High Performance Math

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ABSTRACT

HiPerMath is a program developed to teach California Content and Occupational Educational Standards –in math and science through hands on automotive engine dismantling and assembling, virtual drag racing and math competitions. There are lesson plans for over 70 standards (more to come) with the availability of custom lesson plans available to meet the needs of any student group.

HiPerMath is an innovative teaching design using virtual online models of racing cars getting students to use math applications in competitive solutions to maximize the design and operation of these virtual vehicles. Through the use of virtual and hands-on devices students design engines (bore, stroke, compression), fuel/air mixtures (carburetors), transmissions (gear and power ratios), tires and wheels (power and speed), body design (air drag and slip) and many other automotive functions using equations and problems based at their level of learning algebra, geometry, trigonometry, through to calculus. Projects are multi-dimensional allowing classes to integrate science, engineering, mathematics, and automotive design.

INTRODUCTION

In 2010, the President's Council of Advisors on Science and Technology proposed a two-pronged approach of both *inspiring and preparing* students for college STEM majors and careers. (PCAST, 2010:Veenstra, Padro and Furst-Bowe, 2012). A 21st Century Education calls for rigor and relevance with the engagement of students in addressing real world issues. With our national math proficiency test scores so low, HiPerMath (also known as High Performance Math) was designed to bring the relevance of math, from algebra through calculus, alive through virtual drag racing and math competition on the World Wide Web. HiPerMath is unique because it couples rigorous math standards with the excitement and inspiration of racing.

Our project both inspires and prepares students in math and applied technology and fulfills a need for organizations outside the K-12 system to "enhance STEM education at the K-12 level" and engage students. (Plotkowski, 2012). Significantly, over 60 percent of the participating students are eligible for free and reduced priced meals.

Students access the HiPerMath web site to investigate the science of car and engine design. Students then engineer their cars by performing math calculations. When their car is completed to their satisfaction, the students race on a virtual racetrack. The virtual racetrack is on a racing machine that looks like a video game complete with steering wheel, gearshift and gas and brake pedals. The racing machine was built to respond to even the smallest changes students make to their engines and cars. During the competition, students see the performance of other students' cars and respond by improving their own car. The math portion of the competition involves a standards-based lesson and exercises related to racing.

As presented at last year's Advancing the STEM Agenda Conference at the University of Wisconsin – Stout, HiPerMath was launched in 2010 and was in the beta testing phase. With over 4,000 middle and high school students now served and showing extraordinary results an update from last year will follow.

BACKGROUND

HiPerMath invested 2 years in the development of a highly accurate algorithm for the calculation of engine horsepower and torque. The algorithm is based on air mass flow and real world engineering equations. When a student designs an engine with certain specifications that produces certain horsepower and torque numbers on HiPerMath, that engine design is capable of producing the same horsepower and torque in the real world. By researching hundreds of street cars and factored in: engine horsepower, engine torque, engine size, turbochargers, superchargers, tire size, gearing, weight, center of gravity (cg) and more to create the most accurate virtual drag race possible.

HiPerMath also developed a virtual racetrack which accurately simulates the performance of the racecars the students build. If a racecar were developed in the real world with the specifications of the virtual car the students design, its real world performance would be very close to the simulation. This high level of real world accuracy was accomplished through much research and consultation with fluid dynamics engineer, Gordon Short, and drag race car builder and driver, Dave Meigide.

The program can be integrated into classroom instruction, before, during lunch or after school periods, or even a weekend event. Due to the fun that students have and the healthy competition that develops between them most will go home to continue their search for the fastest car once again reinforcing the math concepts with a real world context. All they need is access to a computer with internet capabilities. One student has spent 188.4 hours on the HiPerMath web site this past year.

This novel way of teaching concepts in geometry, algebra, trigonometry and calculus allows for students to learn more at their own pace. HiPerMath is designed for the student that wishes to explore on their own to be able to do so. Each exercise has questions the student answers to earn competition points. The questions are similar to those found on the California High School Exit Examination (CAHSEE) and there is a specific module for CAHSEE practice questions.

METHODOLOGY

Currently HiPerMath is beta testing in a variety of middle and high schools in the Inland Empire (San Bernardino and Riverside counties in California).

A pretest and posttest (using CAHSEE practice questions designed around drag racing) is administered in each module.

Current programming is being done to track the time each individual student and each class spends on designing their car and engine, both in class and out of class.

With the start of the next academic school year 2012 – 2013, HiPerMath will be working with a specific school district to implement the program in a middle school as an after school project. Using STAR testing results and classroom performance assessments both formative and summative up through and including algebra and geometry, we will compare the after school HiPerMath group with a matched group not participating in HiPerMath.

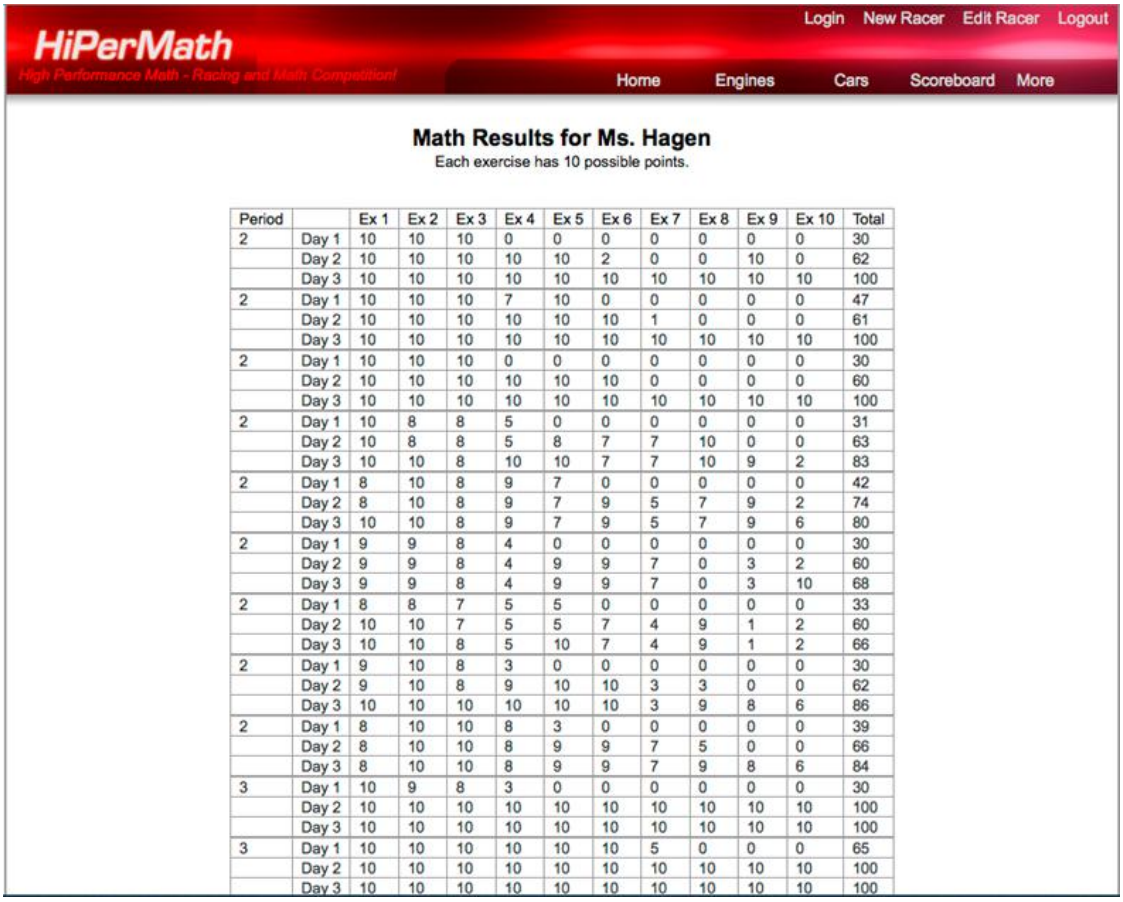
FINDINGS

Although there are many standards that HiPerMath addresses one of the surprising findings was that even students at higher levels of math were still finding it difficult in a simulated real world environment to understand the order of operations, fractions and positive and negative integers. With the new Common Core standards and a focus on implementation, HiPerMath provides students with the ability to think beyond the worksheet.

An observation from a principal at one of the middle schools stated "After reviewing the data ourselves, HiPerMath seemed to have helped our 7th graders the most. Their scores on the semester exam seemed to be significantly better compared with students/classes that did not participate."

Table 1 shows the increasing math understanding each day from a local middle school.

Table 1: Math Results for Mesa View Middle School


HiPerMath
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Math Results for Ms. Hagen
Each exercise has 10 possible points.

Period		Ex 1	Ex 2	Ex 3	Ex 4	Ex 5	Ex 6	Ex 7	Ex 8	Ex 9	Ex 10	Total
2	Day 1	10	10	10	0	0	0	0	0	0	0	30
	Day 2	10	10	10	10	10	2	0	0	10	0	62
	Day 3	10	10	10	10	10	10	10	10	10	10	100
2	Day 1	10	10	10	7	10	0	0	0	0	0	47
	Day 2	10	10	10	10	10	10	1	0	0	0	61
	Day 3	10	10	10	10	10	10	10	10	10	10	100
2	Day 1	10	10	10	0	0	0	0	0	0	0	30
	Day 2	10	10	10	10	10	10	0	0	0	0	60
	Day 3	10	10	10	10	10	10	10	10	10	10	100
2	Day 1	10	8	8	5	0	0	0	0	0	0	31
	Day 2	10	8	8	5	8	7	7	10	0	0	63
	Day 3	10	10	8	10	10	7	7	10	9	2	83
2	Day 1	8	10	8	9	7	0	0	0	0	0	42
	Day 2	8	10	8	9	7	9	5	7	9	2	74
	Day 3	10	10	8	9	7	9	5	7	9	6	80
2	Day 1	9	9	8	4	0	0	0	0	0	0	30
	Day 2	9	9	8	4	9	9	7	0	3	2	60
	Day 3	9	9	8	4	9	9	7	0	3	10	68
2	Day 1	8	8	7	5	5	0	0	0	0	0	33
	Day 2	10	10	7	5	5	7	4	9	1	2	60
	Day 3	10	10	8	5	10	7	4	9	1	2	66
2	Day 1	9	10	8	3	0	0	0	0	0	0	30
	Day 2	9	10	8	9	10	10	3	3	0	0	62
	Day 3	10	10	10	10	10	10	3	9	8	6	86
2	Day 1	8	10	10	8	3	0	0	0	0	0	39
	Day 2	8	10	10	8	9	9	7	5	0	0	66
	Day 3	8	10	10	8	9	9	7	9	8	6	84
3	Day 1	10	9	8	3	0	0	0	0	0	0	30
	Day 2	10	10	10	10	10	10	10	10	10	10	100
	Day 3	10	10	10	10	10	10	10	10	10	10	100
3	Day 1	10	10	10	10	10	10	5	0	0	0	65
	Day 2	10	10	10	10	10	10	10	10	10	10	100
	Day 3	10	10	10	10	10	10	10	10	10	10	100

Over 75% of district students belong to underrepresented minority groups and over 60 percent qualify for Free and Reduced Priced Meals the HiPerMath program engages students regardless of ethnicity, gender and socio-economic status. As the Dean of Students at a continuation school stated "…our student population is comprised of students from group homes, on stipulated expulsions, or just kids extremely lacking in credits…many students told me it was the most fun they ever had in math…Mostly, I wanted you to know that this outreach is having a positive

effect on student learning and engagement. This is something special for us here. Many of our students come to us with an attitude towards school that is very negative and it is programs like this one that can effect (sic) a great change. One student told me…'I never liked math before but now it is my favorite subject.'"

In a preliminary assessment study from 15 minority middle school students (male and female), the average correct pretest score was 1%. The average posttest score was 69%, a significant increase. Based on individual student data from specific questions, 100% of the students learned to calculate the volume of a cylinder and some learned to convert to liters. A female took third place in the overall competition.

SUMMARY

HiPerMath is committed to taking math, engineering and technical learning beyond the textbooks and rows of desks. Today's learner demands a more tailored approach with meaningful opportunities to learn both the standards and their relevancy to the tangible world.

FUTURE WORK

Due to the success of the program principals have requested that HiPerMath be a permanent part of their schools' curriculum. The plans for the construction for the racing simulator (Figure 1 below) are underway and will enable students to build a video game that works with the HiPerMath virtual race cars and tracks. The plans will include pictures of the actual parts of the simulator, which is made of wood, metal and computer parts. Schools will be able to design and build their own racing simulators.

Figure 1: Racing Simulator

The design of the racing simulator is very flexible, so students can modify the simulator in any way they see fit. Any school with a metal shop and wood shop will be able to fabricate the racing simulator on their site. Schools with Computer Aided Design (CAD) classes will also be able to participate. The CAD classes can create a 3-D model of the simulator. Then the metal shop and wood shop students can fabricate the simulator according to the design of the CAD students. The design and fabrication of the racing simulator will enable students to engage in a real world science, technology, engineering and math effort, which also requires students to work together and coordinate their efforts to achieve their goals. The successful result will be a fully functional video game, on which students can race and compete year round.

REFERENCES

Perkins, Katherine K., Patricia J. Loeblein, and Kathryn L. Dessau. "Sims for science:powerful tools to support inquiry-based teaching." The Science Teacher 77.7 (2010): p46.

Perkins/Loeblein/Harlow. 2008 *Creating PhET Activities using Guided Inquiry Strategies*. Retrieved June 13, 2011 from Physics Education Technology Project http://phet.colorado.edu/en/for-teachers/activity-guide

Plotkowski, P.D. "K-12 Outreach Programs in STEM:Strategies for Development and Continuous Improvement", in Veenstra, C.P., Padro, F.F., and Furst-Bowe, J.A. (eds.) *Advancing the STEM Agenda: Quality Improvement Supports STEM,* Milwaukee, WI: ASQ Quality Press.

President's Council of Advisors on Science and Technology (PCAST). 2010 Report to the President: Prepare and Inspire: K-12 Education in Science, Technology, Engineering and Math (STEM) for America's Future. Executive Office of the President. http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-stem-ed-final.pdf

Veenstra, C.P., Padro, F.F. and Furst-Bowe, J.A. 2012. *Advancing the STEM Agenda: Quality Improvement Supports STEM,* Milwaukee, WI: ASQ Quality Press.

AUTHORS INFORMATION

Wendy Zinn is the Program Manager of the CTE Community Collaborative Gran at the San Bernardino Community College District. Ms. Zinn develops and implements programs for five school districts within the San Bernardino County. She was a Program Coordinator, at California State University – San Bernardino, for a federally funded GEAR UP grant that served 3,600 underserved students in four Southern California school districts.

Craig Reisgen is the owner and developer of High Performance Math, an online math and racing competition. He has a degree in developmental psychology and mathematics. Mr. Reisgen was a substitute teacher and home and hospital teacher at Rim of the World School District, Lake Arrowhead, CA. He has been a program director at Club Wilderness, a Boys and Girls Club of Hollywood camp, which used to be located in the San Bernardino Mountains.