Enhancing Calculus in Undergraduate STEM Education with Bloom's Taxonomy

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Introduction

In recent years, there has been increasingly more focus on science, technology, engineering, and mathematics (STEM) education from a national perspective (Gasiewski, Eagan, Garcia, Hurtado, & Chang, 2012). In fact, in 2012, the President's Council of Advisors on Science and Technology developed an article on the state of STEM in America entitled *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics*. This article emphasized the importance of increasing the number of graduates in STEM disciplines in order for the United States of America to maintain scientific preeminence. Yet, based on national college and university statistics, only about 40% of students who plan to complete a degree in a STEM discipline actually do so. Within the article, specific challenges that must be addressed in our college and university classrooms are outlined. Three recommendations were highlighted in the article: (i) *improve the first two years of STEM education* in colleges/universities, (ii) provide all students with the tools and resources they need to excel, and (iii) diversify pathways to STEM degrees (President's Council of Advisors on Science and Technology, 2012). College Calculus, which is a fundamental course for STEM areas of study, has the potential either to deter students from continuing in STEM or to provide students with a strong foundation for more advanced classes and prepare them with the confidence and skills to persist and excel in STEM. As faculty members at a university that awards many STEM degrees, the authors realized that there was a need to improve the success rate in Calculus in order to increase student persistence and graduation in STEM majors.

Since the establishment of colleges and universities the principal method of teaching has been the "teaching by telling" method also known as lecture (Freeman et al., 2014). One reason why this teaching technique has been widely used is because the instructor has the ability to share lots of information in a short amount of time, which leaves little concern about the ability to cover all of the course material during a given term. However, this style of teaching leaves little or no time available for student involvement in the learning experience beyond just listening. There are other theories and techniques which have been developed over the years, which focus on student centered learning and the literature provides evidence of the effectiveness of these methods.

Levels of learning have been the focus of educational research and have been studied extensively to describe the objectives of education (Karaali, 2011). Published in 1956, the original version of *Taxonomy of Educational Objectives* was authored by Benjamin Bloom with collaborators Max Englehart, Edward Furst, Walter Hill, and David Krathwohl. Commonly known as Bloom's Taxonomy, this framework uses a multi-tiered scale to organize the levels of expertise required to achieve measureable student outcomes. Bloom's Taxonomy involves three taxonomies: knowledge based goals, skills based goals, and affective (i.e. values, attitudes, and interests) based goals. Bloom's Taxonomy is a classification of types of thinking into six different levels: knowledge, comprehension, application, analysis, synthesis, and evaluation. In 2001, an updated version of Bloom's Taxonomy was developed by Anderson and Krathwohl. This newer version reorders the two highest levels and converts the different category titles to their active verb counterparts: remember, understand, apply, analyze, evaluate, and create. Even today, this model is widely used at the collegiate level to develop instructional strategies and assessments that are complementary to the course goals and appropriately measure students' levels of mastery/expertise of the subject matter. Therefore, it is critical to design a Calculus I course that embodies the elements of *Bloom's Taxonomy* since Calculus I is a fundamental course for most students majoring in STEM disciplines.

In addition, it is important to implement strategies that engage students in the learning process. Studies have shown that teaching techniques that involve students as active participants improve retention of information and critical thinking skills and can greatly increase STEM major interest and persistence, compared with traditional lecture (President's Council of Advisors on Science and Technology, 2012). In recent years, there have been many studies supporting a move toward *active learning* in college classrooms, particularly in STEM education. The term active learning as it is currently interpreted dates to the early 1990s and the work of Bonwell & Eison (1991), building on the work of Revans (1983) (Conference Board of the Mathematical Sciences, 2016). Active learning encompasses several models of instruction, including cooperative and collaborative learning, problem based learning, inquiry-based learning, discovery learning, and experiential learning (Barkley, 2010). It is a process of education whereby students engage in activities, like reading, writing, discussion, or problem-solving that encourage analysis, synthesis, reflection and evaluation of class content.

Bloom's Taxonomy and active learning techniques have been successfully implemented in undergraduate STEM education to enhance student learning. Therefore, this manuscript will present a Calculus I instructional tool and assessment guide that embodies the elements of both Bloom's Taxonomy and active learning strategies. The goal of this work is to introduce two models that the authors of this manuscript believe have the potential to enhance Calculus I instruction through effective course design and student engagement. The models presented in this manuscript, Enhancing eXcellence by

Creating Engaged Learners (EXCEL) and Calculus in Bloom Model (CBM), will contribute to the body of knowledge in the area of best teaching practices in undergraduate mathematics education. The EXCEL Model development was inspired by the authors' desire to create a tool that could be used by faculty to guide their implementation of active learning and assessment design in Calculus I with an emphasis on levels of thinking. In conjunction with the EXCEL Model, CBM can assist in the development of assessment items to properly measure levels of thinking.

Literature Review

Levels of Thinking

Learning Calculus concepts requires varying degrees of cognitive demands. In the framework of Bloom's Taxonomy, these demands can range from a lower order thinking skill, such as knowledge, to a higher order thinking skill, such as evaluation. Lower order thinking skills involve recalling, understanding, and applying fundamental facts. Higher order thinking skills involve examining and applying information to determine relationships, draw conclusions, and make decisions. Lower order thinking skills include knowledge, comprehension, and application. Higher order thinking skills include analysis, synthesis, and evaluation. Depending on the degree of cognitive demand there may be some overlap in the level of thinking. What follows are summaries of recent studies that have been conducted in collegiate Calculus courses involving Bloom's Taxonomy and other classifications of levels of thinking.

Recognizing the characteristics of each level of cognition is essential to the successful implementation of the Bloom's Taxonomy framework in any academic endeavor. In 2011 Karaali summarized his experience with applying Bloom's Taxonomy to specific tasks in college Calculus by identifying the level of cognition associated with each task. The goal of his work was to create a Calculus task at the highest level of Bloom's Taxonomy, evaluation, and to assess student thinking at this level through a Calculus project (Karaali, 2011). The work presented by the authors in this manuscript instead focuses on identifying tasks (activities and assessments) at all six levels of Bloom's Taxonomy, which can be done by Calculus students throughout the course to enhance their learning.

While the research study by Karaali focused on utilizing Bloom's Taxonomy at the highest level for a single project assignment, in 2014 a study more closely related to the work done by the authors of this manuscript was conducted by White and Mesa. These researchers focused on the cognitive orientation of Calculus I tasks and summarized their examination of materials (bookwork, worksheets, and exams) collected from five instructors teaching Calculus I in a two-year college over a one semester period. The main goal of the study was to identify the quality of instructors' learning goals and students' opportunities to learn in a successful Calculus I program. This was done by categorizing in-class and out-of-class assignments that were used by instructors to assess student learning (White & Mesa, 2014).

In another classification of thinking skills, Brookhart describes transfer, critical thinking, and problem solving as higher order thinking skills (Brookhart, 2010). When compared to Bloom's Taxonomy these skills span comprehension, application, analysis, synthesis, and evaluation. In 2016, Maharaj and Wagh conducted a pilot study to determine what types of tasks could be formulated to target the development of Brookhart's higher order thinking skills in Calculus I students. The study showed that the higher order thinking skills were lacking among study participants (Maharaj & Wagh, 2016). This indicates that there is a need to develop methods of teaching that promote meaningful learning. Maharaj and Wagh indicated that they have a plan to incorporate active learning strategies in the classroom, such as the use of technology, to promote increased student learning in Calculus (Maharaj & Wagh, 2016), which is also an approach that is utilized by the authors of this manuscript.

Active Learning Techniques

For several decades, STEM educators have been encouraged to implement active learning techniques to model the methods and mindsets that are central to scientific inquiry and to give students opportunities to connect theoretical ideas to real world applications in order to gain skills and knowledge that persist beyond the course in which it was acquired (Allen & Tanner, 2005). Therefore, improving the level of student learning is heavily dependent upon the instructional and assessment components of course design. These are opportunities for students to develop multi-level thinking skills which are necessary to solve a range of problems from basic to advanced.

In 2015, Merkel and Brania reported on the implementation and results of a five-year study of a cooperative learning technique in Calculus I at an all-male historically black college or university (HBCU). The goal of the study was to determine the impact of peer-led team learning (PLTL) on retention and success rates and learning gains. The study included data from sixteen sections of Calculus I taught over a span of five years. To measure learning gains, data were obtained from sections of the course in which one instructor taught both a PLTL section and a non-PLTL section in the same semester. To measure retention and success rates, data from all sections were used. The results of the study indicated that PTLT did not significantly enhance students' learning and did not have an apparent effect on student retention. The researchers adhered closely to established guidelines for the implementation of the PTLT model, but suggested the issues of the length of the workshop and the quality of team leaders as being potential barriers to the positive results seen in other PLTL studies (Merkel & Brania, 2015).

In 2017, Fox et al. summarized data collected based on a study which focused on offering a project option in sections of Engineering Calculus II and Engineering Calculus III. If the project option was selected by a student, then they were exempt from taking the course final exam and their grade on the project would replace the final exam grade. Students who chose the project option were required to have a project advisor, not their Calculus instructor, who was a faculty member in STEM. The goal of this project option was to enhance student learning and assist students in making connections between the theoretical concepts covered in Calculus and real-life applications by creating an opportunity for them to complete a summative project in the course. Overall, students who selected the project-option performed better than students in the concurrent courses that were non-project based (Fox et al., 2017).

Development of the Enhancing eXcellence by Creating Engaged Learners Model

As instructors of Calculus at the collegiate level, it is critical to design courses and course activities that teach and inform students and also empower them to think and create independently. With the overarching goal of increasing student knowledge acquisition and success in Calculus I, an intentional and thoughtful effort has been made by the authors to improve this course using particular teaching techniques and assessment design. Unlike the traditional lecture approach, teaching is student centered and consists of lessons that promote student inquiry and discussion, encourage student collaboration, and connect classroom knowledge to real-life applications. It involves developing a strategic plan which includes: identifying the characteristics and academic interests of the students, developing activities that activate prior knowledge, and optimizing the class personality and strengths. This approach to teaching is referred to as Strategic Engagement for Increased Learning (SEIL) Model (Stanberry, 2018). Assessment is designed to complement the SEIL Model and to measure student learning outcomes at different levels of cognition utilizing ideas from Bloom's Taxonomy. Both formative (evaluation of student learning throughout a course) and summative (evaluation at the end of specific content coverage to determine the effectiveness of instruction) assessment items can be matched to learning outcomes and mapped to levels of Bloom's Taxonomy.

Calculus is foundational to STEM disciplines because it is the study of how things change. The knowledge acquired and the skills developed in the first course in the Calculus sequence are essential to studying changes in biological, physical, chemical, and other types of systems. Although the exact material covered in Calculus I varies from institution to institution and even within an institution, common to most courses are the following student learning outcomes: (i) the ability to compute limits of functions, (ii) the ability to select and apply the appropriate differentiation techniques to solve problems, and (iii) the ability to use the Fundamental Theorem of Calculus to evaluate integrals.

Moreover, how the content of Calculus I is taught is very important. In 2015, the Mathematical Association of America (MAA) produced its seminal work on a national study of college Calculus programs. It listed the following five actions as practices related to good teaching of Calculus I:

1. Create a positive atmosphere in which the instructors encourage students to ask questions.

2. Maintain a positive attitude towards students' mistakes.

3. Keep reasonable pacing of the lecture to ensure all students are on the same page, with time for individual, pair, or group work.

4. Set high standards and clear expectations that all students can meet.

5. Have availability to answer student questions and respond to students' needs. (Bressoud, 2015)

Bloom's Taxonomy is a valuable tool for helping professors plan and deliver instruction and design assessment items in ways that incorporate the practices recommended by MAA. The structure of the taxonomy allows for clear expectations to be set at each level of cognition. The hierarchy of the levels promotes meaningful learning that helps students achieve high standards because the lower order thinking skills help to develop the higher order thinking skills. Therefore, it is essential for professors to make sure that the classroom instruction and activities require lower order thinking skills as well as higher order thinking skills. Further, this exposes students to tasks that require higher levels of cognitive demand on formative as well as summative assessments. Studies have shown that higher levels of student achievement in mathematics are associated with higher order thinking skills (Bressoud, 2015).

The use of Bloom's Taxonomy as an instructional aid can be enhanced with the implementation of teaching techniques that promote active student engagement. Studies have shown that active learning techniques increase student performance in mathematics (Freeman et al., 2014). In fact, another recommendation made by the MAA for successful college Calculus programs was to allow time for individual, pair, or group work during instruction. This type of active engagement helps students develop skills at varying levels of cognitive demand.

There were several motivating factors that contributed to the authors' decision to develop and implement techniques beyond the traditional way of teaching Calculus. These factors include the following: (i) departmental Calculus I success rate trend, (ii) authors' experiences teaching Calculus I, and (iii) best practices in undergraduate mathematics education. During the last few years at the university where the authors are faculty members, the success rate in Calculus I has been below sixty percent. Based on classroom observations, interactions, and student feedback, the authors noticed that there was a need to address learning gaps and assist students with making connections between their prior knowledge and skills and Calculus content. Further, over the years there have been a multitude of studies which provide evidence supporting the implementation of teaching methods that engage students in the learning process.

Traditionally, the college Calculus classroom has been a place where professors lecture and students are expected to listen and learn with little to no participation. However, there has been a movement toward transforming the college classroom to foster dynamic student centered learning. The authors believe that even in this paradigm shift there is still value in using lecture as a teaching technique when paired with student centered techniques. The model presented here identifies active learning activities which can be used to supplement various modes of instruction.

While reflecting on the factors that contributed to the authors' motivation for developing the models presented in this paper, best practices in collegiate mathematics instruction were researched. Well-known theories and effective teaching techniques were combined with other innovative instructional methods that were created by the authors in order to fully develop the models. Enhancing eXcellence by Creating Engaged Learners (EXCEL) Model embodies the elements of Bloom's Taxonomy, course assessment design, and active learning strategies with different assessment goals paired with a task and active learning activity. This model can be quite useful in ensuring that class activities and assessments mirror the student learning outcomes and overall course objectives. In addition, EXCEL offers some examples of activities classified by Bloom's Taxonomy which support student engagement. This model will help faculty teaching Calculus create a Calculus course to increase student learning and improve student academic performance. The EXCEL Model is presented in Table 1. For each level of Bloom's Taxonomy, an assessment goal is listed, an associated task is given, and examples of active learning activities are identified.

The merit of the EXCEL Model is in its organization of the theoretical framework of Bloom's taxonomy in relation to Calculus assessment tasks and active learning activities. The design of this model provides information about how Bloom's Taxonomy can be applied to particular Calculus problems along with examples of active learning activities that can be used to assess the same type of problem. EXCEL gives instructors a clear idea about how problems that require both lower order thinking skills and higher order thinking skills can be created using Bloom's Taxonomy in conjunction with Calculus learning outcomes.

Table 1. Enhancing eXcellence by Creating Engaged Learners (EXCEL) Model

	Goal of Assessment	Assessment Task	Examples of active learning activities
Knowledge	The student will be able to recall fundamental facts.	State a theorem, properties, or definition.	Clicker quiz Warm-up question
Comprehension	The student will be able to demonstrate understanding of fundamental facts.	Use a theorem or properties to solve a problem.	Exit tickets Short writing exercise
Application	The student will be able to apply acquired knowledge in a new or different situation.	Solve a multi-step problem that involves more than one theorem or definition.	Think-pair-share Board work
Analysis	The student will be able to analyze information to determine relationships, structure, and relevance.	Determine if a theorem applies to a particular situation.	Cooperative learning Flipped classroom
Synthesis	The student will be able to examine information to arrive at a conclusion.	Generate a function based on given information and valid assumptions.	One-minute paper Write an explanation of problem, techniques for solving, and solution.
Evaluation	The student will be able to prove statements and make judgements based on a set of criteria.	Prove a theorem.	Problem presentation Problem based learning

While implementing class activities which involve students is important, it is also critical for the students to have opportunities to learn outside of the classroom. EXCEL is a powerful tool which can be implemented in-class, but it can also be extended to impact the coursework completed by students outside of class. One way to effectively communicate with students about the course expectations, share their individual progress, and promote student engagement is utilizing a student accessible online platform to post a variety of items, such as, the course syllabus, class notes, pre-reading assignments, information about additional resources to support their learning, and their grades. In addition, textbook assignments and handouts could be given as homework or an online site could be used for homework and quizzes. All activities should complement the course goals and student learning outcomes.

Development of the Calculus in Bloom Model

The Calculus in Bloom Model (CBM), which can be found in Table 2, was created by the authors to guide instructors in developing assessment questions and activities for Calculus I that can be categorized using Bloom's Taxonomy. CBM was created with the goal of identifying Calculus assessment items and or question types at all six levels of Bloom's Taxonomy in order to check student lower order levels of thinking and higher order levels of thinking. Considering the variety of types of assessment items that are available to use for testing in Calculus, this model was developed based Bloom's Taxonomy and the levels of different types of assessments given. Using CBM provides a structure for assessing different levels of thinking based on time available to test and the type of assessment (homework, class work, quiz, test, etc.). This is a powerful tool because it gives instructors insights into designing assessments that are aligned with student learning outcomes at particular levels of Bloom's Taxonomy for the major topics covered in Calculus I: limits, derivatives, and integrals. CBM can also be used by instructors to determine how their current assessments fit into the scope of Bloom's Taxonomy.

Table 2. Calculus in Bloom Model (CBM)

Level	Limits	Derivatives	Integration
Knowledge *Know definitions, theorems, rules, and properties.*	List the conditions necessary for a limit to exist. State the definition of the limit of a function. List the three conditions for continuity at a number.	List the rules for differentiation. State the Mean Value Theorem (MVT). State the limit definition of derivative of a function.	State the Fundamental Theorem of Calculus (FTC). State the formula to find the arc length of a curve. State the formula to compute the volume of a solid of revolution.
Comprehension *Understand definitions, theorems, rules, and properties.*	Find the limit of a function as x approaches infinity. Given the graph of a function identify limiting values.	Find the derivative of a function. Illustrate the graphic that models a related rates problem. Based on the domain of a function and a specified x interval, determine if MVT can be applied.	Find the antiderivative of a polynomial function. Find the definite integral of a function.
Application *Apply definitions, theorems, rules, and properties to solve problems.*	Show that a function is continuous at a number. Apply the Intermediate Value Theorem to an equation.	Describe how to take the derivative of a composite function using chain rule. Find the critical points of a function. Apply MVT to a function with a given interval.	Sketch the region bounded by multiple functions and find the area of the bounded region. Calculate the arc length of the graph of a function over an indicated interval.
Analysis *Analyze a problem to determine the concepts/theorems that apply.*	Classify the type of discontinuity. Explain why a rational function whose numerator and denominator have no common factors, will have vertical asymptotes at each point of discontinuity. Give an example that does not satisfy the definition of continuity.	Analyze the solution of a related rates problem. Determine the intervals on which a function is increasing/decreasing. Show that Rolle's Theorem is a special case of the Mean Value Theorem.	Use a change of variables to solve an integral using the appropriate techniques. Analyze an integral equation to determine why a function must be continuous to apply the FTC.

Synthesis *Use prior knowledge and skills to solve more advanced problems.*	Generalize the type of function whose graph has a vertical asymptote. Generate the graph of a rational function.	Use the First and Second Derivative Tests to generate the graph of a rational function. Find and label any extreme values, discontinuities, and asymptotes. Generate the graph of a function and its derivative.	Estimate the area under a curve using inscribed rectangles of equal width.
Evaluation *Make judgements based on concepts/ theorems*	Prove the limit of a function using the Sandwich Theorem.	Defend the hypothesis and conclusion of the MVT using a geometric interpretation. Given an optimization problem that can be modeled by a function with constraints. Optimize the function and justify your solution.	Assess the difference between computing integrals using Riemann sums and FTC.

By showing specific tasks at each level of thinking, the CBM is also an important resource for students. This tool allows students to see the connections between the various topics in Calculus I and the relationships between cognitive levels and different types of tasks. The authors believe that as students recognize these relationships, they will become more self-aware of their levels of learning. This awareness can help them to study with more purpose and increase the likelihood of new knowledge being retained.

In developing the CBM, the authors believed it was also important to develop a tool that could be used by students to inform them about what knowledge and skills are necessary to perform certain tasks in Calculus I. The prerequisite skills for learning Calculus (PSLC), which can be found in Table 3, highlights the three major topics covered in Calculus I: limits, derivatives, and integrals. The prerequisite skills needed to solve these types of problems are included in Table 3. For students, the CBM is a useful guide to understanding the connections that exist among the concepts in the course content. The PSLC extends these connections by showing students the relevant prerequisite skills necessary for mastering the content in Calculus I and can guide students in studying more effectively in order to meet the learning outcomes of Calculus I.

Table 3 Prerequisite Skills for Learning Calculus (PSLC)

Calculus I Concepts	Calculus I Topics	Prerequisite Skills
LIMITS	Definition of limit	• *Solve absolute value inequalities.*
	Finding limits	• *Evaluate for a given .*
		• *Simplify a rational function.*
		• *Rationalize the denominator/numerator.*
		• *Simplify a complex fraction.*
	Continuity	• *Evaluate for a given .*
		• *Graph a function.*

DERIVATIVES	Rate of change	• *Simplify the difference quotient.*
		• *Rationalize the denominator/numerator.*
		• *Simplify a complex fraction.*
	Chain Rule	• *Compose functions.*
	Implicit differentiation	• *Solve an equation for a certain variable of quantity.*
	Related Rates	• *Solve a right triangle.*
		• *Use formulas for perimeter, area, volume, etc. of basic figures.*
		• *Solve a linear or quadratic equation for an unknown variable.*
	Critical numbers	• *Determine the domain of a function.*
		• *Solve a linear equation.*
		• *Solve an equation by factoring.*
		• *Solve an equation using the quadratic formula.*
		• *Solve a trigonometric equation.*
		• *Find the zeros of a function.*
	Mean Value Theorem	• *Evaluate for a given .*
		• *Find the slope of a secant line.*
	Derivative tests	• *Graph a function.*
		• *Determine the domain of a function.*
		• *Solve an equation by factoring.*
		• *Solve an equation using the quadratic formula.*
		• *Find the zeros of a function.*
	Graphical methods	• *Determine the domain of a function.*
		• *Solve an equation by factoring.*
		• *Solve an equation using the quadratic formula.*
		• *Find the zeros of a function.*
		• *Find - and -intercepts.*
		• *Find vertical and horizontal asymptotes.*
		• *Find holes.*
		• *Graph a function.*
	Optimization	• *Solve a linear, quadratic, or higher order equation.*
		• *Evaluate a function at a given value.*
INTEGRALS	Change of variable	• *Compose functions.*
	Area/Volume	• *Graph a bounded region.*
		• *Solve for points of intersection of graphs.*
		• *Solve an equation.*

Assessment item types can be designed to test different levels of cognition. Instructors must decide how much the assessment material should focus on lower order levels of thinking and higher order levels of thinking based on the learning goals and student learning outcomes. Depending on the type of assessment, time allocated for the assessment, and the resources available to the students, the number of problems covering particular levels of Bloom's Taxonomy may vary. Generally, solving problems at lower order levels of thinking require less time than solving problems at higher order levels of thinking. It is also important to note that mastery at higher levels of cognition indicates a more in depth level of learning, which sometimes may exceed the expectations that must be met based on the student learning outcomes.

EXCEL and CBM are newly created models, which the authors believe have the potential to enhance student learning and academic performance in Calculus I. In the future implementation of these models the authors intend to use them to design assessments and learning activities which align with course learning outcomes. Depending on the type of assessment (homework, quiz, test, etc.), the authors will select problems at particular levels of thinking to measure student cognition. If the authors notice questions in a low stakes assessment, then those topics will be reinforced and presented again on a different assessment. This approach will allow the authors to clearly measure student levels of learning on specific topics in Calculus I and adjust their teaching to address learning gaps. The authors plan to share the PSLC with students at the beginning of the course so that they are aware of the learning outcomes paired with the prerequisite skills and knowledge they will need to be successful. This will give students an opportunity to review and prepare to use their prior knowledge in mathematics and apply it to Calculus topics. Future work will be done which will include an analysis of the data collected based on the implementation of EXCEL and CBM.

Implications and Future Research

Since Calculus I serves as a foundational course for most STEM disciplines, it is of paramount importance that students achieve success in this course. The teaching techniques of the professor play a major role in Calculus I student success. Therefore, thoughtful and deliberate care must be given to the way in which this course is designed and taught. The authors of this manuscript used the levels of learning of Bloom's Taxonomy along with active learning techniques to develop two models for instruction that have the potential to increase student success in Calculus I.

Aligning course and assessment design with the course learning goals is a major component of instruction at the collegiate level. Instructors must also decide the amount and types of opportunities students are given to learn. In addition, instructors must determine how much of the grade weight should be assigned to each particular type of assessment. Overall, the course goals, expected student learning outcomes, categorization of assessment items based on Bloom's Taxonomy, design of assessments, and the active learning activities should be complementary and work together to increase student cognition and enhance student academic performance in Calculus.

EXCEL and CBM have been developed to guide effective instructional practices and appropriate assessment design to aid instructors in developing teaching strategies and assessments that help to advance the levels of thinking of their students. With the Bloom's Taxonomy framework and active learning techniques combined in both models, this type of course planning and creation offers students many opportunities to learn at varying levels of cognition. The inclusion of active learning techniques in the EXCEL Model gives instructors the chance to create opportunities for students to actively engage and participate in the learning process. The specificity of the question types in the CBM is beneficial since it aligns content to assessment items and assessment items to levels of thinking. The authors believe that each of these tools offers opportunities for enhanced student engagement and increased learning in Calculus I, which can significantly increase student success.

While this manuscript reports on the creation of the EXCEL Model and CBM, the data collected will be used to report on the effectiveness of the models based on the performance of the authors' students. Data collection began during the 2018-2019 academic year and upon the full implementation of EXCEL and CBM into the authors' Calculus I classes, they plan to publish the results.

The authors have used the EXCEL Model and CBM to classify a variety of Calculus assessment items (clicker questions, quiz questions, test questions, problem presentations, etc.), which have been administered to their students. The authors are using clickers as a way to check lower order thinking skills and promote higher order thinking skills in preparation for other types of assessments.

Along with providing recommendations for course and assessment design and enhanced instructional practices, the EXCEL Model and CBM also help to extend the body of knowledge concerning collegiate Calculus education by suggesting several avenues for future research. CBM could be utilized to characterize how instructors design assessments, to assess how students perform on questions at varying levels of cognition, and to categorize how students achieve on different types of question items. In addition, EXCEL and CBM can be used with a student response system to inform about how to optimally implement active learning in a Calculus I course with this type of technology. Further, EXCEL can easily be adapted for use in other STEM courses. EXCEL, CBM, and PSLC provide opportunities for instructors to present the course content in more accessible formats which lead to students becoming more engaged learners with enhanced academic performance.

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