
AC 2011-2856: A MODEL FOR ENHANCING PROJECT LEAD THE WAY TEACHER KNOWLEDGE IN SOFTWARE APPLICATIONS

Laura E. LeMire, The Community College of Baltimore County

Laura LeMire, an alumna of the University of Maryland at College Park with a B.S. and Masters in Geotechnical Engineering, started her career at Baltimore Gas and Electric (BGE). During her career there, she was responsible for substation and transmission construction projects, relocation and installation of BGE facilities for Oriole Park at Camden Yards and for a new Light Rail system, and for improving service reliability. After obtaining her MBA, Laura became the Director of Corporate Purchasing and was also a financial analyst handling investor relations. Laura left the utility to become the Director of Women's Sports at STX, Inc., a sporting goods manufacturer, where she became the holder of four patents. Returning to the classroom once again, Laura obtained a Masters in Environmental Engineering from UMBC and became an Affiliate Professor for Project Lead The Way. Now the Engineering Coordinator at the Community College of Baltimore County (CCBC), Laura is endeavoring to grow the engineering transfer program and the new engineering technology program by stimulating interest in high school students and seeking funding to help students cope with the expense of college. As a resident of Catonsville, MD, Laura participates in a variety of athletics, spends whatever free time she can find in her garden, and travels the world.

A Model for Enhancing Project Lead The Way Teacher Knowledge in Software Applications

Abstract

A Maryland model for providing ongoing professional development training to Project Lead The Way (PLTW) teachers is being replicated in other states. The model was developed by The Community College of Baltimore County (CCBC) in response to requests by PLTW teachers and school administrators for additional training. Professional development sessions were conducted for Maryland and District of Columbia PLTW teachers two to three times a year over the three-year period spanning Fall 2007 to Spring 2010. The training was designed to reinforce and supplement the intense two-week summer core training program the teachers attended to receive certification in specific PLTW courses. The goals were to build teacher confidence and increase their knowledge of Autodesk Inventor, the fischertechnik educational building system (including RoboPro), Autodesk Revit, MDSolids, and civil engineering topics covered in the PLTW Civil Engineering and Architecture curriculum. The results of the training showed moderate to dramatic increases in teacher confidence and content knowledge. Using feedback from those participating in the training and data collected from assessments and surveys, the model was refined to further enhance teacher competence using PLTW-required software and teaching the civil engineering curriculum.

With funding from NSF, a train-the-trainer program was designed and put in place to implement the Maryland professional development training model in other parts of the country. For the 2010-11 academic school year, the Maryland instruction team, comprised of a coordinator and a Master Teacher or professor for each of the topic areas (Inventor, fischertechnik, Revit and civil engineering), is working with the New York and Ohio PLTW Affiliate Universities to replicate the model in their respective states. Materials developed by the Maryland training team were shared with their counterparts from the Affiliate Universities. Meetings were then held to obtain input and feedback on the lesson plans and assessments, discuss the structure and frequency of the training, address past challenges and successes, and prepare the new teams for implementation of the professional development model. The first round of training sessions was conducted between September and November 2010 for approximately 80 teachers, and was met with high teacher satisfaction as evidenced by the survey ratings and comments, and a documented increase in teacher knowledge. Scores on the standardized assessments increased 28% for CEA, 23% for Inventor Level 1, 62% for Inventor Level 2 questions and 25% for Inventor Level 2 drawings, and 20% for fischertechnik Level 1. The train-the-trainer program is an effective way to increase teacher confidence and knowledge.

Introduction

For our nation to remain globally competitive in the math and sciences, our public school systems must be able to attract secondary school-aged students to these disciplines and maintain their interest. Teachers continue to be our greatest asset in developing a pool of future science, technology, engineering and math (STEM) workers. K-12 teachers express a need and appreciation for new technologies that keep their students invested and interested in real-world applications. To this end, Maryland began offering Project Lead the Way (PLTW) pre-engineering curriculum in 2002. By 2009, the state had 80 high schools and 34 middle schools teaching PLTW, reaching 100 to 250 students per school.

The University of Maryland, Baltimore County (UMBC), Maryland's Affiliate University for the pre-engineering program, provides training and professional development (PD) to PLTW teachers and guidance counselors and oversees the state's PLTW College Certification process. A recent report by the American Association of Community Colleges, supported by the National Science Foundation (NSF), found that teachers look to community colleges for access to advanced technology and effective strategies.¹ In that vein, for the past three and a half years, the Community College of Baltimore County (CCBC) has partnered with UMBC to provide software specific PD training for Maryland's middle and high school PLTW teachers. In order to build teacher confidence and increase their knowledge of the technological software integrated into the PLTW curriculum, CCBC developed and is currently expanding nationwide its PD training program.

To provide PLTW teachers with material that reinforces and expands the technical knowledge they gained during summer training and in the classroom, a group of four professors and Master teachers conduct training on Autodesk Inventor (Inventor), fischertechnik educational building system (fischertechnik), Revit, MDSolids, and various civil engineering concepts. Maryland's training program is now being implemented in other states through the sponsorship of NSF grant DUE 1003317. A total of seven Affiliate Universities have been targeted nationwide for the train-the-trainer model supported by the NSF grant, and all Affiliate Universities will be provided access to a site on the PLTW webpage containing documents describing the program and the materials utilized for the training.

The objectives of the training are to: design curriculum; develop and coordinate training partnerships between community colleges and four-year institutions; continue to expand training opportunities; provide consulting and advising services to seven PLTW Affiliate Universities that adopt the on-going PD curriculum; and make the program available for adaptation nationwide.

Background

The Community College of Baltimore County

CCBC is the largest community college in the state of Maryland, providing an education to 33,817 credit students, and 33,418 continuing education students in 2010. The mission of the college is to provide an accessible, affordable, and high-quality education that prepares students

for transfer and career success, strengthens the regional workforce, and enriches our community. In support of that mission, CCBC has partnered with UMBC, a PLTW Affiliate University, to provide ongoing PD for instructors who are teaching the PLTW curriculum in Maryland and Washington DC. During the school year, parking and daytime room availability is often scarce at Universities, making a community college such as CCBC a preferred location for the training. In addition, the collaboration between the University and the community college helps to forge a partnership with beneficial results for students transferring from CCBC to UMBC.

STEM Education

The skills and knowledge students should gain through technology education were established by three national documents: Benchmarks for Science Literacy, National Science Education Standards, and Standards for Technological Literacy.² All three documents state that through design, engineering, and technology, students should be able to understand the reciprocal relationships between science and technology, and understand or apply the engineering design process, recognizing design constraints and trade-offs of each design. Unfortunately, there exists a lack of access to adequate resources – including qualified STEM teachers.³ According to the National Center for Education Statistics 2003-4, only 61% of math teachers and 77% of science teachers are fully qualified for their assignment. K-12 teachers lack confidence in their abilities to teach design and engineering and as a result shy away from implementing engineering concepts into the classroom.⁴

The results of a study that evaluated a number of engineering curriculum projects, from small to large, determined that when done well, engineering projects are meaningful to a student's personal experience. It is easier for them to relate to how a city or a bridge is constructed than an abstract geometry problem or even a science experiment. Engineering is a problem-solving discipline that through iteration, experimentation, inquiry and research can capture the interest of a student.⁵

Project Lead the Way

Project Lead the Way is a not-for-profit organization that has developed pre-engineering courses for middle and high school students and provides training to teachers who deliver the curriculum. Students are offered real-world learning in a variety of areas, including engineering, biomechanics, aeronautics, and other applied math and science areas. Started in 1997 with a handful of New York schools, PLTW currently has programs in all 50 states with programs implemented in 3,500 schools impacting 300,000 students. PLTW works with Affiliate University Partners to provide PD experiences for PLTW teachers in their region. The program offers a hands-on, project-based approach to learning that better prepares students for the rigors of college. The program incorporates math, science, English, and technology skills needed for success and utilizes processes that encourage female and minority participation.

Industry representatives are enthusiastic about the success of PLTW as a tool that successfully and realistically introduces students to the engineering field. The strength of PLTW is that it offers a better image of what engineering looks like, while teaching students the value of thoughtfully applying knowledge that they have acquired. Industry representatives want students

to go into college understanding what being an engineer means and PLTW offers the opportunity for students to learn the value of open-ended questions having no easy solution. Maryland industry representatives have found PLTW to be a great transformational program for the average student.

A Report on the Third Year of Implementation of the TrueOutcomes Assessment System for Project Lead the Way⁶ has cited positive student attitudes exhibited relative to PLTW program participation. The study's multiple measures of student attitudes and career goals along with the newly-implemented course evaluation forms show strong evidence that PLTW students receive significant benefits from PLTW courses and are better prepared and more confident of their field of study than if they had not taken PLTW courses. In addition, the Southern Regional Education Board's 2007 report, "Project Lead the Way® Works: A New Type of Career and Technical Program" indicates that PLTW students achieve significantly higher scores in mathematics and science on the National Assessment of Educational Progress-referenced High Schools that Work (HSTW) test than similar HSTW career/technical students. PLTW students also have a GPA 0.21 higher than average freshmen.⁷

There are two sets of curricula and courses available to school districts: Gateway To Technology® (GTT) for middle school, and Pathway to Engineering™ (PE) for high school. The GTT program is comprised of five independent nine-week courses (Design and Modeling™, The Magic of Electrons™, The Science of Technology™, Automation and Robotics™, and Flight and Space™) taught in conjunction with the academic curriculum. Pathway to Engineering (PE) is offered over four years and is integrated into the core curriculum. Students are prepared for college majors in engineering and technology fields through a unique combination of traditional math and science courses coupled with the following PE courses: Principles of Engineering (POE), Introduction to Engineering Design (IED), Civil Engineering and Architecture (CEA), Computer Integrated Manufacturing (CIM), Engineering Design and Development (EDD), Aerospace Engineering (AE), and Digital Electronics (DE). Students participating in PLTW endeavor to complete a total of at least five courses: a minimum of three foundation courses, one specialization course, and a capstone course.

PLTW teachers must be certified in order to teach a PLTW course. To become certified, for each class that they teach, an instructor must successfully complete a two week Summer Training Institute (STI) course. STI courses are intensive training programs that condense a year-long PLTW curriculum into a two week period. They are offered at Affiliate Universities located around the country and are taught by Master Teachers who have a depth of knowledge and experience teaching a PLTW course, and university Affiliate Professors who are degreed in the appropriate engineering field and have attended an STI to learn the curriculum. During the training, teachers learn the latest software programs in three dimensional computer-aided design, digital electronics, robotics, structure analysis and manufacturing processes. Working in teams and with guidance from the instructors, the teachers attending the STI must demonstrate their course knowledge and their ability to utilize the software required for use in the course.

The time between when a teacher takes a training course and the time they utilize the software in class could be weeks, months or even years. As a result, teachers forget various applications and require retraining as well as skill enhancement to challenge more advanced

students. Since teachers' knowledge and perception of a subject is closely related to their self-confidence in teaching that subject¹, it is important to provide teachers with targeted professional development to bolster their skills as well as their confidence.

Methodology

Pilot Program 2007-8

CCBC's pilot PLTW PD program was launched during the 2007-2008 school year through a grant from the Technology and Innovation in Manufacturing and Engineering (TIME) Center, a NSF ATE regional center, and with the support of UMBC. The pilot program was designed to build technical competence and classroom confidence in Baltimore County middle and high school teachers in the use of Inventor and fischertechnik, which are required for multiple PLTW courses. Inventor is incorporated in five of the seven courses, and fischertechnik is utilized in two: GTT and POE. Baltimore County Public Schools (BCPS) supported this PD training and provided substitutes for teachers who participated. The Engineering Coordinator at CCBC was the Coordinator for the project acting as liaison between CCBC personnel, UMBC, Baltimore County administrators, the TIME Center, PLTW teachers, and the instructors.

The Inventor training was a one day eight-hour session administered by the local Autodesk distributor and conducted at the Maryland Center for Career and Technology Education office. The fischertechnik training was a seven-hour session conducted by a CCBC computer science professor at CCBC, Catonsville. Prior to the fischertechnik training, participants completed a Team Building Survey that assessed the teachers' comfort with a computer, experience with fischertechnik and programming, and personality type. This information was used to form project teams.

Effectiveness of the training was ascertained using a self-evaluation survey that encompassed content knowledge, usefulness of the topics covered, the instructor, the facilities, and the location. Teachers answered a series of questions using a scale of 1 to 10. For content knowledge, a 1 indicated no knowledge, 5 indicated they were familiar with the content and a 10 response indicated they were very knowledgeable – an expert. For usefulness, the scale was 1 = not at all, 5 = helpful, and 10 = imperative to have. For the other areas, a 1 was poor, 5 was fine and 10 was excellent.

Pilot Program 2008-9

When designing the PD training program for the 2008-2009 school year, a number of key elements were reviewed including: frequency, timing during the year, length, and location of the training sessions, identification of instructors, and creation of an evaluation tool. The topics to cover and overall organization of the sessions were also re-evaluated due to the disparity of teacher knowledge and experience. Ultimately, it was decided to conduct the training three times over the course of the year, once in the fall, once in the winter and once in the spring on CCBC's Catonsville campus. The training was set up for 4 hours each day in the fall and spring and 3 hours for each topic on the same day in the winter. This enabled teachers traveling far distances

to make the training and allowed local teachers to avoid rush hour traffic. The schedule also made it possible for a teacher to attend both the Inventor and the fischertechnik training series.

The 2008-9 PD training was again coordinated by CCBC's Engineering Coordinator, and was taught by the CCBC computer science professor who conducted the 2007-8 fischertechnik training, and a local Master Teacher who teaches the IED STI at UMBC.

Based on the success of the 2007-8 pilot program, the Maryland State Department of Education (MSDE), Division of Career Technology and Adult Learning (DCTAL) awarded CCBC a grant for the 2008-2009 school year that broadened teacher participation by making the PD available to PLTW teachers throughout the entire state of Maryland. The TIME Center provided additional support as did CCBC's Career and Technology Education office which funded substitutes for teachers from schools in need of assistance. Teachers were assessed a \$30 fee that covered lunch for all three sessions.

A total of 22 teachers from 9 counties and the District of Columbia, attended the Inventor training and 14 teachers from 9 counties and the District of Columbia attended the fischertechnik training. Participants completed a pre-assessment survey to establish a baseline of knowledge and to help the instructors develop the course agenda and form teams. The self assessment was retaken after each of the training sessions. For fischertechnik, a multiple choice test was also administered to garner an objective evaluation of teacher knowledge. Throughout the training, the instructors modeled the same effective pedagogies they advised teachers to use in their classrooms, giving the teachers the tools they need to engage students and to teach them to understand and apply the new concepts.

Pilot Program 2009-10

The key elements of the PD continued to evolve as the following modifications were made to the program for the 2009-2010 training. While the 2007-2008 and 2008-2009 training programs were designed to refresh skills and provide a continued overview of functions, they included advanced material for both the fischertechnik and Inventor software programs that went beyond the standard curriculum. Due to the disparity in knowledge and experience with the software and applications, it was deemed necessary to divide the classes into two levels to best meet the needs of the teachers. As a result, in 2009-2010, CCBC offered Maryland PLTW teachers training for two levels of Inventor and two levels of fischertechnik. In addition, training in CEA software (Revit and MDSolids) and civil engineering applications was added at the teachers' request.

The number of sessions was reduced from three to two to minimize the cost for substitutes. They were held in early fall and winter for seven hours each day since teachers took off the entire day to attend the training. The Coordinator, a civil engineer and Affiliate Professor for CEA, and a local Master Teacher with mastery of Revit were added to the training team for teaching the civil engineering concepts, Revit and MDSolids. Lastly, multiple choice and application oriented evaluation tools were created or revised for each topic to better document teacher progress and understanding. The cost of the training was covered by charging schools \$129 per teacher per session, and through a grant from the TIME Center.

To reach the newly trained teachers who most need the PD, in addition to sending an email to all then current Maryland PLTW teachers, both the schedule and cost were posted on the UMBC Blackboard site for teachers attending the PLTW 2009 STI.

Based on teacher feedback, it became apparent that a manual was needed for use with fischertechnik. The TIME Center awarded CCBC a grant with matching funds from PLTW headquarters to develop a manual during summer 2009. The new manual provides teachers with a readily accessible source of information related to RoboPro software and fischertechnik components, including illustrations and step-by-step assembly instructions for the various PLTW projects and was utilized for the PD. Prior to the development of the manual, no documentation existed for teachers' use constructing the fischertechnik projects.

Train the Trainer Project Fall 2010

Based on the results of the 2007-8 and 2008-9 trainings, PLTW headquarters was contacted to ascertain the need for a national train-the-trainer PD model for the purpose of improving the effectiveness of teachers delivering the PLTW curriculum. That need was confirmed and seven Affiliate Universities in different regions of the United States were identified by PLTW to participate in the NSF sponsored training over a three-year period. The seven sites chosen by PLTW headquarters to participate are: Rochester Institute of Technology in New York (RIT); Sinclair Community College in Ohio (Sinclair CC); San Diego State University in California; University of South Carolina in South Carolina; Purdue University in Indiana; University of Texas at Tyler in Texas; and Milwaukee School of Engineering in Wisconsin. These sites were selected based on: their geographic location, in order to maximize coverage across the country; the number of schools in their region teaching the PLTW curriculum, to maximize the impact of the training; the interest of the Affiliate Director in participating in the training program, to maximize successful outcomes; and the proximity and availability of Master Teachers/professors, to conduct the training.

Trainers were identified by the Affiliate Director at the university and are either a Master Teacher, a university professor, or an experienced instructor with training and certification in the programs being taught. Once trained, the Coordinators and Master Teachers/professors from the Affiliate Universities conduct training for the PLTW teachers in their region during the school year. Training for Maryland teachers will continue as an ongoing test case from which to compare and modify work nationwide. The PD program will result in the training of more PLTW teachers, and will build a community of trained Master Teachers who can share best practices and provide feedback for ongoing enhancements to the program. The growing pool of trainers will also facilitate training for additional Affiliate Universities.

In Spring 2010, the Maryland Training Team (MTT) began working with three trainers and a Coordinator from RIT, the New York Affiliate University, and Sinclair CC, the Ohio PLTW Affiliate University. Representatives from the other five Affiliates will be trained over the next two years. Each of the Affiliate Universities will offer the PD training to the PLTW teachers in their region for the duration of the three year grant; reaching approximately 80 middle and high school teachers per year at each location. The NSF sponsored project is

expected to impact 260 secondary school teachers year one, 530 teachers year two, and 643 teachers year three, potentially impacting a total of 1,433 PLTW teachers and 36,000 secondary school students over the three-year period. To determine the effectiveness of the training, each site will collect data using the same teacher assessments. Teacher feedback is being collected through an online survey as well.

CCBC established Continuing Education classes for Inventor Level 1 and Level 2, fischertechnik Level 1 and Level 2, and CEA for each Affiliate University through the college's WebCT (BlackBoard) system. Hosting the classes on WebCT allows the MTT to readily share assessment materials, compile results, and maintain a record of teacher participation for Continuing Education credit. PLTW teachers signing up for a class first register via a dynamic web-based interface and database to collect background information on their PLTW training, including the location of the STI attended, when they were trained, and the number of times they taught a related PLTW course (if at all). The information is downloaded to an excel spreadsheet and required "student" information is manually entered into CCBC's system. Following a set of detailed instructions, teachers are then able to obtain their student ID and password in order to access the course(s) for which they registered.

The MTT instructs their counterparts from the Affiliate Universities in the methodology, organization of the training, and the assessment tools utilized for fischertechnik, Inventor, and software and applications for the CEA course - Revit, MDSolids and civil engineering topics. The CCBC Coordinator reviews materials related to communication, registration, general administrative requirements, and data collection and analysis with the Affiliate University appointed Coordinators. The Coordinator may be either from the University or a local community college as is the case with CCBC. Throughout the year, ongoing support in the way of technical assistance is provided to the trainers as needed in order to appropriately implement the training with local teachers. Assistance occurs through on-line and telephone communications.

At the end of the 2010-11 training period, CCBC plans to make its PD training materials and information available on the PLTW website where it will be available to all Affiliate Universities using a password-based login. PLTW Affiliate Directors will be provided access to current data, information, curriculum, materials, and the fischertechnik manual. Although funding is not available through NSF, the training or components of the program may be implemented at any site. In addition, questions from the assessments were made available to PLTW headquarters for inclusion in student assessments.

Program Content

The MTT created and codified materials needed to conduct the PLTW teacher PD. In order to do so, they determined the skills and course content needing reinforcement and enhancement in order for PLTW teachers to effectively instruct students in the use of the technical software and other applications. In their lesson plans, they also related skills to specific PLTW projects, and demonstrated use in broader applications. Based on input from the RIT and Sinclair CC trainers, the materials and topics were modified. During the training sessions, it is anticipated that the content will be modified further based on teacher need. In addition,

University Affiliates are encouraged to incorporate additional projects identified by industry in their region that incorporate skills needed by local employers.

The teacher training includes the following topics for fischertechnik Level 1: RoboPro introduction, variables, loops, functions, an overview of the POE/GTT Kit - part identification and assembly, hands-on projects, and review of support websites and materials, including the recently developed manual; fischertechnik Level 2: Support sites, GUI, multiple threads, pneumatics, and best practices; Inventor Level 1: 2010 software changes, Inventor “gotchas,” additive and subtractive extrusion, feature commands, parametric dimensioning, part creation within an assembly, work points, planes, axis, assembly constraints, presentation files, exploded views and parts list, and using the content center; Inventor Level 2: drive and motion constraints, rendering, animating, finite element analysis, and 3D sketch features; CEA civil engineering: beam and column calculations, beam size selection, reaction forces, moments, surveying, soil analysis, water runoff, water supply, and heat gain/loss; for Revit: setup screen and location of commands, creating walls and build-up (layers), 2D to 3D - viewing screen, window/door and other components, dimensioning, creating levels and roofs, top surface, room layouts, stairs, sections, grids, textures, walkthroughs, and camera/renderings; and for MDSolids: sizing beams and load analysis.

Teacher Survey

A teacher survey will be administered at the conclusion of each training session. The survey, developed by the external evaluator, is designed to provide insight into the effectiveness of the program.

Results and Discussion

Pilot Program 2007-8

Feedback on the training was very positive from all 8 middle school and high school teachers who attended the Inventor training and the 10 teachers who attended the fischertechnik training. Based on the self-assessment given before and after the training, content knowledge increased dramatically. On a scale of 1 to 10, with 1 = no knowledge, 5 = familiar with content and 10 = very knowledgeable/expert, the average score for all content areas for Inventor more than doubled, increasing by 4, from 3.7 to 7.7. The increase for fischertechnik was similar, increasing by 4.2, from 3.4 to 7.6. In post-instruction surveys, instructors were rated 10 on a scale of 1 to 10 for knowledge and effectiveness. The topics covered were rated from “helpful” (5) to “imperative to have” (10) on a scale of 1 to 10. In addition, teachers - especially the middle school teachers, appreciated being given a broader perspective of the capabilities of the software.

Pilot Program 2008-9

Data from the second year of PD suggests that the sessions were very effective in enhancing teachers’ technical skills and building teacher confidence. The average score on the post-training Inventor assessment (conducted as a self evaluation) was 7.2% higher than the pre-

training average after the first session, 27.6% higher after the second session, and 84.3% after the third session. Comments from teachers were all very positive and expressed a need for and interest in additional training.

Throughout the year, modifications were made to the evaluation tool, the structure of the classes and the content based on teacher input and in recognition of the disparity in knowledge base. In addition, some teachers were unable to attend all three sessions or did not complete the evaluation each time. As a result, fischertechnik testing showed overall improvement in scores, however, the results were not consistent. The first session of fischertechnik training yielded an average 26.5% increase in teachers' correct test score responses. After the second session, the scores were only 11.2% above the beginning scores. With the exception of one teacher whose score decreased, the balance saw increases of 6% to 28% in their scores. Comments from the teachers indicate the training was very beneficial. Teacher feedback was strongly complimentary, with many requesting additional time and training, particularly in advanced concepts. In the online forum, one teacher commented, "I haven't used RoboPro in over a year and I was very rusty...Once we started I felt very comfortable with the content," while another said of the fischertechnik session, "I wish we could explore this topic more." When asked who would like to attend training during the 2009/10 school year, 100% of the teachers in attendance stated that they would attend.

Based on the 2008-2009 PLTW training test results and feedback from the teachers attending the training sessions, the program was very successful but needs additional modifications. It became evident that Inventor and fischertechnik training needs to be conducted at two ability levels to make more efficient use of instruction time. In addition, only two sessions should be offered for each topic level to make optimum use of teachers' time, to maximize attendance at both sessions, and to minimize the need and cost for substitute teachers. Evaluation tools need to be targeted for the specific audience and the material to be covered in those sessions. In addition, teachers suggested the following times be avoided for training: Fridays, exam weeks, and end of semester time periods. Their input was incorporated into the 2009-10 program schedule.

Pilot Program 2009-10

In 2009-2010, Maryland schools experienced budget cuts resulting in many teachers being unable to attend the PD training due to the cost of the substitute. As a result, although a need existed for two levels of training for fischertechnik and Inventor, only Level 1 sessions were offered.

Both the fischertechnik and Inventor assessments were modified after the first session to better ascertain the teachers' understanding of software related concepts and the application of the software. Although the changes made a direct data comparison inapplicable, the post-training assessment results did show that the teachers had a good basic understanding of the fischertechnik building system and RoboPro, and were able to create drawings of varying complexity using Inventor following training.

A total of six teachers attended the CEA training; four the first session and four the second session - including two teachers who attended the first session. Of the six, only two had attended an STI. As a result, a greater amount of time was allocated to learning Revit during the first session than originally planned. Also, a broad range of civil engineering topics was covered rather than just MDSolids and structures as had been intended and initially assessed. On the structural assessment, the experienced teachers scored 8/14 and 4/14, and the rest scored 0. Based on the need for training in a variety of areas, the CEA PD was changed to incorporate each of the major civil engineering topics covered in the curriculum: structures, MDSolids, soil analysis, surveying, heat loss/gain, and water pressure.

Marketing of the program was found to be critical with respect to maximizing the number of teachers receiving training. In Spring 2010, dates of the 2010/11 training sessions were posted on Statewide training schedules. For some affiliates, it may be necessary to develop additional effective marketing and recruitment strategies. At the suggestion of the teachers, the MTT will begin offering Continuing Education credit in 2010-11 contingent on the teacher attending both sessions and completing all of the assessments. In addition, attendance at the PD training will be restricted to teachers who take the pre-assessment. With regard to the timing of the training, the first week of the host college's spring semester, long weekends, and secondary school standardized test days will be avoided.

Train the Trainer Project Fall 2010

The CEA assessment was administered at the conclusion of the UMBC 2010 STI CEA course. The results were hand tabulated and used to identify areas where teachers needed additional training. Teachers were asked for feedback on the assessment and some modifications were made accordingly. The scores on the CEA assessment varied from 45% to 87% with 5 of the 9 teachers scoring below 60%. On the Revit portion, 6 of 9 were between 60% and 70%, while on the civil engineering portion scores were more diverse ranging from 40% to 97% with 6 of the 9 between 51 and 71%. Nearly all of the teachers stated they could have done better if they had more time.

During the initial semester of the Train-the-Trainer project (Fall 2010), a total of 80 teachers (unduplicated headcount) participated in at least one training session held in Maryland or New York. Due to difficulties encountered by Sinclair CC in Ohio, which attempted to assimilate the training into an existing professional development program, the training was conducted over a much shorter period of time and very few teachers in Ohio were able to participate. Due to the low teacher participation and disparity in the training offered, pre- and post- assessment data for Ohio have been omitted from the data analysis.

Among the Fall 2010 Maryland and New York training participants, three-fourths were male and three-fourths were high school teachers (the others were middle school teachers). For those teachers reporting that they had previously completed STI training in the applicable subject area, the average time lapse between that training and the present training was 2 years for fischertechnik Level 1, 4 years for fischertechnik Level 2, 3 years for Inventor Level 1, 3 years for Inventor Level 2, and 3 years for CEA-Revit. Among those teachers reporting their prior classroom teaching experience in the applicable subject area, the breakouts were as follows:

	Have Not Taught	Taught 1-2 Times	Taught 3-4 Times	Taught 5+ Times
fischertechnik Level1	47%	35%	12%	6%
fischertechnik Level 2	21%	21%	32%	26%
Inventor Level 1	37%	28%	14%	21%
Inventor Level 2	32%	26%	16%	26%
CEA-Revit	31%	31%	23%	15%

There was a greater percentage of experienced teachers in attendance at the Level 2 training sessions than at the Level 1 sessions as would be expected, however, there was a surprisingly large percentage of inexperienced teachers in the Level 2 training sessions, especially ones who had never taught the corresponding course before.

Teachers were required to complete both pre- and post-assessments as part of the training. The table below provides a summary of results from the Fall 2010 teacher assessments by training topic, and only includes data for those teachers who completed both assessments. For the purposes of this analysis, teacher assessment scores from Maryland and New York are combined for each training topic. All assessment scores have been converted to a standard 100-point scale.

Fall 2010 Training Topic	N Teachers Completing Both Assessments	Average Pre-Test Score	Average Post-Test Score	Average Pre to Post Score Δ	% Teachers Increasing Pre to Post Scores	% Teachers Decreasing Pre to Post Scores
CEA-Civil Engineering	12	31.4 Low to High Range: 9-51	40.1 Low to High Range: 16-65	+8.7 (+28%)	67%	33%
Revit	12	40.9 Low to High Range: 12-90	54.5 Low to High Range: 25-87	+13.6 (+33%)	83%	17%
fischertechnik Level 1	20	44.1 Low to High Range: 3-72	53.1 Low to High Range: 34-68	+9.0 (+20%)	65%	35%
Inventor Level 1	25	21.6 Low to High Range: 0-66	26.6 Low to High Range: 5-71	+5.0 (+23%)	72%	28%

Fall 2010 Training Topic	N Teachers Completing Both Assessments	Average Pre-Test Score	Average Post-Test Score	Average Pre to Post Score Δ	% Teachers Increasing Pre to Post Scores	% Teachers Decreasing Pre to Post Scores
Inventor Level 2: Multiple Choice	20	36.1 Low to High Range: 16-74	58.4 Low to High Range: 37-84	+22.3 (+62%)	95%	5%
Inventor Level 2: Drawing	19	67.0 Low to High Range: 39-79	83.9 Low to High Range: 64-100	+16.9 (+25%)	100%	0%

The results of the assessments show large increases in the average score from the pre- to the post test, ranging from 16.9% to 33%. The increases were most notable at the low end of the range. In addition to completing the pre- and post-assessments, participating teachers were asked to respond to a brief survey at the conclusion of each training session. The purpose of the survey was to gain feedback about their satisfaction with various aspects of the training and to assess its perceived impact on their knowledge and skills related to the subject matter, particularly as teachers were looking ahead to incorporate what they had learned from the training into their teaching. The survey contained both Likert-scale questions and open-ended questions.

When asked to rate the quality of their training experiences on a scale from 1 (“lowest”) to 5 (“highest”), teachers (N=81 survey respondents) indicated the following:

Survey Items: Aspects of Training	Mean Response
Registration process	3.53
Instructor knowledge	4.75
Instructor responsiveness	4.78
Interactions with other teachers	4.38
Pace of training	4.14
Amount of material covered	4.06
Use of technology	4.31
Training facilities	4.10

Using a scale from 1 (“strongly disagree”) to 5 (“strongly agree”), teachers were also asked to indicate the extent to which they agreed or disagreed with the following statements related to the training:

Survey Items: Perceptions of Training	Mean Response
I feel well prepared to integrate what I learned through this training into my teaching.	3.92
I believe that I would benefit from additional training support related to this topic.	4.29
I would return to this same site for additional PLTW training in the future.	4.37
Overall, this training met my expectations.	4.04

The results of the quantitative survey items were positive and were echoed in the open-ended teacher responses to the survey, particularly with respect to the effectiveness and responsiveness of the master teachers who led the sessions, and teacher receptiveness to attending additional training in the future. When asked on the survey how the training had impacted them, teachers frequently indicated that it had increased their knowledge and confidence in working with the software applications, and that it had provided them with new ideas and resources for teaching the PLTW curriculum. As one teacher elaborated on his/her training experience, “I feel this course has been a good refresher. There were several concepts that were previously unclear that I now have some understanding of. However, I could benefit from future sessions.”

When asked about any challenges they were anticipating in incorporating what they had learned from the training into their teaching, participants most frequently cited their concerns about technical challenges working with the hardware and software, the availability of sufficient numbers of fischertechnik kits and materials in their schools, and the pressures of on-the-spot troubleshooting with their students. In the written comments on the survey, several teachers mentioned the steep learning curve that they anticipated for their students, many of whom do not have adequate preparation in mathematics. Others pointed to their own need for ongoing practice and professional development with the applications, so they do not lose the knowledge and skills gained from the training. As one teacher shared, “Some of the materials learned will not be used immediately, and so I will need to revisit what was learned in this professional development.” Another participant explained, “The biggest challenge will be sufficient knowledge of the material that will allow me to confidently teach the concepts to my students. I will definitely need to thoroughly review each topic prior to delivering it to the students.”

In a follow up email, one teacher commented that he had learned a lot but did not have enough time on the assessment to demonstrate all that he was able to do. This remark was echoed by a number of teachers and will be incorporated in program changes for 2011-12.

Conclusion

The results of the Fall 2010 training demonstrate that the PLTW PD sessions have been very effective in boosting technical skills and building teacher confidence. Teacher feedback consistently included requests for additional time as well as training in advanced concepts. By

specializing training to address higher skill levels, PLTW teachers are able to ensure that their students' capability to excel is not limited by their own lack of advanced instruction.

Based on the results of the pilot programs, the MTT has found that having an assessment that accurately determines a teacher's content knowledge is critical to determining the success of the training as well as the preparation of the teacher to teach the curriculum. Adding an "I do not know" option eliminated the impact of guessing while allowing for teachers to make an educated choice when they are not sure of an answer. Also, structuring the assessments in multiple parts for application oriented questions allowed teachers to answer more questions and demonstrate their knowledge of different aspects of an application. Previously, if a teacher reached a step they were unable to complete, they would not have been able to respond to any further questions.

The train-the-trainer program continues to evolve with new lessons learned and input from new MTs and APs and feedback from the teachers taking the training. One of the main lessons learned from the Fall 2010 session is the importance of following the program as it is designed. The MTT has learned many lessons over the past several years and the structure of the program is designed to avoid difficulties encountered in the past. Other lessons learned and suggestions under consideration include: making the assessments all multiple choice, setting deadlines for taking the assessments recognizing that most teachers will wait to take the assessment right before the deadline, combining the Revit and civil engineering assessments, and posting information on the training as early as possible. Moving forward, the MTT will collaborate with Affiliate Universities relative to pedagogy process improvement to continue to strengthen training as it is offered in future years.

Changes to the PLTW curriculum will also result in changes to the training program. For example, the fischertechnik manual was to be updated on an annual basis to incorporate any curriculum changes, however, PLTW recently announced that starting in 2011-12, VEX robotics will be used in the curriculum instead of fischertechnik. This change will require a major revision to the training program, necessitating the creation of new assessments and lesson plans.

So far, through CCBC's training program, 40 teachers representing ten counties in Maryland have received PLTW professional development training; and through the NSF funded train-the-trainer program, 43 New York PLTW teachers received training as well. The training has established a line of communication and support for teachers, offered additional projects and topics to cover with students and addressed different learning styles. Most importantly, it has enhanced teacher knowledge and raised confidence in their ability to deliver material on various software applications to their classes.

References

1. Patton, Madeline. "Teaching by Choice: Community Colleges Expand K-12 STEM Pathways and Practices," American Association of Community Colleges, Washington, DC, 2008

2. Yasar, Senay, et al. "Development of a Survey to Assess K-12 Teachers' Perceptions of Engineers and Familiarity with Teaching Design," *Engineering and Technology, Journal of Engineering Education*, July 2006, Vol. 95 No. 3 p 205-216
3. Garrett, Joyce Lynn. "STEM: The 21st Century Sputnik," *Kappa Delta Pi Record*." Indianapolis; Summer 2008. Vol. 44. Iss 4; p 152-153
4. Brophy, Klien, and Portsmore, Meredith. "Advancing engineering education in P-12 Classrooms," *Journal of Engineering Education*, 2008, 97(3), 369-387.
5. Hawes, Julia. "Educators engineer programs to excite students about science," *Medill Reports*, March 5, 2009
6. Halcerz, Douglas. "Report on the Third Year of Implementation of the TrueOutcomes Assessment System for Project Lead the Way," 2006 – 2007, pp. 36-42
7. Bottoms, Gene, and Wlm, John. "Project Lead the Way © Works: A New Type of Career and Technical Program," *Southern Regional Education Board Research Brief*, September 2007, p. 4.