Revitalizing Electronics Engineering Technology Programs Through a Core Curriculum Structure and Emerging Technologies

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REVITALIZING ELECTRONICS ENGINEERING TECHNOLOGY PROGRAMS THROUGH A CORE CURRICULUM STRUCTURE AND EMERGING TECHNOLOGIES

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ABSTRACT: Across the nation, AAS programs in electronics engineering technology (EET) are seeing declines in their enrollments. Many programs have had to close. Reasons for this decline include the student misperception that electronics is a dead-end career path that lacks the high-tech appeal of other emerging technical fields. These closures are having a serious ripple effect that will negatively impact other two-year college technical programs This paper presents reasons for this decline and describes a process for reversing it. The process involves the implementation of an electronics core within emerging technology programs that require solid electronics foundations. Because these emerging technology programs represent interesting and financially viable career options, enrollment in them will continue to increase, which in turn will cause increases in enrollment in the electronics core courses. This paper presents a basic curriculum model that includes an embedded electronics core that supports emerging technology specialty options. Examples are also presented of how two-year colleges are implementing this model.

Introduction

Beginning with the 1990s, the nation experienced a steady decrease in student enrollment in electronics engineering technology (EET) programs.[1] Because of the importance of electronics in most other technical areas, this decline could not be ignored. The situation demanded that steps be taken to determine what caused the decline and how best to reverse it. OP-TEC: The National Center for Optics and Photonics Education knew that for students to work successfully in the photonics industry and other technical fields, they needed a good basic knowledge—both conceptual and hands-on—of electronics fundamentals. With this in mind, OP-TEC set out to identify why enrollments in electronics programs have been declining and to use those findings to develop solutions that would ensure student proficiency in using and applying electronics principles.

OP-TEC identified two key reasons enrollments in electronics programs have been declining.

Reason 1: Students think of electronics as an outdated technology with limited employment opportunities. The electronics industry has been around for more than 100 years and has become the under-grid of almost all modern technologies such as telecommunication, biomedical, high-tech manufacturing, robotics, photonics, and many others. However, the word *electronics* has come to be associated almost exclusively with televisions, VCRs, DVDs, audio systems, and other home appliances that are more costly to repair than to replace with newer, better models.

[1] Science and Engineering Indicators 2006, National Science Board, http://www.nsf.gov/statistics/sein06/.

Home appliances belong to the consumer electronics sector, which will need fewer technicians in the future because of the disposable nature of the products involved.[2] Even in situations in which electronics equipment is worth repairing, the work is usually outsourced to other countries. Thus, prospective technician students see limited employment opportunities in the electronics field.

Since electronic equipment repair is a declining industry in the United States, a shift is needed in two-year college electronics curricula. For many years electronics programs supported the "repair" demands of industry and emphasized in their curricula troubleshooting techniques ranging from circuits down to the component level. The demands of industry have changed. To meet the new demands of technology-based industries, electronics engineering technicians need systems-level knowledge. However, many EET programs still function at the component level, making them as outdated as "TV repair" programs from 20 to 30 years ago. Students look upon these EET programs as relics of the past when compared with emerging fields such as photonics, robotics, and high-tech manufacturing. Consequently, students are moving more toward emerging fields and are not pursuing studies in EET.

So why not change curricula to meet the new demands of industry and breathe life back into EET programs? The answer to this question forms the basis of the second reason for enrollment declines.

Reason 2: Modernizing and revising old curricula is a slow and bureaucratic process. Many instructors and institutions are reluctant to change their curricula. Some are adamantly opposed to change. Yet curriculum change is necessary, at least every few years, in order to add relevant new technologies to our AS or AAS degree programs. The fact that AAS degree programs must be kept to a length of two years and a fixed number of credit hours makes it imperative that we revisit existing curricula and remove what is no longer needed to make room for essential new knowledge. In the 1970s, for example, a digital electronics course taught at one of the colleges that now serves as an OP-TEC partner covered the discrete transistor circuitry that made up an individual AND gate. In the 1980s the course's instructor stopped teaching what is "under the hood" of the AND gate because room had to be made for decoders, encoders, multiplexers, and demultiplexers. As more digital devices were invented, older topics were eliminated to make room for the new. The same approach should be applied systemically to entire electronics programs. First, the most important new technologies should be identified. Then the curriculum should be reviewed to determine what should be removed—without compromising the quality of the curriculum. Courses in topics such as DC and AC circuits and discrete and integrated analog circuits should be regularly revaluated so that they can be aligned to the needs of today's industry and so that all the non-essential circuit analysis can be eliminated to make room for new courses that emphasize a systems-level approach.

Even though many community colleges recognized one or both of these reasons as the causes of the declining enrollments in their EET programs, their bureaucratic processes impeded them from reacting fast enough to make the adjustments necessary to save their programs.[3]

These two reasons highlight changes that are necessary to reinvigorate the study of electronics. One of these changes is to *embed electronics in technical programs in fields that are attractive to*

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[2] U.S. Department of Labor, Bureau of Labor Statistics, Occupational Outlook Handbook 2008–2009, http://www.bls.gov/oco/ocos184.htm#outlook.

[3] L. Frenzel, "The Disappearing Associate Degree Program in Electronics Technology," *Proceedings of the American Society for Engineering Education Annual Conference and Exposition* (2003).

students and that students perceive as pathways to strong employment opportunities. Programs that meet these criteria would include those that address emerging technologies such as photonics, robotics, high-tech manufacturing, biomedical, and telecommunication. Since electronics is integral to all these technologies, embedding electronics in the programs in which they are taught makes sense and supports the development of well-qualified technicians. Electronics programs should be revamped to emphasize systems-level analysis that ensures that the students in those programs are being adequately prepared to work on the electronic systems used in emerging technical specialty fields. For example, AAS programs in photonics should provide ample opportunity for students to study the electronic systems that enable optics and photonics technologies.

OP-TEC has developed a basic curriculum model that incorporates the recommended changes. This model includes a broad electronics core that enables students to acquire the electronics fundamentals necessary to function effectively in the emerging technologies listed above. The model fulfills the function of a core by providing a strong, exciting technical background in electronics.[4] In effect, the model eliminates the misperception of electronics as a dead-end technical area and provides a means for students to gain the systems-level electronics skills used in high-growth/high-employment emerging technologies. The remainder of this paper will present the model and variations of the model being used at three OP-TEC partner colleges: Central Carolina Community College, Indian River State College, and Indian Hills Community College.

Basic Curriculum Model

OP-TEC's basic curriculum model is illustrated in Figure 1.

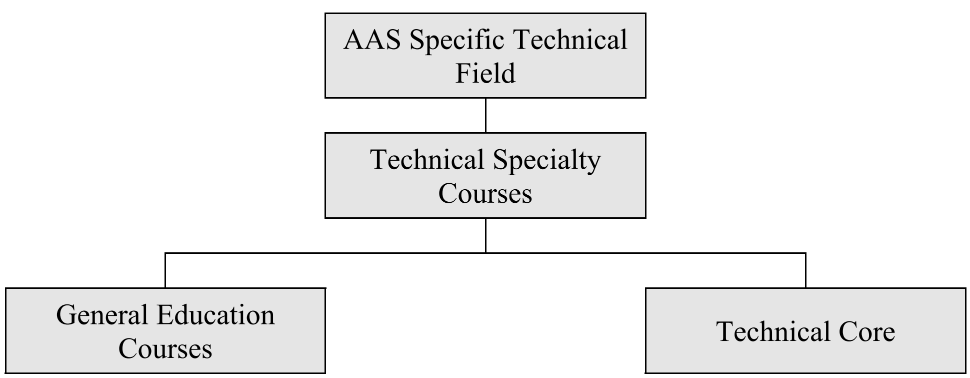

Figure 1. Block Diagram of the Basic Curriculum Model

This model consists of three major components that comprise the courses required for AAS degrees in specified technical programs.

General Education: This component provides mathematics and science prerequisites for a broad range of technical fields. It also gives the curriculum enough breadth to satisfy the requirements of state and local higher education agencies. Table 1 shows a sampling of representative courses in general education.

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[4] Engineering Technology Curriculum Reform in Florida, http://www.flate.org/media/docs/oneplusoneET%20Curriculum%20%20ASEE%202007.pdf.

Table 1. Representative Courses in General Education

Technical Prerequisites	Nontechnical Prerequisites
Technical Math Algebra Trigonometry Applied Science (Physics, Chemistry, etc.) Computer Applications (Software, Internet, Word Processing, Spreadsheets, Databases)	Business Fundamentals English/Communications Humanities Social Science

Technical Core: This component covers the basic principles that underlie applications in emerging technologies. The technical core consists of four distinct subcores: mechanical, electronics, information technology, and "infusion." The first three are self-explanatory. The "infusion" core is an OP-TEC innovation designed to give programs the flexibility to add courses in broad technical areas that "enable" more specialized technical fields. This flexibility gives students a chance to broaden their understanding of the enabling technologies that apply within their specialty fields. For example, a student in telecommunication (a specialty field) would benefit from taking courses on laser safety and operations (a broad, "enabling" field). Table 2 lists typical topics taught in each of the categories of the technical core.

Table 2. Typical Topics Taught within the Technical Core

Mechanical Core	Electronics Core	Information Tech (IT) Core	Infusion Core
Mechanical/Fluid Components and Systems	AC & DC Circuits Logic Circuits Intro to Electronics Trouble Shooting and Repair Techniques	Computer Aided Design Programmable Logic Controllers	Fundamentals of Light and Lasers Photonics Applications

Technical Specialty: This component contains the courses that prepare students to become technicians in specific technical fields. As mentioned earlier, these are high-growth, emerging technologies that are attractive to students and provide strong employment opportunities. The first section of this paper identified some of these fields as photonics, robotics, high-tech manufacturing, biomedical, and telecommunication. The next section identifies courses that could be included in the technical specialty component for various fields.

Before leaving this topic, an important point should be made. The purpose of OP-TEC's basic curriculum model is to attract more students to the study of electronics. A major hurdle that has kept enrollments in electronics low is the perception that a degree in this field is not marketable. The curriculum model described in this paper addresses that misperception. Students are attracted to programs that follow the model because they rightly perceive those programs as pathways to stable, financially rewarding careers. Even though students in specialty areas must gain the same essential electronic skills that are taught in EET programs, programs in specialty areas are more appealing than pure EET programs. And, since students in specialty areas must take a full core of electronics courses, the net effect of the high marketability and attractiveness of emerging technologies is that enrollments in electronics courses will increase. To use an analogy, the emerging technologies act as magnets that pull students through the electronics core to technical specialties.

Three Applications of the Basic Curriculum Model

OP-TEC recognizes that every community college is unique and faces needs and requirements that are unique to its service area. Because of this, OP-TEC has designed its basic curriculum model to be flexible. To demonstrate this flexibility, we will present three variations on how the model can be implemented in community college technical programs. As you review the variations, notice how each is simply a derivative of the basic model presented in the previous section.

Variation 1: Basic Model with One Technical Specialty

This variation is an application of the basic model as presented in Figure 1. It is used in Central Carolina Community College's (CCCC) AAS program in laser and photonics technology. The following is a description of this model as presented by Gary Beasley, instructor of photonics at CCCC.

One solution for CCCC's under-enrollment in its EET associate degree programs was to establish a core electronics curriculum, followed by specialty areas of study. The majority of the technical core courses, including the electronics core, along with general education classes such as English and math, are taken during the first year of study. The second year includes the majority of the technical specialty courses.

Areas of specialty, following an electronics core curriculum, may include the emerging technologies of robotics, high-tech manufacturing, telecommunication, or photonics. The area, or areas, of specialty offered by a college would depend on the local employment market. This paper will focus on the specialty area containing the emerging technology of photonics, which is in high demand throughout CCCC's service area and leads to multiple job offers for its graduates with attractive salaries and sign-on bonuses. The photonics specialty also provides CCCC with a strong student recruiting tool. Students are more attracted to areas of high job growth and high pay in emerging technology fields.

Figure 2 demonstrates how CCCC uses the OP-TEC basic curriculum model to offer its AAS in laser and photonics technology.

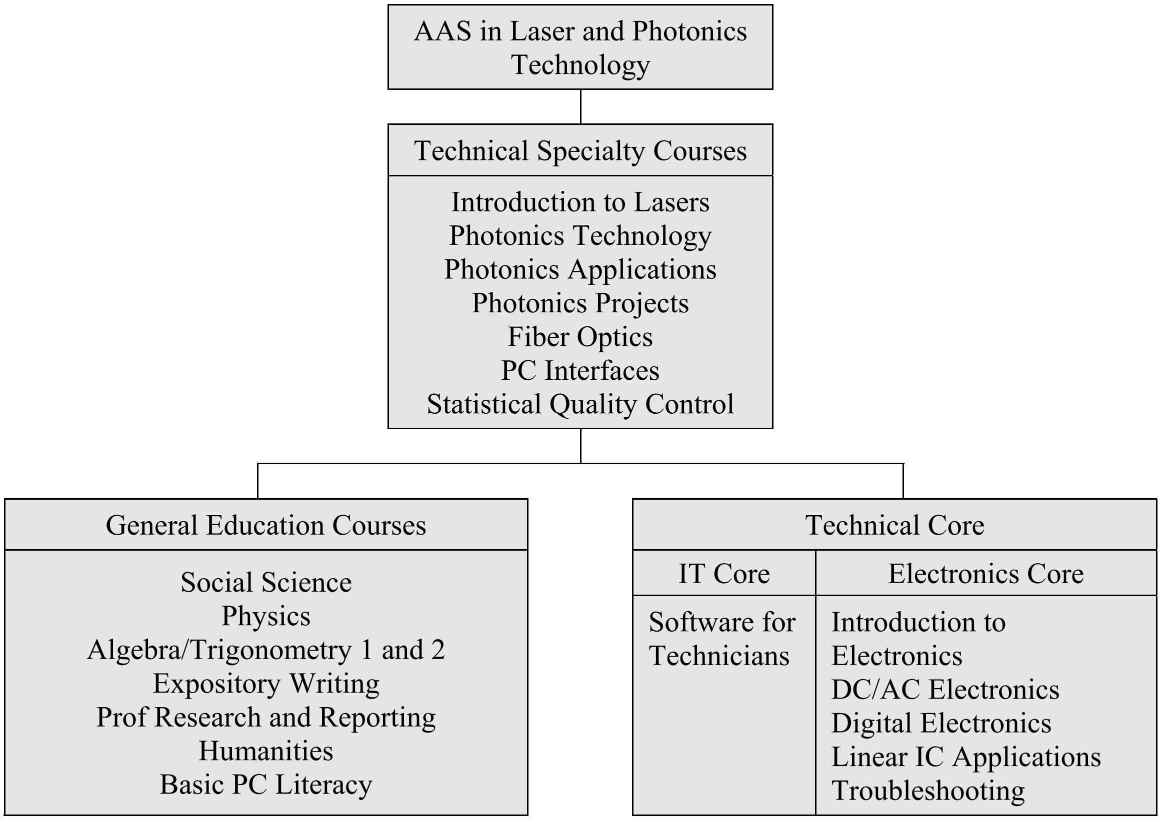

Figure 2. CCCC's AAS in Laser and Photonics Technology Curriculum

In comparison to the OP-TEC basic curriculum model, CCCC has elected not to have a mechanical core or infusion core under its technical core component. This is based on local needs and input from the program's advisory committee. Instead, CCCC's electronics core is robust and its general education component is very broad. (In many other states, only three or four courses are required.) This application of OP-TEC's basic curriculum model supports only one technical specialty area, but for students to pursue the AAS in laser and photonics technology, they must take six electronics-based courses. This gives the students a thorough foundation in this area. Notice in this variation how again the attractiveness of a high-growth/high-employment technical area such as laser electro-optics acts as a magnet for increasing the enrollment in electronics courses. For more details on the courses in the CCCC curriculum, go to http://www.cccc.edu/registrar/catalog/2006/pdfs/Laser-Photonics-A402800.pdf.

Variation 2: Basic Model with Multiple Technical Specialties

This variation is an application of the basic model as presented in Figure 1, with the exception that more than one technical specialty area is supported. It is used at Indian River State College (IRSC), which offers an AAS in EET with specialties in the emerging technology areas of photonics, robotics, telecommunication, computer support, and biomedical. Notice that, through this curriculum, students earn AAS degrees in EET; however, by the time they graduate, they have coursework and experience sufficient to find employment in the five high-growth/high-employment emerging technology areas just listed, and their AAS degrees reflect these specialties. The following is a description of this variation to the basic curriculum model as presented by Chrys Panayiotou, chair of the EET department at IRSC.

The electronics program consists of 68 credit hours, 15 of which are devoted to general education courses. The remaining 53 credit hours are technical courses required to produce high-quality technicians. The 53 credit hours of technical courses are divided into two groups, the technical core (27 credit hours) and the technical specialty courses (26 credit hours), as shown in Table 3. The technical field specialty groups include specializations in telecommunication, computer support, biomedical, photonics, robotics, and photonics and robotics. Each of these options consists of a group of courses totaling 26 credit hours. Once a student completes the general education and the technical core, he or she can choose one of the five options or "cherry pick" courses from any of the options for a total of 26 credits.

TECHNICAL CORE COURSES – 27 credits

CET	1440C	Computer Aided Schematic Design	3 credits
EET	1015C	DC Circuits	3 credits
EET	1025C	AC Circuits	3 credits
EET	1180C	Troubleshooting & Repair Techniques	3 credits
EET	1215C	Introduction to Electronics	3 credits
EET	2141C	Electronic Devices I	3 credits
EST	2542	Programmable Logic Controllers I	3 credits
EST	2544	Programmable Logic Controllers II	3 credits
MTB	1322	Technical Mathematics II	3 credits

TECHNICAL SPECIALIZATION COURSES– 26 credits

PHOTONICS OPTION

CET	1112C	Logic Circuits I	3 credits
CET	1113C	Logic Circuits II	3 credits
EET	2142C	Electronic Devices II	3 credits
EST	2210	Introduction to Photonics	3 credits
EST	2215	Geometrical Optics	3 credits
EST	2220	Fiber Optics and Data Communications	3 credits
EST	2230	Laser Technologies	3 credits
EET	2930	Special Topics in Electronic Engineering	5 credits

ROBOTICS/MANAFACTURING AUTOMATION OPTION

CET	1112C	Logic Circuits I	3 credits
CET	1113C	Logic Circuits II	3 credits
EET	2142C	Electronic Devices II	3 credits
EST	2630	Manufacturing Processes	3 credits
EST	2631	Advanced Manufacturing Processes	3 credits
EST	2676	Introduction to Robotics	3 credits
EST	2678	Industrial Robotics	3 credits
EET	2930	Special Topics in Electronic Engineering	5 credits

BIOMEDICAL OPTION

CET	1112C	Logic Circuits I	3 credits
CET	1113C	Logic Circuits II	3 credits
EET	2142C	Electronic Devices II	3 credits
EST	2424	Biomedical Electronics	3 credits
EST	2427	Advanced Biomedical Electronics	3 credits
EST	2408	Biomedical Seminar	2 credits
HSC	2531	Medical Terminology I	3 credits
EST	2210	Introduction to Photonics	3 credits
EST	2230	Laser Technologies	3 credits

TELECOMMUNICATIONS OPTION

CET	1112C	Logic Circuits I	3 credits
CET	1113C	Logic Circuits II	3 credits
EET	2142C	Electronic Devices II	3 credits
CET	1854	Introduction to Wireless Technologies	3 credits
EET	2325C	Communication Circuits I	3 credits
EET	2335C	Communication Circuits II	3 credits
EST	2220	Fiber Optics and Data Communications	3 credits
CET	1854	Introduction to Wireless Technologies	3 credits
EET	2930	Special Topics in Electronic Engineering	2 credits

COMPUTER TECHNOLOGY OPTION

CET	1112C	Logic Circuits I	3 credits
CET	1113C	Logic Circuits II	3 credits
EET	2142C	Electronic Devices II	3 credits
CET	1041	HTI+ Certification	3 credits
CET	1178	A+ Certification Training I	3 credits
CET	1179	A+ Certification Training II	3 credits
CET	1588	Network + Certification	3 credits
CET	1854	Introduction to Wireless Technologies	3 credits
EET	2930	Special Topics in Electronic Engineering	2 credits

Table 3. The Modified AAS Degree Programs

PHOTONICS/ROBOTICS SPECIALIZATION COURSES - 26 credits

CET	1112C	Logic Circuits I	3 credits
CET	1113C	Logic Circuits II	3 credits
EST	2210	Intro to Photonics	3 credits
EST	2220	Fiber Optics and Data Communications	3 credits
EST	2230	Laser Technologies	3 credits
EST	2676	Introduction to Robotics	3 credits
EST	2678	Industrial Robotics	3 credits
EST	2630	Manufacturing Processes	3 credits
EET	2930	Special Topics in Electronic Engineering	2 credits

Figure 3 shows a block diagram of the IRSC curriculum. We have not filled in the technical specialty courses, since they are listed in Table 3.

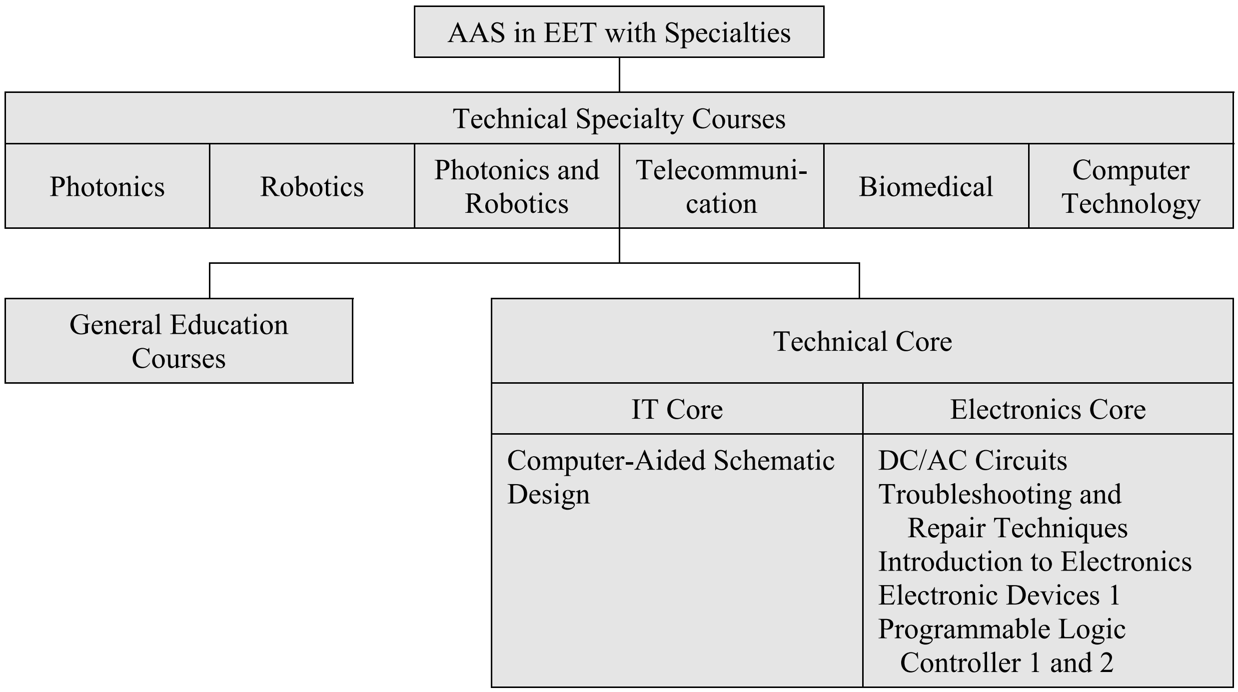

Figure 3. IRSC EET AAS Curriculum

Two points before we leave this variation: First, as in the CCCC variation, IRSC has chosen not to use a mechanical or infusion core. Again, this resulted from local needs and decisions made by the program's advisory committee. Second, in this variation of the basic curriculum model, several programs use the same core structure. This means that the courses and laboratories that support this core will see efficiency and economy in institutional instruction, staffing, and laboratories. For more information on the courses in the IRSC curriculum go to http://faculty.ircc.edu/dept/advancedTechnology/ee/coursedescription.html#cet1112c.

Variation 3: Basic Model with Multiple Technical Specialties and an Infusion Core

This variation is similar to the preceding one. The only difference is that it includes an infusion core, an innovation that was developed by OP-TEC. As described earlier in this paper, the purpose of the infusion core is to provide an opportunity for students to broaden their understanding of the enabling technologies that support their technical specialty fields and learn how those technologies are applied in their chosen fields. In Variation 3, Indian Hills Community College (IHCC) has used the OP-TEC basic curriculum model to support its AAS programs in laser electro-optics, robotics/automation, and electronics/telecommunication. Additionally, since all of these programs are enabled by photonics, IHCC developed an infusion core that includes a survey course that covers the basics of light, optics, laser operations, laser safety, and several laser applications. The following is a description of this variation to the basic curriculum model as presented by Greg Kepner, chair or the manufacturing and industrial department at IHCC.

Many colleges, especially those that do not have large engineering technology enrollments, offer a core curriculum with several specialty options. This arrangement allows more flexibility in faculty assignments and enables colleges to reach the “critical mass” in enrollment necessary to sustain their programs and courses financially. It also provides a curriculum structure that is relatively easy to modify.

Figure 4 provides an example of a basic core curriculum that supports AAS programs in the three technical specialties listed above. In this example, we do not detail the courses in the technical specialties or the general education courses (math, science, English, humanities). However, we do provide detail on the technical core, which once again contains a robust electronics core. As in previous variations, IHCC does not include a mechanical core. Again, this is due to local needs and decisions by our advisory committee. For more details on the courses in the IHCC curriculum, go to http://www.indianhills.edu/catalogs/2008-09catalog.pdf.

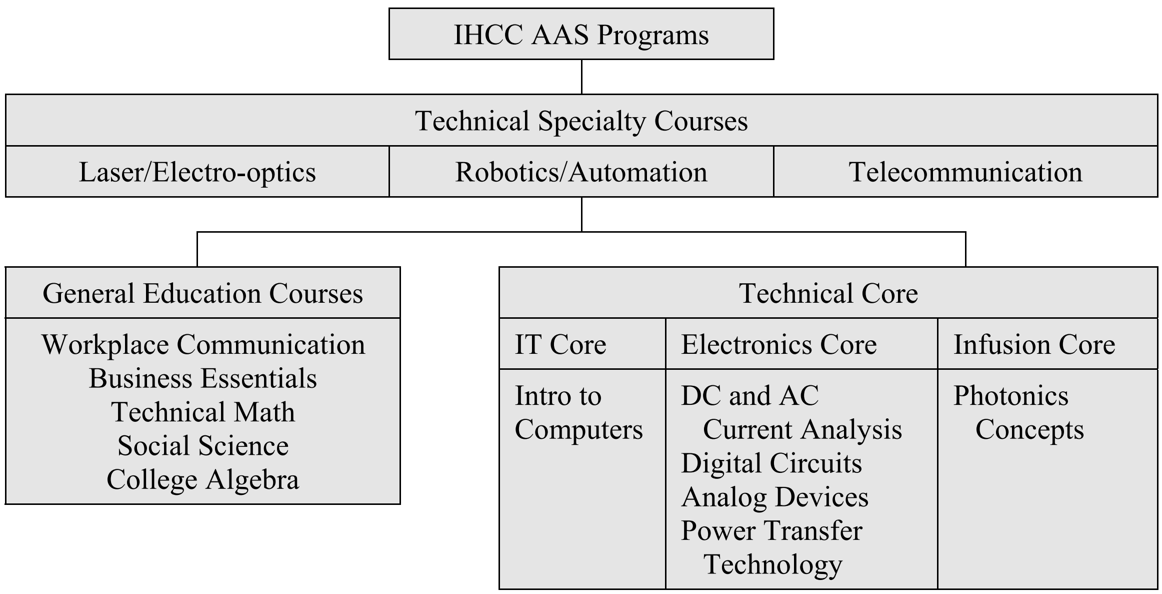

Figure 4. IHCC Basic Core Curriculum for AAS Programs

Recommendations

OP-TEC encourages two-year colleges with EET programs that are experiencing declining enrollments and possible closure to consider “repackaging” those programs as an electronics core that can be embedded in higher-enrollment technical programs based on emerging technologies. OP-TEC’s basic curriculum model is a good starting point for developing this core and embedding it within other technical programs. It is important that electronics departments carefully survey possible “donor” technical programs to make certain that those programs are cutting-edge (i.e., are attractive to students from an interest, growth, and financial perspective), are seeing increasing enrollment trends, and require solid foundations in electronics. With these requirements met, embedding an electronic core within the programs should lead to increases in electronics course enrollments and reestablish a sense of security for faculty and staff within electronics departments.