Quinsigamond Community College
FACULTY EXTERNSHIP
SUMMER 2013
FINAL REPORT

Obtaining Exposure, Knowledge and Experience in Embedded Systems Technologies.

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Externship Overview

My externship project for Summer 2013 was *Obtaining Exposure, Knowledge and Experience in Embedded Systems Technologies*. The knowledge gained from these activities is in support of integrating embedded systems topics into new and existing CSET curriculum.

An embedded system is a computer system designed to do one or a few dedicated and/or specific functions often with real-time computing constraints. It is *embedded* as part of a complete device often including hardware and mechanical parts. Often the embedded system is almost invisible to the user, such as:

- Access control (transportation: subway, interstate toll booths; building area: badges)
- Parcel tracking
- Electronic signage
- Home appliances (Refrigerators, dryers, etc)
- Toys
- Movement tracking (such as GPS)

While other embedded systems are more obvious, such as:

- Automotive control and navigation systems
- Phones
- Point of Sale (POS) terminals and cash registers
- Health devices commonly used in doctors’ offices and hospitals and today, at home
- Television and entertainment systems
- Information kiosks
- Automated Teller Machines (ATMs)

Sometimes, they are embedded as part of a traditional IT device such as a switch, router, or storage device.

The trend of embedding intelligence and computing capabilities into household and business devices is an area of large and intense growth in the information technology field. Many experts believe that the traditional enterprise and computing resources growth is leveling off where custom embedded systems will experience expansive growth.

The University of Massachusetts at Amherst (UMASS-Amherst) has requested that QCC design a 2+2 or a 2+3 program for QCC’s Computer Systems Engineering Technology A.S. degree program and the UMASS Computer Systems Engineering B.S. Program which focuses on embedded systems.

QCC’s existing CSET Program focuses mainly on implementation of general use computer and information technology in a network environment but has always briefly introduced the concepts of embedded systems. As these devices become more commonplace, our students are beginning to be hired for positions in this field (examples include Point of Sale support, automotive control systems, and Access Control systems).
Industry certifications that combine industry with technology (IT in healthcare or IT in retail) are also becoming common. This further shows how the importance of embedded systems is rapidly increasing.

The CSET Program is currently in the Academic Program Review (APR) process. Including embedded systems in CSET curriculum has come up previously in the last APR process as well as the current process.

It is clear that the UMASS CSET Program focuses on the engineering process associated with the invention and design of embedded systems products where the QCC CSET Program currently focuses on the implementation and maintenance of computing and networking infrastructure, which may include embedded systems. A consideration that this raises is whether our students should and/or can make the leap from engineering computing and network solutions to engineering devices.

This project’s outcomes include the following:
1. Obtaining up-to-date knowledge of the embedded systems technologies and practices utilized commonly in businesses today, including the following topics:
   - Use of embedded systems in the business environment including common general use systems (such as POS, access control, etc) used by business and those businesses that have designed custom devices to gain a market edge (such as various parcel and/or movement tracking at UPS or FedEx)
   - Current and future consumer embedded systems market including consumer trends such as automotive, health/fitness devices, home appliances, gaming systems, communications devices, etc.
   - The design, manufacturing, and marketing cycle of embedded systems products from various angles including big business and the small entrepreneur and the supporting industries.
   - Operating systems platforms and supporting software including open source offerings (such as RTOS, NetBSD, Android and Linux) verses a mature operating system (such as Windows) and supplemental libraries and software development environments.
   - Hardware device construction (single board verses component build) including understanding the simple single board designs verses the more complicated board with multiple components and/or sensors.
   - Educational requirements for embedded systems designer/developers/inventors verses product integrators including math, science, electronics, information technology, and business.
2. Defining where in the existing CSET curriculum we should introduce and teach embedded systems integration and maintenance.
3. Determining if CSET should pursue an articulation with UMASS’s CSET (focused on design, development, and invention of embedded systems), whether there is job demand to support it, and what new curriculum would need to be developed at QCC to support it.
4. Planning what resources QCC would need in classroom/laboratory environment to support Outcomes 2 and 3 above.
Externship Goals

The ultimate goal of this project is to make students more employable and able to demand a good salary in this lower employment environment by providing the skills commonly needed in IT positions. The 2013 CSET APR shows a demand for special devices/embedded systems-related skills in many business environments in which students may find themselves employed.

The following is a list of areas within the Massachusetts Department of Elementary and Secondary Education “Core Indicators” that will be benefited by this project:

- **Core Indicator 1P1 – Technical skill attainment** – This skill set, both embedded systems designers and integrators, is in demand in business today. By obtaining these additional skills, students will assure that they are getting the skills that industry needs.
- **Core Indicator 2PI – Credential, certificate, degree** – These skills pertaining to embedded systems integration will aid students in the two-year Associate of Science degree and Network Associate Certificate.
- **Core Indicator 3PI – Retention or transfer** – While expanding the skills taught by the CSET Program, these knowledge/skills will make our CSET students more interested in the field by providing some stimulating hands-on projects that would encourage students to focus their studies.

All populations will benefit by having a better grasp of information technology in business.

Externship Milestones/Activities

To achieve the above defined project outcomes, the following plan was developed:

1. Explore the career field of embedded systems technologies,
2. Visit embedded systems-related companies,
3. Obtain knowledge and experience of the embedded systems product development, manufacturing, sales, and maintenance,
4. Explore the career field of embedded systems technologies,
5. Visit embedded systems-related companies,
6. Obtain knowledge and experience of the embedded systems product development, manufacturing, sales, and maintenance,
7. Work at a local embedded systems company to understand nature of the embedded products’ lifecycle,
8. Understand educational requirements and job skills necessary for work at embedded systems companies, and
9. Determine if this is a new degree/certificate area and/or where these skills fit into the existing curriculum.
Activity Results

Milestone #1 – Explore the career field of embedded systems technologies.

The following is a list of activities completed that are associated with this milestone:

- Attended industry conferences including the Embedded Systems Conference (Fall 2012).
- Attended the Microsoft BUILD Conference (June 2013).
- Researched embedded systems technologies and their implementation trends/methods, including several white papers and industry reports.
- Reviewed technical literature, where available.
- Developed an understanding of embedded systems, both in business and consumer markets today.

Milestone #2 – Visit embedded systems-related companies (including designers, manufacturers, integrators, and users).

The following is a list of activities completed that are associated with this milestone:

1. Visited six companies in the embedded systems industry or that use embedded systems as a major component of their operations:
   - EMC, the global leader in storage devices, in Massachusetts to review their manufacturing engineering environment, including design, manufacturing, and repair of their integrated devices,
   - A Point of Sale (POS) company in Massachusetts that is a Microsoft Partner (systems integrator) that sells, implements, and maintains Point of Sale (POS) terminals to retail businesses,
   - A Massachusetts consulting company that is a Microsoft Partner working on development of automotive dashboard systems (navigation, music, phone, heating and cooling, etc.),
   - UMASS Medical Center in Worcester hospital utilizing various embedded systems devices to see how they were incorporated into their network environment and their maintenance routines,
   - Garmin, a global leader in Global Positioning Systems, in Kansas, to see how support and maintenance is provided for the wide variety of embedded devices manufactured and sold through Garmin, and
   - Linear, a global company manufacturing building access control devices in California to understand the design and manufacturing process.

2. Attended the Embedded Systems Conference in Boston and the Microsoft BUILD conference in San Francisco and visited over a hundred vendors that developed operating systems for embedded systems, manufactured components (such as LEDs, motherboards, sensors, networking, etc.) for embedded systems, offered prototyping services, and/or offered manufacturing for embedded systems devices.

3. Visited a 3D printer company to learn more about the variety of 3D printers available and how to use them. 3D printing is now a common component in the prototyping of embedded systems devices. It is now such common-place that 3D printer support is included in the Windows 8.1 operating system.
Milestone #3 – Obtain knowledge and experience of the embedded systems product development, manufacturing, sales, and maintenance.

The following is a list of activities associated with this milestone:

- Visited a variety of companies developing, manufacturing, or utilizing a variety of different types of embedded devices, as outlined in Milestone #2. Most of these devices were very different from each other running a variety of operating systems, developed by a large variation of companies, and offering many different functions and features.
- Set up development environments to use Cortex and Arduino motherboards in which to develop practice prototype devices with a video camera and integrated the device with VEX Robotics sensors and chassis to develop a little device that I could interface and control with a tablet.
- Learned to use design software (SketchUp) that can interface with a Makerbot 3D printer at Microsoft to print a product casing in which to place the motherboard and related components.
- Attended various Microsoft and www.embedded.com webinars and online training on embedded systems design and development.
- Reviewed various whitepapers and books for technical knowledge on embedded systems hardware and software development.
- Gaining access to manufacturing sites of embedded systems was difficult as the vast majority of this type of manufacturing now is done now overseas. Instead, I toured the MIT Fab Lab in Cambridge in hopes of better understanding issues surrounding the manufacturing of embedded systems.

Milestone #4 – Work at a local embedded systems company to understand nature of the embedded products’ lifecycle.

The following is a list of activities associated with this milestone:

- Worked with a customer service technician to troubleshoot and repair POS terminals.
- Participated in sales presentations of POS, cash register systems, and other retail solutions.
- I had originally planned to work for multiple days with a past student of the QCC CSET Program at a company that is a large reseller of Point of Sale (POS) terminals and other retail devices and systems, however, this student recently switched positions. However, the company did let me visit.

Milestone #5 - Understand educational requirements and job skills necessary for work at embedded systems companies.

The following is a list of activities associated with this milestone:

- Researched and explored the colleges and universities curriculum associated with embedded systems. This is a common curriculum offering in Massachusetts at all major engineering schools, including WPI, MIT, Wentworth, Northeastern, and UMASS Amherst.
- Researched job postings regarding embedded systems.
- Designed a configuration and needed components for use in the CSET lab for integration into existing coursework.
**Milestone #6** - *Determine if this is a new degree/certificate area and/or where these skills fit into the existing curriculum.*

The following is a list of activities associated with this milestone:

1. Determined that more exposure to embedded systems for CSET students is needed. This would include exposing them to common embedded systems such as POS terminals, kiosks, and handheld devices and integrating them into a network, just as they would commonly in the business environment (this could be accomplished in the CST 235 *Network Infrastructure* course). It is also necessary to expose them to the development and maintenance of embedded devices (this could be accomplished in the CSC 233 *Computer Hardware and Support*). Although some funds will need to be expended for this, it could be less than $1,000.

2. Recognized that there is a potential of developing a 2+3 articulation between QCC’s CSET Program (which focuses on Information Technology computing and networking infrastructure) and UMASS Amherst’s CSET Program (which focuses on embedded systems). This could be accomplished by creating an option on the CSET 2-year degree and by utilizing courses in the CSET, Electronics, Engineering, Math, and Science departments. As the 2013 CSET APR progresses, we will pursue this opportunity with UMASS. Possible enrollment in such a program at QCC is still unexplored, therefore we will not develop new courses to support this but rather use existing where we can and leave the rest of the curriculum to UMASS.

**Conclusion**

This project was very successful in achieving the ultimate goal, which was to learn more about the embedded systems skills needed by IT professionals in business today from both the designer/developer/inventor and the product integrator views and to utilize that knowledge to enhance the CSET curriculum.

I was less successful in learning about two areas: manufacturing of embedded systems devices and obtaining hands-on experience and knowledge in maintaining embedded devices.

**References**


