HITEC 2021 Upskilling the Workforce for Smart Manufacturing - A Curriculum Outline

Conrad Leiva, CESMII – The Smart Manufacturing Institute
Sam Samanta, Finger Lakes Community College

Conrad:
Hello, Welcome to our webcast today.

We're going to be talking about the need for Smart Manufacturing education and training modules for the workforce.

(Slide 2)
I am Conrad Leiva, I'm an Industrial Engineer from Georgia tech, with over 30 years of experience in the aerospace manufacturing industry.

Over 20 years in development and implementation of manufacturing systems and over 10 years working on Smart Manufacturing, I am now Director of Ecosystem and Workforce Education at CESMII and I'm focused on executing CESMII's education plan for workforce skills on Smart Manufacturing.

Sam, please introduce yourself and get us started with the agenda.

Sam:
I'm Sam Samanta. I have been at Finger Lakes Community College for last three decades prior to that I had a decade long R&D background in nanoscience.

For the past decade I've been focused on educating the workforce with automation skills at Finger Lakes Rochester high tech ecosystem where we've worked with 50 plus diverse businesses to place students in paid positions and most of them are able to work while they finish their studies, the program is now named Smart Systems Technologies and it has a HyFlex scheduling component, so that it will increase access to local and discipline students.

(Slide 3)
We are going to get started with the agenda.

CESMII, US Smart Manufacturing Innovation Institute, is one of the 16 ManufacturingUSA Institutes and its mission is to democratize Smart Manufacturing technology and education to make it more accessible to all manufacturers, including small and medium manufacturers.

We want a workforce educated on Smart Manufacturing principles and implementation practices and how to leverage Smart Manufacturing insights and technologies in their everyday jobs.

Today we are focused on workforce education at the level of community college with examples of Smart Manufacturing strategies solutions and technologies.

We will discuss CESMII's Member ecosystem, including manufacturing businesses academic institutions, and we want to recruit more Community

Colleges into CESMII, to upskill the workforce in Smart Manufacturing skills that are important to the industry.

Conrad is going to provide us a broader context of Smart Manufacturing and then we are going to focus on the training needed for Community college level.

Conrad:
(Slide 4)
Many manufacturers and manufacturing education programs are stalled on Industry 3.0 type techniques, as examples, I list a few here that we started implementing in the 70s and 80s, a lot of technologies like PLC, CNC, CAD, CAM, ERP, and MES.

But right now there is a real need to add Industry 4.0 techniques, on top of that foundation. Smart Manufacturing techniques that allow a digital transformation of the whole manufacturing ecosystem.

(Slide 5)
When asked about their challenges to realizing the Industry 4.0 vision, manufacturers did not point at technology in fact they mentioned that technology innovation is moving at a very fast pace. It has become more affordable and practical to implement in the last 20 years, and that includes sensors, connectivity, big data, and machine learning.

What they did identify was that they have challenges finding the talent with the skills to implement that technology, and they also have challenges with interoperability, these are two challenges that CESMII is focused on conquering.

We're talking about the educational side today.

(Slide 6)
Because we feel that many manufacturers and education programs might be still in the Apollo and Shuttle era.

Do you have the training programs that manufacturers are looking for today? Or does your education program look a little dated.

We're trying to fix that.

Making the parallel to these cockpits, the manufacturing cockpits have also been evolving significantly in the last few years, and the whole infrastructure and techniques behind those cockpits have also been changing to make the shop floor job easier.

…to streamline the visibility and highlight the information that you need at the right time, the right information for each job, making the job more error proof, with better work guidance and better intelligence.

Sam:
(Slide 7)
Manufacturers need talent that knows how to implement smart manufacturing technologies solutions and strategies.

The workforce educated at Community College ought to understand and practice use of Smart Technologies.

Here's a visualization of the landscape which is built up from devices to solutions to strategies.

Starting with foundation of on-premises technologies, such as sensors, controllers, actuators such as Collaborative robots or cobots, at the bottom we overlay technical solutions, such as wearables, Big data visualizations, Process modeling, digital twins, and Predictive Analysis in context of strategies, such as Troubleshooting, Lean Six Sigma, Business Continuity, and Digital Supply Chain.

Technical workers need to understand these concepts to be effective in the smart manufacturing environment within the business and the broader ecosystem.

Many items are spread over multiple scales; with Industrial cybersecurity spanning all scales.

(Slide 8)

Smart manufacturing skills for the workforce.

They span multiple roles. So we are talking about these topics at different levels of depth for different types of occupations.
For this presentation we are talking focusing on the level of Community college.

We are seeking collaborators for creating learning modules that incorporate hands-on activities for Community college students.

Conrad:
(Slide 9)
The first step for me is to make sure everyone understands what Smart Manufacturing is and the guiding principles behind the vision.

Because Smart Manufacturing is not just about implementing technology it's about how technology can enable new business processes in that digital transformation of the manufacturing ecosystem.

When we architect solutions that follow all these principles, we can realize the Smart Manufacturing vision so part of the curriculum is to cover what Smart Manufacturing means.

Solutions should be secure, scalable, flat and real time, open and interoperable, proactive and semi-autonomous, orchestrated and resilient, and sustainable and energy efficient. And here's a link we provide for you want to get more information on what that means.

Sam:
(Slide 10)

We'll start with data sources (Slide 10).

All of us have become aware of ubiquity of sensors.

Expected to number in trillions of iot sensors and devices within few decades.

Smartphones have six or more sensors which can be used to acquire data, for example, using PhyPhox APP.

Sensors help measure and monitor parameters of interests, such as temperature pressure linear and rotational position accelerometer, etc. More complex sensors include mission-vision and others that identify chemicals and biologics.

Actuators are typically mechanical systems that respond to electrical signals include solenoid and robots inputs that typically electrical voltages, and sometimes current signals from sensors.
Outputs are voltages that drive actuators or control sensor parameters.

Next we discuss automation controllers

(Slide 11)
Microcontrollers such as Arduino are basically microprocessors integrated with memory, analog to digital converters for inputs, and digital to analog converters for outputs.

Programmable Logic Controllers PLCs are used across industries, from Rockwell automation and Siemens, for example.

Field Programmable Gate arrays software create custom logic chip during research and development, they are a lot cheaper than Application Specific Integrated Circuits, ASICs.

GPU, graphics processing unit, accelerate graphics calculations and videos. Jetson Nano costing less than hundred dollars has quad core ARM CPUs and 128 GPUs - useful for machine-vision, industrial Internet of Things and AI

Next we discuss…

Big Data and Predictive Analysis (Slide 12)

The graphic shows data of acceleration magnitude plotted against the frequency - typically for motors, pumps and other systems.

Big Analog Data, typically from vibration sensors, generate vast amount of data, that must be analyzed in real time to extract actionable intelligence, instead of simply storing data.

Big Digital Data – multi-terabytes of data are collected by vision and other systems to help improve processes.

Machine learning and AI can help forecast brewing potential problems, for example, using by vibration sensor data and trigger alarms for predictive maintenance.

We will look at the next slide (Slide 13).

On Cloud and Edge computing.

Cloud computing is basically computing on remote servers with mirrored sites to provide uninterrupted computing as a service.

Examples include remote SQL databases, cloud base image recognition and pattern detection in other sensor data streamed to the cloud.

Zoom and Webex are examples of cloud services cloud computing can provide remote control of industry systems if the Latin time delays can be tolerated.

Edge computing is a computing co located with the source of big analog or digital data.

Accelerometers and Machine Vision, data are used for extracting intelligence real time for immediate action without always having the need to store and or transfer big data.

NVIDIA Jetson Nano, once again, is a good platform for teaching edge computing and cloud computing.

moving to the next slide (14)
Data Visualization.

Our technical students, need to have
Basic Skills
of Plotting and Interpreting data graphs,
and need to be able to work with human machine interfaces, or HDMI.

Advanced Concepts and Skills are needed for smart manufacturing so data visualization facilitates Right-Brain approach to detecting patterns in large table of numbers or text based description of the data sets.

Data visualization is increasingly used for interacting with control algorithms and machines, especially for extracting insights from big data.

Augmented Virtual Reality, AVR is based on special computing which aids visualization and manipulation of 3D simulated entities that interact with real surrounding.

Such as virtual ball bouncing off real walls in a room. Magic Leap Microsoft Hololens2, for example, are the tools.

That are being used in industries as well as some colleges.

Conrad:

(Slide 15)
We just went over a few of the technology topics for Smart Manufacturing but… It is very important that that we don't look at Smart manufacturing as pure technology. That we remember that the worker is at the Center of a lot of the Smart Manufacturing strategies.

Here is a sampling of the type of functionality that we need to cover and curriculum to prepare the worker to be a connected augmented worker.

For example, workers can participate in online team collaboration. Understand how to use these tools.

That they are comfortable with work guidance that helps them with some of the tools Sam was mentioning like Hololens, that help them and guide through the job with step-by-step instructions, highlighting things on their workplace and highlighting where something is. Maybe what is performed out a sequence.

That they're comfortable with receiving data from these IIoT data sensors, machines, from vision systems that provide them insights right there and in real time… about the work that they're working on and the machine they're working with.

And when they run into trouble that they are comfortable using the technology to get remote assistance with video collaboration that they can do with hands free technology in the field or at the machine.

And they could be using an expert, that is not even on site or on location.

Slide 16)
How do we bring all these technologies together? Not only do we need to upskill the IT side with manufacturing specific techniques…
We also need to upskill the operations technologists about how to work with IT to realize the desired production and enterprise Smart Mfg solutions.

As you can see in the center, there are layers of systems, integration, data modeling needed to deliver the solutions that manufacturers need in a flexible, cost effective and very upgradable way. In an INTEROPERABLE way! Because we need to view this landscape as an ever-changing landscape that needs to keep up with the pace of innovation in technologies and business practices.

(Slide 17)
And we have to mention cyber security anytime we talked about systems and education, because the human is at the center of a lot of the cyber security flaws that we can have.

Smart Manufacturing is about integrating operations technology and IT systems and the cloud. And the Internet can be a very scary place and a lot of people might say let's keep that shop disconnected from the Internet, but we need to be connected.

But we need to do it in a safe way. And we do that by considering a framework, like the NIST cybersecurity framework.

Security schemes that include identity verification of all things, not only the people, but the devices and the systems. To make sure that everything in the ecosystem is what it's supposed to be, and not an imposter.

Implementing schemes for access control, for data traffic monitoring, fault tolerance, high availability, anomaly detection, issue containment, and even seamless data recovery, all of these things need to be considered as part of the cybersecurity framework on top of which you're building all these Smart Manufacturing systems.

(Slide 18)
Another dimension of Smart Manufacturing that needs to be part of the curriculum is Sustainable Manufacturing and energy efficiency.

We need to be covering all these methods that help us in general… reduce waste which can be energy waste. Ways to reduce product and material waste because it takes energy to build those materials.

Some of the methodologies that that we talk about for improving and optimizing the energy use include tracking energy usage as an ingredient in the production process, reducing scrap materials and rework.

Heat waste recovery and reuse use of recycled materials, whether we're purchasing it or recycling within our factory or even when we're selling that material to be recycled.

And even methods that allow us to extend the product lifecycle through initiatives like product as-a-service or product remanufacturing.

When we model energy as an ingredient in the recipe, we can apply the optimization methods that Sam is going to talk about.

Sam:

Process Modeling and Optimization (Slide 19)
is often designed by engineers and researchers yet the technicians need to understand the basic concepts, so that they can use these models for process control and optimization.

First principles process modeling involves differential equations, which could be converted to difference equations.

To introduce Community college students to numerical methods using excel lab you and finite element analysis program among other special purpose software.

Chemicals, food or pharmaceuticals can be batch process or through continuous process

Empirical models are useful in many cases for this simplicity and cost savings.

(Slide 20)
Digital Twins are based on detailed processes and system modeling.

Digital twin is a digital simulation/copy of physical system that can be used for cost effective and time saving What if analysis and for troubleshooting.

A digital twin is a virtual representation of real world entities and processes, synchronize at specified frequency and fidelity.

Digital twin use real time and historical data to represent the past and the present system state and simulate predicted futures.

Digital twins are motivated by outcomes tailored to use cases, powered by integration built on data, guided by domain knowledge and implementation in IT and operational technology, OT, systems.

(Slide 21)
Artificial Intelligence. AI and machine learning, ML.

Artificial Intelligence is used for automating information processing for extracting actionable insights, typically in known context.

Researchers have been working on AI for 50 years, however, in the past decade, it is being applied widely due to availability of hardware and machine learning software tools.

It is further accelerated due cheaper hardware and modeling software and big data sets available for training deep neural networks.

Accelerated machine learning.

An example would be data from tesla cars that help improve object identification algorithms that in turn quickly make all tesla car smarter through software updates.

Conrad:
(Slide 22)
You can see how DATA is a theme throughout this curriculum.

What do all the Six-Sigma Problem Solving methods have in common is that they all need data. All these Problem Solving methods require data to detect problems… hopefully, before they become big problems.

Understand the problem and its impact and look for the root cause and then make proper decisions about the adjustment needed to control mechanisms.

We're just giving you here a sampling of some of the techniques that we want to teach in the in the curriculum making sure that the students understand how to leverage data to perform all these kinds of analysis and task in their jobs.

(Slide 23)
And we must remember that the factory is a node in a broader supply chain for many products.

We need to recognize that we used to manage our supply chain in a very linear way. But now, with all this extra data available, we are really managing the supply chain as a more networked function -- a highly connected function.

(Slide 24)
It is also very important that the curriculum these days covers resiliency and business continuity in the supply chain.

A lot of these techniques about how to anticipate, resist, and respond to issues in the marketplace are very important to the future of manufacturing.

(Slide 25)
We just gave you a sampling of the of the type of topics that we want to cover in our curriculum for Smart Manufacturing and all the skills that we want to provide to the workforce.

At CESMII, we are growing the membership that is tackling this challenge. We have over 140 members in our current ecosystem that includes a lot of great manufacturers, universities and technology partners.

(Slide 26)
But we're very interested in increasing the number of community colleges involved in the ecosystem. Colleges that are going to help us deploy this curriculum into workforce training programs.
We are growing the community of colleges, educators and trainers, to help us on this journey and we're welcoming you to join us on this journey.

Our contact information is here, I want to thank Sam for joining me today on this broadcast.

We want to together build out pathways for the workforce to receive training and skills for these generational changing jobs.

We want to upscale the workforce, while they're working and attract talent that might not want to or can't afford a 4 to 6 year university degree as a starting point.

We want to build out quality co-op and internship programs so students can graduate with the experience that manufacturers are seeking.

Also on the slide there is a link to the latest request for proposal by CESMII which includes funding for curriculum development of this type that we are covering today.

Sam, do you want to add something to that.

Sam:

Conrad, I want to thank you for helping me understand the broader framework for Smart Manufacturing that goes beyond existing community college level training.

We want to emphasize that we are seeking to develop modules for community colleges, but these can also be used for manufacturers directly to upskill their existing workforce.

We hope to hear from some of you soon, thank you.

Conrad:

Thank you, thank you very much.

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