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Worcester Polytechnic Institute
Electrical and Computer Engineering Department

A Comparison of High School Pre-Engineering Programs

An Interactive Qualifying Project Report
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By:

Cody Brenneman

Daniel Eggleston

Karim Makram

Prof. Stephen J. Bitar – WPI Faculty Advisor

ABSTRACT

The goal of this project was to create a resource for high schools who are considering the addition of some form of pre-engineering program to their current curriculum. Three programs were researched, including the well-established Advanced Placement (AP) program, an industry initiative called Project Lead the Way (PLTW) and a local program sponsored by the Boston Museum of Science called Engineering the Future (ETF). It was found that the existing AP program is the broadest of the three, with subjects ranging from the Arts and Humanities to History, Mathematics and the Sciences. In contrast, PLTW and ETF are focused primarily on generating student interest in engineering. This research shows that the AP program continues to be the most effective program at promoting the skills necessary to succeed at the college level.

Table of Contents

List of Tables

List of Figures

EDUCATION IN AMERICA TODAY

The purpose of this section is to underline the reasons behind the existence of the subsequent programs. As well as engaging the reader in the search for a solution whether found in this paper or elsewhere.

The Problem and its Impact:

> *"Nationally, for every 100 9th graders, only 68 percent graduate from high school on time, only 40 enroll in college, only 27 are still enrolled as sophomores and only 18 graduate from college on time...*
>
> *...Students who enter the workplace directly from high school find themselves similarly unprepared. Employers estimate that 39 percent of recent high school graduates are unprepared for entry-level jobs, while 45 percent of recent entrants into the workforce are not ready to advance beyond entry-level jobs...*
>
> *...Thirty years ago, students might have gotten by without learning the basics. The diploma itself was often sufficient to find a manufacturing job, make a decent income and raise a family. But those days are gone."*[1]

In Short, 82% of 9th graders do not graduate from college. It is time to find where the problem resides it may be in student motivation, parents involvement or possibly teachers shortcomings. The solution is not to be found as per Manhattan Institute graduate students research in decreasing college entrance requirements. The requirements set are meant to insure that students enrolled acquired the knowledge sufficient enough to understand the materials that would be presented.

[1] http://www.2005summit.org/en_US/about/why.html

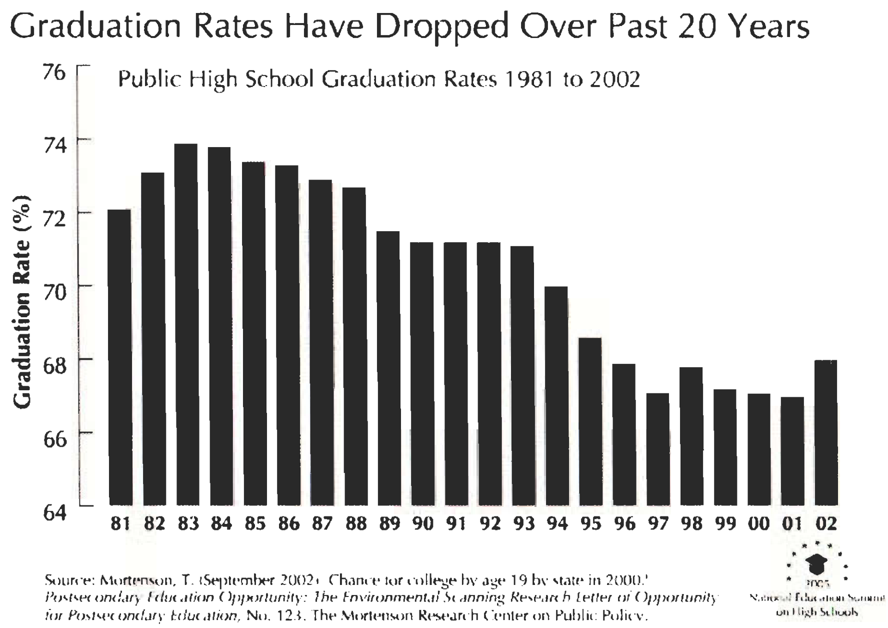

Figure 1: Public High School Graduation Rates 1981 to 2002[2]

Bill Gates statement pin points it:

"Our high schools were designed 50 years ago to meet the needs of another age. Until we design them to meet the needs of this century, we will keep limiting, even ruining, the lives of millions of Americans every year. If we keep the system as it is, millions of children will never get a chance to fulfill their promise."

It is evident that minimally prepared high school graduates results in a minimally prepared workforce as well as minimally prepared college graduates. Yet we keep wondering and blaming the ever sore economy on businesses outsourcing to other countries. Minimally prepared work force is not enough to attract businesses since the same products can be fabricated cheaper and mostly adequate quality.

The following two figures represent the fact that the U.S imports are increasing much faster than exports which is a sign of insufficient production and a declining economy. They also show the U.S share of trade since one of the sources of incomes in the U.S is services which is unaccounted for in domestic products and yet the exports is still growing much faster than imports.

[2] http://www.achieve.org/

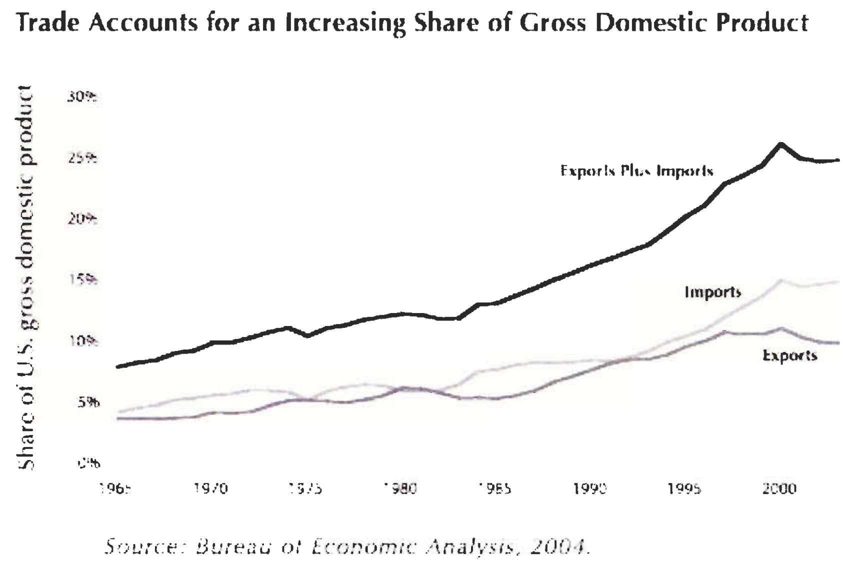

Figure 2: Share of U.S Gross Domestic Product[3]

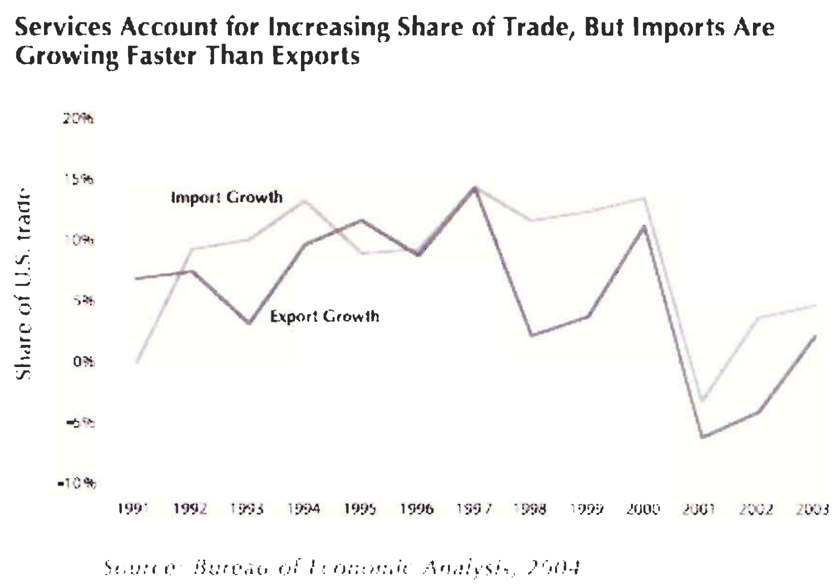

Figure 3: Share of U.S Trade[4]

High schools are in the center of the economic mishap which, in short, led to the increasing imports in the U.S over the exports produced. The following are a few self explanatory slides.

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[3] http://www.achieve.org/
[4] http://www.achieve.org/

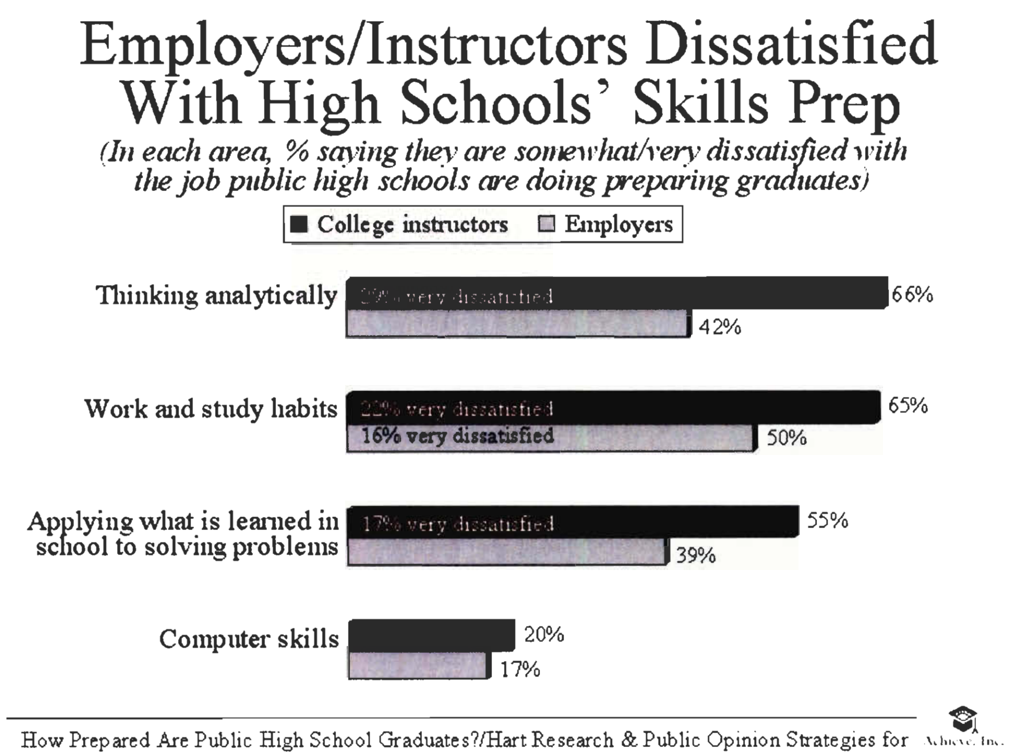

Figure 4: Feedback from Employers and College Instructors Survey[5]

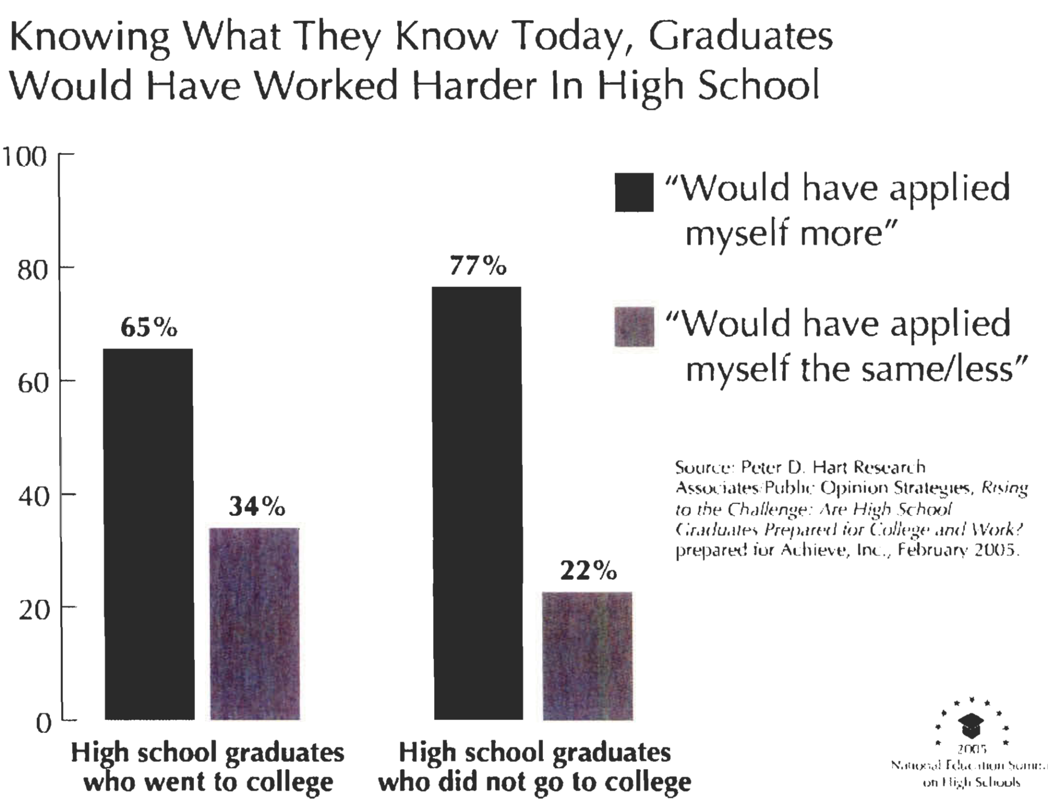

Figure 5: Feedback from Students[6]

[5] http://www.achieve.org/ Poll power point presentation

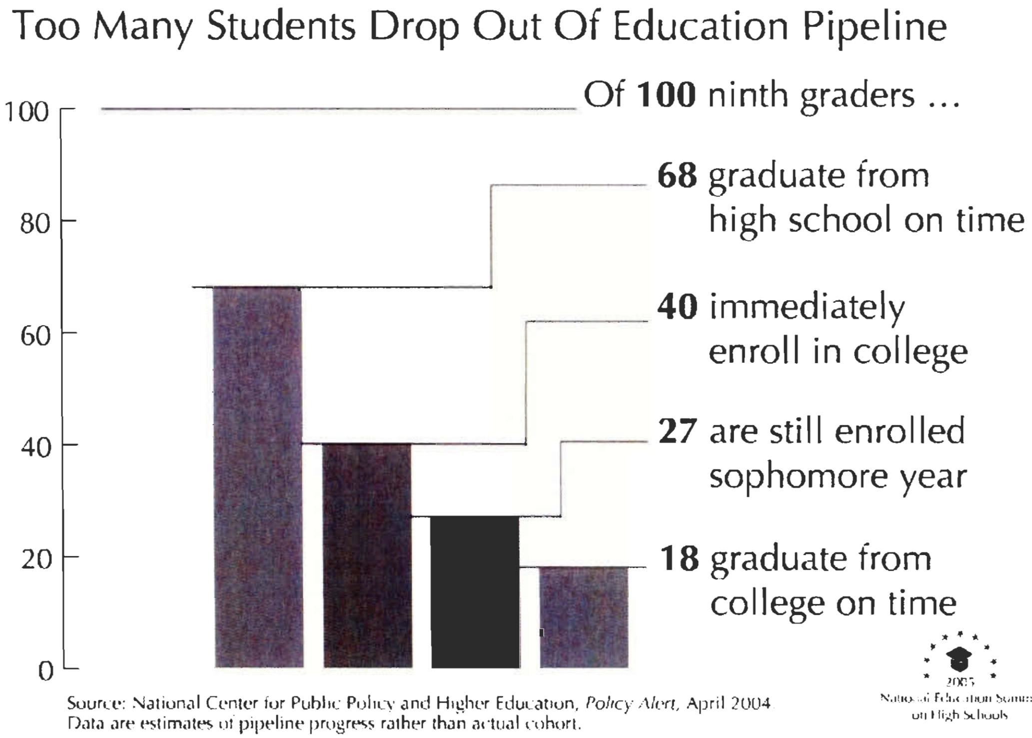

Figure 6: Outrageous Number of Drop Outs[7]

Another study caught our attention on Public High School Graduation and College Readiness Rates in the United States was done by Manhattan Institute graduate students dated September 2003 and funded by *Bill & Melinda Gates Foundation* states. The research conclusion is as follows:

> *"Our calculation of high school graduation rates demonstrates that the public school system is not only losing 30% of all its students before graduation, it also loses disproportionately more black and Hispanic students than white and Asian students. Our calculation of college readiness rates shows that only 32% of all students—fewer than half of those who graduate and about one-third of all students who enter high school—leave high school with the bare minimum qualifications necessary to apply to college. Again, black and Hispanic graduates are disproportionately not college ready as compared to their white and Asian peers...*
>
> *..."Of the 21 countries participating in the Third International Mathematics and Science Study, American high school seniors outperformed only students from Cyprus and South Africa and ranked behind such nations as Sweden, Canada, New Zealand, Russia and the Czech Republic;"*[8]

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[6] http://www.achieve.org/

[7] http://www.achieve.org/

[8] International Association for the Evaluation of Educational Achievement (IEA), Third International Mathematics and Science Study (TIMSS), 1995–96.

Furthermore, "*Non-U.S. residents with temporary visas accounted for a third of the Ph.D's awarded in science and engineering in 2003, despite any post-9/11 difficulties they might have experienced.*"[9]

In Order to have a full overview picture of the problem the following table shows the rate of graduation per country. We decided to add it to close our argument. The data that we provided speaks for itself, high schools need to improve. That being said we have to add that we are proud of the initiatives taken whether through the programs we will present or through the government and businesses. We believe the solution is out there it only needs to be adopted.

Rank OECD Reporting Country College Graduation Rate (%)		
1	Japan	94
2	Turkey	88
3	Ireland	85
4	United Kingdom	83
5	Korea	79
6	Spain	77
7	Finland	75
8	Iceland	73
9	Germany	70
10	Mexico	69
10	Australia	69
10	Denmark	69
10	Netherlands	69
14	**United States**	66
15	Czech Republic	61
16	Belgium (FI.)	60
17	Austria	59
17	France	59
19	Sweden	48
20	Italy	42

Rank OECD Reporting Country high school Graduation Rate (%)		
1	Denmark	100
2	Norway	97
3	Germany	93
4	Japan	92
5	Poland	90
5	Switzerland	90
7	Finland	85
7	Greece	85
9	France	82
9	Hungary	82
9	Italy	82
12	Czech Republic	81
13	Belgium	79
13	Iceland	79
15	Ireland	77
16	**United States**	73
17	Sweden	72
18	Luxembourg	68
18	Spain	68
20	Slovak Republic	61

Table 1: College Graduation rate by Country & High School Graduation by Country[10]

[9] National Science Foundation, Division of Science Research Statistics, *Science and Engineering Doctorate Awards, 2003,* Table 3 (Arlington, Va.: National Science Foundation, December 2004).

[10] http://www.nga.org/cda/files/05edsummithighschools.pdf Source: Organization for Economic Co-operation and Development, *Learning for Tomorrow's World: First Results from PISA 2003,* 2004.

INTRODUCTION

In this project we present a handful of programs intended as a solution. Asking ourselves whether it's time for amending the current system or restructuring the old one is in order. The facts are alarming and calling for action. They are warning for a need to stop and rethink where our high schools are headed and whether we are willing to pursuit healing actions.

> *"High schools leave most students unprepared for college and for today's jobs. When I compare our high schools with what I see when I'm traveling abroad, I am terrified for our work force of tomorrow."* [11] *(Bill Gates)*

With these few words in mind and the glance that we assembled about the Education in America, we will highlight some of the initiatives taken towards recovering and restoring our high schools. Those think tanks fueling those movements have understood that the weak link is the high schools. They understood that its effect ripples across and touches the fundamental fiber of our society. They took their conviction into action shaping the programs that we will present.

Project Lead the Way "PLTW": Fairly New, created by a non-profit organization led by Richard Blais, the program is designed to increase the exposure students receive to engineering concepts in high school. The intend of this program is to attract students to engineering fields based on the conviction by its founders that engineers are becoming a scarce commodity in the US workforce. The path taken is an accelerated jump to expose the students to engineering fundamentals taught in college introductory courses.

Engineering the Future "ETF": In its Trial phase, is being developed by the Boston Museum of Science. This program embarks on a broader path following the discovery strategy of the Museum. Its focus as stated on the web site is to show students the ethics of being an engineer, what lies behind being one and the effect of the decisions made on the society as a hole. It also focuses on introducing key physics concepts and preparing students for the MCAS. It targets what it takes to be an engineer whether the student is to follow an engineering path or otherwise.

Advanced Placement "AP": Confirmed successful, developed by the College Board. It is designed as an addition to the high school curriculum and provides an in depth foundation. It grants an undisputed higher level base in any student chosen interest, in language like English, Spanish, and French, as well as, in science like Biology, Calculus and Physics. Students acquiring this groundwork gain a firm platform on top of which they can build any desired career path.

[11] http://www.2005summit.org/en_US/news/index.html

National Education Summit: It is not the first time that Governors and CEO's meet together to discuss education but it is the first time that they meet to solely discuss high schools. The 2005 Summit is the first step in a series of *frontline assault*[12] on the declining economy the ultimate solution starts in high school level. The focus is not to produce a large number of marginally educated hobbyists, want to be engineers but a well rounded, structured and competitive army ready for the rigorous workforce challenges. The strategy agreed upon is to push for more rigorous science and language foundation. This is the main goal of the AP program and that is the reason behind the States agreeing to endorse it as one of the steps toward a solution.

[12] America's High Schools, *The Front Line in the Battle for Our Economic Future(for full length article Refer to Appendix D)*

PROJECT LEAD THE WAY (PLTW)

How did it start?

PLTW is a one man vision that expanded to be one of the biggest decentralized national programs leading teachers and students alike towards higher education standards. The man that started it all is Richard Blais. In the late 1980's, Mr. Blais held the position of chairman of the Technology Department at Shenendehowa Central School, in upstate New York. Mr. Blais and his Staff reviewed, developed and tested courses in collaboration with the New York Department of Education and Hudson Valley Community College. He also established the Technology Advisory Board. The Board members provided the proficiency needed to realize the main task at hand, as well as a vital turning point to a local project. PLTW, a non profit organization, was ignited by a grant from one of the board members whose family struck wealth in industry. The grant stimulated not only NY state but a nation wide movement.

The current Board of Directors and their respective occupation:[13]

Richard Liebich, Chair
Richard Blais, Executive Director
Dr. Gene Bottoms, V.P. Southern Regional Education Board
Dr. Suellen Reed, Superintendent Indiana Public Instruction
Dr. Herman Viets President, Milwaukee School of Engineering
Cecil Schneider, President, CEC Technologies, P.C.

[13] http://www.pltw.org/bod.shtml For more Background on each Member Please refer to Appendix A

Program Information

PLTW offers courses for high schools and for middle schools. The courses offered for high schools, referred to as the Pathway to Engineering program, is divided into foundation courses, specialization courses and the capstone course.

Foundation: Principles of Engineering (POE), Introduction to Engineering Design (IED), and Digital Electronics (DE).

Specialization: Computer Integrated Manufacturing (CIM), Civil Engineering and Architectural (CEA).

Capstone: Course is Engineering Design and Development (EDD).

The curriculum is revised every two years, Liebich explains, *"in order to keep the material current and to improve what is delivered.*" [14] The following three tables are the outlines of three courses offered starting with Principles of Engineering (POE), Digital Electronics (DE), and Civil Engineering and Architectural (CEA). Unfortunately, we were unable to acquire all courses since we would need access to the teachers' registered website. On the other hand, the available material does give us a good idea about the three courses.

Unit 1: Definition and Types of Engineering	Lesson 1.1 Engineers as Problem Solvers Past, Present and Future Lesson 1.2 Engineering Team Lesson 1.3 Careers in Engineering
Unit 2: Communication and Documentation	Lesson 2.1 Sketching Lesson 2.2 Technical Writing Lesson 2.3 Data Representation and Presentation Lesson 2.4 Presentations
Unit 3: Design Process	Lesson 3.1 Product Development
Unit 4: Engineering Systems	Lesson 4.1 Mechanisms Lesson 4.2 Thermodynamics Lesson 4.3 Fluid Systems Lesson 4.4 Electrical Systems Lesson 4.4 Electrical Systems Lesson 4.5 Control Systems
Unit 5: Statics and Strength of Materials	Lesson 5.1 Statics Lesson 5.2 Strength of Materials
Unit 6: Materials and Materials Testing in Engineering	Lesson 6.1 Categories of Materials Lesson 6.2 Properties of Materials Lesson 6.3 Production Processes Lesson 6.4 Quality Lesson 6.5 Material Testing Processes
Unit 7: Engineering for Reliability	Lesson 7.1 Reliability Lesson 7.2 Case Study
Unit 8: Introduction to Dynamics/Kinematics	Lesson 8.1 Linear Motion Lesson 8.2 Trajectory Motion

Table 2: PLTW POE Sample Curriculum[15]

[14] http://www.pltw.org/news/PhilMagazine.shtml
[15] http://www.pltw.org/sampcurr.shtml 2002 Clifton Park, New York (For more details please refer to Appendix A)

Unit 1: Fundamentals	Lesson 1.1 Safety Lesson 1.2 Basic Electron Theory Lesson 1.3 Prefixes, Engineering Notation Lesson 1.4 Resistors Lesson 1.5 Laws Lesson 1.6 Capacitance Lesson 1.7 Analog and Digital Waveforms Lesson 1.8 Obtaining Data Sheets
Unit 2: Number Systems	Lesson 2.1 Conversions
Unit 3: Gates	Lesson 3.1 Logic Gates
Unit 4: Boolean Algebra	Lesson 4.1 Boolean Expressions Lesson 4.2 Logic Simplifications Lesson 4.3 Duality of Logic Functions
Unit 5: Combinational Circuit Design	Lesson 5.1 Paradigm for Combinational Logic Problems Lesson 5.2 Specific Application MSI Gates Lesson 5.3 Programmable Logic Devices (PLD)
Unit 6: Adding	Lesson 6.1 Binary Addition
Unit 7: Flip-Flops	Lesson 7.1 Introduction to Sequential Logic Lesson 7.2 The J-K Flip-FlopLesson 7.3 Triggers Lesson 7.4 Flip-Flop Timing Considerations Lesson 7.5 Elementary Applications of Flip-Flops
Unit 8: Shift Registers and Counters	Lesson 8.1 Shift Registers Lesson 8.2 Asynchronous Counters Lesson 8.3 Synchronous Counters
Unit 9: Families and Specifications	Lesson 9.1 Logic Families Lesson 9.2 Spec Sheets
Unit 10: Microprocessors	Lesson 10.1 Microcontrollers Lesson 10.2 Interfacing with Motors
Unit 11: Student Directed Study Topic	Lesson 11.1 Design Paradigm

Table 3: PLTW DE Sample Curriculum[16]

[16] http://www.pltw.org/sampcurr.shtml 2002 Clifton Park, New York (For more details please refer to Appendix A)

Unit 1: Overview of Civil Engineering and Architecture	Lesson 1.1 CEA Overview
Unit 2: Intro to Projects	Lesson 2.1 Overview of Project Design Lesson 2.2 Project Documentation
Unit 3: Project Planning	Lesson 3.1 Site Information Lesson 3.2 Development Options, Selection of Project, and Revisit Viability Analysis
Unit 4 : Site Planning	Lesson 4.1 Description of Property Lesson 4.2 Site Plan Requirements Lesson 4.3 Site Plan Layout Lesson 4.4 Public Ingress and Egress Lesson 4.5 Site Grading Lesson 4.6 Utilities Lesson 4.7 Landscaping Lesson 4.8 Water Supply and Wastewater Management
Unit 5 : Architecture	Lesson 5.1 Architecture Lesson 5.2 Floor Plans Lesson 5.3 Energy Systems Lesson 5.4 Elevations Lesson 5.5 Sections and Details Lesson 5.6 Schedules Lesson 5.7 Mechanical, Electrical, and Protection Systems
Unit 6 : Structural Engineering	Lesson 6.1 Introduction to Civil Engineering Lesson 6.2 Load Requirements Lesson 6.3 Roof Systems Lesson 6.4 Columns and Beams Lesson 6.5 Foundations
Unit 7 : Presentations and Reviews	Lesson 7.1 Critiques and Reviews Lesson 7.2 Final Presentations

Table 4: PLTW CEA Sample Curriculum[17]

The course curriculums include a day by day tentative schedule for teachers as well as labs and projects. The curriculum is handed to teachers upon attending the relevant teacher training session. Teachers also gain access to other resources such as PowerPoint presentations for each unit, handouts, lab protocols, and web links to math and science applications.

[17] http://www.pltw.org/sampcurr.shtml 2002 Clifton Park, New York

Table 5 is a sample student schedule provided by PLTW which clearly shows that PLTW program is not a replacement for core high school courses but an addition.

Sample Student Schedule: Option A

Grade 9		Grade 10	
English 9	1 unit	English 10	1 unit
Social Studies 9	1 unit	Social Studies 10	1 unit
Math 9	1 unit	Math 10	1 unit
Science 9	1 unit	Science 10	1 unit
Foreign Language	1 unit	Foreign Language	1 unit
Principles of Engineering		**Intro To Engineering Design**	**1 unit**
Physical Education	**1 unit**	Physical Education	.5 unit
	.5 unit		

Grade 11		Grade 12	
English 11	1 unit	English 12	1 unit
Social Studies 11	1 unit	Social Studies 12	1 unit
Math 11	1 unit	Math 12	1 unit
Science 11	1 unit	Science 12	1 unit
Digital Electronics		**Engineering Design**	
'Computer Integrated	**1 unit**	**and Development**	**1 unit**
Manufacturing		Health	.5 unit
'Civil Engineering and Architecture	**1 unit**	Physical Education	.5 unit
'Biotechnical Engineering	.5 unit		
'Aerospace Engineering			
Physical Education			

'These are the specialty courses in schools offering them.

Student Schedule Options:
Option B: Introduction to Engineering Design, Principles of Engineering, Digital Electronics
Option C (Accelerated Math): Introduction to Engineering Design, Digital Electronics, Principles of Engineering

Table 5: Sample Student Schedule

PLTW offers its program in 38 states and over 700 schools from New York to California. Interested schools must go through a rigorous registration process before implementing PLTW. PLTW offers a certification process to high schools and middle schools which includes a review of the school curriculum and implementation of PLTW designed pre-engineering courses. To be a certified school a checklist of equipment needed to teach the pre-engineering courses must be met. First the school district must be registered and recognized by PLTW. Then the interested school must review and sign a lengthy agreement with PLTW[18]. Part of that agreement states that the school must implement a new course every year until at least 5 of the courses are available to students. According to the agreement, this provision is so that students who begin the PLTW track have the option of continuing through the entire program.

[18] http://www.pltw.org/dsagreement.shtml Please refer to the Website for a full length sample agreement

Table 6 shows the certified schools and partner Universities in the state of Massachusetts.

Certified	School Name	City	Implement Date
H	Cambridge Rindge and Latin High School	Cambridge	2002
H	Greater New Bedford Regional Voc-Tech High School	New Bedford	2001
H	Minuteman Regional High School	Lexington	2000
H	Quincy High School/Center for Technical Education	Quincy	2001
M	Rindge School of Technical Arts at Tobin	Cambridge	2002
P	University of Wisconsin-Stout	Worchester	2099
The Regional Coordinator for MA is Christine Shaw cshaw4224@aol.com		"H" PLTW Certified High School "M" PLTW Recognized Middle/Jr High School "P"A PLTW Partner College or University	

Table 6: PLTW Certified/Partner Schools/Universities in Massachusetts[19]

Students taking the High School PLTW end of course exam have a chance to earn college credits. Teachers must also attend a level 2 training session to be eligible to teach a PLTW course. Table 7 shows a sample of the offered summer 2005 courses, cost and accommodations. The cost of attendance in the training sessions and the equipment availability is the sole burden of the school. This expense is counterweighted by PLTW, since they provide an extensive detailed curriculum for free.

Location	Date	Courses Offered	Cost of Attendace	Lodging
Worcester Polytechnic Institute	7/24/2005 - 8/5/2005	*Introduction To Engineering Design *Digital Electronics	$1,750.00	Housing and Meals Housing: Hampton Inn $89 per night + tax (single or double occ.) Breakfast included. Reservations via Hampton Inn (508) 757-0400Reserve under WPI-Project Lead The Way Lunch included in registration Dinner: on your own
Rochester Institute Of Technology	7/10/2005 - 7/22/2005	*Gateway To Technology *Introduction To Engineering Design *Digital Electronics *Computer Integrated Manufacturing *Engineering Design And Development	$2,000.00	Housing and Meals Level 1: $795 Room & Board $390 - 3 meals per day-commuting $130 - Lunch only-commuting

Table 7: Sample Teacher Training Sessions Location and Cost [20]

[19] http://www.pltw.org/schoollist.asp?toSelect=MA For a complete list please refer to Appendix A

In some states, the PLTW teacher courses are acceptable towards teacher certification requirements. Furthermore, teachers may receive graduate credits. Accepting PLTW courses toward credits varies from University to another whether undergraduate credits for students or graduate credits for teachers. Some universities as shown in Table 8 require a written examination and/ or a paper.

Affiliate/Partner Colleges and Universities	College Credit For Summer Training:	College Credit For High School Students:
Rochester Institute of Technology (RIT)	Teachers may receive RIT Graduate College Credit for all courses in the PLTW program by meeting requirements	RIT requires these students to receive at least an 85 percent average in the course and score 70 or above on the college credit exam. For the students meeting these criteria, RIT awards 4 quarter credits for each of the five courses, and the cost of tuition is $200 per course. RIT's academic departments evaluate the acceptability of these credits in the same manner in which they evaluate and confer transfer credits
Purdue University	Graduate credit is available for Purdue PLTW STI courses. Each course is three credit hours.	by completing each course with an average of "B," by scoring 70 or above on the college credit exam, and by enrolling in IT, ID, or Technology Education programs.
University of Houston	Teachers may receive UH graduate credit for all courses in the PLTW program by meeting the appropriate requirements.	Texas has identified PLTW's IED, DE, and CIM courses as Advanced Technical Credit State-wide Articulated courses. The ATC Program is an advanced placement process for students enrolling in postsecondary workforce education programs. Students meeting criteria outlined in the ATC standard articulation agreement are eligible to receive credit for the corresponding college course(s) listed in the course crosswalk from any college offering the corresponding Workforce Education Course Manual course(s) and participating in the program. More information on the ATC program can be found at www.techpreptexas.org. Additional college credit options are being developed at the University of Houston for Engineering Technology students. Once established, information will be posted at www.texastechnology.com/pltw

[20] http://www.pltw.org/affmain.shtml Please refer to Web site for further information

Duke University	Teachers interested in receiving graduate college credit for courses in the PLTW program may apply to Rochester Institute of Technology (RIT) in New York. To qualify, teachers must successfully complete the two-week Duke PLTW Summer Training Institute, pass the RIT graduate PLTW course exam and meet RIT requirements. In addition, Duke is offering 7.6 Continuing Education Units (CEUs) to teachers who successfully complete the two-week Duke PLTW Summer Training Institute.	for students who have completed PLTW Program courses in a PLTW-certified school, have a "B" average in PLTW courses, have received a 70% or higher on the PLTW college credit exam, and who have registered at Duke. Duke will work with the national College Board to establish Advanced Placement credit for PLTW courses taught in North Carolina. Until AP credit is established, Duke will work with the N.C. Department of Public Instruction to establish Honors status of PLTW courses in N.C.
San Diego State University	Teachers may receive Graduate College Credit through RIT for courses in the PLTW program by meeting requirements.	Secondary school students may receive a total of three SDSU College of Engineering credits for any of the PLTW courses [IED, POE, CIM, CEA and DE]; by completing each course with an average of "B," by scoring 70 or above on the college credit exam, by being enrolled in a PLTW-certified school, and by meeting college enrollment requirements for the BS programs. Please see http://arweb.sdsu.edu/es/admissions/ for SDSU admissions details
The University of New Haven	Teachers may receive UNH Graduate College Credit for all courses in the PLTW program by meeting requirements	Secondary school students from any PLTW-certified school may apply for UNH college credit for each eligible PLTW course [IED 2 credits, DE 3 credits, POE 3 credits and EDD 2 credits]. Students must receive at least 80% average in the course and 70 or above on the college credit exam. The cost of tuition will be $200 per course. Students must meet the college enrollment requirements for UNH majors. UNH engineering programs evaluate the acceptability of these credits similar to evaluating other transfer credits
Penn State University	Teachers may receive Penn State Graduate Credit for any courses offered at the Penn State PLTW Summer Training Institute by meeting the graduate course requirements.	Secondary school students in Pennsylvania from PLTW-certified schools may apply for Pennsylvania State University college credit for three PLTW courses (IED 4 credits, POE 1 credit, & DE 4 credits). Penn State requires students to receive at least an 85 percent average in the PLTW course, score 70 or above on the end of year college credit exam, and meet academic eligibility requirements for a two-year engineering technology major (Electrical Engineering Technology or Mechanical Engineering Technology).

University of South Florida	Participants in Summer Training Institutes can receive University of South Florida graduate credit by paying all applicable tuition and fees	To achieve University of South Florida recognition, secondary school students need to complete a PLTW sequence of courses [IED, POE, DE or EDD and one additional PLTW elective] in a PLTW-certified school, attain an overall unweighted GPA of average of 3.0 in the PLTW courses, and achieve a 70% on the course college credit examination. These students may waive a maximum total of one to four non-transcript credit hours towards the students' required number of program course credit hours, if enrolled in one of the following bachelor degree programs: Civil and Environmental Engineering, Industrial Engineering and Management Systems, or Mechanical Engineering Programs. No grades will be given for the course(s). One non-transcript credit hour may be applied to Chemical Engineering, Computer Science and Engineering, and Electrical Engineering bachelor degree programs. Additional waivers may be used to substitute enrollment in selective courses, or may apply to Alternative Admissions; these are explained on the USF website.
Weber State University	Teachers may receive WSU graduate credit for all courses in the PLTW program by meeting the appropriate requirements	Secondary school students from PLTW-certified schools in the country may apply for WSU college credit for the following PLTW courses: IED - 3 semester credits POE - 2 semester credits DE - 4 semester credits To be awarded college credit, WSU requires these students to have a grade of "B" or better in the course, as well as having 90% attendance in the course. The school must also have a concurrent enrollment agreement in place with Weber State. For schools outside the State of Utah, the tuition is $50 per credit hour. WSU's academic departments evaluate the acceptability of these credits in specific programs in the same manner in which they evaluate and confer transfer credits

University of South Carolina	Three semester-hour graduate credit available for each of the following courses: POE, IED, GTT, DE by meeting the appropriate requirements	Secondary school students from any PLTW-certified school in the country may apply for University of South Carolina credit as follows: PLTW course Digital Electronics may be used for ELCT 101, Introduction to Electrical Engineering; PLTW course Principles of Engineering for ENGR 101, Introduction to Engineering; and PLTW course Introduction to Engineering Design may be used for EMCH 111, Introduction to Engineering Graphics and Visualization. USC requires these students to have an overall "B" average or SAT score of 1100 or PSCAT score of 110 and to receive at least an 85 percent average in the course and score 70 or above on the college credit exam. For the students meeting these criteria, USC awards 3 semester hours of credit with proper application and tuition payment. USC's academic departments evaluate the acceptability of these credits in the same manner in which they evaluate and confer transfer credits
Worcester Polytechnic Institute	WPI is offering graduate credit to teachers who successfully complete the PLTW Summer Training Institute. Graduate credit requires paying all applicable tuition and fees as described at http://grad.wpi.edu/Registration/	Secondary school students may receive college credit at WPI for an introductory level engineering course by completing a PLTW sequence of courses [IED, POE, DE and EDD and one additional PLTW elective] with an average of "B," by being enrolled in a PLTW-certified high school, by meeting college enrollment requirements, and by paying a designated tuition. In addition, students must achieve an 80% on the college credit exam or submit an appropriate portfolio

Table 8: Sample of Universities accreditation for Students and Teachers[21]

[21] http://www.pltw.org/affmain.shtml and/or http://www.pltw.org/AffPolicyCredit.shtml Please refer to website for complete list of Colleges and their accreditation requirements and available offers.

The tests are divided into 3 parts. Part A is mandatory for all students taking the test. Part B is for students that choose to earn credits in their local high schools only. Part C is for students that choose to earn transcript college level credits.[22] All students are required to finish two parts either A and B or A and C.

> *"Total cost for one high school with 20 student stations, equipped for all five courses, is approximately $ 70,555.56 if the CEA course is selected as the specialty course and approximately $ 117,171.39 if CIM is selected as the specialty course. This cost can be reduced if the school already has equipment and/or computers meeting or exceeding the PLTW specifications."*[23]

The estimated cost of implementing the 5 courses varies, but the estimate from PLTW is approximately $100,000 total. This expense can be counteracted by current equipment available at the schools, and by grants from companies such as Intel. Table 9 shows an estimate based on a 26 students per class.

Course	Computers	Equipment	Supplies	Furniture	Software (MS Office, MS Bookshelf, Adobe Photoshop)	Consumables	Grand Total
Computer Lab	$20,020.00	$7,485.00	$155.12	$5,420.00	$1,087.40	$512.40	$34,679.92
IED	$1,545.00	$583.50	$22.00	$399.29	$0	$157.55	$2,707.34
DE	$1,545.00	$4,245.24	$1,647.20	$399.29	$0	$43.30	$7,880.03
POE	$1,545.00	$17,804.25	$97.20	$589.74	$0	$245.54	$20,281.73
Foundation High School Courses Combined	**$24,655.00**	**$30,117.99**	**$1,921.52**	**$6,808.32**	**$1,087.40**	**$958.79**	**$65,549.02**
CEA*	$1,545.00	$3,015.50	$22.00	$399.29	$0	$24.75	$5,006.54
CIM*	$1,545.00	$46,692.90	$88.45	$2,179.67	$0	$1,116.35	$51,622.37

Table 9: Estimated Total Cost for PLTW Implementation[24]

*Denotes a specialty choice. Schools should select one or more and add the cost to the foundation course totals.

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[22] http://www.pltw.org/sampexam.shtml Refer to Appendix A for a Sample Test Part A and B
[23] http://www.pltw.org/costest.shtml
[24] http://www.pltw.org/costest.shtml

Program Evaluation

PLTW as we have seen is targeting to fill the gab between colleges and high schools in terms of engineering majors. The curriculum is designed to provide students with a broad and in depth range of exposure to the engineering field. The strategy used is to enhance teaching by insuring that teachers are adequately trained and possess the tools needed to convey the material.

This program is unique in its strategy its only draw back is its assumption that students have a good base in math and science since it will add an exponential load to student curriculum. The approach is to be more demanding for a more demanding workforce environment. On the other hand this set back is minor in comparison to the profit the students will gain. The students that finish this program are well compensated through college recognitions. And of course it provides an additional bragging right to both students and schools.

We see this program as an exceptionally well planned path for hard working students. Its creators are well known and highly experienced. They have covered student and high schools motivation. They have provided the help need to implement the program through providing a state representative to help diminish any obstacles and to coordinate any high school initiative.[25] They have established a network of schools that are willing to offer the training needed for teachers. They are also encouraging schools to collaborate and join forces in the case of willingness to join their network. The program is expensive along with schools size, insufficient funds, not enough students willing to take the courses are not an acceptable factor PLTW would tolerate for a program rejection. PLTW has established what they call Lead Education Agency (LEA) which is an agreement between one or more education systems that can be a school district, intermediate school unit, a community college, a career and technical school or any entity permitted to offer secondary school courses in a state. [26] PLTW will coordinate the effort but will have no say in the leading school choice. This agreement is done so to enable student to enroll in a course offered in another school. The schools signing the agreement decide which school will offer which course and they form a one entity in term of the PLTW program. This is an added feature for students and for schools.

[25] http://www.pltw.org/stateleaders.asp Please refer to Appendix A for State Leaders List
[26] http://www.pltw.org/LEA_Q_A.shtml

ENGINEERING THE FUTURE: (ETF)

How did it start?

This program is backed by the Museum of Science. Engineering the future is still under development. In consequence, the information provided in this paper will, very likely, change at a fast rate. 2005 - 2006 will mark the "test run" for the program, it will be taught by teachers who have volunteered to test this program in their classrooms. More than 120 registered high school volunteered teachers will collaborate in the program test phase.[27]

This initiative has been in progress since December 14, 2000 based on WPI news release.[28] Engineering the Future expected to be accessible Nation Wide in 2007 for the time being it is restricted to Massachusetts and its surrounding states. After considering these facts we decided to include it out of our respect to the Museum of Science entity and out of the sheer number of high schools involved in its development.

The program is headed by Julie Brenninkmeyer. Julie was previously a high school teacher and is currently the project curriculum developer. We contacted Rebecca Pierik, former curriculum developer and, more recently, developer for the curriculum's textbook. Based on our phone interview a number of consultants were hired by the Museum of Science seeking their advice in addition to the full year test phase enrollment condition which requires volunteered teachers to provide feedback of their implementation.

[27] http://www.mos.org/doc/1413
[28] http://www.wpi.edu/News/Releases/20001/moslecture.html

Program Information

The main goal of the program is to introduce the students to the technology around them and its effect on the society they live in. It's not intended to replace any high school courses already in place. It is developed to enhance their knowledge using hands-on experiments for the sake of exposure to engineering development. It's intended to create awareness of how the surrounding technical advancement changes the way we work and of the choices we make as individuals in any career path. Furthermore, this program is not designed to provide a base for engineering career it is designed to emphasis science in high schools without any intention to pursue an engineering career.

We were unable to receive a copy of the curriculum or its outline since the program is still under development. The only information provided about the textbook is that it will be in two versions: one for students which contains the overview of the units and instructions, and the other for teachers which will include an activities guide and notes about the material presented. The textbook will be provided for free during the first year of the program, starting in September 2005. The teachers will be required to attend a two-day training session in preparation for the courses.

The program is offered in four units over the course of one school year. It is targeting high school students in the freshmen and sophomore levels as an addition to their capstone courses. The Cost to implement the program is approximately $1500 and consumables will be around $250 per year. The Book is provided for free for the first trial year and will be determined later. According to Rebecca Pierik, the program is not designed to replace any courses. The program is also not designed for students seeking an engineering vocation, but rather at all students who wish to learn how to apply their math and science education to their lives and future jobs through experimentation.

The units in this program are: Engineering Design and Manufacturing, Fluid and Thermal Systems, Electricity and Communication, Construction and Integrated Systems.

Unit 1: *Engineering Design and Manufacturing*	*Unit 1 involves two major projects. The first involves students in a hands-on experience with the engineering design process. In the first activity each student builds an organizer for things that they care about. This activity is designed to engage the students in doing something of interest to them, and encourage them to explore the use of sketches and simple materials to fabricate something of their own design. Finally, the students reflect on how they approached the problem, and explain their own problem solving process.* *The second project enables students to develop a system for the manufacture and sale of their organizer. They will conduct market research and develop a business plan for manufacturing and marketing their products. Students will also learn how to create technical drawings of their products and produce detailed plans that can be executed by others on the "factory" floor.*
Unit 2: *Fluid and Thermal Systems*	*A primary goal of Unit 2 is for students to understand the interplay between science and engineering as they investigate the topics of particle theory, thermodynamics energy transfer, fluid mechanics, buoyancy, and motion. Students will build a "putt-putt boat" that runs using a fluid/thermal engine. Their challenge will be to redesign the boat. Before they do that, however, they will learn how to model what's happening inside the boat so that they have a better idea of how to redesign it.* *Students will first build a putt-putt engine to a standard specification. Once they have some familiarity with how the different materials go together to make a functioning engine, they should be able to identify how the parts can be changed. However, students will not yet know what the effects of those changes would be. As students build knowledge of the science behind how the putt-putt boat works, they can take on the role of working engineers applying science to the redesign of a system. Finally students will test their redesign to see if it meets their own criteria for improvement.*
Unit 3: ***Electricity and Communication***	*In Unit 3, students will design and build electrical generators and devise ways for those to be turned by a variety of different energy sources such as wind, hydro, hand-cranked, etc. These generators will supply power to a fictional village and therefore must be designed to utilize area geography and natural resources. They will then design the electricity distribution for the village.* *With a strong foundation in electricity, students will begin to explore communications systems starting with the telephone, an electrical communications device, moving toward communications systems that operate using electromagnetic waves—such as radios, satellites, and fiber optics. In a culminating activity, students will design a communications system for their village.*
Unit 4: *Construction and Integrated Systems*	*In Unit 4, students will explore the various forces that act on structures by designing and building energy-efficient tents. They will experiment with different materials in an effort to create tents well suited for a range of environmental conditions. After students have a strong grasp of construction concepts, they will integrate all that they have learned over the course of the year in the creation of an urban plan for their village that includes power generation systems, municipal wastes and sewerage systems, recreational facilities, schools, and homes. They will hold a "town meeting" in which they will take on the roles of various stakeholders and vote for the most sustainable and energy-efficient plan for their village.*

Table 10: The Units as described by the MOS web site[29]

[29] http://www.mos.org/doc/1412

The following is an estimated list of materials that would be used in the lab experiments. The consumable material is estimated to cost $250.

***Unit One**: Design and Manufacturing*

Composition Notebooks-Quad-ruled
Utility Knives
Rulers
Scissors
Ellipse and Circle Template
Quad-ruled and Isometric graph paper
Cardboard and or Foam Core
Chip Boards or tables on which students can cut cardboard/foam core with utility knives
Optional:
Hand-drills
Band Saw
Lumber
Hammers and Nails
Screwdrivers and Screws
Nuts and Bolts

***Unit Two**: Thermal and Fluid Systems*

Fishing Line
Syringes
Epoxy
Aluminum and copper sheeting
Graduated Cylinders
Ring Stand
Thermometers
Long metal gutter
Milk cartons
Computers with Web Access for two lessons

***Unit Three**: Electrical and Communications*

1 large 0.1F capacitor
4 telephones (new or used hand-sets)
CASTLE kit (includes light bulbs, wires, lamp sockets, and capacitors)
Genicon hand generators
Cardboard
Plastic Bottles
Voltmeters
Ammeters

***Unit Four:** Construction and Integrated Systems*

Popsicle sticks
Brass fasteners
Elastic cord
Straws
Paperclips
Shoe boxes
Plastic sheeting
Samples of insulation
Aluminum foil
Styrofoam
Foam core Push Pins
Colored material swabs
Spring Scales
Plumb bobs
Optional materials:
Cement and stone for making concrete
2 x 4 plywood beam
solar cells – other simple power sources

Table 11: ETF Estimated List of Materials[30]

[30] http://www.mos.org/automedia/static_webpages/edu/additional_resources/engg_the_future/requirements/MaterialList.pdf

Program Evaluation

This program is tailored in Massachusetts to prepare the student for the MCAS, it provides key physics concepts and understanding with a low implementation cost. Engineering the Future has a different focus than PLTW and the AP discussed in the following section. Its focus is centered on enabling student to discover what is meant by being an engineer thorough applying the current theoretical knowledge the regular high school curriculum is feeding them. In Other words, it is not fair to compare Engineering the Future with the more rigorous counter part like PLTW and the AP due to the presence of two very different goals. Simply one stresses on the current material presented, building interest and motivation through experimentation and the others are using the stick and carrot approach targeting well rounded smart students as followers.

A constant feedback will be required from teachers testing the program, and will be gathered through a website designed for this purpose. The web site will include a discussion forum for the teachers where they can discuss problems or suggested updates to the program. It is planned that the same online community environment will be provided in the future for students.

This program is rather difficult to assess in terms of its effectiveness, due to the fact that it has not yet been implemented. We can only deduct from the description at hand and the materials required for the course that the program is leaning towards students' team work environment to set an interest in engineering through encouraging creativity. There is no question in our minds that this approach has its benefits. Nothing drives a student to work harder than his willingness to know more about a specific topic. Creating the interest and letting them loose to finish the path at their own pace. We believe that this is the aim of the Museum of Science in general and is shown clearly in this program.

ADVANCED PLACEMENT: (AP)

How did it start?

The program origins go back to the 1950 where a number of schools, colleges and Universities decided to get together and make a change that would later affect students for a half a century. Around the 1960's the College Board, Inc has adopted the program and assumed the standardized examination responsibility.[31]

The main goal has been and is still to close the gap between high schools and colleges. To provide college level material with college level intensity to willing students. It accentuates the student need for a solid structure formed by a basic foundation that was then and still is a corner stone of the industrial revolution.

[31] http://apcentral.collegeboard.com/article/0,3045,150-155-0-8019,00.html#name2 Please refer to Website for full history information

Program Information

Due to the wide range of options it is unrealistic to fully cover the benefits of this program or its creator. We can not possibly encase either of them in our project. We will try to stress on the points we have discussed in the preceding programs in order to develop a firm ground when forming a final opinion.

The Advanced Placement program (AP), is a collection of courses and exams developed by the College Board, Inc. The courses are designed to be implemented within high school curriculum. The program offers thirty eight courses and exams across twenty three subjects[32]. The extent of this program is apparent by the number of subject areas, listed below:

AP Courses and Exams

Art
Art History
Studio Art: 2-D Design
Studio Art: 3-D Design
Studio Art: Drawing

Biology

Calculus
Calculus AB
Calculus BC

Chemistry

Chinese Language and Culture (2006-07)

Computer Science
Computer Science A
Computer Science AB

Economics
Macroeconomics
Microeconomics

English
English Language and Composition
English Literature and Composition

Environmental Science

French
French Language
French Literature

German Language

Government and Politics
Comparative Government and Politics
United States Government and Politics

History
European History
United States History
World History

Human Geography

Italian Language and Culture (2005-06)

Japanese Language and Culture (2006-07)

Latin
Latin Literature
Latin: Vergil

Music Theory

Physics
Physics B
Physics C: Electricity and Magnetism
Physics C: Mechanics

Psychology

Russian Language and Culture (Date to be determined)

Spanish
Spanish Language
Spanish Literature

Statistics

Table 12: Offered AP Courses[33]

[32] http://www.collegeboard.com/student/testing/ap/about.html
[33] http://apcentral.collegeboard.com/repository/05836apcoursdesccalc0_4313.pdf

The program grading policy is standardized along with a standardized test. The strategy employed is to give students a level from 1 through 5 providing a recommendation to colleges depending on the student performance on the exam.

5	Extremely well qualified
4	Well qualified
3	Qualified
2	Possibly qualified
1	No recommendation

Table 13: AP Final Grade Levels[34]

The grade levels are compared regularly with college grades. The grade level 5 (Extremely well qualified) is made equivalent to the average college level grade of an A. Similarly, the grade level 2 (Possibly qualified) is equivalent to the average college level of a D. This system guarantees an accurate evaluation of the scores obtained by students on a specific exam difficulty. The following table shows the score range of students in History and English and their respective range in term of grade levels.

	AP U.S. History		AP English Language and Composition	
Gr.	2001 Composite Score Range	2002 Composite Score Range	2001 Composite Score Range	2002 Composite Score Range
5	114 to 180	115 to 180	108 to 150	113 to 150
4	92 to 113	94 to 114	93 to 107	96 to 112
3	74 to 91	76 to 93	72 to 92	76 to 95
2	42 to 73	46 to 75	43 to 71	48 to 75
1	0 to 41	0 to 45	0 to 42	0 to 47

Table 14: AP Composite Score vs Grade levels[35]

34 http://www.collegeboard.com/student/testing/ap/exgrd_set.html
35 http://www.collegeboard.com/student/testing/ap/exgrd_set.html

The program is acknowledged by four thousand five hundred institutions within the United States. Each of them reserves the right of its own accreditation policy. The following table is a sample of well known Institutions and their respective policy for full listing refer to the web site indicated in the footnote.

College / University	AP Credit Policy
Massachusetts Institute of Technology	For most secondary school subjects that closely parallel the College Board Advanced Placement guidelines, the only method for generating credit at MIT is through the regular College Board Advanced Placement tests. Students wishing to receive such credit are urged to take those AP tests for which they are prepared. Only one test in a given subject area will be recognized. MIT does not accept AP or transfer credit for all subjects and advanced placement policies can change from year to year. Only one test in a given per subject area will be recognized and no credit is awarded for scores lower than 5 (or 4 in the case of the Calculus BC exam). MIT does not offer partial credit.
Worcester Polytechnic Institute	Worcester Polytechnic Institute accepts AP credit and will award credit for a score of '4' or '5' on any AP examination.
Northeastern University	The University awards credit for test scores of 4 and 5, however, for some exams a score of 3 will earn credit. Please contact the Office of Undergraduate Admissions for an up-to-dateAP listing. Credit awarded: 4–8 semester hours
California Institute of Technology	Caltech encourages all prospective undergraduate applicants to prepare by challenging themselves with the most rigorous course of study available, including the Advanced Placement (AP) and International Baccalaureate (IB) programs. However, college credit for AP or IB classes is not automatic. Course credit and/or placement in an accelerated program is sometimes granted as deemed appropriate by the department faculty. The awarding of Caltech course credit takes place at the time of registration each fall.

Table 15: AP Credit Policy Sample Information[36]

[36] http://www.collegeboard.com/ap/creditpolicy/list/0,4096,a,00.html Please Refer to Website for full listing. Additional Information Provided by Institution.

The scope of the program has rippled to thirty countries listed below. Each country has a number of institutions acknowledging the program for full listing please refer to the web site indicated.

Africa	South Africa
Americas	Bolivia Canada Colombia Dominican Republic Ecuador Guatemala Mexico Uruguay
Asia & the Pacific	Australia China Taiwan
Europe	Austria Belgium Cyprus Denmark France Germany Ireland Poland Switzerland The Netherlands United Kingdom (includes England, Northern Ireland, Scotland, and Wales)
Near East South Asia	Egypt Israel Lebanon Pakistan

Table 16: AP Recognized Countries[37]

[37] http://www.collegeboard.com/student/testing/ap/intad.html

Program costs are the student burden. Each exam cost $82 upon registration. A reduction of $22 is provided with proof of student financial need. On The other hand a number of federal and states funding is available the following table shows each state and the student support available.

State	Federal and/or state exam fee subsidy for low-income students	State exam fee subsidy for other students	Types of state support
Alabama	✔		
Alaska	✔		
Arizona	✔		Grants for minority students, professional development
Arkansas	✔	✔	Exam fees for low-income students, $50 subsidy for students taking more than two exams in one year, professional development, grants for equipment, school incentives
California	✔	✔	Exam fees for students at 200% of poverty, mandatory acceptance of AP grades at public colleges and universities, professional development for AP instructors, AP Vertical Teams?? grants, tutoring services for AP students, instructional materials and equipment for AP courses, support for AP online offerings
Colorado	✔		Tuition reductions reimbursing exam fees for student who receive college credit through AP
Connecticut	✔		Payment for Summer Institutes at Connecticut State University sites
Delaware			Professional Development
D.C.	✔	✔	Exam fees, professional development
Florida	✔	✔	Exam fees, professional development, school and teacher incentives, grants for supplies
Georgia	✔	✔	Exam fees
Hawaii			AP Exam fees for low-income students, professional development, AP Vertical Teams grants, online AP courses
Idaho			AP Exam fees for low-income students, professional development, AP Vertical Teams grants, online AP courses
Illinois	✔		Fees for select schools for online AP courses and test review
Indiana	✔	✔	Exam fees for math, science, and English language, professional development, recommendation that schools offer at least one AP math and AP science course, AP Advisory Committee

Iowa	✔		Fees for online AP courses, AP Advisory Committee
Kansas	✔		Professional development, online training
Kentucky	✔		Exam fee reimbursement, special diploma
Louisiana	✔		
Maine			Reimbursement of AP expenses for low-income districts
Maryland	✔		
Massachusetts			Professional development, grants for materials
Michigan	✔		Tuition for low-income students for online AP courses, tuition for teachers from low-income districts for AP Workshops and Summer Institutes, publication of college AP policies online
Minnesota	✔	✔	Exam fees for public and private school students, fees for online AP courses, professional development for public and private school teachers, publication of college AP policies, AP Advisory Committee
Mississippi	✔		Professional development
Missouri	✔	✔	Exam fees for students who meet proficiency criteria, professional development, publication of college AP policies, AP Advisory Committee
Montana	✔		
Nebraska	✔		Professional development
Nevada	✔		
New Hampshire	✔		
New Jersey	✔		
New Mexico	✔		Exam fees for low-income students, professional development, grants for equipment
New York	✔		AP English and Calculus Examinations scores satisfy English and math Excelsior exam requirements
North Carolina	✔		Mandatory weighted grades, publication of college AP policies
Northern Mariana Islands	✔		
Ohio	✔		
Oklahoma	✔	✔	Professional development, online AP courses, exam fees for low income students, partial exam fees for students taking more than one exam, professional development, AP Vertical Teams grants, school incentives, grants for materials and equipment

Oregon	✔		
Pennsylvania	✔		
Puerto Rico	✔		
Rhode Island	✔		
South Carolina	✔	✔	Exam fees for juniors and seniors, mandatory Summer Institutes for new AP teachers, payment for Summer Institutes for new AP teachers
South Dakota	✔		Professional development, publication of college AP policies, AP testing required to receive dual credit
Tennesse	✔		
Texas	✔	✔	Exam fee subsidy for low-income students, partial payments for all other students, professional development, school incentives, grants for materials and equipment
Utah			Professional development, grants for supplies and other AP costs
Vermont	✔		
Virginia			Special diploma
U.S. Virgin Islands	✔		
Washington	✔		
West Virginia	✔		Mandatory acceptance of AP grades in all public colleges, professional development, publication of college AP policies, AP Advisory Committee
Wisconsin	✔		Exam fees for low-income students, mandatory acceptance of AP grades 3 or higher at public colleges and universities, AP Advisory Committee, online AP courses

Table 17: Federal & State Support for AP[38]

[38] http://www.collegeboard.com/student/testing/ap/cal_fed.html

Program Evaluation

The information provided above is proof enough that this program has captured the respect of a huge network of more than qualified, well respected community. Furthermore, one of the solutions to enhance our high schools that the nation's governors and businesses have decided upon is to encourage the students to use the AP program. The latter is discussed in the next section the 2005 National Education Summit.

The College Board opened the door to a wider range of students to benefit from the advantages of taking the AP tests. It doesn't require taking the course to be eligible to register for an exam. This unique approach has benefited home schooled students as well as students enrolled in schools that does not offer the AP program. We also have to mention the wide support given to establishments, teachers, and students through the College Board and the preparation textbooks available off the self in most book stores.

FEBRUARY 2005 NATIONAL EDUCATION SUMMIT ON HIGH SCHOOLS (NESHS Summit)

Summit Background

President George H.W Bush and the nation's governors have held a summit in 1989. This meeting was held in University of Virginia to carry on the work that was started in the 1980's regarding the modernization, reform of the national education. The meeting importance lies in the agreement between the president and governors in setting national education goals.

February 2005 summit marks the fifth meeting of this nature preceded by three meeting in 1996, 1999, and 2001.

> *"These Summits have become powerful catalysts for improving educational opportunities in America. Moreover, these forums already have resulted in significant movements to bring about standards and accountability and to improve the quality of teaching and learning in our public schools.".*[39]

2005 National Education Summit is sponsored by two major groups. The first is Achive, Inc which is a non profit organization created by the nation's governors and business leaders. The Second which is the National Governors Association (NGA) one of the most respected public policy organizations in Washington DC. They provide services like policy reports on innovative state programs and hosting seminars for the state government executive branch officials. The Partners of the summit are Business Roundtable, The Education Commission of the States (ECS), and Hunt Institute. The Summit is also funded by businesses like Prudential Financial, Washington Mutual, State Farm, Intel Foundation, IBM Corporation, The Bill & Melinda Gates Foundation also provided support for Summit planning activities.[40]

The Summit gained the attention of this paper due to its focus. The focus, for the first time in US history, was solely on High Schools.

> "*Governors and CEOs have been at the forefront of states' efforts to improve student achievement. Significant progress has been made in the nation's elementary and middle schools. Now we must extend that effort to high schools.*"[41]

[39] http://www.achieve.org/ Summit Guide
[40] http://www.2005summit.org/en_US/about/sponsors.html
[41] http://www.achieve.org/achieve.nsf/StandardForm3?openform&parentunid=093D60E82F23011D85256F33006B9C15

Summit Recommendations and Conclusion

> *"NGA has identified 10 steps governors can take to quickly put states on the path to system-wide reform, so that 'Redesigning the American High School' becomes a national reality. 'Getting it Done' offers a series of best practices and achievable policy actions governors can use to get started on high school reform in the next 12 to 18 months. Relatively inexpensive, these short-term strategies can have a long-term positive impact on the number of students that graduate high school and continue their education."*
>
> *"We are united in our conviction that high schools must be targeted for comprehensive reform and sustained change, and we believe that work begins today,"*[42]

—NGA Chairman Virginia Governor Mark R. Warner

The summit was intended as a gathering of governors. 45 governors attended and 13 state governors have committed to adopting four goals. The committed states are Arkansas, Georgia, Indiana, Kentucky, Louisiana, Massachusetts, Michigan, New Jersey, Ohio, Oregon, Pennsylvania, Rhode Island and Texas.

The goals as stated on Archive web site are as follows: [43]

> *1. Aligning high school standards and assessments with the knowledge and skills required for success in postsecondary education and work.*
>
> *Accomplishing this will require state postsecondary systems and institutions to define clearly the knowledge and skills necessary for enrolling in credit-bearing courses and the K–12 system to align its standards and assessments with those expectations. States are encouraged to use the ADP*[44] *benchmarks in English and math as a starting point for this work.*
>
> *2. Administering a college- and work-ready assessment, aligned to state standards, to high school students, so that students get clear and timely information and are able to address critical skill deficiencies while still in high school.*
>
> *This does not necessarily need to be a high-stakes graduation exam. Achieve's research has found that current exit exams do not measure the higher-level knowledge and skills required by colleges and employers.*

[42] http://www.washingtonpost.com/wp-dyn/articles/A56466-2005Feb26.html

[43] http://www.achieve.org/achieve.nsf/ADP-Network?OpenForm

[44] ADP: American Diploma Project. Launched as an Achieve initiative, it identified standards and graduation requirements for states that match the skills demanded by colleges and employers.

3. Requiring all students to take a college- and work-ready curriculum to earn a high school diploma.

The ADP research found that there is a common core of knowledge and skills, particularly in English and math, which students must master to be prepared for both postsecondary education and well-paying jobs. States should require all students to complete a curriculum that teaches this content. Many states will accomplish this by specifying courses students must take to earn a diploma. States that delegate the establishment of high school graduation requirements to local districts will need to consider other approaches. All states will want to pay more attention to the content that students are taught rather than simply to course titles and Carnegie units alone.

Achieve's research has found that current course-taking requirements are not challenging enough. Moreover, in an Achieve survey recent high school graduates acknowledge that they weren't particularly challenged and would have worked harder if expectations had been higher.

4. Holding high schools accountable for graduating students who are college-ready, and holding postsecondary institutions accountable for their success once enrolled.

To promote more successful transitions from secondary to postsecondary education, states will have to establish strong accountability systems that provide results-based incentives, both to high schools and postsecondary institutions. To establish genuine accountability systems, many states will need to strengthen their data and information systems, as well, by developing systems for following individual students grade to grade and school to school, from kindergarten to postsecondary education and the workplace. They also will need to develop accurate and consistent measures of dropout and graduation rates.

Although participation in the ADP Network requires commitment to a common policy agenda, it does not require a one-size-fits-all approach. States are expected and encouraged to take different approaches to address this agenda.

Recommendation in ten steps to achieve the above 4 goals agreed upon:

Getting it done: Ten steps to a state action agenda	
1	Create a permanent education roundtable or commission
2	Define a rigorous college and work preparatory curriculum for high school graduation
3	Challenge business, education, parent, community, and faith based organizations to support statewide initiatives that improve college awareness
4	Give college and work readiness assessments in high school
5	Create statewide common course agreements
6	Provide financial incentives for disadvantaged students to take rigorous AP exams and college and work preparatory classes[45]
7	Expand college-level learning opportunities in high school
8	Help get low-performing students back on track by designing literacy and math recovery programs
9	Develop and fund supports to help students pass the high school exit exam
10	Develop statewide pathways to industry certification

Figure 7: Getting it done[46]

> *"ADP recommends that a rigorous high school curriculum include Advanced Placement courses, four years of English and math that covers geometry, advanced algebra and data analysis and statistics. Only Texas and Arkansas require students to take math courses through advanced algebra.*
>
> *Eight states Colorado, Iowa, Massachusetts, Michigan, Nebraska, North Dakota, Pennsylvania and Rhode Island have no state course requirements for high school graduation, Achieve found. Only 40 percent of high schools nationwide offer Advanced Placement courses, which have proved to greatly increase students' chances of succeeding in college."[47]*

[45] Recommendation conforms to our research conclusion pushing further the AP program into high schools.
[46] Redesign the American High School getting it done: Ten Steps to a State Action Agenda, guidebook of promising states and local practices.
[47] http://www.stateline.org/live/ViewPage.action?siteNodeId=136&languageId=1&contentId=15998

CONCLUSION

We presented three programs targeting high school students. One focuses on engineering basics (PLTW), the second focuses on motivation (ETF), and the third lays a foundation by focusing on the basics (AP). For weeks we have been trying to decide, to lean toward one of those approaches.

It is our opinion that PLTW fits very nicely as a replacement or addition to vocational high schools curriculum since it focuses on the basic engineering knowledge that is covered in depth in engineering colleges. The courses offered are redundant to what is offered in colleges and taught by experienced professors, well qualified and professional in their respective fields. It is our opinion that it is crucial for students' survival in their chosen colleges to attend the introductory courses in their chosen colleges to adapt to their respective college offered sequence and in effect be able to follow more advance courses.

The ETF initiative based on the knowledge we acquired about the program should not be added to a high school curriculum. It fits very well a summer discovery course such as the ones the Museum of Science is famous for. The fun, motivation and experimenting aspect drove us to this conclusion. Yes, motivation is what drives us all to excel in our fields but the times have changed. The demand for more knowledge is outweighed in the current fast paste age, and economic competition. We believe that the time spend by students on this program should be more rightfully allocated to more basics math and science.

We came close to choosing the AP as a solution for its well rounded foundation it creates. But then how many students will be forsaken, ousted by their inability to handle the load if the program became a mandatory requirement by colleges. Is it fast, high IQ students that we are looking for? Is it a filtering scheme? It is true that other countries, like Bill Gates mentioned, have a higher High School standards. It is also true that high schools in those countries are a nightmare for average and less than average students. How many lives became derelict in those countries when landing in a last option college or just giving up the hope of going to college? We believe it is a filtering scheme those countries seek the diversity that the U.S enjoys. We do see the benefits of the AP program, but we fear the outcome of shoving it at students till it becomes the rule not an option.

For the sake of comparison and the reasons behind our AP opinion, we would like to take a closer look to the high school curriculum in Egypt as an example. The math curriculum is made of the four calculus courses offered in WPI in a one year course. Differential equation is a separate elective course offered in conjunction. Some adventurous souls venture to take it for extra credits toward their final score. Physics curriculum is one course made of the four physics courses in WPI. Chemistry is also a one course comparable to three chemistry courses offered in WPI in addition to a separate part of the course focusing on organic chemistry. Biology curriculum focuses on cells organism and human organs functions. These courses are offered in one year, last year of high school, along with a high level Arabic language course that include a good number of poetry and their respective analysis. This package is a mandatory requirement for all wishing for any science related field like medical or engineering. It is not high school specific. The curriculum is set by the government, standardized with a standardized two weeks final examination. Two weeks of brutal examination determines the future of a student. College acceptance is determined by the grade obtained in those two weeks as well as college availability. Since colleges are ranked, it is meant by college availability that each accepts a huge but strict amount of students per year and each in their respective rank sequence accepts the highest grades of students willing to enroll. Five years ago, medical school accepted only student above 97% and most engineering schools accepted only students above 95%. Work was being done to relax this nightmarish load since then. What was done is distributing the previous to last year of high school over the previous years and expanding the last year to two years. We assume that this is not something we would like to see in the U.S high schools but it is where we are headed if we start adding more materials and more courses.

Steering the future of a generation of high school graduates is a heavy task that lies in the hands of our educators. We have tried to show our concerns in this conclusion seeking not to enlighten our decision makers but to request their attention towards our concerns. We admit that something needs to be done to improve our high schools. We are pleased to see more than one initiative taken towards that common goal. We strongly believe the fact that the United States might is in its equal opportunity and its diversity.

We decided to conclude our paper with a table shown below that can be useful in providing a simple overview for the sake of a quick comparison between the programs we presented.

	Advanced Placement Program (AP)	**Engineering the Future Program (ETF)**	**Project Lead The Way Program (PLTW)**
Acknowledged	Well established and recognized	Unimplemented Yet	Feedback Unclear
Founders	The College Board	Museum of Science	A Group of highly qualified pioneers
Tests	Standardized	Unimplemented Yet	Standardized
Tests grading	Centralized ensuring a national standard	Unimplemented Yet	
Courses	Specialized large variety	Series of four Courses	Stand Alone 9 courses, 4 required for certification
Program Expected Duration	Unlimited	One Year	Two Years
Program Flexibility	Flexible	Students must complete all Units.	Students must complete all Units.
Student Certification and Accreditation	- College Accreditation - Non Monetary AP Scholar Awards (achievement acknowledge on any grade reports sent to colleges)	Not Available	Certification provided upon completion. College Accreditation in progress.
MCAS Readiness	College level courses	Claims to prepare students for MCAS	Unconfirmed
Teacher Certification	Registered Teachers	Registered Teachers	Registered Teachers
Teacher preparation	Insured by Certification	Teacher will be required to attend a 2-day summer preparation session.	Teacher will be required to attend a 2 weeks summer preparation session.
Provided material	Online teacher Community Resources (feedback, guidelines, tips)	Online teacher Community Resources (feedback, guidelines, tips)	Online teacher Community Resources (feedback, guidelines, tips)

Table 18: Brief Summary

APPENDIX A (PLTW)

A.1 Sample Curriculum

Principles of Engineering

Unit 1: Definition and Types of Engineering
- Lesson 1.1 Engineers as Problem Solvers Past, Present and Future
- Lesson 1.2 Engineering Team
- Lesson 1.3 Careers in Engineering
  - 1.3.1 Engineering
  - 1.3.2 Engineering Technology
  - 1.3.3 Distinction between Engineering and Engineering Technology

Unit 2: Communication and Documentation
- Lesson 2.1 Sketching
- Lesson 2.2 Technical Writing
  - 2.2.1 Engineer's Notebook
  - 2.2.2 Technical Reports
  - 2.2.3 Style
- Lesson 2.3 Data Representation and Presentation
- Lesson 2.4 Presentations

Unit 3: Design Process
- Lesson 3.1 Product Development
  - 3.1.1. Problem Identification
    - 3.1.1.1. Design Brief
  - 3.1.2. Problem Analysis
  - 3.1.3. Information Gathering
  - 3.1.4. Alternative Solutions and Optimization
  - 3.1.5. Modeling
  - 3.1.6. Testing and Evaluation
  - 3.1.7. Presentation of Solution

Unit 4: Engineering Systems
- Lesson 4.1 Mechanisms
  - 4.1.1. Mechanical Advantage
  - 4.1.2. Simple Machines
    - 4.1.2.1. Levers
    - 4.1.2.2. Inclined Plane
    - 4.1.2.3. Wedge
    - 4.1.2.4. Wheel and Axle
    - 4.1.2.5. Pulley
    - 4.1.2.6. Screw
  - 4.1.3. Gears
  - 4.1.4. Cams
  - 4.1.5. Linkages
- Lesson 4.2 Thermodynamics
  - 4.2.1 Units
  - 4.2.2 Forms of Energy
    - 4.2.2.1 Mechanical
    - 4.2.2.2 Chemical
    - 4.2.2.3. Electromagnetic
    - 4.2.2.4. Nuclear
    - 4.2.2.5. Thermal
    - 4.2.2.6. Solar
  - 4.2.3 Energy Conversion
  - 4.2.4 Cycles
    - 4.2.4.1 Open

4.2.4.2 Closed
4.2.5 Efficiency
4.2.6 Energy Loss
4.2.6.1. Conduction
4.2.6.2. Convection
4.2.6.3. Radiation
4.2.7 Heat Engines
4.2.7.1 Steam
4.2.7.2 Internal Combustion
4.2.7.3 Turbines
Lesson 4.3 Fluid Systems
4.3.1. Hydraulic Systems
4.3.1.1 Pascal's Law
4.3.1.2Components
4.3.2. Pneumatic Systems
4.3.2.1 Boyle's Law
4.3.2. 2Components
Lesson 4.4 Electrical Systems
4.4.1. Electrical Theory
4.4.1.1. Sources of Electromotive Force
4.4.1.2. Ohms Law
4.4.1.3. Kirchhoff's Laws
4.4.1.4. Watt's Law
4.4.2. Metering Devices
4.4.3. Motors and Generators
4.4.3.1. DC Motor
4.4.3.1.1. Permanent Magnet
4.4.3.1.2. Electromagnet
4.4.3.1.3. Components
4.4.3.2. DC Generator
4.4.3.3. AC Generator
4.4.3.3.1. Single Phase
4.4.3.3.2. Three Phase
4.4.3.4. AC Motor
4.4.3.4.1. Synchronous
4.4.3.4.2. Induction
4.4.3.5. Transformers
4.4.3.5.1 Single Phase
4.4.3.5.2. Multi-Phase
4.4.3.6. Electric Transmission Systems
Lesson 4.5 Control Systems
4.5.1. Open Loop System
4.5.2. Closed Loop System
4.5.2.1 Sensors and Actuators
4.5.2.2. Basic Concept of Automation, FMS and System Integration Programming
4.5.2.3 Flow Chart
4.5.2.4 PLC – Programmable Logic Control

Unit 5: Statics and Strength of Materials

Lesson 5.1 Statics
5.1.1 Strength of Shapes
5.1.2 Forces
5.1.3 Static Equilibrium
5.1.4 Vectors
5.1.5 Free body Diagrams
5.1.6 Moments
5.1.7 Reaction Forces

5.1.8 Trusses
5.1.9 Bridges
Lesson 5.2 Strength of Materials
5.2.1. Properties of Areas
5.2.1.1. Center of Gravity
5.2.1.2. Moments of Inertia
5.2.1.3. Calculating Mass Properties Using CAE Tools
5.2.2. Stress
5.2.3. Strain
5.2.4. Deflection

Unit 6: Materials and Materials Testing in Engineering

Lesson 6.1 Categories of Materials
6.1.1. Metals
6.1.2. Alloys
6.1.3. Nonmetals
6.1.4. Composites
Lesson 6.2 Properties of Materials
6.2.1. Chemical Properties
6.2.2. Physical Properties
6.2.3. Mechanical Properties
6.2.4. Dimensional Properties
Lesson 6.3 Production Processes
Lesson 6.4 Quality
6.4.1 Engineering Statistics
6.4.2 Precision Measurement Tools and Techniques
6.4.3 Statistical Process Control
Lesson 6.5 Material Testing Processes
6.5.1. Nondestructive Inspection and Testing
6.5.2. Destructive Testing

Unit 7: Engineering for Reliability

Lesson 7.1 Reliability
7.1.1. Determining Failure Rates
7.1.2. Identifying Critical Components
7.1.3 Redundancy
7.1.4 Risk Analysis
7.1.5 Factors of Safety
7.1.6 Liability and Ethics
Lesson 7.2 Case Study

Unit 8: Introduction to Dynamics/Kinematics

Lesson 8.1 Linear Motion
8.1.1. Displacement
8.1.2. Velocity
8.1.3 Acceleration
Lesson 8.2 Trajectory Motion

Digital Electronics

Unit 1: Fundamentals

- Lesson 1.1 Safety
  - 1.1.1. Electrical
  - 1.1.2. Equipment
  - 1.1.3. Hand Tools
  - 1.1.4. Clothing
  - 1.1.5. Procedures
  - 1.1.6. Material Safety Data
- Lesson 1.2 Basic Electron Theory
  - 1.2.1. Current Flow
    - 1.2.1.1. Conventional vs. Electron Flow
    - 1.2.1.2. DC
    - 1.2.1.3. AC
  - 1.2.2 Structure of Atoms
    - 1.2.2.1 Nucleus
    - 1.2.2.2 Protons
    - 1.2.2.3 Electrons
    - 1.2.2.4 Electron Orbit
- Lesson 1.3 Prefixes, Engineering Notation
  - 1.3.1. Mega
  - 1.3.2. Kilo
  - 1.3.3. milli
  - 1.3.4. micro
  - 1.3.5. micro-micro
  - 1.3.6. nano
  - 1.3.7. pico
- Lesson 1.4 Resistors
  - 1.4.1. Theory
  - 1.4.2. Units
    - 1.4.2.1. Ohms
    - 1.4.2.2. Wattage
  - 1.4.3. Fixed
  - 1.4.4. Color Code
  - 1.4.5. Measuring Resistance
  - 1.4.6. Variable
- Lesson 1.5 Laws
  - 1.5.1 Circuits
    - 1.5.1.1. Parts to a Simple Circuit
      - 1.5.1.1.1. Source
      - 1.5.1.1.2. Load
      - 1.5.1.1.3. Control
      - 1.5.1.1.4. Conductor
    - 1.5.1.2. Schematics
    - 1.5.1.3. Series
    - 1.5.1.4. Parallel
    - 1.5.1.5. Series – Parallel
    - 1.5.1.6. Open/closed loop
    - 1.5.1.7. Switches
      - 1.5.1.7.1. Single Pole Single Throw
      - 1.5.1.7.2. Single Pole Double Throw
      - 1.5.1.7.3. Push Button Normally Closed
      - 1.5.1.7.4. Push Button Normally Closed
    - 1.5.1.8. Short Circuit
    - 1.5.1.9. Continuity

1.5.2. Ohm's Law
1.5.2.1. Measuring Voltage
1.5.2.2. Measuring Current
1.5.3. Kirchhoff's Law
1.5.3.1. Current
1.5.3.2. Voltage
1.5.4. Voltage
1.5.4.1. In series
1.5.4.2. In parallel
1.5.5. Current
1.5.5.1. In series
1.5.5.2. In parallel
1.5.6. Resistance
1.5.6.1. In series
1.5.6.2. In parallel
Lesson 1.6 Capacitance
1.6.1 Theory
1.6.2. Reading the value
1.6.3. Units
1.6.3.1. Farads
1.6.3.2. Voltage
1.6.4. Type
1.6.4.1. Ceramic
1.6.4.2. Electrolytic
1.6.5. Polarity
1.6.6. Measuring
1.6.6.1. Scope
1.6.6.1.1. Time
1.6.6.1.2. Voltage
1.6.6.2. Capacity Checker
Lesson 1.7 Analog and Digital Waveforms
1.7.1. Reading Waveforms
1.7.1.1. Signal Generator
1.7.1.2. Wave types
1.7.1.2.1. Square
1.7.1.2.2. Sine
1.7.1.2.3. Sawtooth
1.7.1.3. Period/Wavelength
1.7.1.4. Amplitude
1.7.1.5. Rise and Fall time
1.7.1.6. Offset
1.7.1.7. Pulse Width
1.7.1.8. Duty Cycle
1.7.1.9. Calculating Frequency
1.7.2. Logic Conditions
1.7.2.1. High
1.7.2.2. Low
1.7.3. Multivibrators
Lesson 1.8 Obtaining Data Sheets
1.8.1 Internet Search
1.8.2 Information included

Unit 2: Number Systems

Lesson 2.1 Conversions
2.1.1. Binary to Decimal
2.1.2. Decimal to Binary
2.1.3. Hexadecimal to Binary
2.1.4. Binary to Hexadecimal

2.1.5. Hexadecimal to Decimal
2.1.6. Decimal to Hexadecimal

Unit 3: Gates

Lesson 3.1 Logic Gates
- 3.1.1. The Logic Symbols for the AND, OR, NOT, NAND, NOR Gates
- 3.1.2. Reading Pin-out Diagram
- 3.1.3. Truth Tables
- 3.1.4. Boolean Expression
- 3.1.5. Creating Multiple Input Gates

Unit 4: Boolean Algebra

Lesson 4.1 Boolean Expressions
- 4.1.1. Boolean Expressions and Truth Tables
- 4.1.2. Minterm Expressions, Sum of Products
- 4.1.3. Maxterm Expressions, Product of Sums
- 4.1.4. Unsimplified Boolean Expression and Schematic Circuits

Lesson 4.2 Logic Simplifications
- 4.2.1. Boolean Simplification
- 4.2.2. DeMorgan's Theorems
- 4.2.3. Karnaugh Mapping
- 4.2.4. Electronic Simplification Tools

Lesson 4.3 Duality of Logic Functions
- 4.3.1. Using NOR Gates to Emulate All Logic Functions
- 4.3.2. Using NAND Gates to Emulate All Logic Functions

Unit 5: Combinational Circuit Design

Lesson 5.1 Paradigm for Combinational Logic Problems
- 5.1.1. Word Problem
- 5.1.2. Construct Truth Table
- 5.1.3. Create a Logic Equation from a Truth Table
- 5.1.4. Simplify the Logic Equation
- 5.1.5. Simulate the Circuit
- 5.1.6. Construct the Circuit
- 5.1.7. Troubleshoot

Lesson 5.2 Specific Application MSI Gates
- 5.2.1. Levels of Integration (SSI, MSI, LSI)
- 5.2.2. Display Drivers
- 5.2.3. Code Converters
  - 2.3.1. Binary Coded Decimal (BCD)
    - 5.2.3.1.1. BCD to Decimal
    - 5.2.3.1.2. Decimal to BCD
    - 5.2.3.1.3. Binary to Hexadecimal

Lesson 5.3 Programmable Logic Devices (PLD)
- 5.3.1. Introduction to PLD
- 5.3.2. PLD Programming Software
- 5.3.3. PLD Programming Hardware

Unit 6: Adding

Lesson 6.1 Binary Addition
- 6.1.1. 2's Complement Notation, Addition and Subtraction
- 6.1.2. The Exclusive OR and Exclusive NOR Functions
- 6.1.3. Half Adder Design
- 6.1.4. Full Adder Design
- 6.1.5. N Bit Adder Design

Unit 7: Flip-Flops

Lesson 7.1 Introduction to Sequential Logic
- 7.1.1. Latches
- 7.1.2. Flip-Flop
- 7.1.3. Timing Diagrams

Lesson 7.2 The J-K Flip-Flop

7.2.1. Operation of J-K Flip-Flop
7.2.2. Asynchronous Inputs
7.2.3. Synchronous Inputs

Lesson 7.3 Triggers

7.3.1. Positive-Edge Trigger
7.3.2. Negative-Edge Trigger
7.3.3. Positive-Level Trigger (Latch)
7.3.4. Negative-Level Trigger (Latch)

Lesson 7.4 Flip-Flop Timing Considerations

7.4.1. Setup and Hold Times
7.4.2. Propagation Delays
7.4.3. Timing Limitations (f_{max}, Minimum Pulse Width)

Lesson 7.5 Elementary Applications of Flip-Flops

7.5.1. Data Storage
7.5.2. Logic Synchronizing
7.5.3. Clock Division
7.5.4. Switch Debouncing

Unit 8: Shift Registers and Counters

Lesson 8.1 Shift Registers

8.1.1 Discrete Shift Register
8.1.2 Integrated Shift Register

Lesson 8.2 Asynchronous Counters

8.2.1. Discrete Ripple Counter
8.2.2. Discrete Modulus-N Ripple Counter
8.2.3. Integrated Ripple Counter (7493)
8.2.4. Other MSI Counter

Lesson 8.3 Synchronous Counters

8.3.1. Discrete Up Counter
8.3.2. Discrete Down Counter
8.3.3. Discrete Modulus-N Synchronous Counter
8.3.4. Integrated 4-Bit Binary Counter (74163)
8.3.5. Integrated 4-Bit Binary Up/Down Counter (74193)

Unit 9: Families and Specifications

Lesson 9.1 Logic Families

9.1.1. CMOS
9.1.2. TTL
9.1.3. Interfacing Different Logic Families

Lesson 9.2 Spec Sheets

9.2.1. Electronic Sites
9.2.2. Voltage Levels
9.2.3. Current Levels
9.2.4. Fan-out
9.2.5. Switching Characteristics – Propagation Delay

Unit 10: Microprocessors

Lesson 10.1 Microcontrollers

10.1.1. Programming
10.1.2. Development Tools
10.1.3. Output to Sound
10.1.4. Output pins
10.1.5. Limitations
10.1.6. Input devices
10.1.6.1. Switches
10.1.6.2. Phototransistors
10.1.7. Analog to Digital
10.1.7.1. A to D converters
10.1.7.2. CaDmium Sulfide Cells
10.1.7.3. Thermistors

Lesson 10.2 Interfacing with Motors
- 10.2.1. Types of Motors
  - 10.2.1.1. AC
  - 10.2.1.2. DC
  - 10.2.1.3. Stepper
- 10.2.2. Interface Devices
  - 10.2.2.1. Relays
  - 10.2.2.2. H-Bridges
  - 10.2.2.3. OptoIsolators

Unit 11: Student Directed Study Topic

Lesson 11.1 Design Paradigm

A.2 PLTW Current Board of Directors and Credentials

Richard Liebich, Chair
Richard Blais, Executive Director
Dr. Gene Bottoms, V.P. Southern Regional Education Board
Dr. Suellen Reed, Superintendent Indiana Public Instruction
Dr. Herman Viets President, Milwaukee School of Engineering
Cecil Schneider, President, CEC Technologies, P.C.

Richard Liebich, Chair

Saratoga Springs, NY — March 1, 2004 the Charitable Leadership Foundation, of Clifton Park, New York, has pledged $1,250,000 to assist with the development and implementation of Empire State College's new Master of Arts in Teaching degree program. The gift is the largest amount from a private foundation that the college has ever received. Richard Liebich, CEO of the Charitable Leadership Foundation.[48]

Richard Liebich saw both the problem and the potential to create something with lasting impact. As an engineer himself, having graduated from Michigan State University, he understood firsthand the rigors of the university engineering curriculum. And as the son of the late Herbert Liebich and a trustee of the foundation he founded (*Charitable Leadership Foundation*), Liebich also was in a position to make a real difference in the preparedness of K-12 students for university engineering coursework. From his home in Clifton Park, New York, Richard Liebich began searching in the early 1990s for a K-12 pre-engineering program he could replicate and take nationally.

He didn't have to look far. In the mid-1990s, Liebich was sitting on the advisory board of a program created by Richard Blais-then chairman of the technology department of a school district in New York-to give high school students pre-engineering training. Using the resources of Charitable Leadership Foundation, Liebich seized on the nascent program in 1997 and created Project Lead the Way from Blais's program.

[48] http://www.esc.edu/esconline/across_esc/infonews.nsf/0/79265b44d4a425e585256e4d00656362?OpenDocument

Dr. Gene Bottoms, Senior Vice President, Southern Regional Education Board

592 Tenth Street, NW, Atlanta, GA 30318
Phone: (404) 875-9211 x249
Fax: (404) 872-1477
gene.bottoms@sreb.org

Dr. Gene Bottoms is founding director of the Southern Regional Education Board's High Schools that Work (HSTW) the nation's largest school improvement initiative to raise the achievement of career-bound students. More than 1,000 schools in 23 states have adopted HSTW's framework of goals and key practices. The program offers a challenging academic foundation with a career/technical or academic concentration to prepare high school students for the workplace and further education. Dr. Bottoms is the recipient of numerous awards for his work in helping high schools improve curriculum, instruction, and student learning.[49]

Established in 1987 by the Southern Regional Education Board (SREB), High Schools That Work (HSTW) is the nation's first widespread effort to combine challenging academic courses and a modern vocational curriculum to enhance the achievement of high school students. HSTW was founded on the principle that if incorporated into an environment which continually encourages success, most students can master complex academic and technical concepts. Dr. Gene Bottoms, Senior Vice President of SREB, reports a rapid progression of HSTW from 28 pilot sites in 13 states to its current size of over 800 sites in 22 states.

MAJOR GOALS
According to Dr. Bottoms, HSTW pursues two major goals:

1. To improve the mathematics, science, communication, problem-solving and technical achievement of the nation's high school students.

2. To blend the essential content of traditional college preparatory studies--mathematics, science, language arts and social studies--with quality vocational and technical studies by creating conditions that support school leaders, teachers and counselors in carrying out key practices.[50]

[49] http://www.woodrow.org/CommissionOnTheSeniorYear/Commission_Directory/bottoms.html
[50] http://www.aypf.org/forumbriefs/1998/fb011698.htm

Dr. Suellen Reed, State of Indiana Superintendent of Public Instruction[51]

Room 229, State House Indianapolis, Indiana, 46204-2798
Voice: 317-232-6665
Fax: 317-232-8004
www.doe.state.in.us
sreed@doe.state.in.us

"Dr. Suellen Reed has served as co-chair of Indiana's Education Roundtable, since 1998, and has served as co-chair of the Indiana Commission for Early Learning and School Readiness. Dr. Reed served as president of the Council of Chief State School Officers (CCSSO) in 2001-2002. Prior to that, she had served as president-elect and vice president. Currently, she serves on the International Education Committee. She has also served on the CCSSO Task Force on Strengthening Professional Practice. Dr. Reed is a commissioner for the Education Commission of the States (ECS). She is a member of the Executive Committee. She was a member of the Steering Committee 1994-1998, and is again beginning in 2002. She was formerly Treasurer of the group, and served as chair of the Policy and Priorities Committee which set the direction and priorities for ECS work on education reform. She was the first national chairman of the K-12 Compact for Learning and Citizenship, a national organization dedicated to the advancement of school-based service and service learning as integral components of K-12 education. She is past president, 1993-1997, and 2002, of the North Central Regional Education Laboratory (NCREL) located in Naperville, Illinois, which is a federally-sponsored educational research laboratory. Dr. Reed is a member of the Indiana Historic Landmarks Foundation Board of Directors; Honorary Board Member of the Indianapolis Zoological Society; AIT, Agency for Instructional Technology Board of Directors; VHS, Virtual High School, Board of Directors, 2003-2005; and Women's Council on Literacy for the Indiana Literacy Foundation. She is a member of the Board of Trustees of Hanover College, the Commission for Drug-Free Indiana, the Indiana Commission on Community Service, the Indiana Higher Education Telecommunication System (IHETS), and the Honorary Board Member of the Rush County Community Foundation.

Honorary Doctorate of Humane Letters, Hanover College, May 2003
Honorary Doctorate of Humane Letters, St. Joseph College, May 1999
Honorary Doctorate of Laws, Ball State University, May 1997
Honorary Doctorate of Letters, University of Indianapolis, April 1997
Honorary Doctorate in Education, Vincennes University, May 1996"[52]

[51] http://ideanet.doe.state.in.us/reed/
[52] http://ideanet.doe.state.in.us/reed/reed_skrbiograph.html Please refer to web site for complete Biography

Dr. Herman Viets President, Milwaukee School of Engineering

Dr. Hermann Viets Polytechnic University '65 '66 '70[53]
Can be reached at (414) 277-7100
viets@msoe.edu

Cecil Schneider, President, CEC Technologies, P.C

"Schneider is manager of the Advanced Structures & Materials Division at Lockheed Martin Aeronautical Systems Marietta, Ga., where he directs R & D projects in structures, materials and manufacturing technology as well as producibility, materials and process support of production programs. With Lockheed since 1964, Schneider spent two years as deputy director of the Composites Development Center in Burbank, Calif., before returning to Marietta in 1990. Schneider is board chair and director of Composites Materials Characterization (CMC) Inc., a consortium of aerospace companies that screens and tests new composite materials. He also serves as Lockheed Martin's liaison on several industry and governmental committees in the area of advanced materials and manufacturing processes. He has a bachelors degree in aeronautical engineering from Wichita State University, a masters degree in engineering mechanics from Georgia Institute of Technology and is a registered Professional Engineer (PE) in Georgia." [54]

53 http://media.poly.edu/mechanical/page/template/mehistorychairs.cfm
54 http://www.sme-toronto-26.org/smeto26/pages/innov99spkschneider.htm

A.3 Schools in the PLTW Network in MA

Certified	School Name	City	Implement Date
	Assabet Valley Regional Technical High School	Marlborough	
	Blue Hills Technical High School	Canton	2004
H	Cambridge Rindge and Latin High School	Cambridge	2002
	Central Middle School - MA	Quincy	2002
	Charles H. McCann Technical School	North Adams	
	Charlestown High School	Charlestown	2004
	Concord Middle School	Concord	2002
	Doherty Memorial High School	Worcester	2000
	Forest Grove Middle School	Worcester	2000
	Framingham High School	Framingham	2005
	Gateway Regional High School	Huntington	2002
H	Greater New Bedford Regional Voc-Tech High School	New Bedford	2001
	Leominster High School	Leominster	2001
	Memorial Middle School	Hull	2002
H	Minuteman Regional High School	Lexington	2000
	Nashoba Valley Technical High School	Westford	2003
	Pathfinder Regional Voc-Tech High School	Palmer	
	Putnam Vocational Technical High School	Springfield	2004
H	Quincy High School/Center for Technical Education	Quincy	2001
M	Rindge School of Technical Arts at Tobin	Cambridge	2002
	Salem High School	Salem	2001
	Smith Vocational and Agricultural High School	Northampton	2004
	Sterling Middle School	Quincy	2002
	Tri-County RVTHS	Franklin	
P	University of Wisconsin-Stout	Worchester	2099
	Worcester East Middle School	Worcester	2001
	Worcester Polytechnic Institute	Worcester	
	Worcester Vocational High School	Worcester	2002
	WPI Davis High School	Worchester	2003

The Regional Coordinator for MA is Christine Shaw cshaw4224@aol.com	"H" PLTW Certified High School "M" PLTW Recognized Middle/Jr High School "P"A PLTW Partner College or University

A.4 Sample Part A Student Exam

Introduction To Engineering Design

Multiple Choice

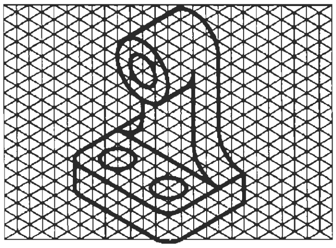
Directions: **Select the letter of the response which best completes the item or answers the question.**

Design

1. The first step of the design process is to ____________________.
   - ***A.*** solve the problem
   - ***B.*** evaluate concepts
   - ***C.*** take a break
   - ***D.*** identify a need
2. ____________________ a number of possible solutions.
   - ***A.*** Brainstorm
   - ***B.*** Research
   - ***C.*** Search for
   - ***D.*** Formulate in detail
3. Before the design process can be considered complete, you should always ____________ and ____________ your solution.
   - ***A.*** operate and analyze
   - ***B.*** decorate and protect
   - ***C.*** evaluate and test
   - ***D.*** destroy and film
4. The relationship of sizes to one another is called…
   - ***A.*** balance
   - ***B.*** proportion
   - ***C.*** transition
   - ***D.*** repetition
5. A thorough understanding of the problem being addressed is ____________ to ensure the best outcome of the design process.
   - ***A.*** nice to have
   - ***B.*** not necessary
   - ***C.*** important
   - ***D.*** critical
6. Squares, rectangles, circles and ovals are…
   - ***A.*** lines
   - ***B.*** shapes
   - ***C.*** Colors
   - ***D.*** sketches

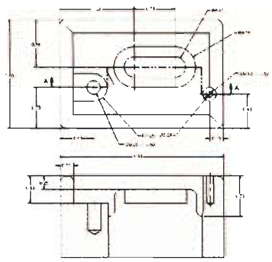
Sketching and Visualization

7. There are two basic types of dimensions: _________ and ___________.
   - ***A.*** size, feature
   - ***B.*** size, location
   - ***C.*** feature, location
   - ***D.*** Position, feature
8. Light lines used for the layout and the size of the basic shape of a part are...
   - ***A.*** object lines
   - ***B.*** guide lines
   - ***C.*** construction lines
   - ***D.*** border lines
9. The process of adding dimensions and notes to a drawing is called __________.
   - ***A.*** annotating
   - ***B.*** documenting
   - ***C.*** illustrating
   - ***D.*** forecasting

10.  This type of sketch is called a(n) ______________ .

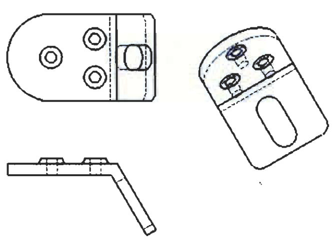
A. oblique **C.** two point perspective

B. isometric **D.** section view

11.  This type of drawing as called a(n) ____________.

A. auxiliary view **C.** section view

B. revolution **D.** development

12.  This type of drawing is known as a(n) ________.

A. pictorial **C.** full section

B. auxiliary view **D.** revolution

13. A ______________________ is used on each dimension to define the total permissible variation in a size or location while machining a part.

A. limit **C.** tolerance

B. range **D.** variation

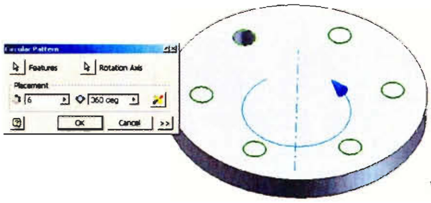
Geometric Relationships

14. Two common techniques of building complex geometries are ___________ and _______________.

A. expansion, contraction **C.** slicing, dicing

B. additive, subtractive **D.** AND logic, OR logic

15.



Which type of coordinate system is the mathematical premise behind this type of placed feature?

A. Polar ***C.*** absolute

B. Relative ***D.*** cartesian

16. What is the absolute coordinate located 2 units to the left and 6 units above the absolute coordinate X=3, Y=5?

A. X=3, Y=-1 ***C.*** X=1, Y=11

B. X=9, Y=7 ***D.*** X=2, Y=6

17. Vertical, horizontal, perpendicular and equal are a few of the __________ that can be applied to a sketch.

A. Updates ***C.*** dimensions

B. Features ***D.*** 2D constraints

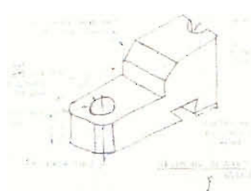
18. Two terms that are associated with the construction of regular polygons are…

A. radius and chord length ***C.*** center point and circumference

B. inscribed and circumscribed ***D.*** across flats and length of side

Modeling

19.



A sketch or set of sketches, like the one pictured, that are ready to be further defined and analyzed are called…

A. Prototypes ***C.*** preliminary ideas

B. concept models ***D.*** idea models

20. Changes to ____________ dimensions will effect all other functionally related dimensions in the part or assembly.

A. evolving ***C.*** parametric

B. changeable ***D.*** editable

21. What assembly constraint would be used to assemble a circular shaft into a round opening?

A. Mate ***C.*** Insert

B. Flush ***D.*** Angle

22. Creating parts as separate files to be brought into an assembly is known as the ___________________ assembly technique.

   A. bottom up
   B. parts up
   C. top down
   D. linear integration

23. A properly dimensioned drawing of a drilled hole in a rectangular block of material would provide the machinist making the part with…

   A. the drill bit size only.
   B. the diameter of the hole and the location to the center of the hole.
   C. nothing, they machine it where they want.
   D. where the edge of the hole starts and the size of the drill bit.

24. Files of 3D models can be exported and then produced by a(an) _____________ prototyping operation.

   A. customary
   B. traditional
   C. rapid
   D. articulated

25. Volume, mass and density are all considered _________________ of a part.

   A. principles and elements
   B. physical properties/mass properties
   C. product characteristics
   D. standard deviations

Presentations

26. When making a presentation to an audience using a digital projector, it is most effective to _______________.

   A. read the contents of the slides to the audience
   B. speak directly to the audience, using the slides as a visual aid.
   C. write everything you intend to say on the slides so that you don't forget to say anything
   D. put interesting content on the slides even if it doesn't have anything to do with the presentation topic

27. A collection of work used for evaluation of one's capabilities is called a(n)…

   A. binder.
   B. file folder.
   C. engineering log.
   D. portfolio.

28. A teleconference requires which set of skills and techniques?

   A. Voice variation and preparation
   B. Proper posture and eye contact
   C. Eye contact and intonation
   D. The three V's… visuals, voice variation and vocabulary

29. The documentation of one's daily work on a project is called a(an)…

   A. Design diary
   B. Engineering log
   C. Daily data
   D. Patent Pending

30. You are making a presentation for your engineering firm highlighting the construction progress of a building for your client. What type of visual aid would be best suited for this presentation?

A. Video clips
B. Charts and graphs
C. Written report
D. Blueprints

Production and Marketing

31. DFM stands for…

A. Draw For Machining
B. Deliver From Manufacturing
C. Design For Manufacturability
D. Dynamic Flexible Machinery

32. CNC stand for…

A. Computer Numerical Control
B. Controlled Noise Contamination
C. Common Numeric Computing
D. Computerized Nominal Cutting

33. Which term below is associated with the statement "approach to guaranteeing that the system is one that is never satisfied with the status quo."

A. Real Time Inspection
B. Just In time
C. Total Quality Management
D. The Pursuit of Excellence and the Agony of Defeat

34. What term below is best associated with the following scenario. When an assembly line worker completes their task in the manufacture of a product, inspects it at that point and determines whether the part should continue on to the next station or be rejected.

A. Just In time
B. Total Quality Management
C. Point of Production Inspection
D. Real Time Inspection

35. During the design process, marketing considerations include effective ____________ and product analysis.

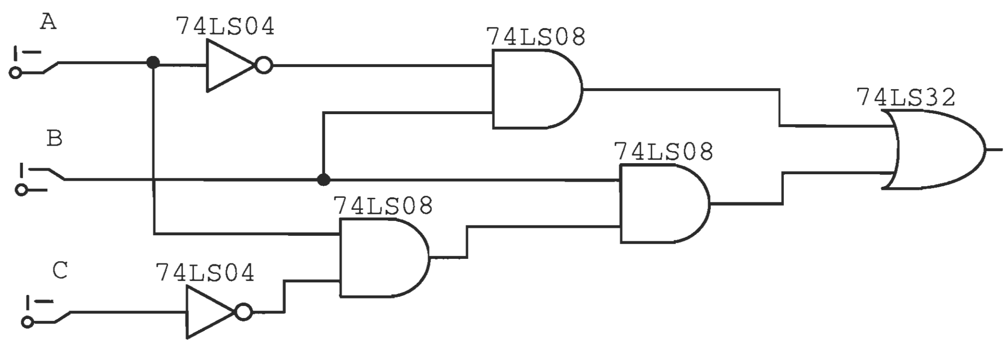
A. Advertisement
B. Economics
C. ergonomics
D. packaging

A.5 Sample Part B Student Exam (High School Credit)

Digital Electronics

Show ALL work - Partial credit may be awarded.

For the circuit shown below, complete the following steps. Be sure to *obtain signatures*.



1. Write the unsimplified Boolean Expression for the above circuit. (4 pts)

   F =

2. Locate and print data sheets for the three logic gates in this circuit design. (4 pts)

   Teacher's Signature: ______________________

3. Complete the truth table for the above circuit below: (4 pts)

A	B	C	F
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

4. K-Map the Boolean Expression (4 points)

5. Write the simplified Boolean Expression below: (4 pts)

   F =

6. Using a simulation tool, implement either a NAND ONLY circuit or a NOR ONLY circuit in its simplified form. Add input switches, and an output LED. Test the circuit's operation. When it works correctly, demonstrate the working circuit to your teacher. (15 pts). Print out a copy and attach to the test.

Teacher's Signature: ______________________

7. Using a Breadboard, construct the simplified NAND ONLY circuit or the NOR ONLY circuit you created in step # 6 above. Use switches for the inputs and an LED for the output. Test your circuit. When it works correctly, demonstrate the operation of the circuit to your teacher. (15 pts)

Teacher's Signature: ______________________

A.6 PLTW State Leaders - By State

(Some states may have more than one)

State/Province	Coordinator	Email
Alabama	Ben Scheierman	bscheir@alsde.edu
Alaska	Edward Hughes	etph28@aol.com
American Samoa	CJ Amarosa	cjamarosa@pltw.org
Arizona	Edward Hughes	etph28@aol.com
Arkansas	Dick Burchett	dick.burchett@mail.state.ar.us
California	Duane Crum	dcrum@engineering.sdsu.edu
Colorado	William Lehman	bill_lehman@att.net
Connecticut	Gregory Kane	gregory.kane@po.state.ct.us
Delaware	Sharon Rookard	srookard@doe.k12.de.us
District Of Columbia	Terri Prayer	terri.prayer@k12.dc.us
Florida	Mellissa Morrow	mellissa.morrow@fldoe.org
Georgia	Ron Barker	rbarker@doe.k12.ga.us
Hawaii	Edward Hughes	etph28@aol.com
Idaho	Monti Pittman	mpittman@pte.state.id.us
Illinois	Gwen Pollock	gpollock@isbe.net
Indiana	Ken Thompson	kthopmso@doe.state.in.us
Indiana	Patricia Shutt	pshutt@doe.state.in.us
Indiana	Dave Wilkinson	dwilkins@doe.state.in.us
Iowa	Ken Maguire	ken.maguire@ed.state.ia.us
Kansas	Craig A. Haugsness	cah@ksde.org
Kentucky	Henry Lacy	hlacy@kde.state.ky.us
Kentucky	Larry Helphinstine	lhelphin@kde.state.ky.us
Louisiana	Carolyn Helm	carolyn.helm@sreb.org
Maine	John Stivers	john.stivers@state.me.us
Maryland	Lynne Gilli	lgilli@msde.state.md.us
Massachusetts	Christine Shaw	cshaw4224@aol.com
Michigan	Christine Reiff	reiffC@michigan.gov
Minnesota	Jim Mecklenburg	jim.mecklenburg@state.mn.us
Mississippi	Lynn Basham	lbasham@mde.k12.ms.us
Missouri	Doug Miller	w.doug.miller@dese.mo.gov
Montana	Edward Hughes	etph28@aol.com
Nebraska	Tony Glenn	tglenn@nde.state.ne.us
Nevada	Phyllis Dryden	pdryden@nsn.k12.nv.us
New Hampshire	Jim Leon	jleon@nhctc.edu
New Jersey	Connie Waldie	cwalde@doe.state.nj.us
New Mexico	Edward Hughes	etph28@aol.com
New York	Diana Jensen Dooling	ddooling@monroe2boces.org
New York	Gary Adelson	garade@aol.com
North Carolina	Brian Moye	bmoye@dpi.state.nc.us
North Dakota	Don Fisher	dgfiscne@state.nd.us
Ohio	Kathy Sommers	kathy.sommers@ode.state.oh.us
Oklahoma	Robin Schott	rscho@okcareertech.org
Oregon	Tim Brower	browert@oit.edu
Pennsylvania	Eileen Rinaudo	eer3@psu.edu
Rhode Island	Paul Williams	rid03261@ride.ri.net

South Carolina	**B.T. Martin**	btmartin@sde.state.sc.us
South Dakota	**Edward Hughes**	etph28@aol.com
Tennessee	**Will Lewis**	will.lewis@state.tn.us
Texas	**Karen Batchelor**	kbatchel@tea.state.tx.us
United Kingdom	**Edward Hughes**	etph28@aol.com
Utah	**Melvin L. Robinson**	mrobinso@usoe.k12.ut.us
Vermont	**Edward Hughes**	etph28@aol.com
Virgin Islands	**Edward Hughes**	etph28@aol.com
Virginia	**George Willcox**	gwillcox@pen.k12.va.us
Washington	**Nancy Verheyden**	nverheyden@sccd.ctc.edu
West Virginia	**Carolyn Helm**	carolyn.helm@sreb.org
Wisconsin	**Kenneth Starkman**	kenneth.starkman@dpi.state.wi.us
Wyoming	**Edward Hughes**	etph28@aol.com

APPENDIX B (ETF)

B.1 ETF Main Emphasis Explained[55]

Major goals of the course, which reflect these standards, can best be expressed as the following essential questions that will be posed to students in various ways throughout the four units:

What is technology?

Throughout the course the students will develop a deep and rich understanding of the term "technology", including the earliest technologies invented by humans, the evolution of technologies for food, shelter, and clothing, the technologies of the modern world, and appropriate technologies for developing nations.

What do engineers do?

Students will learn about many different kinds of engineers, the type of work that they do, and who they are as people through first-person textbook chapters written by a diverse cadre of working engineers. The students will also apply the engineering design process and actually construct things so as to better appreciate what it feels like to be an engineer.

What should someone know about science to create or improve technology?

The process of design becomes engineering when students learn to apply science and mathematics to the task. Units two, three, and four will provide ample opportunities for students to apply fundamental concepts in physics and introductory high school mathematics to concrete engineering projects, thereby becoming more comfortable with how science and mathematics are applied in the real world.

What are the implications of new technologies?

Citizens are rarely asked to vote on whether or not they would like to see a new technology developed and introduced. Nonetheless, as workers and consumers in modern society, we collectively make those decisions every day. All new technologies have a profound effect on human societies worldwide. The students will be encouraged to analyze the effects of technological revolutions of the past, and consider ways that they choose to affect the world of the future.

[55] http://www.mos.org/doc/1411

APPENDIX C (AP)

C.1 College Board in a Nutshell[56]

The College Board is a non-profit examination board in the USA, comprised of over 4,500 institutions of higher learning. It is known principally for managing standardized tests such as the SAT, PSAT, CLEP and the subject-specific SAT II and AP tests. The SAT, the most well known of these, is a test widely used for admission to universities in United States, which over 3 million prospective college students take yearly. All of the tests are actually administered by the Educational Testing Service, which is an independent non-profit organization that also administers other tests like the GRE and TOEFL.

The SAT has been subjected to increasing criticism in recent years, and College Board has decided to completely overhaul the test in 2005. In addition, the Board decided that the name "SAT", which was formerly an acronym for "Scholastic Aptitude Test", should no longer stand for anything. Schools no longer put as much weight into SAT scores into making admission decisions as was once the case, and some now disregard them entirely.

The College Board also supervises the Advanced Placement Program. Students in the later years of high school can take certain advanced courses, after which they take an *AP test*; many colleges will treat them as having taken an equivalent college-level credit class depending on their score. Different colleges have differing requirements for score levels and test areas that they will accept.

The Board's headquarters are in New York City.

[56] http://www.absoluteastronomy.com/encyclopedia/C/Co/College_Board.htm# (Exact Article)

C.2 Advanced Placement Program in a Nutshell[57]

The Advanced Placement Program (also Advanced Placement, AP) is a United States program that offers high school students the opportunity to receive college credit for their work during high school. The non-profit, which has run the program since 1955, develops and maintains courses in various subject areas, supports those who teach the courses, supports colleges as they define their policies related to AP grades, and develops and coordinates the administration of annual AP examinations. These activities are funded through fees charged to students taking AP Exams.

In 2002, over one million high school students participated in AP courses; over 90% of whom took the corresponding AP exam. Many high schools offer AP courses, though the College Board allows the home-schooled and others who have not taken a course at a high school to take the exam.

AP exams

Each May, participating schools administer AP exams. They are an integral part of the program. With one exception, the exam combines multiple-choice questions with a free-response section in either essay or problem-solving form. The exception is Studio Art, where the exam is replaced by a portfolio assessment.

Each June, the free-response sections and the Studio Art portfolios are scored by thousands of college faculty and AP course teachers at the AP Reading. These scores are combined with the results of computer-scored multiple-choice questions, and converted into a grade on AP's five-point scale:

5: Extremely well-qualified
4: Well-qualified
3: Qualified
2: Possibly qualified
1: No recommendation

Many colleges and universities in the U.S. grant credits or advanced placement based on AP grades; those in over twenty other countries do likewise. Policies vary by institution. Most require at least a three to give a student credit. Others may only waive pre-requisites. Colleges may also take AP grades into account when deciding which students to accept, though this is not part of the official AP program.

[57] http://www.absoluteastronomy.com/encyclopedia/A/Ad/Advanced_Placement_Program.htm (Exact Article)

Subject areas

The College Board offers AP exams in the following subject areas:

Art History
Biology
Calculus AB: both differential and integral
Calculus BC: superset of AB, covering functions of a single variable, including polynomials and Chemistry
Computer Science A: object-oriented programming methodology; switched from C++ to Java for the 2003-4 academic year
Computer Science AB: superset of A, with more formal and in-depth study of algorithms, data structures, design, and
abstraction; also switched from C++ to Java for the 2003-4 academic year
English Language
English Literature
Environmental Science
European History
French Language
French Literature
German Language
German Literature
United States Government and Politics
Comparative Government and Politics
Human Geography
Latin (Vergil), based on the Aeneid
Latin Literature, based on any two of the following: Catullus, Cicero, and Horace
Macroeconomics
Microeconomics
Music Theory
Physics B: (for those pursuing majors in the life sciences, pre-medicine, and some applied sciences)
Physics C: (for those pursuing majors in the physical sciences or engineering. The level C test requires the use of calculus, while the level B test does not.)
Psychology
Spanish Language
Spanish Literature
Statistics
Studio Art (2-D, 3-D, drawing)
U.S. History
World History

In 2003, trustees of the College Board approved in principle a plan for new courses in Italian, Chinese, Japanese, and Russian. The first of these was announced several months later: an AP course and exam in Italian Language and Culture, with the first examination in 2006.

APPENDIX D (NESHS Summit)

D.1 America's High Schools The Front Line in the Battle for Our Economic Future[58]

Too many Americans think of high school only as an adolescent rite of passage, a place where the joy and turmoil of the teenage years are romanticized on television and in film and where the struggle for academic proficiency is merely one aspect of a larger drama. But the time has come to think of high school in a more crucial and substantial context. High school is where America's young people enter the adult world, not just socially, but more important, economically. Whether they realize it or not, it is where they begin preparing themselves for the economic environment in which they will compete and earn their livelihoods. Its importance is seen in the alarming reality that the United States has one of the lowest graduation rates of all developed nations, in the strikingly low percentage of students ready to use high school as a springboard for success in college and beyond, and in the pressing need for lifelong learning and effective citizenship in an increasingly demanding era of technology and global linkage.

This paper investigates the relationship between America's high schools and the challenges our economy faces. The message found here is a simple but clear one: *High school is now the front line in America's battle to remain competitive on the increasingly competitive International economic stage.* Over the past few years, Achieve, Inc., and the National Governors Association Center for Best Practices have undertaken a series of activities regarding the importance of high school and identified a path to high school education reform. This paper is a "call to action" for the nation's governors and business and education leaders to combine that understanding with an appropriate sense of urgency — and to turn the nation's high schools into a path toward economic success for all students.

Economic Change in the Years Ahead: A "Perfect Storm"

Economic change and growth are inseparable. Growth occurs as innovation and investment create new ways of doing things, which in turn make society more productive and better off. This steady stream of innovation and investment, multiplied over the years, has made America the most prosperous nation in the history of the planet. When one takes into account the convenience, mobility, health and range of amenities available to average Americans, they have a standard of living far greater than kings of previous centuries did. But economic change also entails costs — the dislocations and displacements that occur as the old activities are replaced by the new, from mule drivers and wheelwrights to the makers of tube radios and adding machines. Over the generations of American economic history, the growth created by change has traditionally been strong enough to create new pursuits and new economic roles for those displaced by innovation. There is no reason to doubt our economy will continue to have that capacity. However, there also are important reasons to believe our economy is about to face stresses like never before, and we must prepare for these challenges.

In fact, our economy is entering a "perfect storm" of economic change, in which three powerful forces are converging upon us at once:

[58] http://www.nga.org/cda/files/05edsummithighschools.pdf

Technology is accelerating, and its effects are becoming more pervasive. It affects not just what we produce but also what is asked of us and how we are organized to produce it.
Globalization is accelerating as well, with the links among nations becoming not just more numerous, but deeper, as the developing world moves to higher-valued services once thought the exclusive province of the advanced nations.
Demographics in the United States are about to change dramatically, as baby boomers enter retirement and the prime-age adult populations shrink in comparison to the numbers of old and young.

The demographic challenge facing America, and the entire developed world, is well known. It has created expectations for health care and retirement policy that, if unchanged, the nation can no longer afford to keep. But the full extent of technological change and globalization — and the way they interact — is yet to be fully understood.

The New Realities of the International Economy

Despite its obvious benefits, trade has fueled economic controversy for centuries. But regardless of one's view of trade, the new realities of the international marketplace are undeniable. First, trade is becoming pervasive. Successive rounds of trade negotiations have opened the global economy. The share of U.S. gross domestic product taken up by trade has risen from about 9 percent 40 years ago to about 18 percent 20 years ago to more than 25 percent today.[1] Over those last 20 years, U.S. foreign investment has grown six times faster than trade itself. Second, trade is no longer a matter of shipments of goods from an exporter to an importer. A growing share of U.S. trade occurs through "flag-affiliated" companies — that is, U.S. subsidiaries abroad — and a growing share of trade consists of services. The two are often related — as they would be, for example, in the case of a U.S. corporation that set up an off-shore data center, technical help-line or corporate backroom operation in a low-wage nation. In short, we are increasingly competing with ourselves in international trade.

Trade in services was once seen as America's ace in the hole. And, in fact, America has a variety of very strong service industries, from education to software to entertainment, that sell to customers around the world. But America's trade surplus in services is steadily shrinking — service imports have grown faster than service exports for seven straight years.[2] A third reality is that an increasing number of industries and activities are now subject to international competition. As digital technology drives down the cost of information and communications, it is possible to transact business from across the globe. A company can find suppliers, partners and customers anywhere in the world thanks to pervasive information networks. Any activity within a firm — not just component manufacturing, but such business services as product design, payroll management, accounting and invoicing, systems integration and management, and even research and development itself — can be held to the standard of the world's best competitors. And if it fails that standard, it can be "outsourced" to a company that meets it, often by bringing lower costs to the fore. The result is firms are now making themselves more competitive by breaking down into their constituent activities and making sure that each activity is being done in the "right" place. As a result, more of these services are becoming tradable, and more of the American economy — including more of its higher-value services — is exposed to global competition. Headlines about call centers moving to India are just one example of this phenomenon, as are Web designers in Ireland, software developers in Eastern Europe and customer service centers in the Philippines. Today, almost *anything* can be done *anywhere.*
This integration of the world economy through low-cost information and communications has an even more important implication than the dramatic expansion of both the volume of trade and what can be traded. *Trade and technology are making all the nations of the world more alike.* Together they can bring all of the world's companies the same resources — the same scientific research, the same capital, the same parts and components, the same business services, and even

the same skills. For example, India's 200 research universities now turn out more than 5,000 Ph.D.s a year. Although this compares to 40,000 new Ph.D.s in the United States, it is a stark indication of the potential of the developing economies to compete in new and more advanced areas. Talented young people can attend universities in Bombay, Dublin or Seoul and become what demographers call "global denizens" who travel the world looking for seasonal high-tech work. These competitors, therefore, are becoming more like us — they have rising skill levels, a strong work ethic, their own world-class university systems, and access to the world's capital and product markets. But there remains one critical difference between those nations and our own: *Their costs are lower.*

How Will America Respond?

Despite sporadic successes, the American response to date has been one of complacency leading to mediocrity. The towering heights of American achievement remain unmatched around the world — our Nobel-winning scientists, the cutting edge of American technology, the balanced working of the American economy and its entrepreneurial culture. But below these heights, the base is withering. Consider these facts alone:

A recent study by the Organisation for Economic Co-operation and Development (OECD) showed that America's literacy rate is average among the nations of the industrialized world and that our high school graduation rate — 73 percent — is one of the lowest among the industrialized nations;[3]

ß Once the leader in education, the United States now ranks 14th in the number of years a 5-year-old may expect to attend school during the course of his or her life;[4]

ß The U.S. university dropout rate — 38 percent — is among the highest in the industrialized world;[5]

ß Of the 21 countries participating in the Third International Mathematics and Science Study, American high school seniors outperformed only students from Cyprus and South Africa and ranked behind such nations as Sweden, Canada, New Zealand, Russia and the Czech Republic;[6]

ß Non-U.S. residents with temporary visas accounted for a third of the Ph.D.s awarded in science and engineering in 2003, despite any post-9/11 difficulties they might have experienced.[7]

Again, the U.S. economy has compelling assets. But it faces a fundamental challenge: whether it will keep up with the swift pace of human capital development being set elsewhere around the world. Mastering that challenge must start with reforming American high schools.

United States Trails Most Countries in High School Graduation Rate

Rank	OECD Reporting Country	Graduation Rate (%)
1	Denmark	100
2	Norway	97
3	Germany	93
4	Japan	92
5	Poland	90
5	Switzerland	90
7	Finland	85
7	Greece	85
9	France	82
9	Hungary	82
9	Italy	82
12	Czech Republic	81
13	Belgium	79
13	Iceland	79
15	Ireland	77
16	**United States**	**73**

17 Sweden 72
18 Luxembourg 68
18 Spain 68
20 Slovak Republic 61
Source: Organisation for Economic Co-operation and Development,
Learning for Tomorrow's World: First Results from PISA 2003, 2004.

New Skills for a New Age

Our high schools are not working for too many of our students. Consider, for example, the results of the OECD's international comparisons of math and science conducted in 2003.[8] Among those ranked, U.S. high school students tied for 27th place in math with Latvia and were slightly ahead of Portugal. Their science skills were roughly comparable to those of students in Iceland and Austria. These deficient skills translate directly into a reduced ability to solve basic problems, such as map-reading, scheduling, and converting weights and measures.
American teenagers rank at the bottom of the industrialized world in math problem solving and only in the middle of a list of nations at dramatically lower levels of development. How important is this skills difference? Economist Eric Hanushek of Stanford University estimates that if the gap were closed, American economic growth would increase by half a percentage point every year, or about a 20 percent increase in the economy's long-term potential.[9]

American Teenagers Lag Behind Their Developed World Counterparts in Problem Solving …

Country Mean Score
Japan 547
Australia 530
Canada 529
Belgium 525
Switzerland 521
Netherlands 520
France 519
Germany 513
Sweden 509
Ireland 498
United States 477
Italy 469
Note: This table includes a representative sample of developed nations that participated in the PISA study.
Source: Organisation for Economic Co-operation and Development, *Learning for Tomorrow's World: First Results from PISA 2003*, 2004.

… And They Are Often Not Competitive with Teenagers from Less Developed Nations

Country Mean Score
Korea 550
Hong Kong-China 548
Czech Republic 516
Poland 487
Latvia 483
Russian Federation 479
United States 477
Thailand 425

Serbia 420
Brazil 371
Note: This table includes a representative sample of less developed nations that participated in the PISA study.
Source: Organisation for Economic Co-operation and Development, *Learning for Tomorrow's World: First Results from PISA 2003,* 2004.

High school is important not just because it allows those who complete it to be more productive and to earn more, but because it is the first rung of an earnings ladder that provides affluence and mobility to those who climb it. Economists understand that education leads to productivity, which leads to income. Census data show the median earnings of a high school graduate ($30,800) are 43 percent higher than those of a nongraduate ($21,600) and those of a college graduate are 62 percent higher than those of a high school graduate.[10]
But technology is amplifying these differences; it is demanding new and advanced skills that our high schools are failing to teach. A generation ago, insurance claims adjusting, truck dispatching, steel foundry process management and machine lathing were all dramatically different in every respect. Today, they are all fundamentally similar — each requires manipulating data on a computer screen and using them to solve problems. Technology has changed the skills people need to work; as Harvard Business School's Shoshana Zuboff said in her epochal *In the Age of the Smart Machine,* technology has "migrated work from the muscles to the senses."[11] Economists David Autor, Frank Levy and Richard Murmane found that these changes in the skills required *in existing jobs and occupations* — that is, not even considering new jobs and occupations — accounted for a third or more of the greater demand for college graduates, mostly since 1980.[12]

These changes are pervasive. Economists Anthony Carnevale and Donna Desrochers found almost all categories of employment now require more advanced education today than they did 30 years ago.[13] They show the share of office workers with "some college" has increased from 37 percent to 60 percent over that span; the share with a bachelor's degree has almost doubled, from 20 percent to 38 percent. Even factory work demonstrates the trend — the share of factory workers with some higher education has increased *fourfold*, from 8 percent to 31 percent in the past three decades. And along with these higher levels of skill have come higher incomes. In a seminal report, economist Alan Krueger estimated that simply working with a computer implies a 15 percent increase in earnings, even after education and other factors are taken into account. In short, when jobs pay well, it is often because they demand the skills of a trade-intensive, high-tech world.[14]

In addition, trade is accelerating this trend toward higher skills. As foreign suppliers step into more advanced service industries, American workers must respond by becoming more productive. Insurance adjusters, truck dispatchers, lathers, machinists and foundry workers were the middle class of a generation ago. But the middle class of the next generation will be the people who work at terminals controlling those processes and the people who create the technology — the ideas, machines, software and services — that allow those jobs to change. Thus, America is faced with a stark choice — we can either climb the productivity ladder and e-create the American middle class, or we can watch our nation's middle class fade away as other countries' teenagers continue to outperform our children.

Why High School?

Taken together, these various findings display a disturbing pattern — *our high schools are failing to provide enough of our children with the skills that are becoming most important.* This is the one of the reasons why repairing our nation's high schools is so vital. America's distressingly low secondary graduation rate would be cause enough to justify a massive intervention in high school education. But high school is the bridge to higher education, and the bridge is increasingly in danger of collapse.

It is high school, specifically, where the failure occurs. For example, international student comparisons show American students report levels of both accomplishment and interest in math and science on par with their counterparts in other nations at both the 4th and 8^{th} grade levels. But by grade 12, they fall far behind in their proficiency and report dramatically lower levels of interest. It is between 8th and 12th grade where the failure occurs.

And the failure resonates throughout the rest of a student's education. Success in high school readily translates into access to, and success at, higher levels of education. Research from the U.S. Department of Education indicates that the rigor of high school coursework is more important than parent education level, family income or race/ethnicity in predicting whether a student will earn a postsecondary credential.[15] In short, being prepared for college is the best ticket for getting there. However, Jay Greene of the Manhattan Institute estimates that the high school graduation rate — by his estimate, 71 percent — is already low by international standards. Moreover, the share of high school students who take a course load preparing them for college is as low as 34 percent,[16] and the share of high school students who are actually "college ready" is only 32 percent.[17] In fact, his work shows that the college-ready rate is below 50 percent *in every state in the nation.* Moreover, this share of college-ready students is disproportionately low for nonwhites, who are growing as a share of the overall youth population.

This breakdown in building a bridge to college education is even more disturbing when the efforts of the 50 states to provide higher education and advanced graduate training are considered. Together, the 50 states spend $63 billion annually to subsidize higher education. Obviously, this is an important part of a strategy to build local economies and attract a skilled workforce. Yet these investments will not yield the expected dividends unless high schools do a far better job of preparing students for postsecondary education. We register great concern over the declining number of U.S.-born or permanent resident Ph.D.s in the math, science and engineering areas. By tolerating low levels of achievement in high school, we are dramatically curtailing the pool of potential new Ph.D.s. Beyond allowing American students access to higher levels of productivity and earnings, functioning high schools generate compelling societal benefits. As the endogenous growth theorists, led by economist Paul Romer, have noted, an ample supply of skilled workers accelerates the innovation process throughout the economy. Greater numbers of skilled and educated workers make it easier to produce the "incremental improvements" that account for the vast majority of long-term economic growth: They lower the cost of doing research; they make it easier to disseminate new knowledge and adopt it to new uses; and they allow for greater specialization in research and science, among other benefits. In short, high schools are the spring from which these vital sources of growth flow. And high school builds a better citizenry. Aside from the obvious benefits of educational achievement — lower demands for social services, lower rates of incarceration, better parenting and public health, and better preparation of the subsequent generation of small children for school, among many others — higher levels of education prepare our citizenry for the ever more sophisticated issues they must confront.

The Road Not Taken

High school, beyond the front line of international economic competition, is the dividing line between those workers whose incomes have been rising and those whose incomes have been falling. The average wages of high school graduates and those individuals who never graduated high school have fallen over the last two decades; the average incomes of those who went beyond high school have risen. This demarcation promises to become even starker in the coming years, as technology and trade separate the economy into two camps — those with the skills to participate in the global economy and those who lack them. If we do not make a concerted effort to move our society beyond this boundary, we will find ourselves a society cut in two — one side enfranchised in the modern economy, experiencing its affluence, the other lacking the means of access to the future. In short, we run the risk of losing our middle class. A nation that cannot compete will never achieve prosperity. Absent the productivity that generates income, no combination of monetary or tax policies can undo the economy's hollowness. A lower standard of living will be forced on us. We will be engulfed in new service imports and will sell our assets to the rest of the world to pay for them. As growth slows, we will be unable to pay for an ever-shrinking pool of public services and will watch as our federal debt spirals out of control. At the very least, we will experience slow growth and stagnant wages with an upper tier of the labor force that gradually detaches from the rest of America's economy.

There is an alternative, but it is an alternative that requires our focus and effort. Economic hange need not damage us if we prepare for it. There have always been exciting innovations in the economy. There have always been cheaper foreign competitors. And there have always been complex challenges to our economic growth. If we anticipate them and act, they can be turned into the basis for a higher standard of living for future generations of Americans.

High school lies at the center of this crisis. Fifty years ago, it was finishing school for the American middle class. Today, it must be more. It must be a bridge to higher education, to a productive and innovative economy, and to an informed citizenry. It is time to transform our country's high schools to reflect these new realities.

Notes

1. Bureau of Economic Analysis (BEA), data tables, "Real Exports and Imports of Goods and Services by Type of Product," Quantity Indexes (Washington, D.C.). Available: http://www.bea.doc.gov.

2. BEA, data tables, "Real Exports and Imports of Goods and Services by Type of Product," Quantity Indexes (Washington, D.C.). Available: http://www.bea.doc.gov.

3. Organisation for Economic Co-operation and Development (OECD), *Learning for Tomorrow's World: First Results from PISA 2003* (Paris, France, December 2004). Available: http//www.oecd.org.

4. OECD, *Education at a Glance, 2004,* Table C1.1 (Paris, France, September 2004). Available: http://www.oecd.org/dataoecd/62/16/33671115.xls.

5. OECD, *Education at a Glance, 2004,* Table A3.2 (Paris, France, September 2004). Available: http://www.oecd.org/dataoecd/52/38/33669031.xls.

6. International Association for the Evaluation of Educational Achievement (IEA), Third International Mathematics and Science Study (TIMSS), 1995–96.

7. National Science Foundation, Division of Science Research Statistics, *Science and Engineering Doctorate Awards, 2003,* Table 3 (Arlington, Va.: National Science Foundation, December 2004).

8. OECD, *Learning for Tomorrow's World: First Results from PISA 2003* (Paris, France, December 2004). Available: http//www.oecd.org.

9. Eric Hanushek and Dongwook Kim, "Education, Laborforce Quality, and Economic Growth," Working Paper 5399 (Cambridge, Mass.: National Bureau of Economic Research, December 1995).

10. Cited in *Education Pays 2004* (New York: College Board) p.10.

11. Shoshana Zuboff, *In the Age of the Smart Machine: The Future of Work and Power* (New York: Basic Books, 1989).

12. David Autor, Frank Levy and Richard Murmane, "The Skill Content of Recent Technological Change: An Empirical Exploration," Working Paper 8337 (Cambridge, Mass.: National Bureau of Economic Research, June 2001).

13. Anthony Carnevale and Donna Desrochers, *Standards for What? The Economic Roots of K–16 Reform* (Princeton, N.J.: Educational Testing Service, 2003).

14. Alan B. Krueger, "How Computers Have Changed the Wage Structure: Evidence from Microdata, 1984–1989," *Quarterly Journal of Economics* February 1993: 33–60.

15. Clifford Adelman, *Answers in the Tool Box: Academic Intensity, Attendance Patterns, and Bachelor's Degree Attainment* (Washington, D.C.: U.S. Department of Education Office of Educational Research and Improvement, 1999).
16. Jay P. Greene, *Public High School Graduation and College Readiness Rates: 1991–2002* (New York: Manhattan Institute, forthcoming). Available: http://www.manhattan-institute.org/html/ewp_08.htm.
17. Jay P. Greene and Greg Forster, "Public High School Graduation and College Readiness Rates in the United States," Working Paper 3 (New York: Manhattan Institute Education, September 2003).

D.2 Bill Gates National Governors Association/Achieve Summit Prepared Remarks

February 26, 2005[59]

Thank you for that kind introduction.

I also want to thank you, Governor Warner, and your fellow governors, for your leadership in hosting this education summit on America's high schools. It is rare to bring together people with such broad responsibilities and focus their attention on one single issue. But if there is one single issue worth your focused attention – it is the state of America's high schools.

Many of us here have stories about how we came to embrace high schools as an urgent cause. Let me tell you ours.

Everything Melinda and I do through our foundation is designed to advance equity.
Around the world, we believe we can do the most by investing in health – especially in the poorest countries.

Here in America, we believe we can do the most to promote equity through education.

A few years ago, when Melinda and I really began to explore opportunities in philanthropy, we heard very compelling stories and statistics about how financial barriers kept minority students from taking their talents to college and making the most of their lives.

That led to one of the largest projects of our foundation. We created the Gates Millennium Scholars program to ensure that talent and energy meet with opportunity for thousands of promising minority students who want to go to college.

Many of our Scholars come from tough backgrounds, and they could bring you to tears with their hopeful plans for the future. They reinforced our belief that higher education is the best possible path for promoting equality and improving lives here in America.

Yet – the more we looked at the data, the more we came to see that there is more than one barrier to college. There's the barrier of being able to pay for college; and there's the barrier of being prepared for it.

When we looked at the millions of students that our high schools are not preparing for higher education – and we looked at the damaging impact that has on their lives – we came to a painful conclusion:

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[59] http://www.achieve.org/dstore.nsf/Lookup/GatesRemarks/$file/GatesRemarks.pdf

America's high schools are obsolete.

By obsolete, I don't just mean that our high schools are broken, flawed, and under-funded – though a case could be made for every one of those points.

By obsolete, I mean that our high schools – even when they're working exactly as designed – cannot teach our kids what they need to know today.

Training the workforce of tomorrow with the high schools of today is like trying to teach kids about today's computers on a 50-year-old mainframe. It's the wrong tool for the times.

Our high schools were designed fifty years ago to meet the needs of another age. Until we design them to meet the needs of the 21st century, we will keep limiting – even ruining – the lives of millions of Americans every year.

Today, only one-third of our students graduate from high school ready for college, work, and citizenship.

The other two-thirds, most of them low-income and minority students, are tracked into courses that won't ever get them ready for college or prepare them for a family-wage job – no matter how well the students learn or the teachers teach.

This isn't an accident or a flaw in the system; it is the system.

In district after district, wealthy white kids are taught Algebra II while low-income minority kids are taught to balance a check book!

The first group goes on to college and careers; the second group will struggle to make a living wage.

Let's be clear. Thanks to dedicated teachers and principals around the country, the best educated kids in the United States are the best-educated kids in the world. We should be proud of that. But only a fraction of our kids are getting the best education.

Once we realize that we are keeping low-income and minority kids out of rigorous courses, there can be only two arguments for keeping it that way – either we think they can't learn, or we think they're not worth teaching. The first argument is factually wrong; the second is morally wrong.

Everyone who understands the importance of education; everyone who believes in equal opportunity; everyone who has been elected to uphold the obligations of public office should be ashamed that we are breaking our promise of a free education for millions of students.

For the sake of our young people and everyone who will depend on them – we must stop rationing education in America.

I'm not here to pose as an education expert. I head a corporation and a foundation. One I get paid for – the other one costs me. But both jobs give me a perspective on education in America, and both perspectives leave me appalled.

When I compare our high schools to what I see when I'm traveling abroad, I am terrified for our workforce of tomorrow. In math and science, our 4th graders are among the top students in the world. By 8th grade, they're in the middle of the pack.

By 12th grade, U.S. students are scoring near the bottom of all industrialized nations.

We have one of the highest high school dropout rates in the industrialized world. Many who graduate do not go onto college. And many who do go on to college are not well prepared – and end up dropping out. That is one reason why the U.S. college dropout rate is also one of the highest in the industrialized world. The poor performance of our high schools in preparing students for college is a major reason why the United States has now dropped from first to fifth in the percentage of young adults with a college degree.

The percentage of a population with a college degree is important, but so are sheer numbers. In 2001, India graduated almost a million more students from college than the United States did. China graduates twice as many students with bachelor's degrees as the U.S., and they have six times as many graduates majoring in engineering.

In the international competition to have the biggest and best supply of knowledge workers, America is falling behind.

That is the heart of the economic argument for better high schools. It essentially says: "We'd better do something about these kids not getting an education, because it's hurting us." But there's also a moral argument for better high schools, and it says: "We'd better do something about these kids not getting an education, because it's hurting them."

Today, most jobs that allow you to support a family require some postsecondary education. This could mean a four-year college, a community college, or technical school. Unfortunately, only half of all students who enter high school ever enroll in a postsecondary institution.

That means that half of all students starting high school today are unlikely to get a job that allows them to support a family.

Students who graduate from high school, but never go on to college, will earn – on average – about twenty-five thousand dollars a year. For a family of five, that's close to the poverty line. But if you're Hispanic, you earn less. If you're black, you earn even less – about 14 percent less than a white high school graduate.

Those who drop out have it even worse. Only 40 percent have jobs. They are nearly four times more likely to be arrested than their friends who stayed in high school. They are far more likely to have children in their teens. One in four turn to welfare or other kinds of government assistance.

Everyone agrees this is tragic. But these are our high schools that keep letting these kids fall through the cracks, and we act as if it can't be helped.

It can be helped. We designed these high schools; we can redesign them.

But first we have to understand that today's high schools are not the cause of the problem; they are the result. The key problem is political will. Elected officials have not yet done away with the idea underlying the old design. The idea behind the old design was that you could train an adequate workforce by sending only a third of your kids to college – and that the other kids either couldn't do college work or didn't need to. The idea behind the new design is that all students can do rigorous work, and – for their sake and ours – they have to.

Fortunately, there is mounting evidence that the new design works.

The Kansas City, Kansas public school district, where 79 percent of students are minorities and 74 percent live below the poverty line, was struggling with high dropout rates and low test scores when it adopted the school-reform model called First Things First in 1996. This included setting high academic standards for all students, educing teacher-student ratios, and giving teachers and administrators the responsibility to improve student performance and the resources they needed to do it. The district's graduation rate has climbed more than 30 percentage points.

These are the kind of results you can get when you design high schools to prepare every student for college.

At the Met School in Providence, Rhode Island, 70 percent of the students are black or Hispanic. More than 60 percent live below the poverty line. Nearly 40 percent come from families where English is a second language. As part of its special mission, the Met enrolls only students who have dropped out in the past or were in danger of dropping out. Yet, even with this student body, the Met now has the lowest dropout rate and the highest college placement rate of any high school in the state.

These are the kind of results you can get when you design a high school to prepare every student for college.

Two years ago, I visited High Tech High in San Diego. It was conceived in 1998 by a group of San Diego business leaders who became alarmed by the city's shortage of talented high-tech workers. Thirty-five percent of High Tech High students are black or Hispanic. All of them study courses like computer animation and biotechnology in the school's state-of-the-art labs. High Tech High's scores on statewide academic tests are 15 percent higher than the rest of the district; their SAT scores are an average of 139 points higher.

These are the kind of results you can get when you design a high school to prepare every student for college.

These are not isolated examples. These are schools built on principles that can be applied anywhere – the new three R's, the basic building blocks of better high schools:

• The first R is Rigor – making sure all students are given a challenging curriculum that prepares them for college or work;

• The second R is Relevance – making sure kids have courses and projects that clearly relate to their lives and their goals;

• The third R is Relationships – making sure kids have a number of adults who know them, look out for them, and push them to achieve.

The three R's are almost always easier to promote in smaller high schools. The smaller size gives teachers and staff the chance to create an environment where students achieve at a higher level and rarely fall through the cracks. Students in smaller schools are more motivated, have higher attendance rates, feel safer, and graduate and attend college in higher numbers.

Yet every governor knows that the success of one school is not an answer to this crisis. You have to be able to make systems of schools work for all students. For this, we believe we need stable and effective governance. We need equitable school choice. We need performance-oriented employment agreements. And we need the capacity to intervene in low-performing schools.

Our foundation has invested nearly one billion dollars so far to help redesign the American high school. We are supporting more than fifteen hundred high schools – about half are totally new, and the other half are existing schools that have been redesigned. Four hundred fifty of these schools, both new and redesigned, are already open and operating. Chicago plans to open 100 new schools. New York City is opening 200. Exciting redesign work is under way in Oakland, Milwaukee, Cleveland, and Boston.

This kind of change is never easy. But I believe there are three steps that governors and CEOs can take that will help build momentum for change in our schools.

Number 1. Declare that all students can and should graduate from high school ready for college, work, and citizenship. How would you respond to a ninth grader's mother who said: "My son is bright. He wants to learn. How come they won't let him take Algebra?" What would you say? I ask the governors and business leaders here to become the top advocates in your states for the belief that every child should take courses that prepare him for college – because every child can succeed, and every child deserves the chance.

The states that have committed to getting all students ready for college have made good progress – but every state must make the same commitment.

Number 2. Publish the data that measures our progress toward that goal. The focus on measuring success in the past few years has been important – it has helped us realize he extent of the problem. But we need to know more: What percentage of students are ropping out? What percentage are graduating? What percentage are going on to college? And we need this data broken down by race and income. The idea of tracking low income and minority kids into dead-end courses is so offensive to our sense of equal opportunity that the only way the practice can survive, is if we hide it. That's why we need to expose it. If we are forced to confront this injustice, I believe we will end it.

Number 3. Turn around failing schools and open new ones. If we believe all kids can learn – and the evidence proves they can –then when the students don't learn, the school must change. Every state needs a strong intervention strategy to improve struggling schools. This needs to include special teams of experts who are given the power and resources to turn things around.

If we can focus on these three steps – high standards for all; public data on our progress; turning around failing schools – we will go a long way toward ensuring that all students have a chance to make the most of their lives.

Our philanthropy is driven by the belief that every human being has equal worth. We are constantly asking ourselves where a dollar of funding and an hour of effort can make the biggest impact for equality. We look for strategic entry points – where the inequality is the greatest, has the worst consequences, and offers the best chance for improvement. We have decided that high schools are a crucial intervention point for equality because that's where children's paths diverge – some go on to lives of accomplishment and privilege; others to lives of frustration, joblessness, and jail.

When I visited High Tech High in San Diego a few years ago, one young student told me that High Tech High was the first school he'd ever gone to where being smart was cool. His neighborhood friends gave him a hard time about that, and he said he wasn't sure he was going to stay. But then he showed me the work he was doing on a special project involving a submarine. This kid was really bright. It was an incredible experience talking to him – because his life really did hang in the balance.

And without teachers who knew him, pushed him, and cared about him, he wouldn't have had a chance.

Think of the difference it will make in his life if he takes that talent to college. Now multiply that by millions. That's what's at stake here.

If we keep the system as it is, millions of children will never get a chance to fulfill their promise because of their zip code, their skin color, or the income of their parents.

That is offensive to our values, and it's an insult to who we are.

Every kid can graduate ready for college. Every kid should have the chance.

Let's redesign our schools to make it happen.

Thank you very much.

D.3 National Governors Association, Achieve to Host National Education Summit on High Schools

October 18, 2004
Christine LaPaille, NGA, 202/624-5334
Matt Maurer & Lani Poblete, Achieve, 202/955-9450

February Meeting Will Bring State, Education and Business Leaders Together To Chart New Course for the American High School

WASHINGTON — **Achieve, Inc.** and the **National Governors Association** (NGA) today announced they will host a National Education Summit on High Schools, bringing together all 55 governors (from all 50 states and U.S. territories) along with top business executives and prominent K–12 and higher education leaders, February 26–27 in Washington. The 2005 Summit will address the urgent need to improve America's high schools, specifically the imperative to increase graduation rates and ensure that a high school diploma truly prepares students to succeed in higher education and the workplace.

The Summit — which will be co-chaired by NGA Chairman Virginia Gov. Mark Warner and Achieve Vice-Chair Kerry Killinger, CEO of Washington Mutual — represents an extraordinary opportunity for the nation's political, educational and business leaders to build consensus around an agenda for high school improvement. Moreover, it combines the strengths of two major national education initiatives — NGA's Redesigning the American High School and Achieve's American Diploma Project.

Previous Summits — held in 1989, 1996, 1999 and 2001 — were instrumental in creating political momentum and public support for raising academic standards and performance in the nation's schools. This year, participants will focus on ensuring that the bar for achievement is high enough to prepare all graduates for college and work and to ensure that all students receive the necessary academic support to meet rigorous graduation standards.

Governors and CEOs have been at the forefront of states' efforts to improve student achievement. Significant progress has been made in the nation's elementary and middle schools. Over the next year, Achieve and NGA's goal is to extend that success to high schools.

"In today's knowledge-based economy, we can no longer conduct business as usual in our nation's high schools," said Gov. Warner. "There is an urgent need throughout the nation to improve the transition from high school to college and to dramatically strengthen career education programs. We also must reach out aggressively to students who are at risk of failure."

"Thirty years ago, students might have gotten by without learning the basics," said Mr. Killinger. "The diploma itself was often sufficient to find a manufacturing job, make a decent income and raise a family. But those days are gone. Today's high school diploma is less meaningful if it does not signify mastery of higher-level skills necessary to succeed in today's workforce and in postsecondary learning."

The 2005 Summit will help address two fundamental problems: the fact that too many students drop out before they earn a high school degree and that those who do graduate are typically not adequately prepared for college and/or work. NGA's report *Ready for Tomorrow: Helping All Students Achieve Secondary and Postsecondary Success* found that as many as 30 percent of entering freshmen leave high school without a diploma. The findings were equally disturbing for postsecondary education, where more than 25 percent of high school graduates who enter four-year colleges — and 50 percent of those who enter two-year institutions — never return for their second year.

According to the recent study, *Ready or Not: Creating a High School Diploma that Counts*, by Achieve's *American Diploma Project*, 53 percent of today's college students end up taking at least one remedial English or math class, relearning material they should have mastered to graduate from high school. It's no surprise, then, that fewer than half of all college students actually attain a degree. Moreover, most employers and college professors say that high school graduates lack even the basic skills in reading, writing and math, and most workers themselves say that they were poorly prepared by their high schools — a majority give their own school a C, D or failing grade.

"The states have made a lot of progress. They have put standards, assessment and accountability measures in place and are closing the achievement gaps. But there is much more to be done. Now we have to turn our attention to ensuring that students are not only prepared to pass our tests but are ready for a competitive future," said Ohio Gov. Bob Taft, co-chair of Achieve and member of the NGA *Redesigning the American High School Task Force*.

To advance state progress toward this goal, Summit participants will identify ways to:

- **Restore integrity to the high school diploma.** The high school diploma should signify not merely a sufficient accumulation of course credits but a mastery of essential skills.
- **Help students to build bridges between high school, college and work.** All students should take a rigorous curriculum that prepares them for success in college and at work and be given meaningful opportunities to earn college credit and/or work toward industry certification while still in high school.
- **Balance accountability with increased academic support and learning opportunities.** As states work to raise expectations and hold students accountable for their skills and knowledge, they also must strengthen instruction and academic support, increase graduation rates, hold schools accountable, and intervene in low-performing schools.

The 2005 National Education Summit on High Schools is sponsored by NGA and Achieve, Inc. in partnership with Business Roundtable, the James B. Hunt Institute and the Education Commission of the States.

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