Learning Objectives: Closing the Loop

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Abstract: There are many ways to "close the loop" when evaluating Learning Objectives. This paper presents Learning Objective statistics gathered over several semesters and the decisions made to "close the loop". You can learn form the evaluation process and improvements made by Wake Technical Community College math instructors.

What We Can Learn from Beyond Crossroads

AMATYC addresses the complex issue of assessment in *Beyond Crossroads: Implementing Mathematics Standards in the First Two Years of College*, available on the website at www.amatyc.org. Class, course, and program assessment are all needed to continue to advance the mathematics programs at our colleges. This workshop will focus on **course assessment**.

Wake Technical Community College (Wake Tech) uses *Beyond Crossroads* to provide the theoretical base for our approach to course assessment. Course level assessment is conducted by the faculty teaching the course. *Beyond Crossroads* promotes that faculty should choose the assessment tools and these tools should remain fairly consistent over a short period of time. Wake Tech faculty create and analyze student learning outcomes (LO) as a primary tool for course assessment. *Beyond Crossroads* emphasizes that a course assessment is used to gain a broad picture of student learning. It is not to be used to evaluate individual instructors. The instructors evaluate their own classroom experiences. All faculty teaching a particular course reflect upon the results of an LO along with the class materials and processes used to teach a given concept. The sharing of best practices in a supportive and collegial atmosphere leads to overall improvements in student leaning, and professional growth for faculty.

There are many schemes for implementing changes based on data. In Chapter 5 of *Beyond Crossroads* AMATYC presents the assessment implementation cycle as a series of 6 steps:

- define/refine student learning outcomes
- design an assessment
- implement the assessment tool
- collect, analyze, and evaluate the data
- identify gaps between desired results and outcomes
- document the results and needed changes

As we repeat the cycle, our goal is to improve student learning in our mathematics courses. When we close the loop, we show whether or not the changes we implement actually lead to positive changes in student learning.

American Mathematical Association of Two-Year Colleges. (2006). *Beyond Crossroads: Implementing Mathematics Standards in the First Two Years of College* (draft v. 7.0). Retrieved October 17, 2006, from www.amatyc.org.

What We Can Learn from Crossroads in Mathematics

The following standards are drawn from AMATYC's 1995 *Crossroads in Mathematics: Standards for Introductory College Mathematics Before Calculus.* The standards provide guidance for writing learning objectives. Using the standards, along with course descriptions and competencies, eases the burden of creating quality course assessment items.

Standards for Intellectual Development

I-1: Problem-solving. Students will engage in substantial mathematical problem solving.
I-2: Modeling. Students will learn mathematics through modeling real-world situations.
I-3: Reasoning. Students will expand their mathematical reasoning skills as they develop convincing mathematical arguments.
I-4: Connecting with other Disciplines. Students will develop the view that mathematics is a growing discipline, interrelated with human culture, and understand its connections to other disciplines.
I-5: Communicating. Students will acquire the ability to read, write, listen to, and speak mathematics.
I-6: Using Technology. Students will use appropriate technology to enhance their mathematical thinking and understanding and to solve mathematical problems and judge the reasonableness of their results.
I-7: Developing Mathematical Power. Students will engage in rich experiences that encourage independent, nontrivial exploration in mathematics, develop and reinforce tenacity and confidence in their abilities to use mathematics, and inspire them to pursue the student of mathematics and related disciplines.

Standards for Content

C-1: Number Sense. Students will perform arithmetic operations, as well as reason and draw conclusions from numerical information.
C-2: Symbolism and Algebra. Students will translate problem situations into their symbolic representations and use those representations to solve problems.
C-3: Geometry. Students will develop a spatial and measurement sense.
C-4: Function. Students will demonstrate understanding of the concept of function by several means (verbally, numerically, graphically, and symbolically) and incorporate it as a central theme into their use of mathematics.
C-5: Discrete Mathematics. Students will use discrete mathematical algorithms and develop combinatorial abilities in order to solve problems of finite character and enumerate sets without direct counting.

C-6: Probability and Statistics. Students will analyze data and use probability and statistical models to make inferences about real-world situations.

C-7: Deductive Proof. Students will appreciate the deductive nature of mathematics as an identifying characteristic of the disciplines, recognize the roles of definitions, axioms, and theorems, and identify and construct valid deductive arguments.

Cohen, Don (Ed.). (1995). *Crossroads in mathematics: Standards for introductory college mathematics before calculus*. Memphis, TN:
American Mathematical Association of Two-Year Colleges.

What We Can Learn by Experience

Using *Crossroads* and *Beyond Crossroads* helps guide the evaluation process. Choosing appropriate student learning outcomes and designing a reasonable assessment strategy are only part of the challenge we all face as busy instructors teaching multiple courses who desire to have on-going improvement for our courses. It is important to design a plan so that the evaluation of the data includes a useful summary of results and comparison to previous results.

Consider the evolution of the LO assessments at Wake Tech. The mathematics courses at Wake Tech are organized around course committees, each with a lead instructor. Faculty give common tests and final exams, as well as many of the same projects and lab activities. Faculty record their students' LO results and report to the lead instructor, who then combines the data for the course assessment.

Wake Tech's current approach to course assessment emerged from on-going analysis of end-of-semester data such as grade distributions and pass rates. Starting in Fall 2004 we placed an emphasis on collecting useful data from learning outcomes. Faculty determined the LO's and so some courses started with 5 LO's, while others had 12 or more. Common final exam questions were used to obtain data. End-of-semester reports for each course were produced. The course reports show LO results for a given semester, along with commentary regarding changes implemented and changes proposed. The reports continue to include grade distributions, retention, and success rates.

Each semester the process is improved. Most courses now have 8-15 LO's and the faculty match LO's with the competencies or benchmarks listed on the syllabus. For Spring 2006, several lead instructors provided a clear graphical snapshot of results for the past several semesters. The new graphs will allow instructors to track trends and gain new insights from the visual impact of results. The separate, detailed end-of-semester reports are still important documents and will continue to be compiled.

After determining the learning objective and assessment item it is time to collect, analyze, and evaluate the data; identify gaps between desired results and outcomes; and document the results and needed changes.

The examples presented below are from Wake Technical Community College's MAT 161, MAT 115, and MAT 263 courses. The Los were recorded for the last several semesters. What trends do you notice? What questions are raised?

What We Can Learn by Experience and Closing the Loop: MAT 161 College Algebra

Spring 2005

The MAT 161 course committee started collecting LO data in the Fall of 2004 and reported the data in Spring of 2005 using an Excel spreadsheet. Objective 10 is shown below. The results of this particular learning objective were disappointing and it was decided to change the course to include rates of change throughout the entire course and not just at the end of the course.

Learning Objective	Total MAT 161 Responses Fall 2004				Total MAT 161 Responses Spring 2005			
After completing the course, the student will: 10. use appropriate technology to solve mathematical problems. This will be demonstrated by their ability to to use the calculator to find a rate of change.	Measure	Number of correct responses	Total number of students	% correct	Measure	Number of correct responses	Total number of students	% correct
16.a. Find dh/dx at 734 feet downrange.	16a	113	244	46.31	5a.	131	232	56.47

Fall 2005

The course committee saw some improvement, but based on data collected about the student population it was decided to change the question on the Spring 2006 exam to a business application.

Learning Objectives	Spring 2005				Fall 2005			
After completing the course, the student will: 10. use appropriate technology to solve mathematical problems. This will be demonstrated by their ability to to use the calculator to find a rate of change.	Measure	Number of correct responses	Total number of students	% correct	Measure	Number of correct responses	Total number of students	% correct
16.a. Find dh/dx at 734 feet downrange.	16a	131	232	56.47	4a.	232	333	69.67

Spring 2006

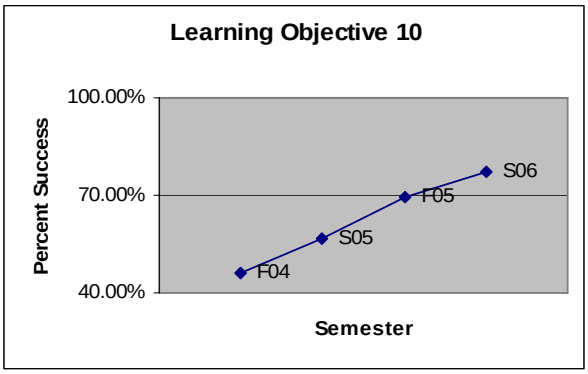
Beginning in the Spring of 2006 it was decided to maintain an Excel spreadsheet with all past data, a graph of the data, and committee discussion about the LO. Below is what is in the Excel spreadsheet.

Learning Objective – After completing this course, the student will use appropriate technology to solve mathematical problems. This will be demonstrated by their ability to use the calculator to find a rate of change.

Previous Semester's Question: A cannonball is fired with a muzzle velocity of 240 feet per second and follows the path of the graph modeled by the following function: $h(x) = x - 32(x/240)^2$, where h is the height of the cannonball measured in feet and the distance downrange, x, is also measured in feet. Find dh/dx at 734 feet downrange.

Spring 2006 Question: The number of Starbucks Stores, S, can be modeled by $S(t) = 48.58t^2 + 309.78t + 162.4$ for $0 < t < 10$, where t is the number of years since 1995.
Source: Starbucks.com/aboutusa. Find dS/dt if $t = 8$.

Data	
F04	46.31%
S05	56.47%
F05	69.67%
S06	77.06%



Notes:

Fall 04 – Rate of change covered throughout the semester instead of only at the end.

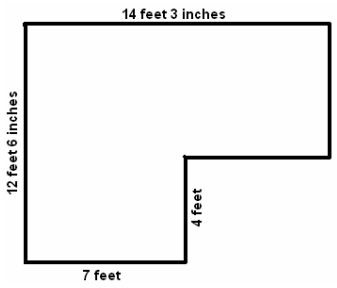
Spring 05 – Increase emphasis on rates of change during each chapter.

Fall 05 – Final Exam Question will be changed to a business application to reflect the student population.

Spring 06 – No change made affecting this objective.

What We Can Learn by Experience and Closing the Loop: MAT 115 Mathematical Models

Learning Objective – After completing the course, the student will be quantitatively literate. This will be demonstrated by their ability to apply measures in calculating costs.



TEST 1
Calculate the cost of a wallpaper border that will go around the top of the walls in the room (Figure6), if the border costs $1.79 per foot and must be purchased in six-foot rolls.

Fall 2004

The MAT 115 committee counted the number of students who computed this question correctly and found that 30.61% of the students were successful. In discussion of these results the MAT 115 committee decided that this LO needed to be covered more thoroughly.

Spring 2005

After implementing increased coverage of the concept, 34.71% of the students were successful on this assessment item. In the discussion of these results the MAT 115 committee decided that it would be helpful to break out the steps necessary for getting credit for the assessment item and to continue to find ways to strengthen students' ability to handle multi-step problems.

Fall 2005

For Fall 2005, 57.7% showed an understanding of perimeter, 48.7% calculated the cost correctly, and 51.9% showed clear logic and reason. Instructors used these more specific results to design activities to help students handle the multi-step problem. While it appears outcomes for student learning did improve, instructors neglected to record the overall success rate. A Wake Tech Foundation grant was applied for and received that enabled Spring 2006 students to have a hands-on learning activity for computing the cost of wallpaper border.

Spring 2006

For Spring 2005, 50.57% showed an understanding of perimeter, 71.26% showed an understanding of how to compute the number of rolls, 62.07% calculated the cost correctly, 68.97% showed clear logic and reason, and 40.23% were successful on the overall problem. Again the outcomes for student learning improved, but they are still lower than desired. However, the increased ability to communicate the logic and reasoning used in the process was very encouraging.

Fall 2006

This semester's students demonstrated the following competencies on the LO item: 63.85% showed an understanding of perimeter, 62.31% showed an understanding of how to compute the number of rolls, 46.92% calculated the cost correctly, 63.85% showed clear logic and reason, and 41.54% were successful on the overall problem. Instructors decided that the wording of the problem is not realistic and will change the wording of the problem for next semester.

What We Can Learn by Experience and Closing the Loop: MAT 263 Brief Calculus

Spring 2006

LO – **The student will be able to collect data, analyze models and communicate results with appropriate technology.**	Correct	Total students	% correct

Project 2				
The student collected appropriate real-world data and displayed in a table and with a graph	**Yes**	**62**	**66**	**93.9%**
The student correctly applied Riemann sums and definite integrals to their data set.	**Yes**	**50**	**66**	**75.8%**
The students analyzed their results at a level appropriate to the course.	**Yes**	**32**	**66**	**48.5%**

This LO was not assessed in prior semesters. Project 2 was an open-ended project, without a detailed rubric. Instructors were pleased at the level of presenting appropriate data, but were disappointed at the poor conclusions the students presented. Instructors will refer to the college's QEP Critical Thinking notebook for ideas to use to improve the students' ability to analyze results.

What we can learn by applying theory: Closing the Loop Worksheets

Following are some assessment scenarios to discuss. Analyze the LO results and decide on changes to implement that would help close the loop, improving the student learning for future classes.

Scenario 1 – MAT 161 College Algebra

Learning Objective – After completing this course, the student will be quantitatively literate. This will be demonstrated by their ability to apply arithmetic skills to evaluate the output of a function given an input.

Final Exam

#4a. It has been determined that the population of fish in a certain lake after time, t, in months, is given by the function: $P(t) = \frac{2500}{(1 + 5.25e^{-0.32t})}$. Calculate P(6).

In the Fall of 2004 the percentage of students correctly completing the LO was 86.48%. In the Spring of 2005 the percentage was 90.09%. However, in Fall of 2005 the percentage was 84.68%. During the discussion of this LO the MAT 161 instructors noted that between the Spring of 2005 and the Fall of 2005 we had decided to eliminate two sections of Chapter 1 in order to have more time on other important topics. In particular one of the sections eliminated was on evaluating functions by formula.

Analyze and discuss possible changes that could be made.

Scenario 2 – MAT 171 Precalculus Algebra

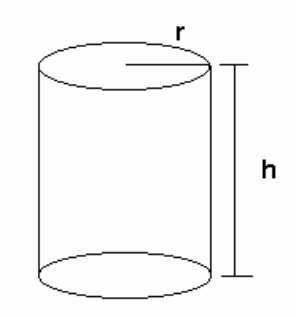
Learning Objective – Solve applied problems that can be modeled by linear, quadratic, rational or polynomial equations**.**

Final Exam

#8. Refer to the sketch of the soda can below. The following formulas will be useful:

$SA = 2\pi r^2 + 2\pi rh$ gives the surface area of the can, including the top and bottom.

$V = \pi r^2 h$ gives the amount of liquid the can will hold.



a) Suppose the can holds 400 cubic centimeters of soda. Express the surface area of the can as a function of the radius alone.
b) What is a reasonable domain for the surface area function?
c) Graph the function, using your answer in (b), to determine the viewing window. Sketch your graph below.
d) Determine the radius of the can with the least surface area.

The Fall 2005 MAT 171 committee reported that 21% of the students were 100% correct on the problem and 34.8% received at least 50% partial credit.

Analyze and discuss possible changes that could be made.

Scenario 3 – MAT 263 Brief Calculus

Compare the following two LO's

Learning Objective – The student will be able to find future value of an annuity.

Test 4 question

#7: Find the future value of $9500 in 20 years if the account earns 3.3% APR compounded continuously.

Spring of 2005 Assessment Item: 86% correct

Fall of 2005 Assessment Item: 91% correct

Learning Objective – The student will be able to find the present value of an annuity.

Test 4 question

#5: Sally agreed to buy Bob's car. She originally agreed to pay $6375 in 5 years. She has gotten a bonus at work and would like to pay the entire amount now. How much should she pay Bob if he can invest the money at 3.25% APR?

Spring of 2005 Assessment Item: 49% correct

Fall of 2005 Assessment Item: 53% correct

Analyze and discuss the discrepancy in LO results, and possible changes that could be made.

Scenario 4 – MAT 161 College Algebra

The MAT 161 Learning Objective document has several LOs tied to the following Final Exam question:

16. A cannonball is fired with a muzzle velocity of 240 feet per second and follows the path of the graph modeled by the following function: $h = x - 32(\frac{x}{240})^2$

In general the LO results for the items tied to this Final Exam question were below 70%. In committee discussions, it was discovered that approximately 30% of the students in MAT 161 were business majors.

Analyze and discuss possible changes that could be made.