The One-Room Math Schoolhouse in a Manufacturing Environment

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Abstract

This paper will describe in detail three self-paced University level Mathematics courses initially developed at Focus:HOPE for the Greenfield Coalition. These courses have been delivered at Focus:HOPE which is the location of a new engineering paradigm in engineering education. This paradigm is a National Science Foundation (NSF) funded project called the Greenfield Coalition and the academic delivery is through computer-based instruction and self-paced learning activities.

The courses have been offered individually as a self-paced learning experience and more recently, all three together in a “one-room schoolhouse” concept. The purpose of the “one-room schoolhouse” is to provide help to those individuals who have problems with some of the content. The schoolhouse is unique because its delivery is via Video Teleconferencing. Therefore, the students can be at Focus:HOPE and interact with the mathematics instructor on the university campus. Included is the description of the structure of the courses, materials used, a summary of our experience in administering them and our vision for the future of such courses.

Introduction

The technical calculus course described in this paper was developed in the summer of 1996 by Professor Barbara Chambers of Northern Virginia Community College and Professor Pamela Lowry of Lawrence Technological University for the Greenfield Curriculum at Focus:HOPE in Detroit, MI. Focus:HOPE is a metropolitan Detroit civil and human rights organization; it was founded in 1968 following the 1967 Detroit riots, by Eleanor Josaitis and Father William Cunningham. The goal of Focus:HOPE is to help build a strong community among people of diverse backgrounds through practical action to overcome racism, poverty, and injustice.

Focus:HOPE began with a food service program, Tec Express, for low income families and senior citizens. Over the years it has expanded to include the following:

1) Fast Track, the first level of Focus:HOPE's three-tiered technology training program, is outfitted with 146 personal computers in two computer labs where candidates tackle math, reading and writing concepts and applications. This is an intense program that lasts for seven weeks, six days per week. [1]

2) Machinist Training Institute (MTI) constitutes the second level of Focus:HOPE's three-tiered technology training program. The MTI, a yearlong, full-time program, teaches precision metalworking, machining, and computer-aided design and manufacturing (CAD/CAM) through classroom instruction and hands-on experience. Candidates learn to set up, operate, and maintain conventional lathers, mills, grinders, and Computer Numerical Control (CNC) equipment.[1]

3) The Center for Advanced Technologies (CAT) is a national demonstration of the content, resources, and methodology needed to educate advanced manufacturing engineer-technologist at world-class levels. The pinnacle of Focus:HOPE's three-tiered technology training program, the CAT offers a technology and engineering degree program in which candidates learn to use expertly computer-integrated, flexible manufacturing equipment and systems. The innovative curriculum, designed and conducted through five universities and six industry partners, aligns engineering instruction to the equipment and process challenges of actual production contracts.[1]

The Greenfield Curriculum is funded by the National Science Foundation (NSF) and it is a grant that was awarded to the following: Five universities which include Wayne State University, Lawrence Technological University, The University of Detroit Mercy, The University of Michigan and Lehigh University under the direction of Dr. Fred W. Beaufait, Director, Greenfield Coalition and Lloyd Reuss, CAT Executive Dean. The CAT's Industry Partners include: Detroit Diesel Corporation, Ford Motor Company, General Motors Corporation, Chrysler Corporation, Cincinnati Milacron and EDS together with the Society of Manufacturing Engineers.[1] There are three degree pathways; (1) an Associate Degree in Manufacturing Technology from Lawrence Technological University, (2) a Bachelor of Manufacturing Technology from Wayne State University and (3) a Bachelors in Manufacturing Engineering from University of Detroit Mercy.

The typical candidate is 20 years old or older and has progressed through the Fast Tract and MTI programs to be eligible for the CAT. They work full-time beginning their day at 6:00 am and ending at 2:30 pm. At 2:45 - 5:45 pm they attend classes, on-site, provided by the partner academic institutions. The method of delivery of the academic coursework is through computer-based instruction (CBI) modules and self-paced instructional booklets as we will describe.

To be admitted into the CAT, the candidate takes a diagnostic math test which will place he/she in one of 18 mathematics modules. The modules (18) are based on the Technical Mathematics 1 and Technical Mathematics 2 courses delivered at Lawrence Technological University (LTU). LTU is a private co-educational, accredited University founded in 1932 in Southfield, MI. The University is composed of the Colleges of Architecture and Design, Arts and Sciences, Engineering, and Management with approximately 5000 full and part-time students.

Once the candidate is placed in a math module he/she will proceed on a self-paced basis until it is time to take a module test. The candidate must score 85% or higher on the test to proceed to the next module. Once he/she has passed the final exams for Technical Mathematics 1 and 2 (modules 9-18) they can proceed to Technical Calculus. Prior to the summer of 1996 Technical Calculus had not been developed into self-paced modules. The delivery of Technical Calculus at Focus:HOPE/CAT was through an imported traditional version of LTU's Technical Calculus. There was a need to develop this course as a self-paced course to also be consistent with Technical Mathematics 1 and 2. During the summer of 1996 Barbara Chambers and Pam Lowry developed eight self-paced modules that make up the Technical Calculus course.

Structure of the Technical Calculus Course

The course is designed as an introduction to Calculus for Manufacturing Engineering Technology. This is a course in which the candidate works at their own pace and should take no more than 15 weeks to complete. The course is made up of the following eight modules:

1) Limits and derivatives
2) More derivative rules
3) Applications of derivatives
4) Curve sketching
5) Derivative of trigonometric, logarithmic, and exponential functions
6) Integration
7) Applications of integration
8) Methods of integration

When the assignments in a unit are completed and understood, a unit test is taken. There is also a comprehensive final exam following completion of the eighth module. A unit test, on which a grade below 75% is scored, may optionally be retaken only once with the higher of the two scores counting towards the candidate's average. The final exam may only be taken once. Pam Lowry spends approximately 2 hours twice weekly at Focus:HOPE either tutoring the candidates, administering exams, or conducting mini workshops with a few of the candidates. The semester grade is based 50% on unit tests and 50% on the final exam. The grading scale is:

Average	Grade	Average	Grade
95-100	A	73-76	C
90-94	A-	70-72	C-
87-89	B+	67-69	D+
83-86	B	63-66	D
80-82	B-	60-62	D-
77-79	C+	below 60	F

Materials for the Technical Calculus Course

The book that was developed summarized each module, with an assignment sheet for each unit keyed to the textbook entitled ***Basic Technical Mathematics with Calculus*** by Allyn J. Washington, 6th Ed., Addison Wesley Publishing. The units utilize video tapes which are basically lectures on demand, along with worksheets, and Calculus software. The software available at Focus:HOPE/CAT is ***Calculus*** by Broderbund and ***Calculus Connections.*** There are 20 video tapes available for the course, with each module requiring the student to view anywhere from 1 to 5 tapes. The use of a graphing calculator is also strongly encouraged.

Summary of the Self-Paced Technical Calculus at Focus:HOPE

Pam Lowry has been facilitating the self-paced Technical Calculus at Focus:HOPE/CAT since the Summer semester 1996, the first time Pam taught Technical Calculus at Focus:HOPE/CAT was in the Winter 1996 semester. The modules were not developed at that time so the class was a lecture course. If a candidate does not complete the course in 15 weeks they are given a grade of “I” and the opportunity to complete the course in the next 15 weeks. If after that time they do not complete the course, they receive an “F” grade and they have to register for the course at another time. There are many reasons that this can occur. Since all the candidates work at least 40 hours/week at Focus:HOPE to produce parts under contract with the Big Three auto makers, their jobs often interfere with the coursework. Production scheduling can vary from week to week to meet the customer’s demands for parts. In other cases they may be overburdened with the other courses that they are taking that are not self-paced. They are strongly encouraged to register for the class again at their earliest convenience since the mathematics is a basis for their other engineering courses.

The One-Room Schoolhouse

Some of the problems realized with self-paced study are as follows:

1) Slow progress through modules (other things get in the way).
2) High failure rate because of #1, with I’s changing to F’s.
3) Additional help that is needed by the “Human” interaction.

To overcome the problems, it was determined that there should be a *classroom* experience. However, the Greenfield Curriculum design is to deliver the knowledge in an environment free of books and traditional classroom lectures. To solve the problem the idea of a *one-room schoolhouse* came about. This is a specific time twice weekly where the candidate gets one-on-one help with individual math problems. The candidates are assigned to this time slot and attendance is required. It has developed into a unique experience and the test results have shown the improvement.

Starting in the Spring semester 1998, the *one-room schoolhouse* will be conducted by Pam Lowry from the LTU campus via Video Teleconferencing. The results of this will be reported in a subsequent paper.

Summary of Math Applications in the Manufacturing Environment

The manufacturing examples used throughout the modular instruction include applications in the following areas:

1) Understanding measurement according to the requirements of industry. The candidate must understand decimals, decimal fractions, units, conversions and their applications in reading measurement devices.
2) Comprehending measurement and calculating areas, volumes and capacities.
3) Algebra in the shop has an important application because most manufacturing work is expressed in formulas. It is essential for solving geometry and trigonometry problems which have frequent applications in the manufacturing toolroom.
4) Learning about the concept of power. Power can be expressed as an algebraic equation in which all the terms must be understood. Applications of power in manufacturing are countless. The form of the equation can be given in various ways such as, $P = T\,\omega$, $P = \mathbf{F} \bullet \mathbf{v}$, and $P = \Delta W / \Delta t$. With an understanding of power, the candidate can visualize and understand the mathematics behind torque, rotational speed, cutting force, moment of force, cutting speeds and the concept of work.
5) The concepts of stress and strain are essential in manufacturing applications. The candidate must understand that the math involved is theorized by calculus.
6) Other applications with direct use of derived formulas involve being able to calculate and understand the spindle speed, material removal rate, and table feed rate for a milling machine. Similarly, in turning and drilling you need to understand cutting speed, cutting time, and material removal rate.
7) The mathematics used in the application of programming for Computer Numerical-Controlled machines and the concepts in *Visual Basic*.

Future Considerations

It is quoted from Prados that much of the learning that now takes place through formal lectures (which educational research has repeatedly shown to be the least effective way to impart knowledge) will be accomplished more effectively and economically through interactive, computer-based tutorials, jointly produced by cognitive science and content specialists[2]. The requirements to fulfill the NSF grant include adapting all coursework, except applied projects and directed studies, into CBI modules. The Greenfield Coalition has an Authorware (computer software package for development of multi-media interactive subject material) team that works together with faculty course developers (content experts) to prepare the CBI modules for each learning experience. The math team which is comprised of faculty from LTU, UDM and Focus:HOPE are working with the CBI team to develop the modules.

In January, 1998 the one-room schoolhouse will be conducted by Vtel between Focus:HOPE/CAT candidates and Pam Lowry at the LTU campus.

Conclusion

Good educational software is active, not passive. Students ought to be doing something, not watching something [3]. The CBI modules will be an interactive, self-paced course of study with access by email and the internet to tutors and information. As we reach out via distance education to attract more non-traditional and place-bound students, we need to think of them as our students[4]. Distance education is not a new phenomenon; it has been a mode of teaching and learning for countless individuals for at least the past one hundred years[5]. Imagine a nontraditional learner where learning can take place anytime, anywhere, and where the learner makes the choices[6].

Distance education offers students more choices and increases access to higher education. Dooley believes that with the technology now available, education is entering the most creative period it has ever seen[7]. There is definitely a need to provide distance educators with systematic guidelines for selecting instructional strategies[7]. The purpose of distance education is to meet the diverse learning and scheduling needs of students. Interactivity is an important aspect of learning regardless of whether the class is being taught in the traditional lecture mode or as a self-paced course. It is the contention of the authors that this type of learning experience is the wave of the future.

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Author Biographies

Tina Harkin is a Mechanical Engineer who has taught in the field since 1989. She formerly was department chair of Mechanical Engineering Technology at the University of Hartford's Ward College of Technology. She is currently a Senior Lecturer of Mechanical Engineering Technology at Lawrence Technological University and Program Manager for the Lawrence Technological Associate Degree of Science in Manufacturing at The Center for Advanced Technologies located at Focus:HOPE in Detroit, MI.

Pam Lowry is an Associate Professor of Mathematics/Computer Science at Lawrence Technological University and has taught high school and university level mathematics since 1971. She is currently pursuing a Ph.D in Instructional Technology from Wayne State University. She has been instrumental in the development of the modular self-paced instructional mathematics courses for Lawrence Technological's Associate Degree of Science in Manufacturing at Focus:HOPE in Detroit, MI since 1993.