

Numeracy: Preparing Students for Success in Algebra

Dr. Whitney Gaskins, University of Cincinnati

Dr. Gaskins joined the Engineering Education Department in 2015 as an assistant professor educator. She earned her Bachelor's Degree in Biomedical Engineering from the University of Cincinnati in 2008. Whitney earned her Masters of Business Administration in Quantitative Analysis from the University of Cincinnati, Lindner College of Business in 2010. She earned her Doctorate of Philosophy in Biomedical Engineering/Engineering Education also from the University of Cincinnati. Whitney also works with the Emerging Ethnic Engineers (E3) Program. She teaches Calculus 1 during the Summer Bridge program and instructs Cooperative Calculus 1 during the school year.

Continuing with her commitment to community involvement, Whitney has previously served on the National Executive Board for the National Society of Black Engineers, a student-managed organization with more than 30,000 members. She served as the Planning Chairperson for the 2013 Annual Convention and is currently an advisor for the Great Lakes Region.

Dr. Gaskins is the President of the Sigma Omega graduate chapter of Alpha Kappa Alpha Sorority, Inc. She is also a member of the Society of Women Engineers, the Women's Alliance, the National Technical Association, The Biomedical Engineering Society and the National Alliance of Black School Educators amongst other activities. She is Deaconess at New Friendship Baptist Church. Whitney was recognized in the 2013 Edition of Who's Who in Black Cincinnati.

Dr. Darryl Dickerson, Purdue University-Main Campus, West Lafayette (College of Engineering)

Darryl A. Dickerson, PhD serves as Associate Director of the Minority Engineering Program at Purdue University and Chief Executive Officer of Advanced Regenerative Technologies. He received his PhD in 2009 from the Weldon School of Biomedical Engineering where his research focused on the development of naturally-derived biomaterials specifically for the regeneration of interfaces between hard and soft tissues. Subsequently, he founded BioRegeneration Technologies to translate the benchtop work performed during his graduate studies to clinical practice. During his time as a graduate student, Dr. Dickerson gained significant management and leadership experience as a member of the Board of Directors (2004 – 2009) of the National Society of Black Engineers (NSBE). His work with NSBE culminated in his service as President, Chairman of the Board, and Chief Executive Officer and the launch of the Summer Engineering Experience for Kids (SEEK) program in 2007 – 2008. In 2012, he joined the staff of the Minority Engineering Program at Purdue and has since taken on the role of Associate Director. In this capacity, he manages the staff members in executing programming designed to transform the College of Engineering into a more diverse and inclusive environment by increasing enrollment, retention, and success of underrepresented minority students in engineering.

Ms. Virginia Lynn Booth-Womack, Purdue University-Main Campus, West Lafayette (College of Engineering)

Virginia received her B.S. in Industrial Engineering and a B.A. in Psychology while at Purdue University. She is currently the Director of Minority Engineering Programs in the College of Engineering. She assumed the position in 2004 after 18 years of manufacturing experience. Her last assignment was Lean Manufacturing Manager for the 3.7L and 4.7L Mack Engine facilities at Chrysler Corporation in Detroit, Michigan. Virginia has applied lean manufacturing concepts to identify and close the achievement gap between under-represented minority engineering students and the total engineering cohort. This was achieved focusing on first semester performance and first year retention through implementation of an aggressive transition program targeting first year engineering students from historically under-represented groups. She recently was called upon to serve as interim Executive Director for the National Society of Black Engineers from December 2013 through August 2014 during which time the organization experienced membership growth and strong metric focus towards goal attainment.

Mr. Delano White, The Gaskins Foundation

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Abstract

Algebra has been universally accepted as a gateway skill. It is a bridge to high-level math course: Geometry, Algebra II, Trigonometry and Pre-Calculus and Calculus. Students who take an Algebra course by the 8th grade are more likely to pursue careers in Engineering and other STEM fields. Students who take Algebra by the 8th grade will be able to take a Calculus course while in high school. Students who are exposed to Calculus in High School generally are more successful in their first-year mathematics courses in college.

Algebra by 7th Grade (AB7G) has been launched as a pilot program from National Association of Multicultural Engineering Program Advocates (NAMEPA), hosted by the University of Cincinnati and Purdue University. The program begins with students in the 3rd grade and continues each year until the 7th grade where the students are exposed to Algebra and hands on projects. The students' progress and test scores are tracked and monitored.

Our pilot sites meet two Saturdays of each month. All participants are required to have access to the Assessment and Learning in Knowledge Spaces (ALEKS) web-based student assessment system or a similar software program. The system can measure which skills the student has mastered and skills in which the students need more practice and training. Staff and volunteers also supplement the ALEKS training with hands-on lessons and activities designed to further challenge and engage the students.

Introduction

Students in the United States are falling behind their global counterparts. One of the biggest cross-national tests is the Programme for International Student Assessment (PISA), which every three years measures reading ability, math and science literacy, and other key skills among 15-year-olds in dozens of developed and developing countries. The most recent PISA results, from 2015,

placed the U.S. an unimpressive 38th out of 71 countries in math and 24th in science. Among the 35 members of the Organization for Economic Cooperation and Development, which sponsors the PISA initiative, the U.S. ranked 30th in math and 19th in science [1].

While the data shows an educational gap between the US and other countries, there is also a performance gap between different ethnic groups. Underrepresented minority (URM) students perform lower than White and Asian students on standardized tests. As early as the 4th grade, the data begins to show a significant performance gap on standardized assessment.

When analyzing test scores for URM students in Mathematics, the results indicate a significant divide between URM students and other students. According to the National Assessment of Educational Progress (NAEP), less than 20% of African-American 4th grade students were proficient in Mathematics. By the 8th grade, less than 15% of African-American students are proficient in Mathematics and by the 12th Grade less than 10% of African-American students tested as proficient in Mathematics. The results are only slightly higher for American Indian and Hispanic students on 4th and 8th Grade proficiency tests. By the 12th grade, less than 15% of American Indian and Hispanic students are proficient in Mathematics.

The impact of the low percentage of students who are Math-proficient in grades 4, 8 and 12 can directly be seen in average ACT scores by demographic. URM students who are not proficient in their Math assessments also do not perform well on standardized tests such as the ACT and this continues to present a major barrier to URM student access to 4- and 5- year engineering programs. Standardized test scores are used by most competitive engineering programs as a primary criterion for admission. The average ACT Math score in 2017 was 20.7 with most engineering programs having an engineering score in the mid-high 20s. In order to broaden participation for historically underrepresented minorities in engineering, we must increase early preparation in developing in math proficiency. To address this challenge, the Algebra by the 7th Grade (Ab7G) program was created as an innovative mathematics and engineering enrichment program that teaches elementary age students and their parents how to advance their mathematics skills and engineering knowledge in an out-of-school setting.

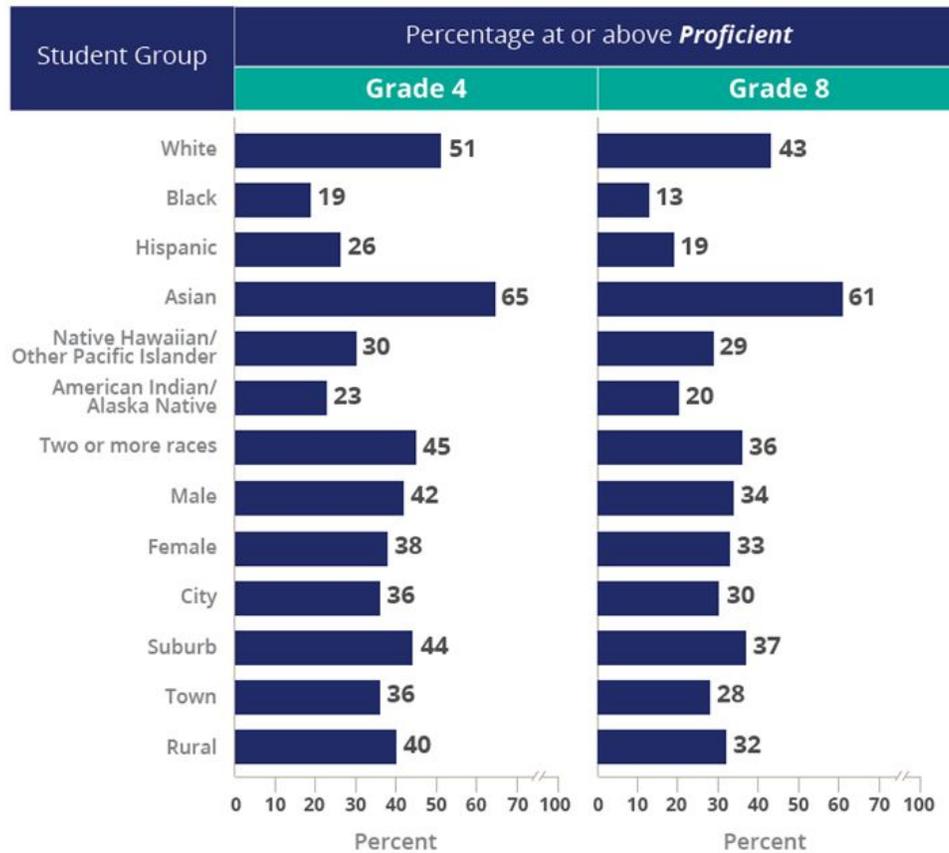


Figure 1: Percentage at or above proficiency in NAEP for selected student groups in 2015

Pilot Sites

Two sites were chosen for the Ab7G pilot: Cincinnati, OH and West Lafayette, IN. The Cincinnati pilot is hosted by STEMulates. STEMulates is a community-center 501(c)3 non-profit organization that provides extraordinary opportunities for under recognized and underrepresented youth. The mission of the program is to present, engage, and prepare students of all ages to become leaders in STEM using algebra, programming, and design concepts. STEMulates hosts AB7G at multiple locations. Our central location is the University of Cincinnati College of Engineering and Applied Science. The program also operates at New Friendship Baptist Church (New Friendship) in the Avondale neighborhood of Cincinnati. The New Friendship site is part of STEMulates' informal STEM training program. The informal STEM program increases STEM efficacy in socioeconomically disadvantaged communities by bringing training to institutions within those neighborhoods.

The West Lafayette pilot is hosted by the Purdue University Minority Engineering Program (MEP) in partnership with the Lafayette School Corporation (LSC). The LSC schools are in the backyard of the Purdue University – West Lafayette campus. LSC is considered an urban school district and has the highest level of underrepresented minority, low SES students in the area. Three schools were chosen for this pilot program: Vinton Elementary, Thomas Miller Elementary, and Oakland Elementary Schools. These schools have populations over 400 students, over 80% of the students receive Reduced Price Meals, and an ethnicity breakdown of over 40% underrepresented minority (URM) students.

About The Program

Algebra by 7th Grade (AB7G) is a cohort model that is designed to help ensure that students are proficient in Algebra by the 8th grade. Students who have passed an Algebra course by the 8th grade have demonstrated a higher capacity to matriculate into engineering pathways and subsequently into engineering careers. Completing an Algebra course by the end of the 8th grade year is a step towards completing a Calculus course prior to entering college. Students who have completed a Calculus course prior to entering college generally experience greater success in the first year of an engineering program.

Our AB7G cohort model begins in the third grade. Students are registered as a class and begin a supplemental course that enhances and measures their success against state-recognized goals.

Ab7G Objectives:

- Increase self efficacy in students from historically underrepresented groups through mentorship and engagement
- Provide ethnicity and gender-matched mentors to historically underrepresented students through engaging Purdue engineering and STEM students
- Engage parents in fun activities to increase their involvement in student learning activities

The AB7G program meets on the 2nd and 4th Saturday of each month. There is no cost to enroll in the program. Each session lasts two hours, generally from 9 – 11am. The first hour of each session is spent using the “**A**ssessment and **L**earning in **K**nowledge **S**paces” (ALEKS) web-based instructional software. Students work through the program individually with monitoring from volunteers. For the 2nd hour of the session, the students participate in hands-on and/or group projects that 1) help reinforce the lessons learned in their classroom and

ALEKS and 2) help increase student excitement and efficacy towards learning STEM concepts.

Students enter the program at the beginning of their 3rd grade year. These students are grouped as a cohort. The first cohort in West Lafayette launched in 2017. The first cohort for Cincinnati launched in Fall, 2018. Upon completion of the first cohort, the 3rd grade will be advanced to the 4th grade cohort. A new 3rd cohort will be added each Fall. At full capacity, Algebra by 7th Grade will operate five (5) cohorts, in grades 3-7, respectively. Each cohort will have access to ALEKS to provide supplemental instruction and support for the students.

Why ALEKS

We utilize ALEKS as a partner as it gives us a resource to work with our students through their elementary and secondary school careers. ALEKS is a Web-based, artificially intelligent assessment and learning system. ALEKS uses adaptive questioning to quickly and accurately determine exactly what a student knows and doesn't know in a course. ALEKS then instructs the student on the topics that they are most ready to learn. As a student works through a course, ALEKS periodically reassesses the student to ensure that topics learned are also retained. ALEKS courses are complete in their topic coverage and ALEKS avoids multiple-choice questions. One goal is for a student who shows a high level of mastery of an ALEKS course will be successful in the actual course he/she is taking. ALEKS also provides the advantages of one-on-one instruction, 24/7, from virtually any Web-based computer.

ALEKS provides the benefit of allowing our instructors to track the progress of each students. In addition to monitoring student progress during the sessions, because the tool is web-based, the students can complete tasks at home. Instructors can monitor student progress at any time, which includes 1) the number of topics covered 2) percent completion towards the topic goals and 3) amount of time spent during each session. Instructors can create assignments for the students as well as assign a number of topics or an expected time goal spent in ALEKS. This allows real-time monitoring of student performance and modification of assignments as a result.

ALEKS



Figure 2: Screenshot of Instruction, tracking student progress

Course Instruction

In addition to the ALEKS modules, the curriculum for the sessions is created by University faculty and graduate students. Graduate students led each session. Additional support is provided by engineering students and professionals. They support the students with their ALEKS completion and offer guidance in completing their hands-on activities. They also serve as mentors and role models for the students. It has been shown that the lack of self efficacy in underrepresented minorities to negative stereotypes reinforced in the media and in low income communities are also barriers to student entry into STEM careers [2-4]. Our goal is to have at least 1 volunteer/mentor for every 3 students.

Evaluation and Assessment

The assessment modules in ALEKS serve as the primary assessment for students. Upon their first login, students are required to take an initial assessment within the ALEKS system. Students were periodically assessed to determine their progress. At the closing session of the program, students completed a final assessment within ALEKS.

Additionally, all students in our programs are required to submit their most recent grade report. Our team notes student grades in Math and Science courses. These initial scores give us a baseline for the student. Throughout the year, we receive mid-year grade report and progress reports to measure their academic performance and track improvement.

We also give students two assessments which have been developed by our team. The first assessment is a STEM attitudes assessment. This assessment measures how students view and feel about STEM-related topics. This assessment is given at the beginning and the end of the program. We track the variance in the results. The second is a standardized math assessment which measures their understanding of concepts to which they have been previously introduced. This allows us to generate supplemental lessons if necessary.

The third measure is a post-session survey. This is given at the end of each session. The survey has three questions: 1) Did you like the session? 2) What did you learn today and 3) What did you learn from this session? Our volunteers track the results to the three questions. The report out for the survey has three sections: The overall class, boys in the session and girls in the session.

Preliminary Results

At the West Lafayette site, a total of 26 students attended at least 1 session of the program. There were 18 students fully enrolled students in the program, defined as those who attended 5 or more of the total 13 possible sessions. Of the 18 students enrolled, 8 students reached the target 4.25 grade level by the end of the program year, including one student who reached the 5th grade level (Figure 3). Two additional students were assessed at the 4th grade level. The enrolled students math grade level improved by an average of 0.69 ± 0.54 .

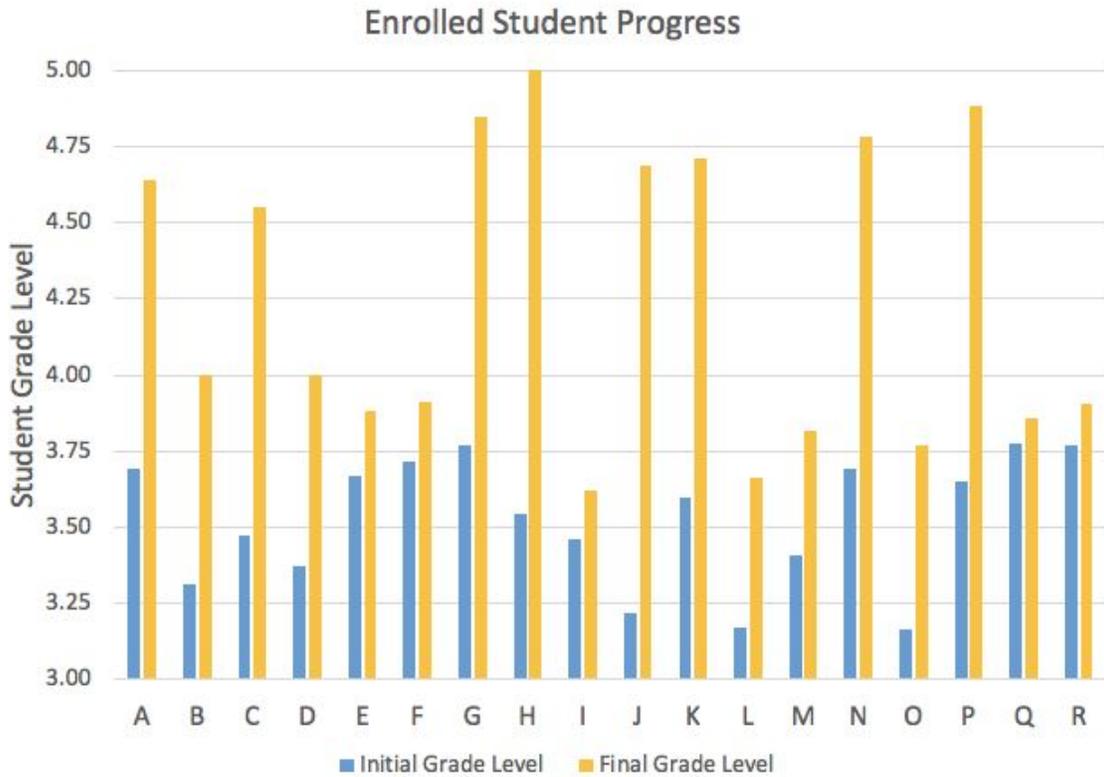


Figure 3: West Lafayette Cohort #1 - Initial and Final Grade Level as measured by ALEKS

Student ID	Attended Fall Sessions	Attended Spring Sessions	Number of Sessions	Total Time on ALEKS	Initial Grade Level	Final Grade Level	Improvement (Grade Level)
A	6	5	11	16.0	3.69	4.64	0.95
B	7	6	13	12.2	3.31	4.00	0.60
C	3	2	5	12.3	3.47	4.55	0.42
D	4	5	9	15.5	3.38	4.00	0.46
E	4	4	8	7.6	3.67	3.88	0.16
F	3	2	5	4.5	3.72	3.91	0.17
G	4	5	9	6.7	3.77	4.85	0.84
H	7	6	13	61.8	3.54	5.59	2.05
I	2	3	5	4.5	3.46	3.62	0.16
J	4	4	8	18.3	3.22	4.69	1.47
K	6	5	11	16.0	3.60	4.71	1.12
L	7	5	12	22.9	3.17	3.66	0.49
M	7	6	13	9.5	3.41	3.82	0.41
N	6	6	12	24.4	3.69	4.78	1.09
O	5	2	7	30.1	3.16	3.77	0.61
P	5	5	10	55.3	3.65	4.88	1.23
Q	0	6	6	6.1	3.77	3.86	0.08
R	0	5	5	4.6	3.77	3.91	0.14

Table 1: West Lafayette Cohort #1 Progress Data.

Students who reached a final math grade level of 4 are highlighted in yellow in the table.

At the Cincinnati site, a total of 10 students were enrolled for the program. 5 students participated in the initial assessment. This is a cohort that commenced in October, 2018.

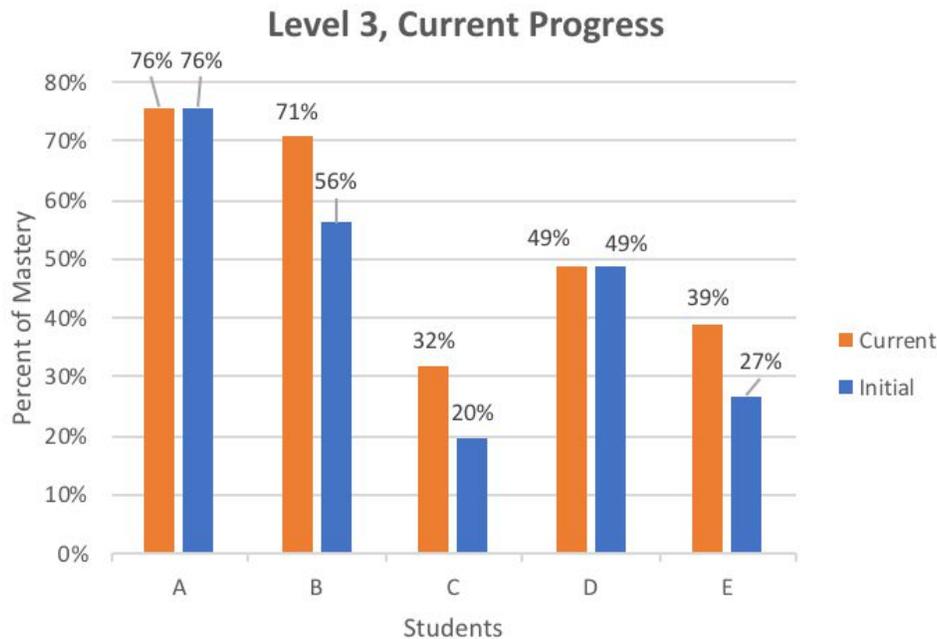


Figure 4: Cincinnati Cohort #1 Current Mastery Level vs. Initial Mastery Level

Some students did not have access to the internet at home, as a result there was not progression after the initial assessment.

Conclusions

The Algebra by 7th Grade program pilots launched at the Cincinnati and the West Lafayette sites provide promising initial results. The biweekly out-of-school math and engineering exploration program facilitated accelerated math achievement in a majority of students enrolled in the program. One vital component of the program, the utilization of ALEKS to allow individualized learning progress at home, is also a primary limitation as not all students enrolled have internet access at home. Our next steps in program development are to develop daily mathematics activities that can support individualized learning to replace home ALEKS usage for students without access to such tools.

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