A few more minor suggestions were sent by them, which the Assessment Committee considered to produce the final version. These documents were uploaded to the web page of department and are accessible to everyone.



Fig. 1. Department Chair introduces the topics.



Fig. 2. Chair of Assessment committee leads the discussion.



Fig. 3. Department faculty discuss program outcomes during the retreat.

University Assessment

The Assessment process at TAMIU is annual. Departments fill an Annual Institutional Effectiveness Review (AIER) report each year to report their assessment results. As explained before, departments pick the program outcomes to be assessed each year. During the fall semester of 2008 the department decided to pick outcome 1 (see the *Developing Program Outcomes* section for a list of outcomes) to assess our undergraduate degrees in Mathematics. This was due to the fact that there is a course that could be used to collect all the information that was needed. The department had created a course called “Communication in Mathematics”, which is used to teach students technical writing in Mathematics at the sophomore level. This course is the perfect setting for the assessment of the writing and speaking outcomes. Originally, this course was designed to concentrate on technical writing skills, however, the Assessment Committee decided to request the instructor of the course to ask students in that course to give an oral presentation and write a paper on ethics in their major. A rubric was developed for assessing the oral presentation. The written technical paper would be evaluated using a rubric developed by the university to assess the writing outcome for graduating seniors, while the paper on ethics would be evaluated by the instructor, as part of the course. The instructor of the course graciously agreed to all the requests of the committee, and assessment was conducted at the end of fall 2008.

In order for programs to be successful in their assessment of Outcome 1, 100% of the students in each major must reach a specific benchmark, determined by the committee. Of course this is not realistic; if one student in each major fails to reach the benchmark, in any of the above categories, then the department fails to reach its program goal. On the other hand, this shows that the department takes this outcome seriously, and thinks that this is such an important part of the student preparation that it wants all of them to succeed.

The result of the assessment was not very encouraging. At the technical writing level, no student reached the level of mastery that was required by the committee. The Assessment Committee believes that this was due to the fact that it evaluated a paper that was not checked by anyone else before it was turned in. That is, the faculty member teaching the course did not provide feedback on the paper that would have helped the student improve their exposition, before it was graded. On the other hand, and although this was not part of the evaluation, the committee felt that students needed more practice to communicate in writing. The committee thought that students had not reached a point where they could communicate even at a non-technical level, so the expectation of them being able to communicate at a technical writing level was excessive at this point. Because of these observations, the committee is recommending that instructors who teach the course provide feedback on the paper, before it is submitted for a grade. It was also recommended that students be required to take their papers for revision to the *Writing Center*, for checking grammar, prior to turning any paper. This recommendation will give students a more personalized instruction in the matter of writing. Finally, it was remarked that the use of a rubric designed for seniors, may not be appropriate for a sophomore class, and the committee feels that a different rubric may be used next time papers be evaluated in that course.

In regards to speaking, students gave a presentation, which was evaluated by part of the Assessment Committee. In this case, students gave a ten minute presentation, which included the possibility of asking questions at the end of the talk. Most students did not know how to give a presentation, and the average score of the presentations fell below the expected passing grade. The committee recommended in this case that students gave a practice presentation before their official one. The practice presentation will only be evaluated by the professor teaching the course as well as students in the class, as a way to provide feedback before the real presentation is made.

Finally, in regards to the paper on ethics, students were assigned to read a paper on ethics and look for another one that matches their major. In this case, students that were given a sample paper from their

discipline obtained better scores than those who were not. The committee recommended in this case that students be provided with a sample paper related to their major, and be asked to find a second one by themselves.

These examples illustrate one principle, in which assessment has an important input on academic programs. Of course faculty can find all of these matters by themselves, and they can modify their teaching techniques without the need to have a committee evaluate their course, but in this case the assessment committee has completed a job that will be useful for *anyone* teaching this course in the future. The assessment cycle has been completed and all that remains to be done now is to wait for the next assessment cycle to see the result of these recommendations.

Another component of the assessment is the analysis of the results that students obtain in the TexES exam. This exam is mandatory in Texas for any person that wants to teach at the middle or high school level. While in one major the department accomplished the benchmark, in order to guarantee a better performance, or at least maintain the level of performance of students in this major, the Assessment Committee will revise the curriculum so it understands better the relationship between the contents of the exam and the content of the required courses for this exam. Also, in order to help students prepare for the exam, the department agreed to add some activities to a capstone course that graduating students must take.

Once the results of the year 2008 assessment cycle were known, they were shared with the faculty, and their input was sought. The Assessment Committee gave recommendations on all areas, good or bad, which were shared with the faculty, who were requested to share their input too. Any input gathered from the faculty was considered and added, when appropriate, to the report. Faculty had an opportunity to see the AIER report twice, once with the recommendations of the Assessment Committee, and a second time with the corrections and suggestions from the faculty. The second version was chosen as the final version and was submitted to the University Administration as the report of the Department Assessment.

Student Learning Outcomes

The program goals that were written in the spring 2008 semester were also used as the basis of learning outcomes at the course level. In order to support the program outcomes, faculty needed to work in developing student learning outcomes for each course. The main difference between a Student Learning Outcome and a program outcome is that the former emphasizes the activity that is done, rather than the content that is taught. An example of a learning outcome in a business mathematics course could be “Students will apply derivatives to find the maximum profit”, while a program outcome could be “students will have a working understanding of Calculus”. This is an example of a program outcome, which is being supported, at the course level, by studying maximization or minimization problems in the context of business applications.

The main problem in this case has been that faculty members do not understand that for purposes of learning outcomes the activity plays a much more important role than the program outcome. This is a paradigm shift that many find hard to do. Faculty members were given a list of verbs that would be appropriate to use when constructing sentences that describe the learning outcomes for that course. This list follows Bloom's Taxonomy of knowledge. Each faculty must decide what level of knowledge will be required from the student in a course, and choose from the list of verbs, one that would capture the expected level of knowledge required in that course.

Once faculty submitted their syllabi to the Department chair, they were sent to the Assessment Committee for review. The review was quick, and it was done in a relaxed atmosphere. It did not take long for members of the committee to understand what to look for in a syllabus to figure out how far (or close) from the guidelines the outcomes were written. We hope this also provided training for all its members

that will result in a faster and better job the next time the committee has to go through this review. It was also noted during the meeting that it was very useful to have the faculty that wrote the syllabus to be part of the meeting, since that communication provided clarification of the intent of the faculty when writing the syllabus, and so the committee would be able to provide a more effective feedback to that faculty, which could only result in a better syllabus.

The comments made by the committee were distributed to faculty, and each faculty was in charge of revising their syllabi according to these recommendations and resubmit revised syllabi. After syllabi were resubmitted, they were reviewed again by the Assessment Committee, which produced a document that contained all syllabus and its recommendations. In most cases, there were no further recommendations. In cases where there were further recommendations, the Assessment Committee recognized that its job is to guide faculty to become better outcome writers, not to argue with anyone in particular about the particular choice of outcomes or verbs to express them. Therefore, it was decided that a forum, with the participation of all faculty, would be the appropriate means of deciding the final form of the outcomes. Copies of the document produced by the committee were shared with all faculty members several days in advance of the forum. This document included a copy of the program goals, and an appropriate list of verbs for each category in Bloom's Taxonomy.

During the forum, faculty received feedback from the Assessment Committee as to why some outcomes still needed to be improved, and most issues were resolved this way. There are a few cases where the Assessment Committee will have to work harder to complete its task (either by working directly with each faculty, or by opening the proposal of outcomes for a single course to all faculty members). Given that most cases have already been solved, it is expected that this process will be over at the end of spring 2009.

Conclusion

Assessment and Curriculum are not mutually exclusive. Decisions made in one area affect the other. They feed each other, in a cycle whose only purpose is to improve the results of the next cycle. The intention of the department is to use assessment as a tool used to diagnose the current status of its programs and look for ways to improve them. The department is about to complete its first cycle under the new paradigm, and implement the recommendations made by the Assessment Committee. This process has been followed by all programs offered in the department, and the new Systems Engineering degree will follow this process starting 2009.

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