KBOR Assessment Annual Report 2015: University of Kansas

Executive Summary

To integrate the KU Core review process and the KBOR assessment, we identified College Algebra MATH 101 (N=972) and Calculus I MATH 121 (N= 547) for this year's reporting, due to their large enrollment size and representation of KU Core learning outcome 1.2 "Quantitative Literacy."

To assess this learning outcome, we used four unit exams from MATH 101, and the derivatives gateway exam from MATH 121. The unit exams in MATH 101 address four content areas of College Algebra and use a five-point scale to define levels of competency. The gateway exam selected for MATH 121 involves two steps. First, students take the exam online at home as many times as they need before a deadline. Once the students pass the online version, they can take the proctored in-lab version in a computer lab. Both versions have 10 questions, randomly generated from 10 groups of questions about a central computational skill for the course, and require at least eight exactly correct responses for students to receive a passing grade.

Assessment results from MATH 101 indicate that the majority of the students (nearly 70%) have achieved at least the basic competency in College Algebra, but had difficulty grasping the third concept, "Representation," where 45% of the students didn't achieve the expected learning outcomes (see Table 1). Furthermore, non-calculus-bound students (i.e. who will take a statistics or a topics course as a second level math course) have more challenges in achieving the learning outcome, and are four times more likely to withdraw from the course than students who expect to take calculus.

ALL MATH 101 Students (N=972 including 101 Withdrawals)					
Dimension	**Exemplary** (>= 90%)	**Good** (>= 80%)	**Satisfactory** (>= 70%)	**Basic** (>= 60%)	**Not Achieved** (< 60%)
Computation: Solving Equations and Inequalities; carrying out appropriate calculations and symbolic manipulations	20%	24%	22%	12%	22%
Methodology: Conceptual knowledge of function families and functional relationships; creating new functions from basic functions	19%	30%	19%	12%	20%
Representation: Analyzing and synthesizing symbolic and graphic representations of power functions and rational functions	6%	17%	17%	15%	45%
Interpretation: Applying knowledge of functional relationships in the context of growth and decay and drawing relevant conclusions	17%	20%	19%	9%	34%

Table 1: MATH 101 student performance in four content areas

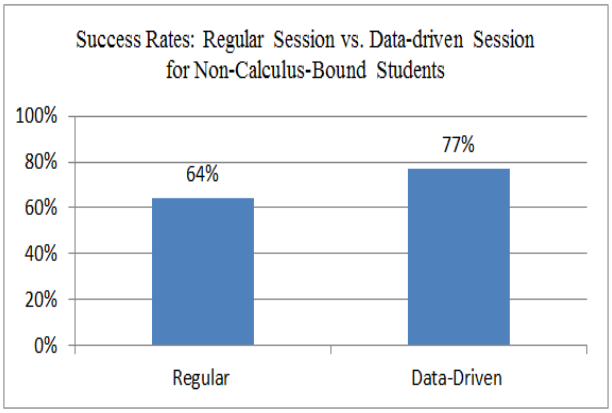

Figure 1: Comparison of success rates between sessions

The current version of MATH 101 (College Algebra) focuses on calculus preparation; with some adjustments it can better meet the interests and needs of the students who will not take calculus (70% of the enrolled students). The assessment data from MATH 101 reinforces this observation and suggests a different focus for College Algebra for non-calculus-bound students. As a result, an applied (data-driven) version of College Algebra MATH 101 was piloted in fall 2014 for students who will take as a second level course a statistics or a topics course. The success rate in this fall 2014 pilot session (data-driven session) was 77% (80% when the data-driven session was repeated in spring

2015), significantly higher than the 64% success rate for non-calculus-bound students in the regular MATH 101 session (see Figure 1 above).

For MATH 121, nearly 95% of the students passed the online gateway exam last year overall, and about 85% received a passing grade for the in-lab version (See Figure 2). Students enrolled in fall 2014 performed slightly better than the spring 2014 students (more Engineering students were enrolled in the fall than in the spring).

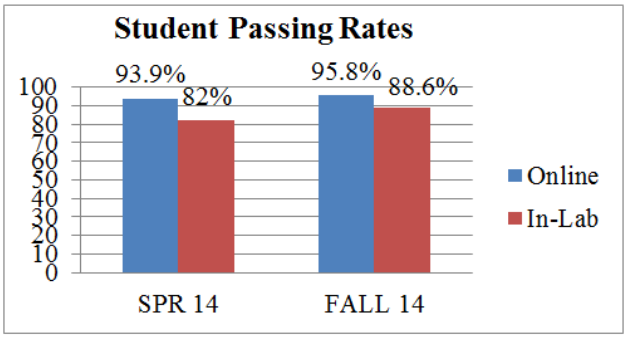

Figure 2: Student passing rates by semesters

Among the ten questions used in the gateway exams, question 9 is the most difficult, addressing the concept of "compound problems: product, quotient rule, and compositions of all types of functions" (62.7% student success rate) (see Table 2).

Question #	Content Domain	Spring 2014 (N=244)	Fall 2014 (N=509)	2014 Weighted Average (N=753)
1	power and sum rules	79.9%	85.1%	83.4%
2	product rule	76.6%	83.1%	81.0%
3	quotient rule	84.0%	89.0%	87.4%
4	generalized power rule (simple form of chain rule)	85.7%	89.0%	87.9%
5	compound problems: chain rule combined with another chain rule, product rule or quotient rule	79.1%	81.1%	80.5%
6	exponential functions	63.1%	68.8%	67.0%
7	logarithmic functions	66.0%	72.1%	70.1%
8	trigonometric functions	76.2%	79.4%	78.4%
9	compound problems: product, quotient rule, and compositions of all types of functions	60.2%	63.9%	62.7%
10	compositions of transcendental functions (exponential, logarithmic, trigonometric)	66.8%	80.4%	76.0%

Table 2: Student success rates by items (based students' last attempts in the in-lab exam)

Based on the assessment findings, we plan to implement the following:

- Prepare KU Core review reports for MATH 101 and 121 based on the assessment results by September 2015 and share them with the rest of the KU Core community.
- Secure funding from the university to expand the applied version of College Algebra MATH 101 for non-calculus-bound students.
- Adjust instruction in MATH 101 and MATH 121 to put additional emphases on the concepts that students have most difficulty with. Additional practice opportunities, such as assignments or group work, will be used to help pinpoint students' learning barriers and offer students concrete feedback for improvement.
- Track student use of existing math resources and supports to find out whether those resources are sufficient and whether students use them effectively.

KBOR Assessment Annual Report 2015

Short Version (May 2015)

To integrate the KU Core review process and the KBOR assessment, we identified College Algebra MATH 101 (N=972) and Calculus I MATH 121 (N= 547) for this year's reporting, due to their large enrollment size and representation of KU Core learning outcome 1.2 "Quantitative Literacy."

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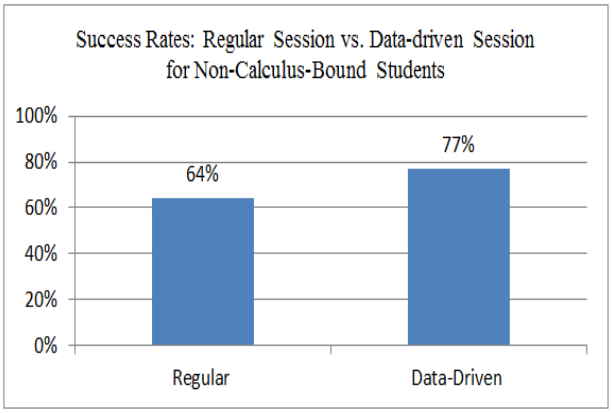

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session (data-driven session) was 77% (80% when the data-driven session was repeated in spring 2015), significantly higher than the 64% success rate for non-calculus-bound students in the regular MATH 101 session (see Figure 1 above).

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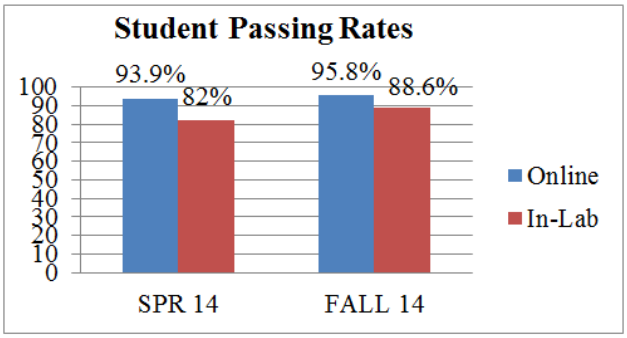

Figure 2: Student passing rates by semesters

Among the ten questions used in the gateway exams, question 9 is the most difficult, addressing the concept of "compound problems: product, quotient rule, and compositions of all types of functions" (62.7% student success rate) (see Table 2).

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Based on the assessment findings, we plan to implement the following:

- Prepare KU Core review reports for MATH 101 and 121 based on the assessment results by September 2015 and share them with the rest of the KU Core community.
- Secure funding from the university to expand the applied version of College Algebra MATH 101 for non-calculus-bound students.
- Adjust instruction in MATH 101 and MATH 121 to put additional emphases on the concepts that students have most difficulty with. Additional practice opportunities, such as assignments or group work, will be used to help pinpoint students' learning barriers and offer students concrete feedback for improvement.
- Track student use of existing math resources and supports to find out whether those resources are sufficient and whether students use them effectively.

KBOR Assessment Annual Report 2015

Full Version (May 2015)

I: Introduction: What did we measure and why did we measure it?

The KBOR learning outcome "Mathematics and Analytical Reasoning" is well aligned with KU Core learning outcome 1.2 "Quantitative Literacy." To integrate the KU Core assessment process and the KBOR assessment requirements, we identified College Algebra MATH 101 (N=972) and Calculus I MATH 121 (N= 547) as our target courses for this year's KBOR assessment reporting, due to their large enrollment size and representation of KU Core learning outcome 1.2. The goals of this assessment are to produce examples for the KU Core assessment process in KU Core Learning Outcome 1.2, and provide information that aligns with instruction and curriculum design for the department and the course instructors. In addition, MATH 101 piloted an applied version (data driven) in fall 2014, and this assessment will shed light on the pilot and help KU evaluate the benefits of scaling up this new version of College Algebra.

II: Assessment Process and Methodologies: How did we measure it?

Best practices in assessment suggest that embedded assessments align with instruction closely and provide information that can lead to improved student learning. KU is purposefully utilizing this strategy to cultivate a culture of assessment and get faculty buy-in. Aware of assessment limitations of course assignments; we developed a set of criteria to guide our selection of evidence:

1) Does this assignment/test/project focus substantially on mathematics and analytical reasoning?
2) Does this assignment/test/project require students to demonstrate this learning outcome at an appropriate level?
3) Is this assignment/test/project evaluated by an evaluation metric to provide both summative and formative information?
4) Does the assignment/test/project count towards students' final grade to motivate students to put forth their best effort? Those questions also match the criteria used for the KU Core Recertification.

Based on those criteria, we chose four unit exams from MATH 101, and a skills test, the derivatives gateway exam, from MATH 121. The unit exams in MATH 101 address four content areas of College Algebra. We use a five-point scale to define levels of competency based on the percent of students' correct responses (see Table 1). The gateway exam selected for MATH 121 involves two steps. First, students take the exam online at home as many times as they need before a deadline. Once the students pass the online version, they can take the proctored in-lab version in a computer lab. Both versions have 10 questions, randomly generated from 10 groups of questions about a central computational skill for the course, and require at least eight exactly correct responses for students to receive a passing grade. Students who fail the online version are not allowed to take the in-lab version. Students who fail the gateway exam will receive a reduction of their grades (one letter grade down). TAs are available for students to get help with their practice questions.

III: Assessment Results: What did the data tell us?

MATH 101 Data

The following table summarizes performance levels in 4 exams of all the students in Math 101 during the fall of 2014. The exams are centered on the content areas of computation, methodology, representation and interpretation that encompass all the college algebra core outcomes. The student count in the table includes 101 students who withdrew from the course. Performance in the areas of representation and interpretation also includes a group of students who remained enrolled but were not active in the course in the last half of the semester and may not have completed the assessment for the dimension measured.

ALL MATH 101 Students (N=972)					
Dimension	**Exemplary** (>= 90%)	**Good** (>= 80%)	**Satisfactory** (>= 70%)	**Basic** (>= 60%)	**Not Achieved** (< 60%)
Computation: Solving Equations and Inequalities; carrying out appropriate calculations and symbolic manipulations	20%	24%	22%	12%	22%
Methodology: Conceptual knowledge of function families and functional relationships; creating new functions from basic functions	19%	30%	19%	12%	20%
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Interpretation: Applying knowledge of functional relationships in the context of growth and decay and drawing relevant conclusions	17%	20%	19%	9%	34%

Table 1: MATH 101 student performance in four content areas

Table 1 indicates that the majority of the students (nearly 70%) have achieved at least the basic competency in College Algebra, but had difficulty grasping the third concept, "Representation," where 45% of the students didn't achieve the expected learning outcomes (please note that this data includes withdrawals). In order to better understand the student achievement, the data is broken down by student interest codes (calculus-bound vs. non-calculus-bound). Figure 1 compares student performance levels between non-calculus (686 students) and calculus-bound students (286 students) and it is very clear that students who are non-calculus-bound (i.e. who will take a statistics or a topics course as a second level math course) have more challenges in achieving expected MATH 101 learning outcomes than students who expect to take calculus. Furthermore, the number of students in the non-calculus-bound group who withdrew from the course was four times as many as from the calculus-bound group of students**.**

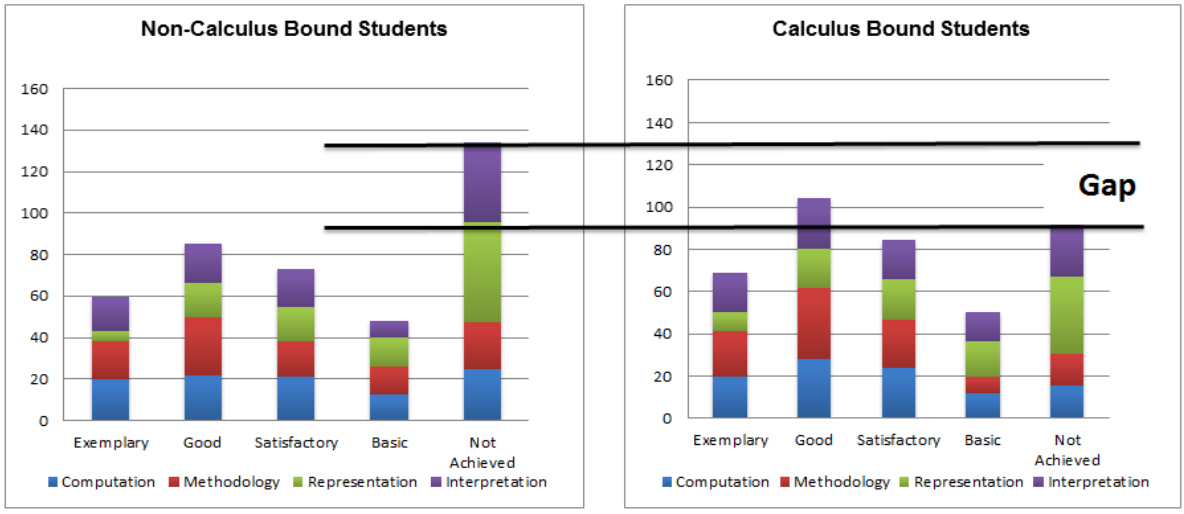

Figure 1: Student performance comparison between non-calculus bound students and calculus bound students in MATH 101

Our first explanation to this difference in performance was the difference in the background of the students. However, when we looked at the ability bands, college readiness, and the demographics of the two groups, we were surprised to find that the data (Figure 2, Table 2 and Table 3) demonstrated that the two groups of students are very similar.

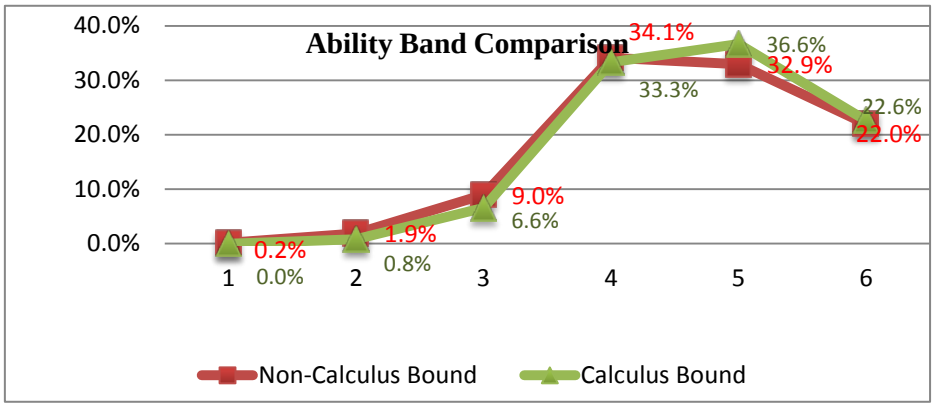

Figure 2: Ability band comparison between non-calculus bound and calculus-bound students

	Math ACT		High School GPA	
	Mean	**Median**	**Mean**	**Median**
Non-Calculus-Bound	21.79	23	3.24	3.32
Calculus-Bound	22.37	23	3.12	3.2

Table 2: College readiness comparisons

		AMIND	ASIAN	BLACK	HISPA	NOTHISPA	NSPEC	PACIF	WHITE
Non-Calculus-Bound	#	3	13	40	27	12	9	4	578
	%	0.4%	1.9%	5.8%	3.9%	1.8%	1.3%	0.6%	84.3%
Calculus-Bound	#	1	8	19	10	1	9	0	238
	%	0.4%	2.8%	6.6%	3.5%	0.4%	3.2%	0.0%	83.2%

Table 3: Demographics comparisons

MATH 121 Data

On average, nearly 95% of the students passed the online gateway exam last year, and about 85% received a passing grade for the in-lab version (See Figure 3). Students enrolled in fall 2014 performed slightly better than the spring 2014 students. The student distribution difference between spring 2014 (52% Engineering, 16.6% pre-Engineering, and 31.4% non-Engineering majors) and fall 2014 (67.8% Engineering, 11.3% pre-Engineering, and 20.9% non-Engineering majors) reflects the fact that many students admitted to Engineering are better prepared to start calculus from the beginning.

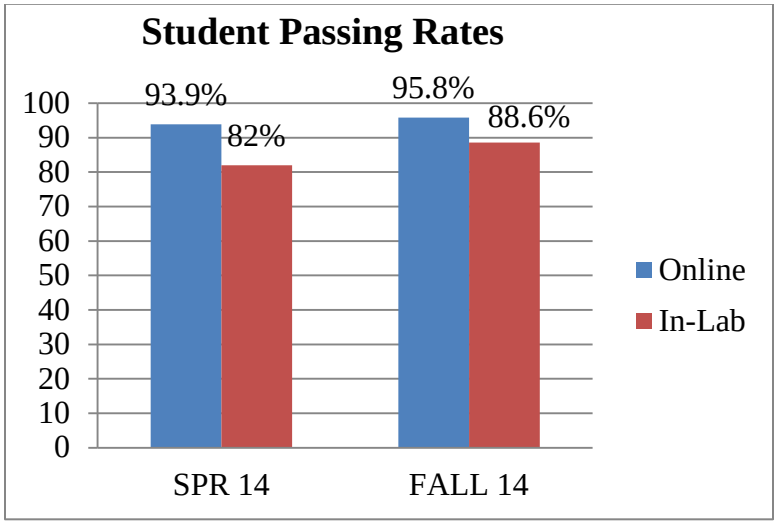

Figure 3: Student passing rates by semesters

Among the ten questions, which increase in complexity and difficulty from question 1 to 10, question 9 is the most difficult, addressing the concept of "compound problems: product, quotient rule, and compositions of all types of functions" (62.7% student success rate) (see Table 4).

Question #	Content Domain	Spring 2014 (N=244)	Fall 2014 (N=509)	2014 Weighted Average (N=753)
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Table 4: Student success rates by items (based students' last attempts in the in-lab exam)

We also looked at student testing behaviors in the gateway exam. A large majority of the students took both the online and in-lab exams multiple times (upwards of 15 times) in order to pass, which suggests that many students rely on retaking the test multiple times to get feedback.

IV: Closing the Loop: What did we do with the results?

University-Level

As we mentioned earlier, one use of this assessment is to help refine the KU Core Review process. The framework adopted by the KU Core Committee has been tested by this assessment, and we found that faculty could easily adapt their course-embedded assessment to generate information for their KU Core review. This assessment will be converted to KU Core review reports to be used for MATH 101 and 121, and shared with the rest of KU Core instructors as examples.

We will start reviewing all courses in the category of KU Core Goal 1.1 (Critical Thinking) and 1.2 (Quantitative Literacy) this September, and courses contributing to KU Core Goal 2.1 (Written Communication) and 2.2 (Oral Communication) next fall. With this process in place and implemented, we will use assessment results collected through the KU Core review process for future KBOR reporting.

Program/Curriculum-Level

A large percent of the students enrolled in MATH 101 (70% of them) do not plan to take calculus. The current version of MATH 101 (College Algebra) focuses on calculus preparation; with some adjustments it can better meet the interests and needs of the students who will not take calculus. The assessment data from MATH 101 reinforces this observation and suggests a different focus for College Algebra for non-calculus-bound students. As a result, an applied (data-driven) version of College Algebra MATH 101 was piloted in fall 2014 for students who will take as a second level course a statistics or a topics course. The success rate in this fall 2014 pilot session (data-driven session) was 77%

(80% when the data-driven session was repeated in spring 2015), significantly higher than the 64% success rate for non-calculus-bound students in the regular MATH 101 session (see Figure 4).

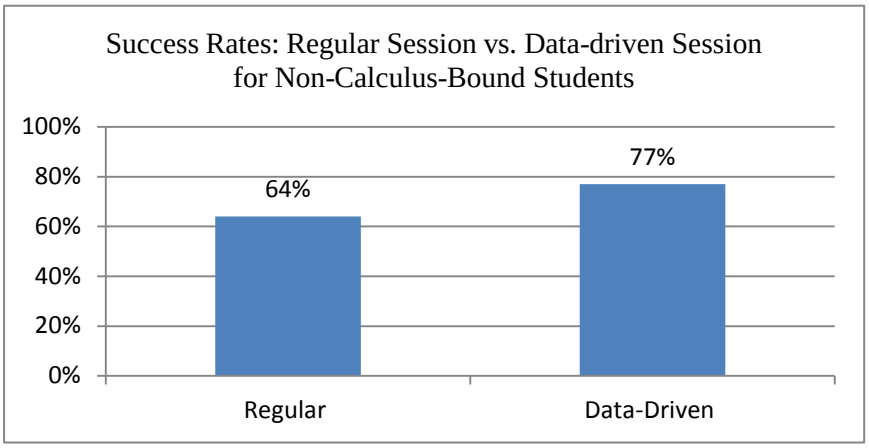

Figure 4: Comparison of success rates between sessions

These promising results have encouraged the Mathematics department to seek funding to support the expansion of the data-driven model. Meanwhile, more assessment is planned to track how the data-driven version of College Algebra impacts students' learning outcomes in their subsequent courses such as MATH 105 (Introduction to Topics in Math) and MATH 365 (Elementary Statistics). Students' retention rates will be monitored, as well.

While we are celebrating the promising results from the MATH 101 pilot, assessment from both courses brings light to the issue of student college readiness in mathematics. In MATH 101, students need to have a working knowledge of certain mathematical concepts or skills, such as fractions, in order to master complex concepts, such as rational functions. For MATH 121, students need to know how to follow order of operations and mathematical procedures and to type the corresponding mathematical symbols in an online system in order to perform well in the gateway exams. Those skills are taught in high school at a minimal level and need to be reinforced both before and during the college-level math courses.

Course-Level

The data show that a large number of students attempted the MATH 121 gateway exam at least 15 times before they gave up or succeeded. Students need additional help and practice before repeating the exams. Online practice exams are available to the students throughout the exam periods, allowing students to practice on the problems, get used to the online testing system, and learn how to enter mathematical symbols correctly in the online environment. Assistance is available in the calculus help room and the instructors' office hours. However, many students do not take advantage of these opportunities. We need more investigation on the use of these aids and on measures to increase student use of them.

We will need to conduct further study on gateway exam item 9 on the concept of "compound problems: product, quotient rule, and compositions of all types of functions" for MATH 121 and the unit exam on the concept of "Representation**:** Analyzing and synthesizing symbolic and graphic representations of

power functions and rational functions" for MATH 101. We are planning to introduce a module in the regular version of MATH 101 to address the low level of achievement in the representation dimension. Students will have to successfully evaluate complex computations with integers and rational numbers (evaluation of rational functions at integers and at rational numbers) before they will be asked to analyze the corresponding functions symbolically.

Other possible approaches would include:

1) Add assignments on those concepts to allow students to demonstrate their problem-solving process step-by-step so that issues can be pinpointed. Look into the results that students enter into the testing system to figure out whether typing errors (e.g., missing parentheses) cause suboptimal performance.
2) Coordinate between the redesign of Math 104, Precalculus, (the prerequisite for Math 121) and symbolic skills necessary in Math 121

Student-Level

We are also looking into the literature to better understand individual factors that influence students' mathematical skills and performance. Intrinsic motivation to succeed in math, competence beliefs, attitudes, values, and personal interest have been recognized as important components of understanding students' level of success in mathematics (Maltese & Tai, 2010, 2011). Findings from this assessment make us believe that student motivation and the relevance and applicability of mathematical concepts and skills in students' intended fields play an important role in student achievement and performance in mathematics. A study conducted by Hieb, Lyle, Ralston, and Chariker in 2014 suggests that internal goal orientation and test anxiety are factors that predict exam scores. This suggests that a combination of skills (math skills, online test-taking skills, and reflection about internal goals in mathematic learning) might be needed to increase math performance.

Another factor that influences student performance is the opportunity to learn, consisting of the learning activities a student engages in prior to testing (Shriberg, 2007), as well as the feedback that students get on problems similar to those in the test. In one study, De La Cuesta (2008) found that providing students assignments that include specific, challenging, short-term but achievable goals based on weak components of a previously taken test not only increase student confidence and commitment but also increase student performance (and overall passing rate) on a subsequent test. Similarly, Swan (2002) suggests three factors that are associated with success, specifically for online assessments and learning. The most relevant factor is instructor feedback/instructor-student interaction. It is not enough to provide students feedback on their performance, but the feedback should come directly from the instructor, and there should be some type of interaction (F2F or online interaction) where there is active dialog between instructor and student.

KU's Department of Mathematics and their instructors have been working diligently to provide various resources and feedback loops to students. For example, students are encouraged to come to the help rooms and computer labs to practice math problems and receive assistance from tutors and TAs. Online tutorials, practice problems and links to external resources are imbedded in the Math 101 curriculum. Recitation sessions led by GTAs are another place where students can get help with their

mathematical learning. However, it is unknown how students utilize those resources and supports currently in place. Analytical statistics regarding student use of available resources might help us understand whether those resources are sufficient and are used by students effectively.

Action Items:

- Prepare KU Core review reports for MATH 101 and 121 based on the assessment results by September 2015 and share them with the rest of the KU Core community.
- Secure funding from the university to expand the applied version of College Algebra MATH 101 for non-calculus-bound students.
- Adjust instruction in MATH 101 and MATH 121 to put additional emphases on the concepts that students have most difficulty with. Additional practice opportunities, such as assignments or group work, will be used to help pinpoint students' learning barriers and offer students concrete feedback for improvement.
- Track student use of existing math resources and supports to find out whether those resources are sufficient and whether students use them effectively.

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