Issues for Universities Working With K-12 Institutions Implementing Prepackaged Pre-Engineering Curricula such as Project Lead the Way

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Abstract:

The implementation of pre-engineering, standard curricula in K-12 schools is growing at a rapid pace. One such curriculum model, Project Lead the Way, consists of six standardized courses requiring significant training for teachers, specified laboratory equipment, standard topics, exams, etc. Schools implementing Project Lead the Way implement an entire series of courses and commit to each aspect of the program in order to become a certified Project Lead the Way school. This implementation typically requires significant change for the schools, often requiring funding, building renovation, laboratory development and requirements for teachers and guidance counselors. Schools are also required to invite industry and academia to form an advisory board. This particular program has grown from 13 schools with 1100 students in 1997-1998 to 65,000 students in 43 states by 2004. The state of Indiana has encouraged schools to adopt the program, and has over 120 school districts with over 20,000 students in Project Lead the Way.

This paper will detail issues involving higher education institutions working with high schools implementing prepackaged curricula, including assisting in identifying funding sources, teacher training, and laboratory development. Model articulation agreements will be presented. This discussion will apply to a growing number of institutions of higher learning as more K-12 standards are adjusted to include technology or pre-engineering. The principles discussed here will help any K-12 and higher education institutions work together to more effectively promote engineering at the K-12 level, and will apply to any pre-engineering curriculum. Additional Internet links available in the paper will direct interested parties to sample articulation agreements, and supplemental material available for some of the courses suitable for use by teachers or students.

This paper will also detail issues from the K-12 sector, including effectively incorporating these courses in student schedules, and dealing with state and national standards.

The authors have extensive experience, having assisted area K-12 schools in efforts to implement pre-engineering curricula, including the establishment of articulation agreements with these schools and assistance in securing necessary funding.

Key Phrases:

- Educational considerations in the pre-college environment
- Engineering-based curriculum development
- Adoption in schools
- Curriculum standards
- University-school interaction
- Assessment/Evaluation
- Engineering content in science and mathematics instruction
- Activities that stimulate student interest in engineering careers
- Pre-college programs

Review of the Literature:

In a recent publication by the National Academy of Engineering titled, *"The Engineer of 2020: Visions of Engineering in the New Century*, the authors discuss a vision for the future of engineering and engineering technology {1}. The authors ask if it "serves the nation well to permit the engineering profession and engineering education to lag technology and society, especially as technological change occurs at a faster and faster pace…….or, should the engineering profession anticipate needed advances and prepare for a future where it will provide more benefit to human-kind"{1}? The study suggests that if the engineering profession is to take the initiative in defining its own future it must proactively deal with five issues: 1) agreement on an exciting vision for the future; 2) transformation of engineering education to help achieve the vision; 3) development of a clear image of the new roles for engineering, including as broad-based technology leaders, in the minds of the public and prospective students who can replenish and improve the talent base of an aging engineering workforce; 4) accommodation of innovative developments from non-engineering fields; and 5) discovery of ways to focus the energies of the different disciplines of engineering toward common goals{1}.

Clearly, engineering education is at a crossroads. The issues delineated above are all related to pro-active strategic visioning, strategic planning, education and the use of new and innovative technologies to attract the next generation of leaders within the field; and the field is growing increasingly deep and wide. Certainly, the creation of a "feeder system" to

science, technology, engineering and math (STEM) careers at the K-12 level is paramount to the effort. In addition, graduate education opportunities provided by schools of engineering, engineering technology and education for secondary STEM instructors will play a key role in the visioning and strategic planning process. New teaching and learning technologies in the area of distance learning will most certainly impact the delivery of courses for the foreseeable future. However, to provide a quality graduate education experience at a distance requires strategic planning and visioning in the areas of pre-planning, training, implementation, assessment and feedback.

Recently, the American Society for Engineering Education (ASEE) has embarked on an ambitious effort to promote and improve K-12 engineering and engineering technology education. Since 2003, the ASEE has created a new K-12 division dedicated to K-12 engineering education, created a guidebook for high school students called Engineering, Go for It! that was distributed to almost 350,000 secondary students, created an e newsletter that reaches 10,000 secondary teachers, guidance counselors, and outreach program leaders, and created a survey to understand what secondary teachers think of engineering as an academic and career pathway for their students. Finally, ASEE brought together leaders from industry and higher education along with K-12 teachers for a Leadership Workshop on K-12 Engineering Outreach, held just before the ASEE 2004 Annual Conference and Exposition in Salt Lake City, Utah. A recent paper detailing the results of that conference and delineating guidelines for how K-12 engineering education works best and defines key challenges confronting the field was recently published{2}.

Clearly, there is a movement by the engineering and engineering technology communities to gain a better understanding of the K-12 issues that impact enrollment at post-secondary institutions, and to generate research to answer the question of how stakeholders from many levels – K-12 teachers, university professors, industry, and government representatives – can advance the state of engineering and engineering technology education. Coupled with the information from the aforementioned surveys, the ideas and suggestions from conference attendees and current research in the field of K-12 education, Dougless, Iversen and Kalyandurg have developed a set of six guidelines for improving K-12 engineering education and outreach:

1. *Hands-on learning*: Make K-12 science curriculum less theory-based and more context-based, emphasizing the social good of engineering and demonstrating how it is relevant to the real world
2. *Interdisciplinary approach*: Add a technological component to all subjects and lessons, and implement writing guidelines in math and science courses
3. *Standards*: Involve engineering in K-12 lessons that map to state standards for math and science. Further, states should follow Massachusetts and enact state standards for engineering
4. *Use/Improve K-12 Teachers*: Engage more K-12 teachers in outreach efforts and curriculum writing, and increase teacher salaries to attract the best technological minds to teaching
5. *Make Engineers "Cool"*: Outreach to urban schools and females more aggressively, and create more mentors and role models to attract these constituencies
6. *Partnerships*: Create better incentives for all groups to engage in K-12 outreach (especially higher education and industry){2}

According to Dougless, Iverson and Kaylendurg there is no magical list of recommendations to promote and enhance engineering education in the K-12 world, but these six guidelines emerge from current outreach efforts and seek to move them a step further, offering a broader base for improving the quality, methodology, and reach of K-12 engineering education{2}. A key component to all six of these recommendations is recommendation number four: *Use/Improve K-12 Teachers*. Without quality K-12 instructors in STEM areas, the pathways for students to be a part of post-secondary STEM degree programs will be filled with barriers. With a renewed focus on the quality of secondary STEM instructors, the issue of university involvement in the creation of delivery of professional development for K-12 STEM instructors is an ongoing question.

One of the strongest indicators of a student who will successfully navigate the "pipeline" to college is rigorous high school curriculum that has been specifically mapped during a consultation with high school counselors, parents/guardians and the high school student, according to Horn {3}. Adequate academic preparation is crucial to this matriculation and if a student, especially an at-risk student, has not taken courses to sufficiently prepare for university level work, the odds are great that he/she

will not be successful in a four year program. An increasing number of states are also giving greater emphasis to pre-engineering in the K-12 curriculum, including the adoption of programs such as Project Lead The Way (PLTW) {4}. PLTW is one such rigorous, well planned plans of study implemented in the middle school and high school.

Project Lead the Way:

PLTW is a prepackaged high school curriculum in which students are introduced to engineering and engineering technology through a series of rigorous academic courses. Curriculum, textbooks, software and labs are standardized throughout the experience regardless of geographic location, and all PLTW teachers undergo extensive training in curriculum, pedagogy and delivery of the program. Project Lead the Way is a hands-on, contextual curriculum that uses an interdisciplinary approach and is based on national, state and local Science, Technology, Engineering and Math standards.

According to the official website, Project Lead The Way Inc. (PLTW) is a national program forming partnerships among Public Schools, Higher Education Institutions and the Private Sector to increase the quantity and quality of engineers and engineering technologists graduating from the education system. First developed in the 1980's, PLTW is now offered in 45 states and the District of Columbia. {5}

Project Lead The Way provides local, state and national organization for leadership and support, a model curriculum, teacher training and development through its affiliation with some of the nation's leading colleges and universities, and a network of consultants throughout the country. Today, Project Lead The Way is the nation's leading pre-engineering middle school and high school program.

Among the core values listed by Project Lead The Way are those similar to objectives for many university programs:

- Committing to diversity promotes opportunities for individuals, enhances creativity and strengthens organizations.
- Individuals and teams working in a culture of collaboration toward clear and common goals achieve greater satisfaction and superior results.
- The passionate and unwavering pursuit of continuous improvement is essential to high levels of achievement.
- All people are capable of achieving at higher levels and deserve the opportunity to achieve their full potential.
- Learning is a lifelong process.
- Honesty, integrity and the highest ethical standards are essential attributes of an effective organization.

Project Lead The Way has developed a comprehensive strategic plan in an effort to further its mission and vision. Again, many of the goals of PLTW correspond with goals of many universities:

- By the end of the second year of membership in PLTW each school will have an effective school partnership team.
- By 2005, 100% of PLTW students will meet college entrance requirements for engineering and engineering technology; of those students, at least 90% will successfully complete their first year of further study and at least 75 % will graduate from two or four year engineering and engineering technology programs.
- By 2005, the enrollment of females in PLTW courses will be 10 percentage points higher than the current female national enrollment in engineering and engineering technology programs. In addition, the racial and ethnic minority student population in schools with PLTW courses will be collectively proportionate to the overall state population.{5}

Project Lead The Way has developed a comprehensive middle school and high school curriculum; the high school curriculum will be described here. The High School Program is a four year sequence of courses which, when combined with traditional mathematics and science courses in high school, introduces students to the scope, rigor and discipline of engineering prior to entering college. However, those not intending to pursue further formal education will benefit greatly from the knowledge and logical thought processes that result from taking some or all of the courses provided in the curriculum.

The foundation courses are:

- Principles of Engineering - A course that helps students understand the field of engineering/engineering technology. Exploring various technology systems and manufacturing processes help students learn how engineers and technicians use math, science and technology in an engineering problem solving process to benefit people. The course also includes concerns about social and political consequences of technological change.

- Digital Electronics - A course in applied logic that encompasses the application of electronic circuits and devices. Computer simulation software is used to design and test digital circuitry prior to the actual construction of circuits and devices.
- Introduction to Engineering Design - A course that teaches problem-solving skills using a design development process. Models of product solutions are created, analyzed and communicated using solid modeling computer design software. In New York state, the course is called Design and Drawing for Production and follows the syllabus developed by the State Education Department.
- Computer Integrated Manufacturing - A course that applies principles of robotics and automation. The course builds on computer solid modeling skills developed in Introduction to Engineering Design, and Design and Drawing for Production. Students use CNC equipment to produce actual models of their three-dimensional designs. Fundamental concepts of robotics used in automated manufacturing, and design analysis are included.
- Civil Engineering and Architecture - This course provides an overview of the fields of Civil Engineering and Architecture, while emphasizing the interrelationship and dependence of both fields on each other. Students use state of the art software to solve real world problems and communicate solutions to hands-on projects and activities. This course covers topics such as: The Roles of Civil Engineers and Architects, Project Planning, Site Planning, Building Design, Project Documentation and Presentation
- Engineering Design and Development - An engineering research course in which students work in teams to research, design and construct a solution to an open-ended engineering problem. Students apply principles developed in the four preceding courses and are guided by a community mentor. They must present progress reports, submit a final written report and defend their solutions to a panel of outside reviewers at the end of the school year.

Two new courses are currently offered for the first time in 2005:

- Aerospace Engineering - The Aerospace Engineering curriculum will be a systemic curriculum package that will introduce students to the world of aeronautics, flight, and engineering.
- Biotechnical Engineering - Biotechnical Engineering will be one of the specialty courses in the PLTW pre-engineering curriculum, which applies and concurrently develops secondary level knowledge and skills in biology, physics, technology, and mathematics. It includes experiences from the diverse fields of Bio-technology, Bio-engineering, Bio-medical engineering, and Bio-molecular engineering. {5}

Project Lead The Way has developed a sample student schedule that helps high school students envision a four year course of study available during their high school years (see table 1).

Sample Student Schedule

Grade 9			Grade 10	
English 9	1 unit		English 10	1 unit
Social Studies 9	1 unit		Social Studies 10	1 unit
Math 9	1 unit		Math 10	1 unit
Science 9	1 unit		Science 10	1 unit
Foreign Language	1 unit		Foreign Language	1 unit
Principles of Engineering	**1 unit**		**Intro To Engineering Design**	**1 unit**
Physical Education	.5 unit		Physical Education	.5 unit
Grade 11			**Grade 12**	
English 11	1 unit		English 12	1 unit
Social Studies 11	1 unit		Social Studies 12	1 unit
Math 11	1 unit		Math 12	1 unit
Science 11	1 unit		Science 12	1 unit
Digital Electronics	**1 unit**		**Engineering Design**	
*** Choice of PLTW specialty course**	**1 unit**		**and Development**	**1 unit**
Physical Education	.5 unit		Health	.5 unit
			Physical Education	.5 unit

* Choices include **Computer Integrated Manufacturing, Civil Engineering and Architecture, Biotechnical Engineering** or **Aerospace Engineering**,

Table 1: Based on Sample Student Schedule: Copyright; 1999 - 2004 Project Lead The Way Inc., Clifton Park NY.

Teacher Training:

Teachers in programs for which articulation agreements are envisioned must be capable and adequately trained to deliver content for which college credit will eventually be awarded.

High school teachers in the PLTW program begin their training by completing an online assessment of skills self-test and questionnaire. The purpose of this assessment process is to assure that all teachers arrive for the summer institute training ready to prepare for their September teaching assignment. They then participate in a 2-week summer institute, where they are trained in the curriculum to be used in their PLTW course. These courses are two weeks, full time classes with homework, projects and exams. The courses are typically offered at a University within the teacher's home state, and in some cases, can be taken for college credit. Each teacher must successfully complete this course prior to teaching a PLTW course. Other courses are offered after the initial training for enrichment. Instructors for enrichment courses are also certified by PLTW, and attend training prior to being certified as an Affiliate Professor.

The School District Agreement executed between the local school corporation and the national Project Lead the Way organization ***requires*** that any person assigned to teach PLTW courses will attend the training session(s) and have at least a baccalaureate degree.

Funding and Implementation:

The State Departments of Education and, in Indiana, the State Department of Workforce Development have been key funding agencies for the adoption of programs such as Project Lead The Way. The Indiana Department of Workforce Development has awarded grant dollars to secondary and post secondary partners to accomplish tasks such as:

- establish articulation agreements between secondary and post secondary schools, giving students who successfully complete PLTW and other approved curricula (such as computer programming courses) college credit
- establish the development of a summer course for K-12 teachers offered in cooperation with a post secondary institution, and
- set up advisory and review boards for schools implementing pre-engineering curricula {6}

The Indiana Department of Education has played an active role in the statewide implementation of Project Lead The Way with teacher certification and reimbursement to schools and school corporations for students who complete Project Lead The Way courses. As of December, 2004, over 100 Indiana middle and high schools offered PLTW courses to nearly 14,000 students. {7}

A grant from the Indiana Higher Education Telecommunication System (IHETS) {8} funded the development of online curriculum assistance modules for the Digital Electronics course. These modules are available over the Internet for use by teachers or students, or teachers that may wish to implement extra material into the class. The modules can be viewed from:

http://www.iupui.edu/~ecet109/

Additional materials such as these Internet modules have been well received by high school teachers; those teachers informally surveyed before the start of the school year all indicated that they plan to use these modules in their classes.

Articulation Agreements

Students completing the PLTW courses have the option of a final exam which can be used to demonstrate mastery of course content. Students passing the course with a sufficient score on this exam are eligible for credit from partner universities including Rochester Institute Of Technology and Purdue University. Students scoring 85% or better plus a 70% or better on the exam receive credit from RIT. Students may receive three college credits in the Department of Industrial Technology at Purdue University by completing an eligible PLTW course with a 'B' or better from a PLTW certified school, scoring 70 or above on the college credit exam, and by enrolling in IT, ID, or Technology Education programs. Individual partner schools establish agreements, with specific details on the Project Lead The Way website. Other universities including Indiana University Purdue University Indianapolis IUPUI have established articulation agreements for most of the PLTW courses. These agreements were piloted as agreements between the university and an interested school district; these agreements were then reviewed and offered as blanket agreements to any school system nationwide implementing the PLTW curriculum. Other agreements for specific courses or programs have also been developed, but programs that do not have a standard curriculum must be reviewed and considered on an individual basis. One sample agreement is included as an appendix: other articulation agreements are available for review at IUPUI School of Engineering

and Technology web site:

http://www.engr.iupui.edu/k_12/index.shtml

In this example, students completing the Digital Electronics course with a 'B' or better, scoring a 70% or more on the final and with a 'B' or better in Advanced Algebra or higher will receive credit for ECET 109 (Digital Fundamentals) which applies to plans of study for students seeking degrees in Electrical Engineering Technology, Computer Engineering Technology or Biomedical Engineering Technology. These credits are offered at no cost to the student.

Specific articulation agreements that have been developed with the PLTW program are as follows:

PLTW Digital Electronics = ECET 109: Principles of Digital Electronics
PLTW Civil Engineering and Architecture = CNT 105: Introduction to Construction Technology
PLTW Principles of Engineering = CNT 100: Construction Elective Credit

Other prepackaged curricula articulation agreements include

MOS/MOUS Certification = CIT 106: Using a Personal Computer
A+ Certification = 2 credits towards a 3 credit ECET 234: PC Systems I

Additional articulation agreements have been issued on a case by case basis with individual schools on the area; however, those that do not include a prepackaged curriculum or rely on some certification require that the university and high school actively communicate to be sure that the course operates at an expected level year after year.

Lessons Learned through the Articulation Process

Through the course of developing articulation agreements, the main lesson learned is that it is essential to review the curriculum of the school, visit the laboratory facilities, and review some of the exam material and student work if possible. Schools that have courses similar in scope to courses offered in a program at a university may cover vastly different areas. Prepackaged curricula certainly streamline the process, as the laboratory equipment is specified and exams cover a certain defined amount of material.

Digital Electronics can be used as an example. Most courses in Electrical Engineering Technology have an introductory course in Digital Electronics, and many high schools have a course with a similar name. Some of these courses are run as a pre-engineering course, and others are run as vocational courses, leading to significant differences in the rigor and assessment of student success. For example, three schools in the Indianapolis area were reviewed for articulation agreements. One school which had implemented Project Lead The Way had the standard, required laboratory and exams, required students to maintain a portfolio, and had designed a course with a level of rigor nearly equivalent to a first semester freshman level course. Students in this classroom were finishing the year working on designs they created, preparing written reports and oral presentations, and maintaining written documentation of their design process. This school served as a prototype in the development of the state-wide articulation agreement with any PLTW school.

One school had an existing, well-respected program in existence for 20+ years, with a very well-developed laboratory; they used programmable devices (used within the IUPUI course), they had rigorous exams, and we saw very motivated students during the classroom visit. An articulation agreement, very similar to the PLTW agreement, was written. The only change was that we require a periodic review of the curriculum, and require that the high school notify IUPUI if there are any significant changes to the curriculum or if they use a new course coordinator.

An inner-city school with a vocational electronics course was investigated for articulation. Although this school had an exceptionally strong instructor, the students were largely unmotivated, and they were not generally able to cover a sufficient amount of material during the school year. IUPUI was able to assist the instructor with supplemental Web pages and sample laboratories. The agreement written with this particular school awarded students credit on a case-by-case basis with an instructor recommendation. This agreement was in effect for three years, and we had no inquiries from this program. The program has since lost their instructor, and the school district is adopting PLTW, which will effectively end their vocational electronics program.

One more example of a non-PLTW curriculum leading to an articulation involves a high school with a very strong computer programming sequence. They have a two-year sequence involving programming in Visual Basic, C++ and Java. A review of their curriculum showed that they studied Object Oriented programming, a requirement of IUPUI Electrical and Computer

Engineering programming course. Students ended their two-year sequence with a substantial design project; the textbook, exams and curriculum were sufficiently complete and rigorous. Students completing this two-year sequence are granted credit for ECET 164: Applied Object Oriented Programming. This agreement again stipulates that IUPUI must be notified of any significant changes in curriculum or instructor.

Universities interested in articulating with high schools should review the following before establishing an agreement:

- Review the curriculum, including depth of instruction to assure adequate coverage of material,
- Meet the instructor; discuss topics that are covered to be sure of a sufficient background
- Review exams to compare their rigor to those from the university,
- Review laboratory equipment and experiments,
- Include language requiring the student to enroll in the desired departments, following the appropriate plan(s) of study, and
- Have agreements signed by all parties from both institutions. The university signatures should go sufficiently high to ensure that credit can be granted.

Conclusions:

The Project Lead The Way program is quickly being implemented in middle schools and high schools nationwide, introducing many students to engineering and technology who may not otherwise be exposed to engineering or technology. With requirements for rigorous teacher training, counselor training, school certification, curriculum and required laboratory equipment, this program offers a standard of high quality and consistency. Students and parents have described the program as valuable and challenging, and industrial advisory board members have praised the program during visits.

PLTW and similar programs should increase the pool of students ready, willing and able to enter engineering and technology from high school. Students from the PLTW program who have passed the final exam should be excellent candidates to receive credit through articulation agreements.

There are many opportunities for university faculty and industry representatives to assist in the implementation of these prepackaged curricula, including volunteering to serve on advisory councils, participation in the classroom or assisting in the development of projects for students in project courses.

Schools wishing to articulate to offer college credit benefit from prepackaged curricula; other individual high school programs require additional monitoring to ensure that they meet the requirements set forth by the university.

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Appendix A: Articulation Agreement for Digital Electronics

Note that this agreement is only signed by university officials: This agreement applies to any school implementing the Project Lead The Way curriculum. Individual agreements would also be signed by the high school and administration.

ARTICULATION STATEMENT
From the
Purdue School of Engineering and Technology (IUPUI)

The Purdue School of Engineering and Technology, Indiana University Purdue University Indianapolis (IUPUI) hereby announces this articulation agreement effective April 1, 2005 for students who have completed the following courses of instruction:

- One year of Project Lead the Way (PLTW) Digital Electronics
    - o with a grade of B or higher
    - o pass the College Credit exam with a 70% or better
- Math course(s) of Advanced Algebra or higher (with grades of B or higher)

while attending any Project Lead the Way Certified high school.

The purpose of this agreement is to:

1. Encourage students who are attending a Project Lead the Way Certified high school to further their careers by enrolling in an advanced course of study at the Purdue School of Engineering and Technology.

2. Eliminate repetition and unnecessary duplication of academic experiences already acquired while enrolled in their secondary school program and aid in more appropriate placement in an undergraduate curriculum of their choice.

3. Encourage increased dialogue between administrators, staff and teaching faculty of both institutions in order to promote academic and occupational awareness, information exchange, and understanding.

The agreement:

1. During the senior year at a Project Lead the Way Certified high school, the individual student should make application to Indiana University Purdue University Indianapolis and successfully fulfill all admission requirements for an academic program offered within the Purdue School of Engineering and Technology. The student should take the SAT or ACT test while in high school, preferable early in the senior year.

2. The student will complete all placement tests that may be required for admission and enroll on campus as a new student. Enrollment may be on either a full-time or part-time basis as the student may determine. Under terms of this agreement, if matriculation at IUPUI is delayed for any reason, enrollment must occur within a period of 27 months following high school graduation to earn credit.

3. The student will furnish the Purdue School of Engineering and Technology an official high school transcript verifying completion of ***PLTW Digital Electronics*** with a grade of "B" or above, and completion of at least two semesters of mathematics at a level of ***Advanced Algebra*** or above with a grade of "B" or higher. Students will also furnish proof that they have passed the PLTW college credit exam with a score of 70% or better.

4. Upon completion of steps 1 through 3 as listed above, the Purdue School of Engineering and Technology will notify the IUPUI Registrar that the student is to be awarded three semester hours of academic credit for ECET 109: Digital Fundamentals without additional charge. This credit will be recorded as "Special Credit" on the academic transcripts, without a specific grade, and will be excluded when calculating the student's grade point average. There will be no cost to the student for Special Credit obtained in this manner.
5. The Purdue School of Engineering and Technology will make available to students a description of all college level courses, which are offered through an articulation agreement and identify how these courses will be considered in enabling a student to fulfill academic requirements for a degree.

6. Project Lead the Way certified high schools should identify and publicize this opportunity in an appropriate manner for all eligible students.

7. It is understood that Project Lead the Way certified high schools agree to ensure that the Project Lead the Way curriculum is followed in the Digital Electronics class. All parties understand that any changes made in the course syllabus, in instructional contact, or in instructional equipment or laboratory experiences afforded to the student may result in immediate termination of this agreement.

This agreement will become effective upon approval by the Purdue School of Engineering and Technology for all students who are enrolled in the course noted above during academic year 2004-2005 and thereafter. The agreement will continue on an annual basis unless terminated by the Purdue School of Engineering and Technology. Articulation agreements, however, are not retroactive prior to the specified period.

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Purdue School of Engineering and Technology

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