Contents

Introduction

During the 2016-2017 academic year, the LMC Math Department underwent assessing its transfer-level PLSOs with respect to the calculus pipeline (40, 50, 60 and 70, pre-calc through multi-variable calc), attempting to answer the research question, “Are LMC calculus students making satisfactory progress toward becoming proficient with respect to our transfer-level math PSLOs?” To answer this question, Maria Magante, Maria Perrone, Tue Rust and Jim Cohen attempted to summarize, synthesize, analyze and draw conclusions from previous CSLO assessments using a newly created calculus-based PSLO rubric.

This document loosely follows TLC’s PSLO reporting template[1]. First is a summary of the CSLO assessments. Next is a matrix summarizing the CSLO assessments with respect to the PSLO rubric. Following is a narrative that ultimately shares next steps. Included at the end is the newly created PSLO rubric and the complete assessments of each course with respect to the transfer-level math PSLOs.

[1] http://www.losmedanos.edu/intra-out/tlp/resources.asp

Summary of CSLO Assessments

As a precursor to analyzing the CSLO Assessments with respect to the PSLO rubric, we wish to first summarize the CSLO Assessment results. During 2010-2014, the math department assessed math 40, 50, 60 and 70 (pre-calculus, differentiation, integration and multi-variable calculus).

Math 40 students showed proficiency with technology and struggled with the ability to analyze domain, range, asymptotes and intercepts from equations. Students also struggled with algebra and symbolic manipulation. The assessors suggested increasing contact time with students. All the assessment tools adequately aligned with the CSLOs, creating meaningful results.

Math 50 students showed proficiency in finding limits and struggled interpreting them. They showed strong proficiency in finding derivatives and struggled to solve an optimization problem (it was noted that the given problem was difficult to understand and needs to be changed). The committee suggested major changes to all three assessment tools.

Math 60 students showed proficiency in knowing when NOT to use various integration techniques (de-contextualized) and struggled with contextualized problems involving area and volume. Students showed proficiency in applying convergence tests to sequences and series and struggled to represent functions as power series. The committee suggested major changes to all but one assessment.

Math 70 students showed proficiency in calculus literacy and struggled with applications. Students showed moderate proficiency (48%) with multiple representations. The committee suggested major changes to all three assessment tools.

In conclusion, although pre-calculus students struggled with algebra, students showed proficiency with decontextualized problems throughout the rest of the calculus sequence. However, students consistently struggled with contextualized calculus problems. Also there is evidence for training on how to write effective assessment tools with respect to CSLOs.

Assessment Plan

PSLO	Method Used	Proficiency Criteria	Student Population Assessed
PSLO 1 : Preparation and Mathematical Maturity	Analysis of math 40, 50 60 and 70 CSLO assessments with respect to a PSLO rubric	Correctly applies a known concept to a new situation AND shows some progress toward generalizing this concept. Example: can generalize how derivatives measure rates of nonlinear relationships that do not involve time.	During Fall 2011 there were 3 sections of math 40 taught by two instructors at the Pittsburg campus. A comprehensive exam, counting at least 20% of the course grade, is required for this course. Further, the math department provides common final exam questions to be used by all instructors, which comprise at least 50% of the final exam. For Fall 2011 the instructors together wrote the remaining portion of the final exam and administered identical finals to all students in all three sections. A total 81 students took the common final exam. The final exams were assessed for each CSLO using a holistic rubric. In Fall 2014, five sections of Math 50 were assessed between both the Pittsburg and Brentwood campuses to see how well students understood the material from the course outline. Three anonymous quizzes (see attached) were given throughout the semester, and a random sample was taken from the quizzes. In Spring 2015, four sections of Math 60 were assessed between both the Pittsburg and Brentwood campuses to see how well students understood the material from the course outline. Four anonymous quizzes and one lab assignment activity (see attached) were given throughout the semester, and a random sample was taken from the quizzes. The results are summarized below.
PSLO 2 : Mathematical Literacy	Analysis of math 40, 50 60 and 70 CSLO assessments with respect to a PSLO rubric	Correctly **interprets** mathematical concepts and key terms within a written text. Correctly **defines** key terms and clearly explains main concepts. Without being prompted, **documents** their solution process and provides coherent justifications. Uses proper and precise **notation** and vocabulary.	
PSLO 3: Problem-solving ability	Analysis of math 40, 50 60 and 70 CSLO assessments with respect to a PSLO rubric	Documents the use of a problem solving process to diagnose, evaluate, and solve a contextualized problem. Consistently applies mathematical concepts in real-world contexts that differ from those previously discussed with possibly only minor errors. Fluently uses technology to analyze and solve problems. Writes answer using proper context and units. Verifies and defends the reasonableness of answers.	

PSLO	Method Used	Proficiency Criteria	Student Population Assessed
PSLO 4: Modeling ability	Analysis of math 40, 50 60 and 70 CSLO assessments with respect to a PSLO rubric	Correctly constructs mathematical models appropriate for solution techniques. Fluently uses all of the standard representations (numerical, graphical, symbolic, verbal). Describes or explains the limitations or requirements of a solution method with possible minor errors.	In Fall 2015, two sections of Math 70 were assessed between both the Pittsburg and Brentwood campuses to see how well students understood the material from the course outline. Three anonymous quizzes (see attached) were given throughout the semester. The results are summarized below.
PSLO 5: Effective Learning skills	Analysis of math 40, 50 60 and 70 CSLO assessments with respect to a PSLO rubric	Shows strengths in gathering, organizing, or utilizing notes and/or reference materials. Able to independently acquire further mathematical knowledge. Curates and organizes useful information. Succeeds in different learning environments and works collaboratively with others to verify the accuracy of their work before submitting it for evaluation	

Matrix Summary

	Math 40	Math 50	Math 60	Math 70
Preparation and Mathematical Maturity: Be prepared for the mathematical or statistical reasoning required in upper division work in their major, including the ability to generalize mathematical concepts and comprehend increasing levels of mathematical abstraction.	Majority proficient Struggled with equation form and algebra Those not proficient incorrectly interpreted rate of change and concavity	N/A CSLO 1 is not aligned with PSLO 1	Vast majority not proficient Suggest more focus on extending and generalizing concepts	N/A CSLO assessments were copied from the textbook and didn't assess generalizing a concept to a new situation.
Mathematical Literacy: Communicate using mathematics: Read with comprehension documents having mathematical content and participate cogently in discussions involving mathematics; Clearly articulate mathematical information accurately and effectively, using a form, structure and style that suit the purpose (including written and face-to-face presentation).	N/A CSLO assessments did not evaluate communication	Majority not proficient at interpreting and explaining mathematical concepts	N/A Assessment tool was decontextualized Suggest focusing more on, and assessing with respect to, mathematical literacy	Vast majority not proficient Struggled with interpreting solutions. Parts of this PSLO were not assessed in all 3 assessment tools used.

Problem-solving ability: Reason with and apply mathematical concepts, principles and methods to solve problems or analyze scenarios in real-world contexts relevant to their major; Use technology effectively to analyze situations and solve problems; Estimate and check answers to mathematical problems in order to determine reasonableness, identify alternatives, and select optimal results.	Majority proficient Struggled interpreting concavity and rate of change in context and with units and using polynomials in context. Estimation and checking answers not mentioned in CSLOs	N/A Suggest CSLO 3's description needs to be rewritten to include contextualized problem solving	Vast majority not proficient Suggest using contextualized problems in CSLO assessment	N/A PSLO was not directly addressed in all 3 assessment tools used. Suggest in future CSLO assessments, asking to show the use of a problem solving process, using technology and verify/defend reasonableness of answers
Modeling ability: Construct and interpret mathematical models using numerical, graphical, symbolic and verbal representations with the help of technology where appropriate in order to draw conclusions or make predictions; Recognize and describe the limits of mathematical and statistical methods.	Proficient with calculators but not with limitations. Students struggled to use graphs to identify range, asymptotes and multiple intersections. Suggest deemphasizing quadratics, more time on exp, logs, periodic and polys	Majority not proficient Students struggled with understanding and decoding what the problem is asking.	Vast majority not proficient Suggest in CSLO assessments, asking students construct models more often. May need to alter CSLOs to focus more on modeling.	Majority not proficient Struggled to evaluate an integral and analyze a graph Suggest in CSLO assessments, asking students to recognize and describe the limits of their solution method.

Effective Learning skills: Independently acquire further mathematical knowledge without guidance, take responsibility for their own learning, determine appropriateness and correctness of their own work, and function effectively in different learning environments. Succeed in different learning environments, particularly in a group setting of working collaboratively with others.	N/A CSLOs assessed (2,3,5) do not align with this PSLO. Suggest creating a way to effectively assess PSLO 5 and math 40's CSLO 4.	N/A No math 50 CSLO aligns with PSLO 5.	N/A No math 60 CSLO aligns with PSLO 5.	N/A Not assessed

Synthesis, Analysis and Conclusions

Synthesis

All assessment tools were given in-class either as a quiz or on the final exam. In general, instructors analyzed the percent proficient for each CSLO and then wrote generalized findings. In all sections, not all of the CSLOs were assessed.

Analysis

Math 40 students were proficient wrt PSLO 1 (Preparation and Mathematical Maturity). Math 60 students were not proficient. Math 50 and 70 students were not assessed.

Math 50 and 70 students were not proficient wrt PSLO 2 (Mathematical Literacy). Math 40 and 60 students were not assessed.

The majority of Math 40 students were proficient wrt PSLO 3 (Problem Solving Ability), but the majority of math 60 students were not. Math 50 and 70 students were not assessed.

Math 40 students were proficient with parts of PSLO 4 (Modeling Ability), but the majority of math 50, 60 and 70 students were not.

PSLO 5 (Effective Learning) was not assessed because it does not exist as a CSLO in any COOR.

Conclusions

Although there seemed to be an adequate amount of time and effort put into developing, assessing and analyzing the CSLOs in math 40, 50, 60 and 70, there were several misalignments with respect to the PSLOs. For example, there are no CSLOs in any COOR that map to PSLO 5.

It appears that our calculus pipeline needs improvement at creating proficiency with respect to any PSLOs. These results may stem from a misalignment between the curricula, the CSLOs and the PSLOs.

From the “Summary of CSLO Assessments” section, there is evidence of a need for training in writing assessments with respect to CSLOs.

Next Steps

We suggest using a “working backwards approach” infused with funded professional development. The math department should first review, then change and/or affirm our PSLOs. This project should be an “Objective” in the next Program Review in order to seek RAP funding.

Upon completion of the PSLO project, instructors can then spend much of their assessment energies reviewing the alignment between the CSLOs and the PSLOs, changing the CSLOs as needed and **documenting the analysis, conclusions and changes**.

As CSLOs are being assessed, there needs to be professional development around developing assessment tools with respect to CSLOs. There also needs to be ongoing professional development around creating and implementing pedagogy and curriculum that aligns with CSLOs.

During the next PSLO cycle, we suggest instructors summarize the documented CSLO/PSLO alignment process across math 40, 50,60 and 70.

We foresee that, by the end of 2022, we will have curriculum and pedagogy that align with our CSLOs, which in turn align with our PSLOs. We will then be able to close the loop by performing this same PSLO assessment.

PSLO Rubric

PSLO	2	3	5
Preparation and Mathematical Maturity: Be prepared for the mathematical or statistical reasoning required in upper division work in their major, including the ability to generalize mathematical concepts and comprehend increasing levels of mathematical abstraction.	Unable to apply a concept to a new type of situation. Example: After basic understanding of the derivative, cannot graph and explain in words the behavior of a ball rolling down a hill in terms of speed.	Correctly applies a known concept to a new situation AND shows some progress toward generalizing this concept. Example: correctly graphs and explains rolling down a hill but is not able to create a new scenario, point out flaws in another's solution or generalize to acceleration.	Correctly extend an algorithmic process beyond the learned constraints. Generalize a new concept given a new set of axioms, rules or conditions. Example: discovers critical points and points of inflection as they relate to speed and acceleration.
Mathematical Literacy: Communicate using mathematics: Read with comprehension documents having mathematical content and participate cogently in discussions involving mathematics; Clearly articulate mathematical information accurately and effectively, using a form, structure and style that suit the purpose (including written and face-to-face presentation).	Incorrectly interprets mathematical concepts within a rigorous a scholarly article. Incorrectly explains a calculus concept when prompted.	Shows basic understanding of core, mathematical concepts through analyzing articles, giving presentations and taking exams. May struggle to engage in fast-paced discussions where fluidity of knowledge and/or mathematical reasoning is required.	Through independent research, correctly interprets articles beyond the scope of the class, shares the concepts in a clear, concise manner that is at the appropriate level of the class.

PSLO	2	3	5
Problem-solving ability: Reason with and apply mathematical concepts, principles and methods to solve problems or analyze scenarios in real-world contexts relevant to their major; Use technology effectively to analyze situations and solve problems; Estimate and check answers to mathematical problems in order to determine reasonableness, identify alternatives, and select optimal results.	Unable to apply mathematical concepts correctly in real-world contexts. Unable to use technology to solve problems. Unable to check answers using alternate means.	Able to apply mathematical concepts in real-world contexts with minor errors. Mastery of technology to solve problems. Generally able to check answers using alternate means.	Correctly apply mathematical concepts to unsolvable real-world problems, and cite specifically why the problem solving process breaks down. Develop new code or new technology. Develop new ways to analyze a situation using technology. Use existing problem solving techniques to find multiple ways to solve a problem. Then develop or discover a better problem solving method.
Modeling ability: Construct and interpret mathematical models using numerical, graphical, symbolic and verbal representations with the help of technology where appropriate in order to draw conclusions or make predictions; Recognize and describe the limits of mathematical and statistical methods.	Makes many minor mistakes or a few major mistakes when constructing a mathematical model using multiple representations.	Correctly constructs mathematical models across using representations. Makes mistakes when interpreting across mathematical models. With minor mistakes, describes the limits of mathematical and statistical methods.	Correctly constructs a new mathematical model. With minor mistakes, correctly interprets a new mathematical model across multiple representations. When given a new mathematical or statistical method, correctly describes its limits.

PSLO	2	3	5
Effective Learning skills: Independently acquire further mathematical knowledge without guidance, take responsibility for their own learning, determine appropriateness and correctness of their own work, and function effectively in different learning environments. Succeed in different learning environments, particularly in a group setting of working collaboratively with others.	Unable to acquire further mathematical knowledge independently. Independently acquires incorrect mathematical knowledge. Greatly struggles in different learning environments.	Able to acquire further mathematical knowledge independently. Independently acquires mathematical knowledge. Succeeds in different learning environments.	Independently acquires mathematical knowledge beyond the scope of the class. Becomes an effective leader, mentor or teacher within a group setting. Independently creates an optimal learning environment, given a challenging problem.

Math 40 PSLO Assessment

Course-Level Student Learning Outcomes (CSLOs):

CSLO 1: Pre-calculus literacy (PSLOs 1, 2, and 5)

Students will be able to understand written examples and explanations of pre-calculus concepts, and explain what they have read verbally and in writing using appropriate mathematical language and concepts.

CSLO 2: Functions and Their Representations (PSLOs 1 and 4)

Students will be able to solve a given problem using different representations of functions; Students will construct, analyze and use linear, exponential, logarithmic, rational, polynomial, and sinusoidal functions, in symbolic, numerical, and graphical form, to investigate concepts and solve problems.

CSLO 3: Functions and Modeling (PSLOs 1, 3, and 4)

Students will be able to identify an appropriate type of function to model a situation, and to find a specific function to model the situation in order to solve problems; Students will also be able to identify the key aspects of the function (e.g. function values, zeros) that will allow them to solve the problem and to interpret the meaning of these features in context.

CSLO 4: Effective Learning (PSLO 5)

Students will be able to effectively work with peers in order to solve problems, revise their work, and develop understanding of course concepts; Students will take responsibility for leaning and self-assessment.

CSLO5: Technology (PSLO 3 and 4)

Students will be able to use the computational, tabular, graphical, and regression functions of a graphing calculator, computer algebra system or the equivalent to solve problems and investigate concepts; Students will also understand the limitations of the use of technology.

Analysis

Program-Level Student Learning Outcomes (PSLOs)

PSLO 1: Preparation and Mathematical Maturity: Be prepared for the mathematical or statistical reasoning required in upper division work in their major, including the ability to generalize mathematical concepts and comprehend increasing levels of mathematical abstraction.

In the assessment result for CSLO 2 (Functions and their Representations), 72.8% meets proficiency, 2.5% of students were highly proficient, and 24.7% of students were below proficient. It was noted that students struggled finding the domain, range, intercepts, and asymptotes of functions in equation form. It was also noted that students need improvement in algebra skills and algebraic analysis of equations.

In the assessment result for CSLO 3 (Functions and Modeling), 58% meets proficiency, 4.9% of students were highly proficient, and 37% of students were below proficient. It was noted that the students who scored below proficient incorrectly interpreted rate of change and concavity.

PSLO 2: Mathematical Literacy:

Communicate mathematics:

a) Read with comprehension documents having mathematical content and participate cogently in discussion involving mathematics;
b) Clearly articulate mathematical information accurately and effectively, using a form, structure and style that suit the purpose (including written and face-to-face presentation).

This PLSO is not linked to any of the CSLOs assessed (CSLO 2, 3, and 5). CSLO 1, which is the only CSLO linked to PSLO 2, was not assessed. Given the types of problems in the common final exam that were used to assess the CSLOs, CSLO 1 could have been assessed using the common final exam questions. This could be done by evaluating the way students are communicating their written work using proper mathematical language, symbols, etc. and whether or not they understand the mathematical terminologies used in the questions based on their answers.

PSLO 3: Problem-Solving Ability:

a) Reason with and apply mathematical concepts, principles and methods to solve problems or analyze scenarios in real-world contexts relevant to their major;
b) Use technology effectively to analyze situations and solve problems;
c) Estimate and check answers to mathematical problems in order to determine reasonableness, identify alternatives, and select optimal results.

In the assessment result for CSLO 3 (Functions and Modeling), 58% meets proficiency, 4.9% of students were highly proficient, and 37% of students were below proficient. In the assessment result for CSLO 5 (Technology), 48.1% meets proficiency, 13.6% of students were highly proficient, 38.3% of students were below proficient. It was noted that students were successful in using equations to obtain function values and produce graphs and tables to answer questions. It was also noted that students had difficulty interpreting solutions in context, more specifically interpreting concavity and rate of change in context of a scenario, including using appropriate units. Students were successful in using exponential functions in context but were not as successful in using polynomial functions.

Estimating and checking answers to determine reasonableness was not assessed and is also not explicitly mentioned in the CSLOs.

PSLO 4: Modeling Ability

a) Construct and interpret mathematical models using numerical, graphical, symbolic and verbal representations with the help of technology where appropriate in order to draw conclusions or make predictions;
b) Recognize and describe the limits of mathematical and statistical methods.

As stated above, students successfully used their calculators to obtain function values, graphs, and tables, given an equation. However, it was noted that students need improvement in understanding the limitations of graphs obtained from graphing calculators. Students also lacked the skill of using graphs to identify the range, asymptotes, and multiple intersections of functions.:

It was also noted that linear and quadratic models should be deemphasized in the course to provide more time on exponential, logarithmic, sinusoidal, and polynomial functions.

PSLO 5: Effective Learning Skills:

a) Independently acquire further mathematical knowledge without guidance, take responsibility for their own learning, determine appropriateness and correctness of their own work, and function effectively in different learning environments.
b) Succeed in different learning environments, particularly in a group setting of working collaboratively with others.

This PLSO is also not linked to any of the CSLOs assessed (CSLO 2, 3, and 5). This PSLO cannot be assessed with the current assessment tool used for this class, which is the common final exam questions. The department should come up with ways that can effectively assess PSLO 5 or CSLO 4.

Math 50 PSLO Assessment

The agreed upon rubric was utilized in determining how well LMC's Math 50 students do with the Program Learning Outcomes.

PSLO 1: Preparation and Mathematical Maturity

Math 50 CSLO 1 is somehow aligned with PSLO 1, as stated in the COOR: Students will be able to articulate generalized concepts of differential and introductory integral calculus, justify claims by citing course concepts, and evaluate both their own mathematical conclusions and those of classmates.

Based on the Fall 2014 course assessment, there is not enough information to determine whether Math 50 students are prepared and mathematically mature as expected by PSLO 1.

PSLO 2: Mathematical Literacy

Math 50 CSLOs 1 and 2 align well with PSLO 2.

Is it to be noted that although students demonstrate overall proficiency in performing computations related to differential and integral calculus, the majority of them are deficient at properly interpreting and clearly explaining mathematical concepts.

Based on the Math 50 Assessment Findings, Math 50 students do very poorly with Mathematical Literacy (PSLO 2).

PSLO 3: Problem Solving Ability

Math 50 CSLO 3 does not seem to be very well aligned with PSLO 3.

Although Math 50's CSLO 3 is *Representation and Problem Solving,* its description appears to relate more to manipulation abilities than problem solving (from the Math 50 COOR: *CSLO3: Given functions in different representations, students will be able to select and apply appropriate strategies to find derivative or anti-derivative, and use technology and knowledge of graphs to verify that the derivative or anti-derivative found is an appropriate solution*).

In the Fall 2014 course assessment, CSLO 3 was assessed through quizzes on differentiation rules (such as product rule, quotient rule and chain rule). Although students performed overall at the proficient level on differentiation rules, there seem to be a misalignment with PSLO 3, which relates to solving abilities in real-world scenarios and contextualized problems.

PSLO 4: Modeling Ability

Math 50 CSLO 4 seem to be well aligned with PSLO 4.

Math 50 students demonstrate very low proficiency when it comes to modeling abilities. Based on the Math 50 Assessment Findings, Math 50 students have difficulties even understanding and decoding what a problem is asking for. This is very likely linked to the low proficiency demonstrated in Mathematical Literacy (PSLO 2).

In summary, Math 50 students do poorly with Modeling Ability (PSLO 4).

PSLO 5: Effective Learning Skills

No Math 50 CSLO seems to be aligned with PSLO 5, hence effective learning skills were not assessed in the Fall 2014 course assessment.

Math 60 PSLO Assessment

Calculus Literacy (PSLOS 1, 2 and 5)

CSLO 1: Comprehend and articulate generalized concepts of integral calculus and introductory differential equations, evaluate both their own mathematical conclusions and those of classmates, and justify their reasoning by citing topics from the course content and using appropriate calculus language.

Strategies for finding the anti-derivative of functions (PSLOS 2, 3, and 4)

CSLO 2: Evaluate definite and indefinite integrals using a variety of integration formulas and techniques.

Applications of Problem Solving (PSLO 3)

CSLO 3: Apply integration to areas and volumes, and other applications such as work or length of a curve;

Integrating at infinity and asymptotes (PSLOS 3 and 4)

CSLO 4: Evaluate improper integrals;

Modelling with Sequences and Series (PSLOS 2, 3 and 4)

CSLO 5: Apply convergence tests to sequences and series;

Modeling with Power Series (PSLOS 3 and 4)

CSLO 6: Represent functions as power series

Translations to polar and parametric (PSLOS 3 and 4)

CSLO 7: Graph, differentiate and integrate functions in polar and parametric form.

Analysis:

PSLO 1

Assessment Quiz 1 seemed to assess PSLO 1 because it appears this was a problem many students had not seen before or were at least unfamiliar with. Since only 4% were proficient, this gives evidence that **math 60 students largely are not proficient with PSLO 1**. None of the other instruments assessed student's ability to extend or generalize.

Suggestion: There may be a need for instructors to focus on regularly challenging students to extend and generalize concepts in class, on homework, on lab assignments and on exams.

PSLO 2

The Lab Assignment assessed students' ability to justify their reasoning using appropriate calculus language. 64% were proficient. Unfortunately, all of the assessments were decontextualized, so it was difficult to judge the other aspects of mathematical literacy (i.e correctly interpreting mathematical concepts and key terms within a written text). There were opportunities to assesses students' communication skills in throughout the Assessment Quizzes, but the assessors tended to solely focus on correct application of an algorithmic problem solving process evaluating proficiency, choosing to not comment on the communication skills of mathematical concepts (i.e. student ability to define key terms, explain, document solutions and use vocabulary**). Therefore it is inconclusive if students are proficient with PSLO 2.**

Suggestion: Mathematical literacy is a PSLO that can be assessed alongside other PSLOs, assuming the problem is contextualized and is assessed with a communication lens. There may also be a need for instructors to focus more on mathematical literacy in their classes.

PSLO 3

Assessment Quiz 1 was the only contextualized assessment instrument. Only 4% were proficient at solving the problem. **Therefore there is no evidence to show that students were proficient with PSLO 3.**

Suggestion: To assess PSLO 3, use contextualized problems.

PSLO 4

In Assessment Quiz 1, only 4% of sampled students showed proficiency in properly constructing a mathematical model (disk or shell method of finding a volume). Of all 5 assessment instruments, only one asked students to construct a model. The Lab Assignment maps to part of CSLO 3, concerning limitations or requirements of a solution method. Although the assessment only asked for why each technique CANNOT be applied to a given integral, the summary suggests that 64% of students went “above and beyond”, citing also when one CAN use each technique. This gives some evidence that students may be able to “correctly construct mathematical models appropriate for solution techniques. However, no assessment asked students to use multiple representations. The summary of Assessment Quiz 1 suggests that students were not able to draw the volume correctly. **In conclusion, there is not sufficient evidence that students are proficient with PSLO 4.**

Suggestion: When doing future CSLO assessments, attempt to have students construct models more often. If this is not possible, then we may need to alter our CSLOs to increase focus on modeling.

PSLO 5

There is no CSLO that maps to PSLO 5. This is a problem! Math 60 needs to have at least one CSLO that focuses on effectively learning skills.

Conclusion:

Based on the math 60 CSLO assessments, Math 60 students are not making any progress toward proficiency in any of the PSLOs. This is cause for concern for many math 60 students should have already taken 1-2 LMC transfer-level math classes and therefore should be making strong progress toward proficiency with respect to our PSLOs. One reason for this problem could be because of a large disconnect between the PSLOs and the CSLO assessment instruments. Students may be proficient with respect to our PSLOs, but we cannot tell based on the CSLO findings.

This misalignment could be due to the CSLOs themselves. The CSLOs are largely algorithmic in nature, not focusing on concepts like literacy, mathematical maturity and modeling. Furthermore, there is no CSLO that focuses on Effective Learning skills.

It is our strong suggestion to relook at the math 60 CSLOs to determine if they need to be rewritten to better align with our PSLOs.

Math 70 PSLO Assessment

CSLO 1: Calculus Literacy (PSLOS 1, 2 and 5)

Students will be able to articulate the concepts of multivariate calculus, justify claims by citing course concepts, and evaluate both their own mathematical conclusions and those of classmates.

CLSO 2: Vectors and the Geometry of Space (PSLOS 2, 3 and 4)

Students will be perform vector operations in two and three dimensional space and demonstrate an understanding of coordinate systems in three dimensional space, as well as determining equations of lines and planes.

CSLO 3: Multi-Dimensional Generalization (PSLOS 1, 2 and 5)

Students will analyze and apply the mathematical concepts that arise when generalizing from two dimensions to three or higher and interpret how these concepts arise from the increased complexity associated with these generalizations, including: finding equations of tangent planes at a point, finding the limit of a function at a point, determining differentiability, evaluating derivatives, finding local extrema and testing for saddle points, or evaluating two and three dimensional integrals

CSLO 4: Representation and Problem Solving (PSLOS 2, 3, and 4)

Given functions of multiple variables in different representations, students will be able to select and apply appropriate strategies to solve problems in multiple dimensions, and use technology and other independent representations to verify the accuracy of their solutions.

CSLO 5: Calculus Applications and Analysis (PSLOS 3, 4 and 5)

Students will be able to apply multi-dimensional and vector calculus concepts to create and justify appropriate models of realistic (including scientific) scenarios, and determine the appropriate contextual interpretation and plausibility of their solutions, including: computing arc length, finding divergence and curl, applying Green's, Stokes' and divergence theorems, solving constraint problems using Lagrange multipliers.

Current Transfer Program PSLO's and assessment of student proficiency based on Fall 2015 CSLO report:

Note: Three different assessments were used to create the Fall 2015 CSLO assessment report for Math 70. The PSLO's associated with each assessment are listed below although some PSLO's are directly assessed and others only cursorily.

Assessment	Associated PSLO's
Quiz #1	2,4 and cursorily 3
Quiz #2	4 and cursorily 2
Quiz #3	2,4 and cursorily 3

PSLO 1: Preparation and Mathematical Maturity:

Be prepared for the mathematical or statistical reasoning required in upper division work in their major, including the ability to generalize mathematical concepts and comprehend increasing levels of mathematical abstraction.

This PSLO was not assessed on any of the three quizzes used. The rubric for this PSLO determines proficiency largely based on a student generalizing a concept to a new situation. No new situations were presented to the students since the quiz problems given were identical to examples in the textbook. For example, Quiz #1 was identical to textbook page 879 #2 and Quiz #3 was identical to textbook page 1073 #18.

Proficiency? Not possible to assess.

PSLO 2: Mathematical Literacy:

Communicate mathematics:

c) Read with comprehension documents having mathematical content and participate cogently in discussion involving mathematics;
d) Clearly articulate mathematical information accurately and effectively, using a form, structure and style that suit the purpose (including written and face-to-face presentation).

Parts of this PSLO were assessed on Quiz #1 and Quiz #3, and to a minor extent in Quiz #2. On quiz #1 30% of students were able to correctly interpret solutions at a level of proficiency or above. Quiz #3 offered students a more simplified opportunity to interpret a force calculation and 82% of those students were able to correctly interpret this calculation at a level of proficiency or above. Quiz #3 asked students to set up and solve a triple integral which could be used to assess a student's ability to document their solution process and use correct mathematical notation. The CSLO report did not aggregate proficiency on these skills. There remain parts of this PSLO that were not assessed using any of the three quizzes included in the CSLO report.

Proficiency? Between 30% and 82%, most likely closer to 30%.

PSLO 3: Problem-Solving Ability:

d) Reason with and apply mathematical concepts, principles and methods to solve problems or analyze scenarios in real-world contexts relevant to their major;
e) Use technology effectively to analyze situations and solve problems;
f) Estimate and check answers to mathematical problems in order to determine reasonableness, identify alternatives, and select optimal results.

This PSLO was not directly assessed on any of the three quizzes. Based on the quiz questions it does not appear that students were asked to show the use of a problem solving process, nor use technology to analyze and solve problems, nor verify and defend the reasonableness of their answers. If students were demonstrating any of these objectives, the CSLO report does not provide levels of proficiency. In quizzes #1 and #3 students are asked to use proper units and/or context with their answers but the CSLO report does not aggregate proficiency on this skill.

Proficiency? Not possible to assess.

PSLO 4: Modeling Ability

c) Construct and interpret mathematical models using numerical, graphical, symbolic and verbal representations with the help of technology where appropriate in order to draw conclusions or make predictions;
d) Recognize and describe the limits of mathematical and statistical methods.

Quiz #1 asked students to use and interpret a table, quiz #2 required students to understand a three-dimensional region to evaluate an integral, and quiz #3 had students analyze a graph. None of the quizzes asked students to recognize and describe the limits of their solution method(s). Quiz #1 saw 48% of students proficient or above, quiz #2 had 50% of students proficient or above, quiz #3 showed 35% of students proficient or above.

Proficiency? Between 35% and 50%.

PSLO 5: Effective Learning Skills:

c) Independently acquire further mathematical knowledge without guidance, take responsibility for their own learning, determine appropriateness and correctness of their own work, and function effectively in different learning environments.
d) Succeed in different learning environments, particularly in a group setting of working collaboratively with others.

This PSLO was not assessed on any of the three quizzes used. The rubric for this PSLO determines proficiency largely based on a student's ability to use and create

source materials, independently acquire knowledge, work productively in different learning environments, and verify the accuracy of their work before submission. None of these skills were assessed on any of the three quizzes used.

Proficiency? Not possible to assess.

Summary of findings

The assessment instruments used were not well aligned to the Math 70 CSLO's nor to the Transfer Program PSLO's. Based on the quizzes that were used, there is substantial concern that few students (<50%) are meeting proficiency levels on any of the PLSO's. However, this could merely be a consequence of the assessment instruments used and not the abilities of the students assessed.

It is recommended that future Math 70 CSLO assessments use a wider variety of questions and include avenues for students to show other skills beyond computational acuity and use of different mathematical representations.

Furthermore the Math 70 CSLO's as listed on the COOR may need to be updated to better align with the Transfer Program PSLO's.