EWU Programmatic SLO Assessment
AY 2014-15 and "Closing the Loop" for AY 2013-14

Introduction:

Assessment of student learning is an important and integrated part of faculty and programs. As part of ongoing program assessment at Eastern Washington University, each department is asked to report on assessment results for *each* program and *each* certificate for *at least one* Student Learning Outcome (SLO) this year. To comply with accreditation standards, the programs must also demonstrate efforts to "close the loop" in improving student learning and/or the learning environment. Thus, this template has been revised into two parts.

Resources:

Check this site for sample reports (created with the previous year's template) by EWU programs and other assessment resources: http://access.ewu.edu/undergraduate-studies/faculty-support/student-learning-assessment/program-slo-assessment.xml

Additional resources and support are available to:

1) Determine whether students can do, know or value program goals upon graduation and to what extent;
2) Determine students' progress through the program, while locating potential bottlenecks, curricular redundancies, and more; and
3) Embed assessments in sequenced and meaningful ways that save time.

Contact Dr. Helen Bergland for assistance with assessment in support of student learning and pedagogical approaches: hbergland@ewu.edu or 359.4305.

Use this template to report on your program assessment. **Reports are due to your Dean and to Dr. Helen Bergland (hbergland@ewu.edu), Office of Academic Planning, by Nov. 2, 2015.**

Degree/Certificate: Bachelor of Arts in Mathematics*

Major/Option: BA including all options*
*Combined into a single BS program as of 2015-16

Submitted by: Math Curriculum Committee
Date: 10/xx/2015

Part I – Program SLO Assessment Report for 2014-15

Part I – for the 2014-15 academic year: Because Deans have been asked to create College-Level Synthesis Reports annually, the template has been slightly modified for a) clarity for Chairs and Directors, and b) a closer fit with what the Deans and Associate Deans are being asked to report.

1. **Student Learning Outcome**: The student performance or learning objective as published either in the catalog or elsewhere in your department literature.

   SLO # 1: Demonstrate the ability to create and understand mathematical arguments and proofs
   SLO #2: Demonstrate the ability to communicate mathematical concepts both technically and non-technically;
   SLO # 3: Demonstrate the ability to use numerical and symbolic mathematical technology/software;
   SLO # 4: Demonstrate knowledge of mathematical applications in industry and the sciences.

   SLOs Assessed AY 2014-15: 1,2,3

2. **Overall evaluation of progress on outcome:** Indicate whether or not the SLOs have been met, and if met, to what level.

   _____*SLOs are met after changes resulting from ongoing assessments, referencing assessment results from the previous year to highlight revisions;*
   __X___*SLOs are met, but with changes forthcoming;*
   _____*SLOs are met without change required*

3. **Strategies and methods:** Description of assessment method and choices, why they were used and how they were implemented.

The Math Curriculum Committee (MCC) has developed the program assessment method though a collaborative effort. Furthermore, in order to prepare for the University Core Skills assessment that will take place during the 2015/16 academic year, a universal spreadsheet was developed that serves as a tool for collecting assessment data for both program and University core skills assessment purposes. In the spreadsheet, which will eventually be used for each course taught as part of the program, specific course learning objectives are mapped to both University Core Skills and Program SLOs.

An example of such mappings is shown below:

1	Course:	MATH	385	Section :	1
2	Term:	Fall	2014		
3	Course SLO Assessed:		3,4,5		
4	Core Skill Assessed:		3		
5	Program SLO Assessed:		1,2		

		Course Student Learning Outcome	University Core Skill: 1. Read Critically	2. Write Critically	3. Analyze Quantitatively	4. Perform or Present Publically	Program Student Learning Outcome (BS, Mathematics): 1. Demonstrate the ability to create and understand mathematical arguments and proofs;	2. Demonstrate the ability to communicate mathematical concepts both technically and non-technically;	3. Demonstrate the ability to use numerical and symbolic mathematical technology/software;	4. Demonstrate knowledge of mathematical applications in industry and the sciences.
7	1	Prove and apply counting techniques, including those involving combinations, permutations, partitions and the basic multiplication rule.			x		x	x		
8	2	When presented with a word problem, decide what counting techniques apply and use these to calculate probabilities of events when the sample space	x		x			x		
9	3	**Prove simple probability rules based on stated axioms and results well-known from set theory.**			x		x	x		
10	4	**Solve word problems by applying either the law of total probability and Bayes' rule or tree diagrams combined with the definition of conditional probability.**	x		x			x		
11	5	**Solve word problems which require the ability to recognize and use probabilities implicitly stated as unions, intersections or conditional probabilities.**	x		x			x		
12	6	Determine whether a given function is a valid probability function, probability density function or cumulative distribution function.	x		x			x		
13	7	Calculate the mean and variance of discrete and continuous random variables, including instances when such calculations require the use of infinite series, improper integrals and/or integration rules.			x			x		
14	8	Recognize situations when a standard discrete or continuous probability distribution, including the binomial, geometric, hypergeometric, Poisson, uniform, normal or exponential distribution, can be applied and identify the parameter(s) of the stated distribution.	x					x		
15	9	Use formulae, tables or technology when applicable to find probabilities or a mean and variance when a standard distribution applies.			x			x	x	
16	10	State and apply the Central Limit Theorem.			x			x		
17	11	Given that X has a normal distribution with mean mu and variance sigma^2, derive the distribution of (X-mu)/sigma. Use this result along with normal probability tables to calculate probabilities associated with X			x			x		
		Set-up the appropriate null and alternative hypotheses from word problems								

For the 2014/15 program assessment report, a variety of courses ranging from freshman to senior level were chosen:

Math 162: Calculus II
Math 163: Calculus III
Math 225: Foundations of Mathematics
Math 345: Numerical Analysis I
Math 347: Introductory Differential Equations
Math 385: Probability and an Introduction to Statistics
Math 430: Advanced Linear Algebra
Math 445: Numerical Analysis II
Math 460: Continuous Functions
Math 461: Advanced Calculus I
Math 462: Advanced Calculus II
Math 494: Senior Seminar

In each course, the instructor has chosen at least one question/assignment that ideally relates to at least one course learning objective. The spreadsheet referenced above identifies which program

SLO(s) the question(s) can be used to assess. The student answers or performances are scored for assessment purposes using a scale from 0-5. The following rubric is used to determine whether the SLO is met or not:

0-2: Not meeting goal (student is lacking the skill)
3-4: Minimally meeting goal (student is developing the skill)
5: Fully meeting goal (student has mastered the skill)

For University Core Skills assessment, the same rubric is used. When tabulating the data, it may be useful to compare the percentage of students who have met the goal across the different grades assigned in the course. An example of such results is shown below (color coded for additional emphasis):

Student	Score on Question 3	Total Score on Final Exam (out of 200 points)	Course Grade	Assessment Score 3
1	5	174	3.0	Fully Meeting Goal
2	2	156	3.0	Not Meeting Goal
3	2	176	3.2	Not Meeting Goal
4	3	149	2.6	Minimally Meeting Goal
5	2	107	1.1	Not Meeting Goal
6	2	159	2.9	Not Meeting Goal
7	5	140	2.7	Fully Meeting Goal
8	5	156	2.9	Fully Meeting Goal
9	5	178	3.3	Fully Meeting Goal
10	1	141	2.5	Not Meeting Goal
11	5	191	3.7	Fully Meeting Goal
12	5	200	4.0	Fully Meeting Goal
13	5	176	2.9	Fully Meeting Goal
14	3	153	2.2	Minimally Meeting Goal
15	3	97	0.0	Minimally Meeting Goal
16	3	154	2.4	Minimally Meeting Goal
17	2	110	2.0	Not Meeting Goal
18	5	172	3.0	Fully Meeting Goal
19	3	167	2.9	Minimally Meeting Goal
20	5	178	3.3	Fully Meeting Goal
21	5	139	2.0	Fully Meeting Goal
22	2	110	1.3	Not Meeting Goal
23	5	196	3.9	Fully Meeting Goal
24	1	115	2.3	Not Meeting Goal
25	3	116	2.2	Minimally Meeting Goal
26	3	145	2.0	Minimally Meeting Goal
27	2	144	2.0	Not Meeting Goal
28	3	175	3.0	Minimally Meeting Goal
29	2	144	2.2	Not Meeting Goal
30	2	166	2.8	Not Meeting Goal

Students fully meeting goal (5): 36.67%
Students minimally meeting goal (3-4): 26.67%
Students not meeting goal (0-2): 36.67%

	3.5-4.0	3.0-3.4	2.5-2.9	2.0-2.4	<2.0
Students fully or minimally meeting goal (by course grade)	100.00%	71.43%	62.50%	55.56%	33.33%

Following the analysis of the data for a particular course, the instructor summarizes the results in two brief paragraphs identifying

1) Weaknesses
2) Intervention (changes proposed or implemented)

Based on the collective data as well as weaknesses and interventions identified at the course level the MCC meets and decides for each SLO assessed if the goal has been met or not.

4. **Observations gathered from data**: Include findings and analyses based on the strategies and methods identified in item #3.

The detailed findings and analyses of findings of the 2014/15 data are reported in the attached documentation provided course by course. A summary of course weaknesses and interventions is given below:

Course	**Weaknesses**	**Intervention**	**Faculty Contact**

Math 162	Change of Variables: • Students frequently try to use properties of the definite integral without first using the change of variable theorem. • Students who correctly make the substitution $u = (x+3)/(2)$ sometimes forget to also scale the value of the integrand by the factor of 2 associated with the differential $du = 1/2dx$. Areas between curves: • Despite the hint, students frequently compute a definite integral of $\cos x - \sin x$ on the interval $0 \leq x \leq \pi/2$ which gives the (nonsense) answer of 0. • Students sometimes struggle to correctly incorporate the correct signs both from the definite integral and from the antiderivative. Advanced Integration: • Students frequently identify $dv = \ln x\,dx$ and incorrectly cite that $v = 1/x$.	Change of Variables: • Students should be made aware of when additive and multiplicative properties of the definite integral apply. • As an instructor, I will spend more time discussing the correct substitution and the geometric implication of that substitution. Areas between curves: • Students should always ask themselves whether their answers make sense. • The ability to recognize that the area is symmetric about the line $x = \pi/4$ simplifies the calculation significantly. As an instructor, I should be clear that a understanding of the graph of the functions will help students identify such symmetries. Advanced Integration: • As an instructor, I will be deliberate to discuss techniques to correctly	Dr. Lynch

	• Students occasionally distribute the negative sign from the resulting definite integral incorrectly. • Once in a while, a student integrates the product by using the product of the integrals.	identify u and dv from the outset. • Students should have enough practice problems to draw out problems with arithmetic. • Students should always think about checking their answer with the reverse process (in this case, checking the antiderivative by differentiating).	

Math 163	Prove or disprove 1=0.999… • 31 students participated • 23 proved correctly • 1 said 1= but no proof • 1 went nowhere • 2 claimed 1>0.999… • 4 skipped the problem	(0) A statement was added to all syllabi instructing students to read their text for retention. Verbal statements in class say (1) without memorization students must reconstruct 4000 years in 5 minutes (2) students must be conversant with subject matter: anecdote shows student got a job after discussing topic with senior person at meeting coffee break	Dr. Nievergelt

Math 225	Prove that there exists an irrational r such that r^√2 is a rational number: • The common error here was to not understand how the two cases of the proof worked together to justify an example existed. One of the difficulties with this problem was that they expected the proof to expressly tell them what the example was instead of telling them that one existed. Prove that $\lim_{x \to 3}(x-3)(x+1) = 0$ • Most students could get some of the set up correct (algorithmic part), but when it came to working with the actual pieces they quickly went astray.	When doing the lectures and homework on the topic of existence proofs some more emphasis on proofs using cases in the existence proof setting is warranted. I introduced this topic to the math 225 course because it is a major part of the math 460 course and students tend to have a great deal of difficulty with it. It is hoped that in the long run exposure at this level will help the students in understanding the deeper aspects when they take the math 460 course. There is no time available in the course to spend more time on the topic, so next time I will try to create a set of homework problems focused on the main issues of these types of problems.	Dr. Garraway

Math 345	Root finding: • Overall, the students seem to well understand these concepts. In this class, we had developed several approaches for solving for the root of a non-linear function. This seemingly simple mathematical problem underlies a number of applications and serves as a solid foundation for easing students into numerical methods. Iterative solvers of linear systems: • This pair of HW problems was challenging (both conceptually and code wise). A number of students coded up the Jacobi and G-S iterative schemes in an approximately correct manner (the code was decent but they might have started off from a bad initial vector or their stopping condition was not quite right). In addition many students failed to do the challenging problem Winter Quarter 2015 2 of coding up and comparing the SOR method - whose speed of convergence depends on the relaxation parameter ω.	From the above quantification of how effective students are learning key student learning objectives, the students appear to have learned reasonably well how to analyze and construct Mathematical arguments (SLO #1) which goes hand in hand with the University core skill 3 - analyze quantitatively. The students were also introduced into utilizing mathematical software in this course - relating to SLO #3. The students definitely learned to utilize mathematical software to solve mathematical problems, however there was a marked variance in how well they mastered the use of technology. In this class, students entered (by and large) knowing very little about computer programming and mathematical software. One of the challenges of the course is to teach students the theory of numerical methods and how one analyzes these systems, and at the same time teach them the necessary background in the basics of programming so students may utilize programs such as MATLAB in the assignments. In the future, I will probably dedicate two lectures at the beginning of the quarter for an intense primer in the use of MATLAB - even though strictly speaking it is not a part of the curriculum of numerical analysis. The students on the whole learned a lot on the use of programming to solve mathematical problems	Dr. Oster

		numerically, however, as the assessment suggests students are not experts by the end of the course.	

Math 347	Initial Value Problems: • Students often construct a correct implicit solution to the separable differential equation but fail to identify the explicit solution. • Students often incorrectly compute the integrating factor by either (i) failing to rewrite the differential equation in standard form, (ii) failing to incorporate the negative sign, or (iii) failing to simplify the exponential/logarithmic relationship that results. • Students who correctly compute the integrating factor sometimes incorrectly multiply the original equation (rather than the equation rewritten in standard form), resulting in a useless relationship. • Very few students correctly identified the interval of existence for the solution. General Solutions: • Students who use the method of undetermined coefficients often incorrectly decompose	Initial Value Problems: • Students should see a number of separable differential equations where the explicit solution is obtained through a series of careful manipulation. • As the instructor, I should spend more time on the characteristics of the integrating factor, including the strategy for finding it and common pitfalls. I have changed my lecture on this topic for Fall 2015 to more clearly enunciate these topics. • Throughout the duration of the course, I have restructured my discussion of solutions to emphasize the correct interval. General Solutions: • As an instructor, I should be sure to focus on the principle of	Dr. Lynch

	the function f(t) into the correct linear and exponential parts. • Students who use the Green's function often run into difficulty evaluating the definite integral associated with the Green's function. Modeling: • Students frequently compute the mass of the spring incorrectly. • Students have a difficult time identifying that the effect of the damping is to eliminate the effect of the initial condition, leaving only the effect of the forcing term (that is, the transient solution.	superposition for nonhomogeneous differential equations, especially when discussing the method of undetermined coefficients. • Students who choose to use Green's function should understand that the resulting definite integral might be difficult to evaluate. Modeling: • As the instructor, I intend to spend more time discussing units of mass, acceleration, and force in both the SI and US Customary units systems. • While discussing the physical systems that we are modeling, I will intentionally spend more time building the intuitive understanding of the different phenomena that accompany these systems.	

Math 385	Solve word problems by applying either the law of total probability and Bayes' rule or tree diagrams combined with the definition of conditional probability: • No major weaknesses identified. Students overwhelmingly score high on this topic. Many students have already seen these type of problems in other courses. Prove simple probability rules based on stated axioms and results well-known from set theory: • Except for the top performing students (top 10%), students are having difficulties writing correct proofs. Many students use poor or incorrect notation, or confuse statements to proven with those being assumed.	Solve word problems by applying either the law of total probability and Bayes' rule or tree diagrams combined with the definition of conditional probability: • Perhaps less time can be spent on this topic in class. Otherwise none needed at this time. Prove simple probability rules based on stated axioms and results well-known from set theory: • Increase emphasis on proofs in class. In the Fall 2015, the homework will be graded by the instructor rather than a student paper grader. This is expected to allow for earlier intervention when poor proof writing is being observed.	Dr. Hansen

Math 430	• Had only 7 students and their math ability and prerequisite knowledge was quite dispersed. This caused some difficulty in presenting material. • Not being able to reach a high level of applications (due to length of time with the preliminaries). In particular the topic of diagonalization had to occupy the first week of class. • In a couple of homeworks they needed to give an inductive proof. Apparently 'proof by induction' had not been cemented into their minds.	• I encouraged them to form teams. It was good that the 'strong' students would help the 'weak' students with the homework projects. • Coordinate topics with Math 231 instructors. Should that be part of Math 231 (it is when I teach it)? I would liked to have started with Jordan Block Decomposition.	Dr. Gentle

Math 445	Use of technology: • Overall, the students did well on this problem. It involved fundamental ideas and the ability to approximate the solution to the PDE numerically. By leaving the time step very _ne, then by halving the spatial step - one notes that the error is approximately one quartered. We can then do it in the other order to _nd that the the Crank-Nicolson scheme is scone order accurate in both time and space - making it a go-to numerical scheme. Setting up FD scheme for different types of bdy conditions: • Approximately, half of the class did everything right on this problem, whereas, the other half of the class did reasonable job of setting up the problem - but there were errors. From the above quantification of how effective students are learning key student learning objectives, the students overall did a good job in addressing departmental SLO #3 - utilizing technology. One observation was the variance in the use of MATLAB from past years. Some students had not utilized MATLAB very much in MATH	Perhaps a gentler introduction to numerical simulation in earlier classes may help.	Dr. Oster

	345 from previous years, so these students had a steep learning curve as many HWs had some MATLAB - and towards the end of the class computational problems were playing a dominant role in the HW. I think many students struggled with the degree of coding that was required in this course.		

Math 460	Understanding and being able to use epsilon proofs is in the core of understanding calculus. Students very often relate the variables in a wrong way. Difficulties also come from not understanding the logic in carrying an analysis proof.	Review of basic logic principles. Remind them often about the order in which the variables should be selected.	Dr. Toneva
Math 461	The class last winter had eight students. All of them were very dedicated and mastered the material well. They experienced the usual difficulties switching the perception of derivative from being a slope of a line to being a linear function.But by the end of the quarter they mastered the implicit function theorem and its applications to the Lagrange multipliers and equations solving.	Bringing examples from Math163 helps the understanding of the more complicated multidimensional material.	Dr. Toneva
Math 462	Students find Math 462 easier, than 461. It is related to integration and despite that the differential forms are very abstract in their nature, there are a lot of physical applications. At the end of the class students are able to apply the theory of differential forms to prove the Brower fixed point theorem, which has applications in economics.	Review of integration and the fundamental theorem of calculus.	Dr. Toneva

Math 494	No major weaknesses identified. Then presentations (half done in the block time and the rest during exam week) which had to be accompanied by a write up. For the first time at EWU my overall impression of student talks was positive. I think the fact that earlier the group had had a few discussions about 'student presentations' as part of the math education theme. The other write up was their reflections about mathematics at EWU. I left it a bit open, they could concentrate on their own experiences or try to do an essay type report on EWU math (addressing issues from the articles about math education they had read). Again these were mostly well written and contained a lot of interesting thoughts. I gave copies (without their names) to Jackie because of the abundance of 'math education' content. Based on the two written papers and the discussions which occurred throughout this course all but one student (who dropped out) got 3.0 or more.		Dr. Gentle

5. What program changes will be made based on the assessment results?

a) Describe plans to improve student learning based on assessment findings (e.g., course content, course sequencing, curriculum revision, learning environment or student advising).

The BA program with three separate options was redesigned in 2014/15 to create a new BS in Mathematics program with added flexibility for students to choose a program that fits their interests and career goals. Furthermore, most 4 credit courses were redesigned to a 5 credit course to provide more emphasis on applications and to focus students on fewer courses with more options to seek depth in topics of their choice. The 2 credit Math 494 Senior Seminar has been changed into Math 491: Senior Thesis which counts towards the university capstone course and allows for meaningful experiential learning in their major. In order to strengthen our students' proficiency related to SLO#3 (use of mathematical software), we have introduced a new component (Math 307) to Math 347: Differential Equations in the form of a computer lab experience that accompanies the course. The course contains an introduction to computational technologies used to solve problems in differential equations. The effect of this change will be assessed in the coming year 2015/16.

b) Provide a broad timeline of how and when identified changes will be addressed in the upcoming year.

The changes described above were implemented effective Fall 2015.

6. Description of revisions to the assessment process the results suggest are needed and an evaluation of the assessment plan/process itself.

Copies of the program and course change proposals submitted to UAC are on file in the Mathematics Department and available on request.

PART II – CLOSING THE LOOP

FOLLOW-UP FROM THE 2013-14 PROGRAM ASSESSMENT REPORT

In response to the university's accrediting body, the Northwest Commission on Colleges and Universities, this section has been added. This should be viewed as a follow up to the previous year's findings. In other words, begin with findings from 2013-14, and then describe actions taken during 2014-15 to improve student learning along, provide a brief summary of findings, and describe possible next steps.

PLEASE NOTE: The College-Level Synthesis report includes a section asking Deans to summarize which programs/certificates have demonstrated "closing-the-loop" assessments and findings based on the previous year's assessment report.

> ***Working definition for closing the loop***: *Using assessment results to improve student learning as well as pedagogical practices. This is an essential step in the continuous cycle of assessing student learning. It is the collaborative process through which programs use evidence of student learning to gauge the efficacy of collective educational practices, and to identify and implement strategies for improving student learning." Adapted 8.21.13 from http://www.hamline.edu/learning-outcomes/closing-loop.html.*

1. **Student Learning Outcome(s)** assessed for 2013-14

   SLO # 1: Demonstrate the ability to create and understand mathematical arguments and proofs

2. **Strategies implemented** during 2014-15 to improve student learning, based on findings of the 2013-14 assessment activities.

   Program and course changes (described above)

3. **Summary of results** (may include comparative data or narrative; description of changes made to curriculum, pedagogy, mode of delivery, etc.): Describe the effect of the changes towards improving student learning and/or the learning environment.

   The effect of program and course changes have not yet been observed since these were implemented in 2015/16. Because different courses were used in the 2013/14 and the 2014/15 assessment reports, a course by course comparison is not possible. For the 2015/16 program assessment report course by course comparisons will be available for a selection of courses offered every year.

4. What **further changes to curriculum, pedagogy, mode of delivery,** etc. are projected based on closing-the-loop data, findings and analysis?

   None planned at this time.

Definitions:

1. **Student Learning Outcome**: The student performance or learning objective as published either in the catalog or elsewhere in your department literature.
2. **Overall evaluation of progress on outcome:** This checklist informs the reader whether or not the SLO has been met, and if met, to what level.
3. **Strategies and methods used to gather student performance data,** including assessment instruments used, and a description of how and when the assessments were conducted. Examples of strategies/methods: embedded test questions in a course or courses, portfolios, in-class activities, standardized test scores, case studies, analysis of written projects, etc. Additional information could describe the use of rubrics, etc. as part of the assessment process.
4. **Observations gathered from data**: This section includes findings and analyses based on the above strategies and methods, and provides data to substantiate the distinction made in #2. For that reason this section has been divided into parts (a) and (b) to provide space for both the findings and the analysis of findings.
5. **Program changes based on the assessment results:** This section is where the program lists plans to improve student learning, based on assessment findings, and provides a broad timeline of how and when identified changes will be addressed in the upcoming year. Programs often find assessment is part of an ongoing process of continual improvement.

6. **Description of revisions to the assessment process the results suggest are needed.** Evaluation of the assessment plan and process itself: what worked in the assessment planning and process, what did not, and why.

Some elements of this document have been drawn or adapted from the University of Massachusetts' assessment handbook, "Program-Based Review and Assessment: Tools and Techniques for Program Improvement" (2001). Retrieved from http://www.umass.edu/oapa/oapa/publications/online_handbooks/program_based.pdf