To: Wyoming Select Committee on Recalibration

From: Allan Odden and Larry Picus[52]

Re: Career and Technical Education

Date: October 29, 2010

This memo describes our recommendations for a cost based approach to Career and Technical Education Costs for the Wyoming School Funding Model. In our desk audit, we recommended that Wyoming modify the parameters of the model for vocational education. Given small class sizes in Wyoming, we stated that there might be no strong rationale for even smaller classes for vocational education, particularly if the vocational education programs transform into more career/technical education which often requires no or few additional resources. Further, school districts actually spent considerably less on vocational education supplies and equipment than is provided in the extra funding formula, spending just 59.8 percent of the resources allocated for vocational education supplies and equipment.

CURRENT STATUS

Additional resources are provided for career, technical and vocational education, by weighting ADM in approved vocational education programs by an additional 29 percent. This generates additional teaching positions at a school to provide for vocational education classes that have fewer than 21 students. In addition, the model includes an ECA adjusted $9,027.27 per vocational education teacher for equipment, supplies and replacement.

In addition, the Wyoming Legislature also provided additional grants for new and demonstration career/technical education programs. A school district may apply to the Wyoming Department of Education (WDE) for state assistance to fund expenses associated with the planning, developing and implementing a career-technical education demonstration project as a new or an expansion to any existing high school career-vocational education program in the district. Amounts awarded are to be used for curricular development and project design costs and

[52] L. Allen Phelps, Professor of Educational Leadership and Policy Analysis, School of Education, and Director, Center on Education and Work, University of Wisconsin-Madison and Miles Tokheim, Career and Technical Education Resource Teacher, Career and Technical Education, Madison Metropolitan School Districts helped in providing background and costing information for this document.

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THE CASE FOR HIGH QUALITY CAREER AND TECHNICAL EDUCATION IN AMERICA'S HIGH SCHOOLS

Improving the college and career readiness of U.S. high school graduates is a recurrent, major theme in recent state and federal education initiatives, including Wyoming's Strategic Plan for *New Directions for High School Career and Technical Education*. As part of this process, states are reorganizing and restructuring what used to be "vocational" education courses into programs that help students become college and career ready. This is occurring particularly in high wage/high skills job areas, and especially in science, technology, engineering and mathematics (STEM). By 2020, the current U.S. President expects the proportion of Americans ages 25 to 34 with college degrees and credentials representing 21st century workforce skills to increase from 40% to 60%. This is deemed essential for sustaining U.S. competitiveness in the global economy. In support of these ambitious goals, ACHIEVE.org – a national organization of business and state leaders – is working actively to make college and career readiness a priority of K-12 education systems across the country. ACHIEVE's American Diploma Project Network now includes 35 states educating nearly 85 percent of all U.S. public school students. Though the Network does not currently include Wyoming, the issue of enhancing the rigor of Wyoming high school graduation requirements, including joining ACHIEVE, has emerged during the course of the recalibration meetings. The goal is to make all high school graduates career and college ready, i.e., prepared to do high quality work whether taking a job directly out of high school or entering college or a post-secondary education program.

What constitutes career and college readiness for high school graduates? The following three paragraphs, excerpted from America Diploma Project Network's recent Policy Brief, offer a description of the key constructs for policy makers and education leaders.[53]

> **What is COLLEGE ready?**
> College today means much more than just pursuing a four- year degree at a university. Being "college ready" means being prepared for any postsecondary education or training experience, including study at two- and four-year institutions leading to a postsecondary credential (i.e. a certificate, license, Associates or Bachelor's degree). Being *ready* for college means that a high school graduate has the English and mathematics knowledge and analytic skills necessary to qualify for and succeed in entry-level, credit-bearing college courses without the need for remedial coursework.
>
> **What is "*CAREER*" ready?**
> In today's economy, a "career" is not just a job. A career provides a family-sustaining wage and pathways to advancement and requires postsecondary[54] training or education.

[53] http://www.postsecconnect.org/files/CollegeandCareerReadyFINAL31809.pdf
[54] Postsecondary means some training beyond high school that could include specific job training, or training in a technical college, community college or four-year college or university.

A job may be obtained with only a high school diploma, but offers no guarantee of advancement or mobility. Being *ready* for a career means that a high school graduate has the English, and mathematics knowledge and skills needed to qualify for and succeed in the postsecondary job training and/or education necessary for their chosen career (i.e. technical/vocational program, community college, apprenticeship or significant on-the-job training).

Is ready for *COLLEGE* and ready for *CAREER* the same thing?
With respect to the knowledge and skills in English and mathematics expected by employers and postsecondary faculty, the answer is yes. In the last decade, research conducted by ACHIEVE, ACT, the Southern Regional Education Board, as well as others shows a convergence in the expectations of employers and colleges in terms of the knowledge and skills high school grads need to be successful after high school.

Economic reality reflects these converging expectations as does Wyoming's strategic plan for career and technical education. Education today is more valued and more necessary than ever before. The bottom line is that today ALL high school graduates need to be prepared for some postsecondary education – job specific training, technical college, community college or four year college – if they are to have options and opportunities for high wage jobs in the knowledge-based, global economy.

- Thirty five years ago, only 12% of U.S. jobs required some postsecondary training or an associate's degree and only 16% required a bachelor's degree or higher.

- Nearly eight in ten future job openings in the next decade in the U.S. will require postsecondary education or training. Forty-five percent will be in "middle skill" occupations, which require at least some postsecondary education and training, while 33% will be in high skilled occupations for which a Bachelors degree or more is required. By contrast, only 22% of future job openings will be "low skill" and accessible to those with a high school diploma or less.

- Though the U.S. still ranks 3rd in the adult population (25-64 year olds) with an associate's degree or higher among 30 countries, the country now ranks 10th among 25-34 year olds with a two-year degree and above. Competing countries are catching up to – and even outpacing – the U.S. in the educational attainment of their new generation of adults.

- Wyoming's data, included in the career and technical education strategic report, reflect these trends. Though the natural resources and mineral extraction industries account for a solid portion of Wyoming's jobs, with many jobs in those industries not requiring education beyond high school, other industries – education, health care, professional and business services, financial activities, information and government – actually employ larger numbers of individuals with most of these jobs requiring some postsecondary training. However, enrollments in Wyoming CTE school district programs in these areas are substantially under the numbers needed.

- Further, if all Wyoming students are to have access to high wage/high skill jobs in the broader economy even if they move out of the state, larger percentages will need not only a solid high school education but also preparation for additional training that would be required for jobs in other states but not plentiful now in Wyoming.

Higher levels of education lead to elevated wages, a more equitable distribution of income and substantial gains in productivity. For every additional average year of schooling, individual life time earnings rise by 10 percent. Moreover, for every additional year of schooling U.S. citizens complete, the GDP would increase by about 0.37 percentage points – or by 10% – over time.

While many traditional vocational and technical education programs did not produce high skills in math, science and English in their graduates, there is a new "breed" of career technical education programs developing across the country and these programs seek to prepare students for the emerging and most rapidly rising jobs in the broader economy, particularly those in health sciences, biotechnology, engineering, and information technologies. Moreover, it was these career and technical clusters that were emphasized in Wyoming's recent strategic plan for career and technical education. And all of these have rigorous nationally designed programs that states and districts can implement.

Wyoming has already adopted the 16 career clusters identified by the U.S. Department of Education as the basis for organizing CTE programs, and uses the clusters as a platform for reporting purposes. To be approved, districts and schools must offer a program that includes 3 semester courses comprising a CTE concentration. The goal of all these programs is to take courses, including the CTE courses, sufficient to allow the student to enroll in the University of Wyoming, a community or technical college, or a high wage job. It should be noted that 15 of the 16 CTE career clusters require mathematics up to Algebra 2, so the knowledge, skill and concept requirements for successfully engaging in CTE programs are quite similar to, if not the same as, those required to be college ready. Further, although Wyoming students now take CTE courses in five major areas – architecture and construction; agriculture, food and natural resources; business, management and administration; manufacturing; information technology – one goal of the CTE strategic plan is to expand on these offerings so as to cover more career areas requiring higher skills not only in Wyoming but also across the country.

In our effort to identify a cost-basis for these new career and technical programs, we have used Project Lead the Way, as an exemplar. It is one of the most recognized, "high end" career and technical education program in the country and has a growing research base showing that it produces graduates who achieve more than similar students who have not had the program. By high end, we mean it also is one of the most rigorous as well as expensive career and technical programs so can serve as one basis for determining additional resources needed – if any – for career and technical education beyond those in the regular Wyoming Funding Model.

PROJECT LEAD THE WAY: AN EMERGING NATIONAL MODEL

Project Lead the Way (PLTW) is a nationally prominent exemplar for secondary CTE education. Often implemented jointly with local postsecondary education institutions and employer

advisory groups, these programs usually feature project or problem-based learning experiences, career planning and guidance services, and technical and/or academic skills assessments. The program is designed to develop the science, technology, engineering and mathematics skills essential for achievement in the classroom and success in college or jobs not requiring a four-year college education through hands-on experience preparing students for the real world. Developed in upstate New York schools in the early 1990s, PLTW is offered in more than 3,000 high schools in all 50 states and now enrolls over 350,000 total students.

According to the PLTW web site:[55]

> The PLTW Engineering and Biomedical Sciences programs offer students an array of advantages, from career readiness and hands-on experience to college preparatory–level classes, labs, and creative exercises. Its programs are designed to appeal to all students, from those already interested in Science, Technology, Engineering, and Math (STEM)-related fields, to those whose experience in the sciences and math has been less comprehensive or who find themselves uninterested in traditional STEM curricula. PLTW classes are hands-on, based in real-world experience, and fun for students and teachers. The program sets high standards for rigorous, focused, and engaging study, developing students' innovative, collaborative, cooperative, and problem-solving skills.
>
> PLTW is a comprehensive, turnkey program with a quick turnaround time and support for smooth and efficient implementation, whether the school is starting up for the first time or introducing new courses. PLTW.org gives educators 24-hour access to information, sourcing, and purchasing.
>
> PLTW is a true curriculum based on a tried-and-true pedagogy. It can be offered as full year and multi-year primarily for high schools, and both the Engineering and Biomedical Sciences tracks dovetail with current class offerings. Curricula include standards, learning outcomes, sequence and schedule, problems, projects, integrated activities, assessments, and support.
>
> PLTW provides professional development and support. Teachers receive comprehensive training from a PLTW partner university. Training gives teachers full proficiency regardless of previous experience. PLTW's Virtual Academy for Professional Development updates teachers through an online repository of information and references. PLTW also offers counselor conferences to provide high school guidance counselors with a clear understanding of the program and how it fits within a student's scholastic/academic career path.

Appendix A includes more detailed descriptions of both PLTW's Pathway to Engineering and Biomedical Sciences programs, including the course sequences for each.

The curriculum features rigorous, in-depth learning experiences delivered by certified teachers and end-of-course assessments. High-scoring students earn college credit recognized in more

[55] www.pltw.org

than 100 affiliated postsecondary institutions. Courses focused on engineering foundations (design, principles, and digital electronics) and specializations (e.g., architectural and civil engineering, bio-technical engineering) provide students with career and college readiness competencies in engineering and science.

In 2009-10, approximately 130,000 students completed end-of-course assessments. To date, more than 12,000 high school teachers and 8,000 guidance counselors have completed professional development and certification through the national network of higher education institutions.

Evidence of Effectiveness

Currently, longitudinal studies and experimental evaluations of PLTW programs are in process in several states, but several local implementation studies have produced promising results on several outcome measures (Project Lead the Way, 2010, April):

1. *Improving student achievement and college/career readiness:* Phelps, L. A., Camburn, E., & Durham, J. (2008)

   This study of TESLA Engineering Charter School students at Appleton East High School in Wisconsin uses the Project Lead the Way Pathway to Engineering curriculum. In comparing the TESLA Engineering senior students and the Appleton East seniors, the analyses revealed that:
   - TESLA/PLTW students scored significantly higher on the ACT composite measure than the non-PLTW students
   - TESLA/PLTW students scored significantly higher ACT-Mathematics and Science sub-scores than non-PLTW students
   - TESLA/PLTW reported higher levels of college intellectual openness and pursuing career exploration activities that are critical to postsecondary STEM success than their peers.

2. *Significant improvement in Mathematics and Science:* Southern Regional Education Board (SREB) July, 2009.

   This study of PLTW students participating in the 2008 SREB-High Schools That Work (HSTW) assessment determined that:
   - PLTW students were significantly more likely to complete at least four years of mathematics and three years of science courses.
   - Significantly more PLTW students meet readiness goals, aligned with NAEP assessments, in reading, mathematics, and science.
   - PLTW students integrated more academic knowledge and skills in Career Technical Education classes and PLTW students experienced more engaging mathematics instruction.

3. *Significant indicators of college readiness:* Walcerz, Douglas (2008-2009)

This study based on a 12,506 surveys of PLTW students across the nation measured the characteristics and habits of mind students need to succeed in college and plans for postsecondary education and found that:

- 94% - 97% plan to attend either a two or four-year postsecondary institution
- 80% indicated that their PLTW course taught them a lot about engineering and technology careers
- 70% indicated their PLTW experience increased their likelihood of studying engineering and technology after graduating
- Most students said PLTW experiences significantly increased their ability to succeed in postsecondary education

4. *Closing the achievement gap for Latino middle school students:* Heywood, J., White, S., December 31, 2009.

This study evaluated the impact of PLTW in three poverty impacted, largely Latino-populated middle schools. Students from three urban middle schools followed a three-year PLTW Gateway to Technology curriculum plan that focused on science learning. All of the PLTW students began middle school (6^{th} grade) at lower proficiency in math, reading and science and with lower attendance rates than the control group of non-PLTW students.

- By 8^{th} grade, achievement and attendance gaps had been eliminated
- By the end of the third year, PLTW students outperformed the control group

This study suggests that a long-term exposure to the PLTW program has the potential for removing an achievement gap for students in urban settings. It is well-known that if students are not math, science, and reading ready when they finish the eighth grade, the likelihood of their entering and completing career- and college-ready math and science courses is significantly reduced.

In sum, Project Lead the Way is one of the most comprehensive examples of what career and technical education can be, it should be clear that the program is quite different from what has been traditionally called vocational education, the program superbly implements the ideas and strategies of Wyoming's strategic plan on career and technical education and there is emerging research across the country that student's in the program perform at higher levels in multiple areas compared to similar students who have not had the PLTW course experiences.

THE COSTS OF IMPLEMENTING PROJECT LEAD THE WAY IN THE CONTEXT OF WYOMING'S FUNDING MODEL

PLTW's web site has detailed manuals for districts and schools to determine the costs of implementing the program. There are three primary costs:

- Class sizes
- Professional Development
- Equipment.

Class Size

For many districts, PLTW's suggestions for class size usually require a reduction in the number of students. The program recommends that class sizes be around 25 students. This is larger than currently provided in the Wyoming Funding Model for all high school classes, and therefore would not require additional resources. Moreover, assuming PLTW can serve as the cost-basis for a high quality career and technical education program, its class size requirements would not need the additional weighting of 0.29 that Wyoming now provides for such courses either.

Despite the apparent ability of Wyoming school districts to support a program as extensive as PLTW without staffing resources beyond what are available in the base funding model, we would advise the state to continue collecting data on the number of students in career, technical and vocational education courses, as well as have the WDE continue to approve career and technical programs. However, at this time it does not appear that class sizes smaller than the 21 ADM per teaching position in the current model are needed for top quality career and technical programs.

Professional Development

PTLW also has considerable professional development requirements, including summer institutes where teachers are trained and certified to be PLTW course instructors. Our analysis of the fiscal requirements for training to meet the needs of PTLW fit well within what Wyoming already provides through the Funding Model for professional development. This includes 10 pupil free days for training, $116.76 per pupil for training costs, time during the day for teacher collaborative work, and instructional coaches and facilitators in schools. It is our conclusion that no additional professional development funding is required for districts and schools to become involved in PLTW but that current professional development resources would need to be tapped to develop the initial and ongoing teacher capacity to deliver such a program.

Equipment

PLTW also requires substantial computer equipment for most of its classes. Because the program prefers that students work in teams as they collaboratively solve problems, the program recommends at least 1 computer for every 3 students, including a computer for the teacher, and for a few of the classes, a more powerful computer for the teacher. Computer technology as called for by PLTW can be purchased with the $250[56] per pupil that we recommend be included in the Wyoming Funding Model for all schools and programs. The computer technology needs of PLTW for both students and teachers can largely be supported by the resources that are included in the regular funding model.

PLTW does require some special equipment purchases for some programs. For example, the Computer Integrated Manufacturing course requires specialized equipment costing about $40,000 with annual maintenance costs of $4,000 a year. Assuming the equipment lasts five years, the upfront costs can be amortized over 5 years at an annual cost of $8,000 plus the

[56] The Wyoming Funding Model currently provides $290.91 per pupil for computer equipment and technology costs.

ongoing cost of $4,000 for a total equipment cost of $12,000 per teacher/course. Special equipment costs for other courses are much smaller, ranging from $1,500 to $15,000 with annual maintenance costs running from $1,000 to $2,000 a year. Again assuming a five year life of the major equipment purchase, these costs range from approximately $300 to $3,000 a year, plus the maintenance averaging $1,500 a year, or a total of from $1,800 to $4,500 a year. All of these costs can be covered by the $9,027.27 per voc/career/ed teacher allocation in the current funding model. If this allocation is more than is needed in any one year for specialized equipment, the "extra" funds could be devoted to more powerful computers for some PLTW courses.

Appendix B includes a summary of PLTW program costs, delineated by Project Lead the Way, but note that the summary includes costs assuming districts and schools start with an empty classroom, which would not be the case in Wyoming, and also includes professional development costs, which are covered in other portions of the Wyoming Funding Model.

2010 Recommendation

We recommend that Wyoming modify the parameters of the funding model for career, technical and vocational education. Specifically, the state over staffs career and technical education programs by the additional 0.29 weight given to every student in an approved career, technical and vocational education program. The weight is no longer needed because one of the highest end and most effective career technical education programs used by school districts today can be run effectively with class sizes of 21 as funded through the base funding model. We recommend that the state retain the $9,027.27 per vocational/career tech teacher to cover equipment costs beyond those of desktop computers and related software. This funding level would be more than adequate to provide for the equipment needs of a career and technical education program as advanced as Project Lead the Way. It would also provide additional flexibility to enable districts to purchase more than one computer for every three students, and perhaps even more powerful computers for students in advanced career and technical education programs.

APPENDIX A

PROJECT LEAD THE WAY'S
PATHWAY TO ENGINEERING AND BIOMEDICAL SCIENCE PROGRAMS

PLTW's **Pathway To Engineering (PTE)** curriculum is designed as a four-year high school sequence. Three foundation courses – Introduction to Engineering Design, Principles of Engineering, and Digital Electronics – are supplemented by a number of electives to create up to eight rigorous, relevant, reality-based courses:

Foundation Courses

- **Introduction to Engineering Design (IED).** Designed for 9th or 10th grade students, the major focus of the IED course is to expose students to the design process, research and analysis, teamwork, communication methods, global and human impacts, engineering standards and technical documentation. Students use 3D solid modeling design software to help them design solutions to solve proposed problems and learn how to document their work and communicate solutions to peers and members of the professional community.
- **Principles of Engineering (POE).** This survey course of engineering exposes students to major concepts they'll encounter in a postsecondary engineering course of study. Students employ engineering and scientific concepts in the solution of engineering design problems. They develop problem-solving skills and apply their knowledge of research and design to create solutions to various challenges, documenting their work and communicating solutions to peers and members of the professional community.
- **Digital Electronics (DE).** Digital electronics is the foundation of all modern electronic devices such as cellular phones, MP3 players, laptop computers, digital cameras and high-definition televisions. The major focus of the DE course is to expose students to the process of combinational and sequential logic design, teamwork, communication methods, engineering standards and technical documentation. This course is designed for 10th or 11th grade students.

Specialization Courses – usually for students in grades 11 and 12.

- **Aerospace Engineering (AE).** Aerospace Engineering engages students in engineering design problems related to aerospace information systems, astronautics, rocketry, propulsion, the physics of space science, space life sciences, the biology of space science, principles of aeronautics, structures and materials, and systems engineering. Using 3-D design software, students work in teams utilizing hands-on activities, projects and problems and are exposed to various situations encountered by aerospace engineers.
- **Biotechnical Engineering (BE).** Biomedical Engineering exposes students to the diverse fields of biotechnology including biomedical engineering, molecular genetics, bioprocess engineering, and agricultural and environmental engineering. Lessons

engage students in engineering design problems related to biomechanics, cardiovascular engineering, genetic engineering, agricultural biotechnology, tissue engineering, biomedical devices, forensics and bioethics. Students apply biological and engineering concepts to design materials and processes that directly measure, repair, improve and extend living systems.

- **Civil Engineering and Architecture (CEA).** In this course, students apply what they learn about various aspects of civil engineering and architecture to the design and development of a property. Working in teams, students explore hands-on activities and projects to learn the characteristics of civil engineering and architecture. In addition, students use 3D design software to help them design solutions to solve major course projects. Students learn about documenting their project, solving problems and communicating their solutions to their peers and members of the professional community of civil engineering and architecture.
- **Computer Integrated Manufacturing (CIM).** In this course, students answer the questions: How are things made? What processes go into creating products? Is the process for making a water bottle the same as it is for a musical instrument? How do assembly lines work? How has automation changed the face of manufacturing? As students find the answers to these questions, they learn about the history of manufacturing, a sampling of manufacturing processes, robotics and automation. The course is built around several key concepts: computer modeling, Computer Numeric Control (CNC) equipment, Computer Aided Manufacturing (CAM) software, robotics and flexible manufacturing systems.

Capstone Course

- **Engineering Design and Development (EDD).** This course, usually just for 12th graders, is focused on engineering research in which students work in teams to research, design, test and construct a solution to an open-ended engineering problem. The product development life cycle and a design process are used to guide and help the team to reach a solution to the problem. The team presents and defends their solution to a panel of outside reviewers at the conclusion of the course. The EDD course allows students to apply all the skills and knowledge learned in previous Project Lead the Way courses. The use of 3D design software helps students design solutions to the problem their team has chosen. This course also engages students in time management and teamwork skills, a valuable set for students in the future. This course is designed for 12th grade students.

PLTW's **Biomedical Sciences** program parallels the proven PLTW Engineering program. The initial program includes four courses, all aligned with appropriate national learning standards:

- **Principles of the Biomedical Sciences (PBS).** Students investigate the human body systems and various health conditions including heart disease, diabetes, sickle-cell disease, hypercholesterolemia, and infectious diseases. They determine the factors that led to the death of a fictional person, and investigate lifestyle choices and medical treatments that might have prolonged the person's life. The activities and projects introduce students to human physiology, medicine, research processes and bioinformatics. This course is designed to provide an overview of all the courses in the Biomedical Sciences program and lay the scientific foundation for subsequent courses.
- **Human Body Systems (HBS).** Students examine the interactions of body systems as they explore identity, communication, power, movement, protection, and homeostasis. Students design experiments, investigate the structures and functions of the human body, and use data acquisition software to monitor body functions such as muscle movement, reflex and voluntary action, and respiration. Exploring science in action, students build organs and tissues on a skeletal manikin, work through interesting real world cases and often play the role of biomedical professionals to solve medical mysteries.
- **Medical Interventions (MI).** Students investigate the variety of interventions involved in the prevention, diagnosis and treatment of disease as they follow the lives of a fictitious family. The course is a "How-To" manual for maintaining overall health and homeostasis in the body as students explore: how to prevent and fight infection; how to screen and evaluate the code in human DNA; how to prevent, diagnose and treat cancer; and how to prevail when the organs of the body begin to fail. Through these scenarios, students are exposed to the wide range of interventions related to immunology, surgery, genetics, pharmacology, medical devices, and diagnostics. Lifestyle choices and preventive measures are emphasized throughout the course as well as the important roles scientific thinking and engineering design play in the development of interventions of the future.
- **Biomedical Innovation (BI).** In this capstone course, students apply their knowledge and skills to answer questions or solve problems related to the biomedical sciences. Students design innovative solutions for the health challenges of the 21st century as they work through progressively challenging open-ended problems, addressing topics such as clinical medicine, physiology, biomedical engineering, and public health. They have the opportunity to work on an independent project and may work with a mentor or advisor from a university, hospital, physician's office, or industry. Throughout the course, students are expected to present their work to an adult audience that may include representatives from the local business and healthcare community.

APPENDIX H

MEMO ON VOCATIONAL EDUCATION

To: Wyoming Select Committee on Recalibration

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[53] http://www.postsecconnect.org/files/CollegeandCareerReadyFINAL31809.pdf

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A job may be obtained with only a high school diploma, but offers no guarantee of advancement or mobility. Being *ready* for a career means that a high school graduate has the English, and mathematics knowledge and skills needed to qualify for and succeed in the postsecondary job training and/or education necessary for their chosen career (i.e. technical/vocational program, community college, apprenticeship or significant on-the-job training).

Is ready for *COLLEGE* and ready for *CAREER* the same thing?
With respect to the knowledge and skills in English and mathematics expected by employers and postsecondary faculty, the answer is yes. In the last decade, research conducted by ACHIEVE, ACT, the Southern Regional Education Board, as well as others shows a convergence in the expectations of employers and colleges in terms of the knowledge and skills high school grads need to be successful after high school.

Economic reality reflects these converging expectations as does Wyoming's strategic plan for career and technical education. Education today is more valued and more necessary than ever before. The bottom line is that today ALL high school graduates need to be prepared for some postsecondary education – job specific training, technical college, community college or four year college – if they are to have options and opportunities for high wage jobs in the knowledge-based, global economy.

- Thirty five years ago, only 12% of U.S. jobs required some postsecondary training or an associate's degree and only 16% required a bachelor's degree or higher.

- Nearly eight in ten future job openings in the next decade in the U.S. will require postsecondary education or training. Forty-five percent will be in "middle skill" occupations, which require at least some postsecondary education and training, while 33% will be in high skilled occupations for which a Bachelors degree or more is required. By contrast, only 22% of future job openings will be "low skill" and accessible to those with a high school diploma or less.

- Though the U.S. still ranks 3rd in the adult population (25-64 year olds) with an associate's degree or higher among 30 countries, the country now ranks 10th among 25-34 year olds with a two-year degree and above. Competing countries are catching up to – and even outpacing – the U.S. in the educational attainment of their new generation of adults.

- Wyoming's data, included in the career and technical education strategic report, reflect these trends. Though the natural resources and mineral extraction industries account for a solid portion of Wyoming's jobs, with many jobs in those industries not requiring education beyond high school, other industries – education, health care, professional and business services, financial activities, information and government – actually employ larger numbers of individuals with most of these jobs requiring some postsecondary training. However, enrollments in Wyoming CTE school district programs in these areas are substantially under the numbers needed.

- Further, if all Wyoming students are to have access to high wage/high skill jobs in the broader economy even if they move out of the state, larger percentages will need not only a solid high school education but also preparation for additional training that would be required for jobs in other states but not plentiful now in Wyoming.

Higher levels of education lead to elevated wages, a more equitable distribution of income and substantial gains in productivity. For every additional average year of schooling, individual life time earnings rise by 10 percent. Moreover, for every additional year of schooling U.S. citizens complete, the GDP would increase by about 0.37 percentage points – or by 10% – over time.

While many traditional vocational and technical education programs did not produce high skills in math, science and English in their graduates, there is a new "breed" of career technical education programs developing across the country and these programs seek to prepare students for the emerging and most rapidly rising jobs in the broader economy, particularly those in health sciences, biotechnology, engineering, and information technologies. Moreover, it was these career and technical clusters that were emphasized in Wyoming's recent strategic plan for career and technical education. And all of these have rigorous nationally designed programs that states and districts can implement.

Wyoming has already adopted the 16 career clusters identified by the U.S. Department of Education as the basis for organizing CTE programs, and uses the clusters as a platform for reporting purposes. To be approved, districts and schools must offer a program that includes 3 semester courses comprising a CTE concentration. The goal of all these programs is to take courses, including the CTE courses, sufficient to allow the student to enroll in the University of Wyoming, a community or technical college, or a high wage job. It should be noted that 15 of the 16 CTE career clusters require mathematics up to Algebra 2, so the knowledge, skill and concept requirements for successfully engaging in CTE programs are quite similar to, if not the same as, those required to be college ready. Further, although Wyoming students now take CTE courses in five major areas – architecture and construction; agriculture, food and natural resources; business, management and administration; manufacturing; information technology – one goal of the CTE strategic plan is to expand on these offerings so as to cover more career areas requiring higher skills not only in Wyoming but also across the country.

In our effort to identify a cost-basis for these new career and technical programs, we have used Project Lead the Way, as an exemplar. It is one of the most recognized, "high end" career and technical education program in the country and has a growing research base showing that it produces graduates who achieve more than similar students who have not had the program. By high end, we mean it also is one of the most rigorous as well as expensive career and technical programs so can serve as one basis for determining additional resources needed – if any – for career and technical education beyond those in the regular Wyoming Funding Model.

PROJECT LEAD THE WAY: AN EMERGING NATIONAL MODEL

Project Lead the Way (PLTW) is a nationally prominent exemplar for secondary CTE education. Often implemented jointly with local postsecondary education institutions and employer

advisory groups, these programs usually feature project or problem-based learning experiences, career planning and guidance services, and technical and/or academic skills assessments. The program is designed to develop the science, technology, engineering and mathematics skills essential for achievement in the classroom and success in college or jobs not requiring a four-year college education through hands-on experience preparing students for the real world. Developed in upstate New York schools in the early 1990s, PLTW is offered in more than 3,000 high schools in all 50 states and now enrolls over 350,000 total students.

According to the PLTW web site:[55]

> The PLTW Engineering and Biomedical Sciences programs offer students an array of advantages, from career readiness and hands-on experience to college preparatory–level classes, labs, and creative exercises. Its programs are designed to appeal to all students, from those already interested in Science, Technology, Engineering, and Math (STEM)-related fields, to those whose experience in the sciences and math has been less comprehensive or who find themselves uninterested in traditional STEM curricula. PLTW classes are hands-on, based in real-world experience, and fun for students and teachers. The program sets high standards for rigorous, focused, and engaging study, developing students' innovative, collaborative, cooperative, and problem-solving skills.
>
> PLTW is a comprehensive, turnkey program with a quick turnaround time and support for smooth and efficient implementation, whether the school is starting up for the first time or introducing new courses. PLTW.org gives educators 24-hour access to information, sourcing, and purchasing.
>
> PLTW is a true curriculum based on a tried-and-true pedagogy. It can be offered as full year and multi-year primarily for high schools, and both the Engineering and Biomedical Sciences tracks dovetail with current class offerings. Curricula include standards, learning outcomes, sequence and schedule, problems, projects, integrated activities, assessments, and support.
>
> PLTW provides professional development and support. Teachers receive comprehensive training from a PLTW partner university. Training gives teachers full proficiency regardless of previous experience. PLTW's Virtual Academy for Professional Development updates teachers through an online repository of information and references. PLTW also offers counselor conferences to provide high school guidance counselors with a clear understanding of the program and how it fits within a student's scholastic/academic career path.

Appendix A includes more detailed descriptions of both PLTW's Pathway to Engineering and Biomedical Sciences programs, including the course sequences for each.

The curriculum features rigorous, in-depth learning experiences delivered by certified teachers and end-of-course assessments. High-scoring students earn college credit recognized in more

[55] www.pltw.org

than 100 affiliated postsecondary institutions. Courses focused on engineering foundations (design, principles, and digital electronics) and specializations (e.g., architectural and civil engineering, bio-technical engineering) provide students with career and college readiness competencies in engineering and science.

In 2009-10, approximately 130,000 students completed end-of-course assessments. To date, more than 12,000 high school teachers and 8,000 guidance counselors have completed professional development and certification through the national network of higher education institutions.

Evidence of Effectiveness

Currently, longitudinal studies and experimental evaluations of PLTW programs are in process in several states, but several local implementation studies have produced promising results on several outcome measures (Project Lead the Way, 2010, April):

1. *Improving student achievement and college/career readiness:* Phelps, L. A., Camburn, E., & Durham, J. (2008)

   This study of TESLA Engineering Charter School students at Appleton East High School in Wisconsin uses the Project Lead the Way Pathway to Engineering curriculum. In comparing the TESLA Engineering senior students and the Appleton East seniors, the analyses revealed that:
   - TESLA/PLTW students scored significantly higher on the ACT composite measure than the non-PLTW students
   - TESLA/PLTW students scored significantly higher ACT-Mathematics and Science sub-scores than non-PLTW students
   - TESLA/PLTW reported higher levels of college intellectual openness and pursuing career exploration activities that are critical to postsecondary STEM success than their peers.

2. *Significant improvement in Mathematics and Science:* Southern Regional Education Board (SREB) July, 2009.

   This study of PLTW students participating in the 2008 SREB-High Schools That Work (HSTW) assessment determined that:
   - PLTW students were significantly more likely to complete at least four years of mathematics and three years of science courses.
   - Significantly more PLTW students meet readiness goals, aligned with NAEP assessments, in reading, mathematics, and science.
   - PLTW students integrated more academic knowledge and skills in Career Technical Education classes and PLTW students experienced more engaging mathematics instruction.

3. *Significant indicators of college readiness:* Walcerz, Douglas (2008-2009)

This study based on a 12,506 surveys of PLTW students across the nation measured the characteristics and habits of mind students need to succeed in college and plans for postsecondary education and found that:

- 94% - 97% plan to attend either a two or four-year postsecondary institution
- 80% indicated that their PLTW course taught them a lot about engineering and technology careers
- 70% indicated their PLTW experience increased their likelihood of studying engineering and technology after graduating
- Most students said PLTW experiences significantly increased their ability to succeed in postsecondary education

4. *Closing the achievement gap for Latino middle school students:* Heywood, J., White, S., December 31, 2009.

This study evaluated the impact of PLTW in three poverty impacted, largely Latino-populated middle schools. Students from three urban middle schools followed a three-year PLTW Gateway to Technology curriculum plan that focused on science learning. All of the PLTW students began middle school (6^{th} grade) at lower proficiency in math, reading and science and with lower attendance rates than the control group of non-PLTW students.

- By 8^{th} grade, achievement and attendance gaps had been eliminated
- By the end of the third year, PLTW students outperformed the control group

This study suggests that a long-term exposure to the PLTW program has the potential for removing an achievement gap for students in urban settings. It is well-known that if students are not math, science, and reading ready when they finish the eighth grade, the likelihood of their entering and completing career- and college-ready math and science courses is significantly reduced.

In sum, Project Lead the Way is one of the most comprehensive examples of what career and technical education can be, it should be clear that the program is quite different from what has been traditionally called vocational education, the program superbly implements the ideas and strategies of Wyoming's strategic plan on career and technical education and there is emerging research across the country that student's in the program perform at higher levels in multiple areas compared to similar students who have not had the PLTW course experiences.

THE COSTS OF IMPLEMENTING PROJECT LEAD THE WAY IN THE CONTEXT OF WYOMING'S FUNDING MODEL

PLTW's web site has detailed manuals for districts and schools to determine the costs of implementing the program. There are three primary costs:

- Class sizes
- Professional Development
- Equipment.

Class Size

For many districts, PLTW's suggestions for class size usually require a reduction in the number of students. The program recommends that class sizes be around 25 students. This is larger than currently provided in the Wyoming Funding Model for all high school classes, and therefore would not require additional resources. Moreover, assuming PLTW can serve as the cost-basis for a high quality career and technical education program, its class size requirements would not need the additional weighting of 0.29 that Wyoming now provides for such courses either.

Despite the apparent ability of Wyoming school districts to support a program as extensive as PLTW without staffing resources beyond what are available in the base funding model, we would advise the state to continue collecting data on the number of students in career, technical and vocational education courses, as well as have the WDE continue to approve career and technical programs. However, at this time it does not appear that class sizes smaller than the 21 ADM per teaching position in the current model are needed for top quality career and technical programs.

Professional Development

PTLW also has considerable professional development requirements, including summer institutes where teachers are trained and certified to be PLTW course instructors. Our analysis of the fiscal requirements for training to meet the needs of PTLW fit well within what Wyoming already provides through the Funding Model for professional development. This includes 10 pupil free days for training, $116.76 per pupil for training costs, time during the day for teacher collaborative work, and instructional coaches and facilitators in schools. It is our conclusion that no additional professional development funding is required for districts and schools to become involved in PLTW but that current professional development resources would need to be tapped to develop the initial and ongoing teacher capacity to deliver such a program.

Equipment

PLTW also requires substantial computer equipment for most of its classes. Because the program prefers that students work in teams as they collaboratively solve problems, the program recommends at least 1 computer for every 3 students, including a computer for the teacher, and for a few of the classes, a more powerful computer for the teacher. Computer technology as called for by PLTW can be purchased with the $250[56] per pupil that we recommend be included in the Wyoming Funding Model for all schools and programs. The computer technology needs of PLTW for both students and teachers can largely be supported by the resources that are included in the regular funding model.

PLTW does require some special equipment purchases for some programs. For example, the Computer Integrated Manufacturing course requires specialized equipment costing about $40,000 with annual maintenance costs of $4,000 a year. Assuming the equipment lasts five years, the upfront costs can be amortized over 5 years at an annual cost of $8,000 plus the

[56] The Wyoming Funding Model currently provides $290.91 per pupil for computer equipment and technology costs.

ongoing cost of $4,000 for a total equipment cost of $12,000 per teacher/course. Special equipment costs for other courses are much smaller, ranging from $1,500 to $15,000 with annual maintenance costs running from $1,000 to $2,000 a year. Again assuming a five year life of the major equipment purchase, these costs range from approximately $300 to $3,000 a year, plus the maintenance averaging $1,500 a year, or a total of from $1,800 to $4,500 a year. All of these costs can be covered by the $9,027.27 per voc/career/ed teacher allocation in the current funding model. If this allocation is more than is needed in any one year for specialized equipment, the "extra" funds could be devoted to more powerful computers for some PLTW courses.

Appendix B includes a summary of PLTW program costs, delineated by Project Lead the Way, but note that the summary includes costs assuming districts and schools start with an empty classroom, which would not be the case in Wyoming, and also includes professional development costs, which are covered in other portions of the Wyoming Funding Model.

2010 Recommendation

We recommend that Wyoming modify the parameters of the funding model for career, technical and vocational education. Specifically, the state over staffs career and technical education programs by the additional 0.29 weight given to every student in an approved career, technical and vocational education program. The weight is no longer needed because one of the highest end and most effective career technical education programs used by school districts today can be run effectively with class sizes of 21 as funded through the base funding model. We recommend that the state retain the $9,027.27 per vocational/career tech teacher to cover equipment costs beyond those of desktop computers and related software. This funding level would be more than adequate to provide for the equipment needs of a career and technical education program as advanced as Project Lead the Way. It would also provide additional flexibility to enable districts to purchase more than one computer for every three students, and perhaps even more powerful computers for students in advanced career and technical education programs.

APPENDIX A

PROJECT LEAD THE WAY'S
PATHWAY TO ENGINEERING AND BIOMEDICAL SCIENCE PROGRAMS

PLTW's **Pathway To Engineering (PTE)** curriculum is designed as a four-year high school sequence. Three foundation courses – Introduction to Engineering Design, Principles of Engineering, and Digital Electronics – are supplemented by a number of electives to create up to eight rigorous, relevant, reality-based courses:

Foundation Courses

- **Introduction to Engineering Design (IED).** Designed for 9th or 10th grade students, the major focus of the IED course is to expose students to the design process, research and analysis, teamwork, communication methods, global and human impacts, engineering standards and technical documentation. Students use 3D solid modeling design software to help them design solutions to solve proposed problems and learn how to document their work and communicate solutions to peers and members of the professional community.
- **Principles of Engineering (POE).** This survey course of engineering exposes students to major concepts they'll encounter in a postsecondary engineering course of study. Students employ engineering and scientific concepts in the solution of engineering design problems. They develop problem-solving skills and apply their knowledge of research and design to create solutions to various challenges, documenting their work and communicating solutions to peers and members of the professional community.
- **Digital Electronics (DE).** Digital electronics is the foundation of all modern electronic devices such as cellular phones, MP3 players, laptop computers, digital cameras and high-definition televisions. The major focus of the DE course is to expose students to the process of combinational and sequential logic design, teamwork, communication methods, engineering standards and technical documentation. This course is designed for 10th or 11th grade students.

Specialization Courses – usually for students in grades 11 and 12.

- **Aerospace Engineering (AE).** Aerospace Engineering engages students in engineering design problems related to aerospace information systems, astronautics, rocketry, propulsion, the physics of space science, space life sciences, the biology of space science, principles of aeronautics, structures and materials, and systems engineering. Using 3-D design software, students work in teams utilizing hands-on activities, projects and problems and are exposed to various situations encountered by aerospace engineers.
- **Biotechnical Engineering (BE).** Biomedical Engineering exposes students to the diverse fields of biotechnology including biomedical engineering, molecular genetics, bioprocess engineering, and agricultural and environmental engineering. Lessons

engage students in engineering design problems related to biomechanics, cardiovascular engineering, genetic engineering, agricultural biotechnology, tissue engineering, biomedical devices, forensics and bioethics. Students apply biological and engineering concepts to design materials and processes that directly measure, repair, improve and extend living systems.

- **Civil Engineering and Architecture (CEA).** In this course, students apply what they learn about various aspects of civil engineering and architecture to the design and development of a property. Working in teams, students explore hands-on activities and projects to learn the characteristics of civil engineering and architecture. In addition, students use 3D design software to help them design solutions to solve major course projects. Students learn about documenting their project, solving problems and communicating their solutions to their peers and members of the professional community of civil engineering and architecture.
- **Computer Integrated Manufacturing (CIM).** In this course, students answer the questions: How are things made? What processes go into creating products? Is the process for making a water bottle the same as it is for a musical instrument? How do assembly lines work? How has automation changed the face of manufacturing? As students find the answers to these questions, they learn about the history of manufacturing, a sampling of manufacturing processes, robotics and automation. The course is built around several key concepts: computer modeling, Computer Numeric Control (CNC) equipment, Computer Aided Manufacturing (CAM) software, robotics and flexible manufacturing systems.

Capstone Course

- **Engineering Design and Development (EDD).** This course, usually just for 12th graders, is focused on engineering research in which students work in teams to research, design, test and construct a solution to an open-ended engineering problem. The product development life cycle and a design process are used to guide and help the team to reach a solution to the problem. The team presents and defends their solution to a panel of outside reviewers at the conclusion of the course. The EDD course allows students to apply all the skills and knowledge learned in previous Project Lead the Way courses. The use of 3D design software helps students design solutions to the problem their team has chosen. This course also engages students in time management and teamwork skills, a valuable set for students in the future. This course is designed for 12th grade students.

PLTW's **Biomedical Sciences** program parallels the proven PLTW Engineering program. The initial program includes four courses, all aligned with appropriate national learning standards:

- **Principles of the Biomedical Sciences (PBS).** Students investigate the human body systems and various health conditions including heart disease, diabetes, sickle-cell disease, hypercholesterolemia, and infectious diseases. They determine the factors that led to the death of a fictional person, and investigate lifestyle choices and medical treatments that might have prolonged the person's life. The activities and projects introduce students to human physiology, medicine, research processes and bioinformatics. This course is designed to provide an overview of all the courses in the Biomedical Sciences program and lay the scientific foundation for subsequent courses.
- **Human Body Systems (HBS).** Students examine the interactions of body systems as they explore identity, communication, power, movement, protection, and homeostasis. Students design experiments, investigate the structures and functions of the human body, and use data acquisition software to monitor body functions such as muscle movement, reflex and voluntary action, and respiration. Exploring science in action, students build organs and tissues on a skeletal manikin, work through interesting real world cases and often play the role of biomedical professionals to solve medical mysteries.
- **Medical Interventions (MI).** Students investigate the variety of interventions involved in the prevention, diagnosis and treatment of disease as they follow the lives of a fictitious family. The course is a "How-To" manual for maintaining overall health and homeostasis in the body as students explore: how to prevent and fight infection; how to screen and evaluate the code in human DNA; how to prevent, diagnose and treat cancer; and how to prevail when the organs of the body begin to fail. Through these scenarios, students are exposed to the wide range of interventions related to immunology, surgery, genetics, pharmacology, medical devices, and diagnostics. Lifestyle choices and preventive measures are emphasized throughout the course as well as the important roles scientific thinking and engineering design play in the development of interventions of the future.
- **Biomedical Innovation (BI).** In this capstone course, students apply their knowledge and skills to answer questions or solve problems related to the biomedical sciences. Students design innovative solutions for the health challenges of the 21st century as they work through progressively challenging open-ended problems, addressing topics such as clinical medicine, physiology, biomedical engineering, and public health. They have the opportunity to work on an independent project and may work with a mentor or advisor from a university, hospital, physician's office, or industry. Throughout the course, students are expected to present their work to an adult audience that may include representatives from the local business and healthcare community.