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MICRO-CREDENTIALING STRATEGIES FOR 21st CENTURY FOOD & AGRICULTURE

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FOR

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SUMMARY

The purpose of this project is to establish a working definition and framework for micro-credentialing and proficiency-oriented educational designs capable of addressing growing skills gaps in the important industry sectors of Food, Agriculture, Renewable Resources and Environment. An example application of the micro-credentialing framework and multi-stakeholder engagement methods will be focused on the growing industry of Controlled Environment Agriculture (CEA), while the overall model will be designed for portability across diverse industry sectors.

THE NEED

In an environment of rapid change and industry disruption, businesses and individuals alike are challenged with adapting their competencies to remain competitive in the marketplace. As new technologies and 'disruptive innovations' multiply, widening skills gaps challenge traditional approaches to education and workforce development. In Mckinsey's 2013 global survey on education and employment[1], a majority of youth surveyed said that practical, hands-on learning is an effective approach to training; however, only 24 percent of academic-program graduates and 37 percent of vocational graduates said that they are provided with this type of training. At the same time, shortages in qualified candidates are a growing concern facing many U.S. companies in sectors that require hands-on technical training and experience – from entry level jobs to higher-paying, skilled positions.

As changing demands and standards accelerate across industries, one of the most pervasive challenges for the Education and Workforce Development sectors has been to develop effective models for establishing meaningful feedback mechanisms between industry leaders and educators. Micro-credentialing strategies are increasingly being seen as a compelling solution for capturing employer feedback, documenting specific priority skills employers see as employable, and validating proficiency in learners with greater flexibility and immediacy.

[1] Mourshed, M., Farrell, D., & Barton, D.. (2013). *Education to employment: Designing a system that works.* Washington, DC: McKinsey Center for Government.

INTAG
Integrated Agriculture Systems

NATIONAL NEED

For students, educators and institutions, there is significant opportunity in modernizing career pathways into 'future proof' industry sectors expected to experience sustained growth, and in which demand for qualified talent outpaces supply. There are few areas in which talent shortages are as acute as in the sectors of Food, Agriculture, Renewable Natural Resources and Environment.

Analysis and reporting on the 2015-2020 window in the sectors of Food, Agriculture, Renewable Natural Resources and Environment funded by the US Department of Agriculture's National Institute for Food and Agriculture and conducted by Purdue University indicates significant shortages emerging in critical professions.[2]

Annual Job Shortages vs Openings in Food, Agriculture, Renewable Resources and Environment

22,500
annual gap - graduates vs job openings in Food & Agriculture

- Forbes, 2016

57,900: Food, Agriculture & Renewable Resources

25,000: Business Ops & Management

15,000: Science, Technology, Engineering, Math

9000: Sustainable Food & Biomaterials Production

Tier 1 and Tier 2 Most In-Demand Skill Sets

HIGHEST DEMAND:
- ✓ Plant Scientists
- ✓ Food Scientists
- ✓ Sustainable Biomaterials
- ✓ Water Resources Scientists
- ✓ Water Resources Engineers
- ✓ Precision Agriculture
- ✓ Veterinary

HIGH DEMAND:
- ✓ E-commerce Managers
- ✓ Marketing Agents
- ✓ Ecosystem Managers
- ✓ Agri-science Educators
- ✓ Crop Advisors
- ✓ Pest Control Specialists

Source: USDA / Purdue University, 2015

[2] United States Department of Agriculture. (2015). *Employment opportunities for college graduates in food, agriculture, renewable natural resources and the environment: United States, 2015-2020.* Retrieved from https://www.purdue.edu/usda/employment/

STATEWIDE NEED

The PA Department of Agriculture has documented a significant number of high priority career pathways that currently lack adequate training, credentialing opportunities and educational opportunities.

Skills Shortage: Pennsylvania
Sector: Food & Agriculture

75,000
Ag and Food jobs to be filled in Pennsylvania over 9 years

57
Average age of a farmer in Pennsylvania

Skills Shortage:
1. Farming Operations
2. Food Production
3. Farm Managers
4. Sales Representatives
5. Technicians & Repair Workers

>

22
Priority Occupations in Food and Agriculture in Pennsylvania

>

14
Priority Occupations with no adequate career pathways, training or credentialing

Source: Pennsylvania Department of Agriculture, 2015

DEFINING A MICROCREDENTIAL

In simplest terms, a micro-credential verifies that the holder has effectively applied conceptual learning, achieved a specific skill, competency, and/or set of skills or proficiencies. Like a traditional college degree or certificate, a micro-credential should be of rigorous quality and endorsed by the organization issuing it; unlike a traditional college degree or certificate, a micro-credential is generally offered in shorter, more flexible formats and is more narrowly-focused.

Some types of micro-credentials are referred to as digital badges, micro-certifications, mini-degrees, nano-degrees, etc. Regardless of the terminology used, a reputable micro-credential should effectively address all of the following objectives:

1. meet current industry needs and align with relevant standards;
2. communicate transparent learning outcomes and methods of assessment;
3. hold value within the relevant industry, beyond the issuing institution;
4. be compatible with and “stackable” towards a more advanced credential or degree;
5. provide tangible methods for learners to demonstrate competency in specific skills (hard and soft skills) through ‘real world’ application of classroom instruction and academic concepts.

STAKEHOLDER ENGAGEMENT

One notable challenge in creating viable micro-credentialing strategies is that of capturing and incorporating meaningful industry feedback into the curriculum being taught. An effective micro-credentialing solution must address concerns and tangible benefits for diverse stakeholders in every step of the lifecycle of education and employment.

1. **EMPLOYERS & PRIVATE SECTOR**

   Needs: Skills gaps and talent shortages are steadily increasing in many sectors, fueled by rapid industry change and compounded by technological advancement and increasing complexity in the marketplace.

   Opportunities: Many employers are willing to contribute senior level, expert feedback, relevant data and even reusable assets in training content - so long as tangible benefits and near-term impacts can be seen in the form of more qualified candidates that require less on-the-job training. The specificity of micro-credentialing, combined with the flexibility of bundling or stacking micro-credentials into micro-degrees can bring new agility to the talent ramp across the spectrum of education. This creates several attractive opportunities for employers:

   - The potential for career-ready graduates due to better adaptability in educational formats;
   - New opportunities to inform curriculum for greater relevance to industry demands; and
   - Increased validation of the competencies, proficiencies, and specific skills (hard and soft skills) of their employees as a result of the application of classroom instruction in project-based learning activities.

2. **INDUSTRY ASSOCIATIONS**

   Needs: Professional organizations and industry associations need to drive benefit to their subscribers and members. Thus, they need to be in continuous development of new initiatives that support the overall health and vitality of the sectors they serve - particularly in areas where the trust, rapport and neutrality they must cultivate can benefit new initiatives in ways that individual member companies cannot. Access to qualified, career-ready talent is a common need across all employers in their membership base, and the development and maintenance of meaningful proficiency standards is a foundational piece of this equation.

   Opportunities: Professional organizations and industry associations can play several valuable roles in quality control and third party validation of micro-credentialing models. Examples of these roles include the facilitation of multi-stakeholder feedback and industry standardization around expectations of competency/proficiency for industry roles, support and validation of assessment tools, and even product and service development for tools and processes that enable data sharing amongst industry players.

3. **HIGHER EDUCATION**

   Needs: Institutions of higher education face growing external pressures of accountability for student persistence, student debt, post-graduation employment rates, etc.[3] They also face challenges of access for low-socioeconomic individuals, declining undergraduate enrollment rates, and malalignment with industry needs. Colleges and universities that embrace the task of developing innovative education models to address the needs of student and industry stakeholders need to do so in a way that allows for a sustainable business model and a robust mechanism for industry feedback.

[3] Brown, J.T. (2017). The seven silos of accountability in higher education: Systematizing multiple logics and fields. *Research & Practice in Assessment*, 11, 41-58.

Opportunities: Institutions of higher education have the opportunity and ability to take the competencies outlined by industry associations and design a viable 'stackable' credentialing pathway that allows for the seamless integration of workforce-level certifications and micro-credentials within the context of broader degree programs. This has the potential to:

- Increase access to career pathways for low SES students without requiring commitment to a four-year degree;
- Increase student persistence rates due to the opportunity for multiple exit points in a stackable model;
- Decrease student debt by helping to ensure post-graduation employment; and
- Engage K12 students early through dual enrollment opportunities, leading to increased enrollment rates.

4. K-12 EDUCATION

Needs: Industries have a need to increase awareness in younger generations regarding the career opportunities in their fields. It is generally accepted that early exposure to diverse disciplines, technologies and career pathways is critical to keep workforce participation high in skilled and technical fields. This has been found to be especially true in STEM fields where the perceived complexity or technical rigor may seem foreign or intimidating to many students. Furthermore, research has shown that girls and minorities are more likely to suffer a dissonance in their engagement with science and technology, having an interest in STEM fields but feeling that they are not capable of pursuing such careers.[4] As shortages in qualified talent intensify in many sectors in recent years, pressures on educational institutions to improve outcomes in college and career readiness has increased.

Opportunities: Higher Education institutions and future employers alike can benefit from using micro-credentialing strategies to extend the relevance of their content to K-12 education. Project-based application of concepts to real-world scenarios is an essential feature of any effective micro-credentialing strategy, providing unique opportunities for integrating industry-informed content with K12 standards-aligned curriculum appropriate to be taught in schools. Institutions of higher education can provide the connective layer between K-12 education and entry-level competency demanded by employers by curated educational experiences for learners of all ages through accessible, project-based activities with real-world, resume-building relevance.

5. STUDENTS

Needs: Students need access to options and career pathways that do not necessarily require commitment to a four-year degree all at one time. They also need learning opportunities that provide them with the applicable skills necessary to earn higher-paying jobs, while not requiring them to take on large amounts of student debt, and also allowing enough flexibility to fit the programs into their likely busy lives.

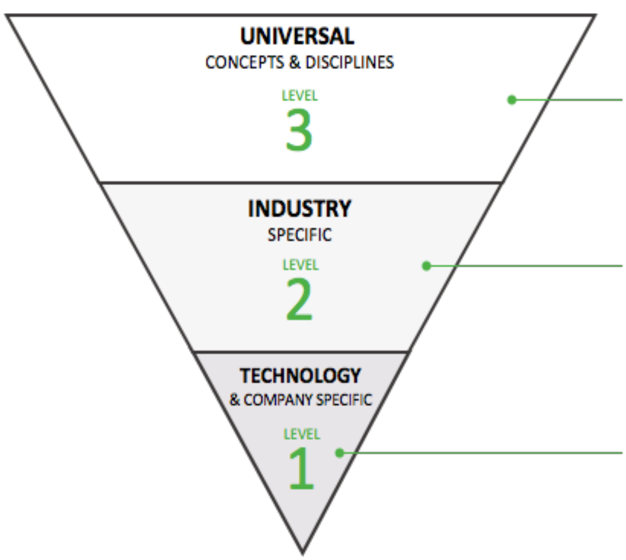
[4] Brickhouse, N. W., Lowery, P., & Schultz, K. (2000). What kind of a girl does science? The construction of school science identities. Journal of Research in Science Teaching, 37(5), 441 – 458.

Opportunities: New micro-credentialing models have the potential to allow students to pursue the competencies and skills they need for the specific industry roles they seek. Flexible learning experiences allow for customization of educational needs, giving students the opportunity to begin with an entry-level credential and build their careers over time. The model also gives students a leg up when seeking employment since industry employers contribute ongoing feedback about the micro-credential needs, giving them a clear understanding during the hiring process of the competence and skills of the students who have completed a specific credential.

FORMAL EDUCATION vs. ON-THE-JOB TRAINING

The following section outlines the differences between the approaches of conventional educational programs vs. on-the-job training provided by employers using a three-tiered competency framework. An effective micro-credentialing strategy allows for a symbiotic blend of both approaches in order to meet the specific workforce needs.

Figure 1. Definitions for a tiered content framework[5]



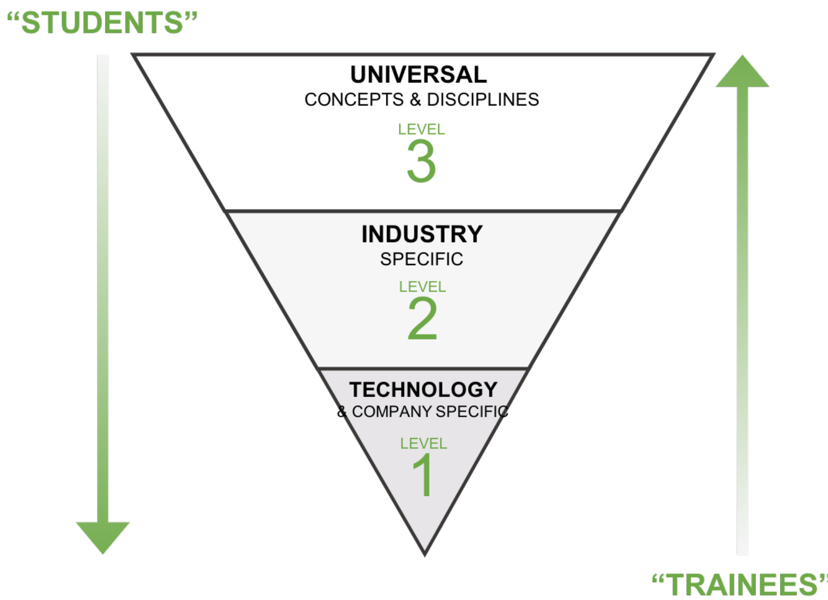
TIER 3: Universal concepts in specific disciplines, as found in most K-12 Schools and Four Year Degree Programs: Learning at this level is generally intended to give learners a deeper and more universally applicable understanding of the laws and dynamics that govern a discipline (i.e. the scientific process, the laws of physics, historical origin of social and political philosophies etc.)

TIER 2: Industry specific knowledge and credentialing, as found in industry certifications and professional associations: Learning at this level is intended to validate a learner's ability to apply both broad and specific knowledge in a professional context - ideally across a range of technologies, processes and employers.

TIER 1: Technology and company-specific training, as found in on-the job (OTJ) training, workplace safety and specific employers' processes and technologies: Learning at this level is intended to teach the most critical practical skills required to operate in the workplace. Training content at this level is focused on workers' abilities to use specific tools, make tactical decisions and generally follow pre-defined processes, protocols and Standard Operating Procedures (SOPs).

[5] Source: B Theory Inc.

Figure 2. Conventional learning processes, academic vs. on-the-job training



In conventional approaches, "students" and "trainees" receive different styles of instruction, often limited to only one tier of educational content.

> **'Students'** enrolled in a conventional K-12 school or four-year college degree program tend to be taught broader universal subjects – often only learning more tangible applied skills relevant to specific career pathways near the end of their educational track in the form of internships.
>
> **'Trainees'** in a vocational or on-the-job training context tend to learn task and equipment specific skills, and gradually progress into broader industry-relevant skills as they continue work within a given profession. Professional knowledge and industry expertise is reinforced with diversified credentials and certifications in many fields.

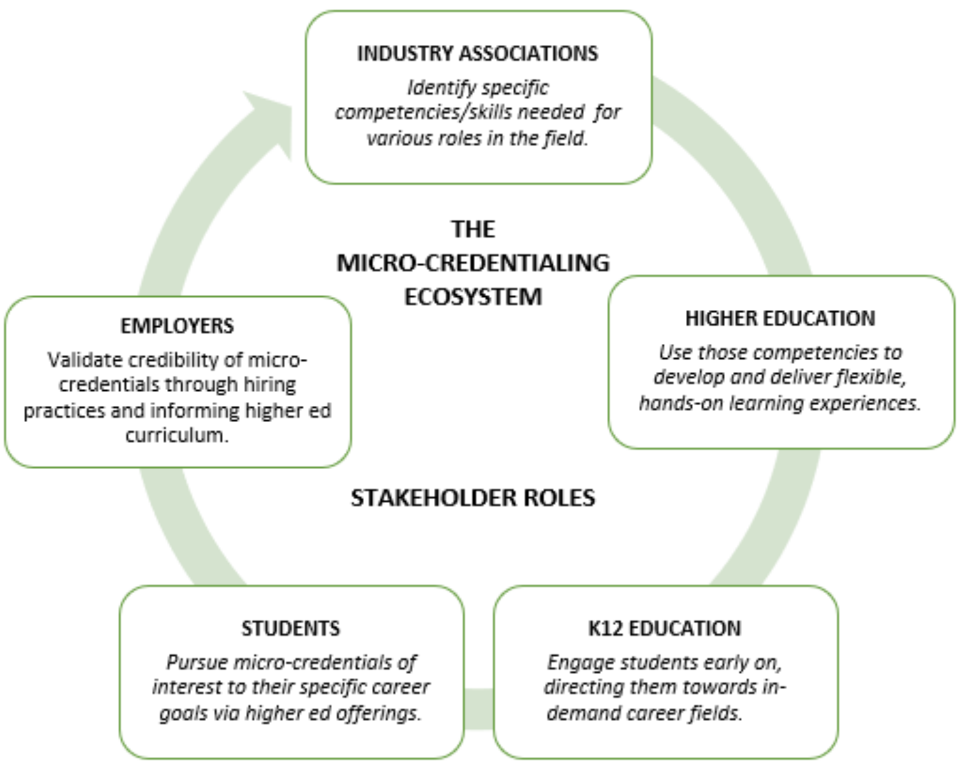
Application of theoretical concepts and the assessment and validation of competencies are foundational features of a true micro-credentialing model. An effective microcredential program will create real-world, project-based experiences in which learners rapidly move between different tiers of competency and content in order to meet the specific objectives needed for the credential they are pursuing. Classroom instruction should occur in close proximity to real world application, improving retention of concepts. The immediacy of outcomes and client feedback from real-world projects demands growth towards proficiency from learners and also develops both tangible "hard" skills and the "soft"skills necessary to work in teams and to interact with the recipients / clients of the project deliverables.

THE MICRO-CREDENTIALING ECOSYSTEM

The concept of a STEM learning ecosystem is already well established in the K-12 environment. In the K-12 context, a STEM learning ecosystem is a collaboration among schools, community programs, science centers, etc. to provide a pathway of STEM learning opportunities for young people by harnessing the unique strengths of each collaborator.[6] The micro-credentialing ecosystem is an extension of this established concept but applied to workforce development and including the stakeholders discussed above: employers, industry associations, institutions of higher education, K-12 education, and students. Each stakeholder holds a specific role in the process, uniquely suited to how they fit into the context.

1. **Industry associations** hold the role of identifying the competencies and skills necessary to validate the different credentials needed in the field;
2. **Institutions of higher education** hold the role of using those industry-aligned competencies to inform program curriculum and to design and deliver accessible, innovative, hands-on learning experiences;
3. **K-12 institutions** serve the role of engaging students early and directing them towards the in-demand fields;
4. **Students** pursue the micro-credentials of interest to their specific career goals through higher education offerings;
5. **Employers** close the loop by validating the credibility of the micro-credentials through hiring practices and informing higher education curriculum, either individually or through an industry association.

Figure 3. Stakeholder roles in a micro-credentialing ecosystem



[6] STEM Ecosystems. (n.d.) *What are STEM learning ecosystems?* Retrieved from http://stemecosystems.org/what-are-stem-ecosystems/

Note: Cross-sector collaborations producing educational content often raise questions of content ownership or other proprietary challenges. For example, an institution of higher education is typically the primary stakeholder whose business is the delivery of educational models and would therefore commonly take ownership of the types of content in tiers two and three, while employers are more likely to focus on content from tiers one and two. In order to facilitate symbiotic relationships, institutions of higher education may consider making content developed in tiers one and two available to their industry partners for use in corporate training applications through specialized agreements that provide adequate value to all parties.

APPLICATION OF MICRO-CREDENTIALING ECOSYSTEMS FOR CEA OPERATIONS

Controlled Environment Agriculture (CEA) is a fast growing industry in the United States. Although currently far more prevalent in Europe and Asia, adoption of CEA in the U.S. is experiencing strong growth, driven by increasing public demand for more localized production of fresh produce, particularly in metro areas. Hydroponics and Aquaponics are both methods of soilless growing in which plants are fed with nutrient-infused water - predominantly within climate controlled environments (CEA) including greenhouses and indoor enclosures equipped with artificial lighting for plants. Plants need 17 different maco and micro nutrients to grow. In a hydroponic system, these nutrients are mixed together in water with other additives to assist in the nutrient utilization by plants.

ABOUT THE CEA INDUSTRY[7]

CEA involves agricultural production within enclosures that provide meaningful levels of biosecurity and climate control — either indoors with artificial lighting or in various types of greenhouse enclosures. CEA manages and monitors contained microclimates in order to maximize plant growth for high-yield and year-round crop production. While these controlled growing environments can be established in a range of enclosures, from greenhouses to indoor spaces equipped with artificial lighting, CEA installations generally control ambient temperatures around plants and their root zone (rhizosphere), along with relative humidity, $CO2$ levels, lighting, nutrient sources and the nutrient levels being delivered to plants.

CEA is also usually used to refer to soilless growing methods that include **Hydroponics** (growing plants in nutrient-infused water), **Aquaponics** (integrating the raising of fish and aquatic life as a natural source of nutrients for plants) and **Aeroponics** (involving the periodic ‘misting’ of exposed plant root systems with nutrient-infused water).

The past four years have seen a wave of new interest, investment and innovation in CEA in the United States. From indoor and vertical farming to advanced greenhouses, these tech-enabled farming operations have been making headlines and sparking lively speculation on the potential for systemic changes in our food supply. The field of ‘novel farming systems,’ which includes CEA, hydroponics and aquaponics as well as fish and insect farming, has now emerged as the single fastest-growing area for new investment in the food and agriculture sector, with over 233% growth

[7] The following section includes excerpts from a CEA industry survey authored by Ian D. Kanski (INTAG) and David Kowert (NextTack Consulting) for a report entitled *Controlled Environment Agriculture for South Carolina* commissioned by the Palmetto AgriBusiness Council in 2017 with funding from the South Carolina Department of Agriculture.

between 2014 and today. During that same time frame, just five of the top emerging U.S. companies in vertical farming and advanced hydroponic greenhouses have raised over half a billion dollars of new investment from some of the leading names in tech and finance, including Google, Amazon, SoftBank, Goldman Sachs and Prudential.

While these increasingly high-profile, tech-enabled farming models are often championed in the U.S. as “disruptive innovation,” with the potential to radically transform supply chains for a widening menu of greens, fruits and vegetables, the underlying systems and methods involved in CEA actually have a long and successful history. Commercial-scale CEA in advanced greenhouse operations have been successfully supporting food and agriculture production around the world for decades — particularly in areas where climate conditions and geographical limitations make traditional agricultural methods challenging.

For context, the United States hosts an estimated 2000 acres of greenhouse vegetable production, while Europe is home to over 400,000 acres of greenhouse vegetable production. Perhaps the single greatest case study for the adoption of CEA is that of the Netherlands which, as stated in a 2017 report by National Geographic, is “the globe’s number two exporter of food as measured by value, second only to the United States, which has 270 times its landmass.” In fact, the Dutch horticulture industry has been pioneering commercial-scale hydroponic growing in glass greenhouses aggressively since the 1980s after legislation protecting groundwater effectively stopped the soil growing of many crops in greenhouses – indirectly launching decades of innovation in hydroponic growing methods. Today, the Netherlands achieves this impressive second place rank in global food export value with only half of its greenhouse infrastructure being used for food crops, while the other half is dedicated to dominating the world market for flowers.

ROLES AND COMPETENCIES IN CEA OPERATIONS

Job roles within a CEA facility (greenhouses or indoor farms) require general knowledge of multiple areas of operations with most functions being easily taught and accessible to entry-level workers. The roles most demanding of greater experience and advanced learning in these settings are those that involve oversight of crop health, plant science and managing environmental controls to meet the needs of the specific plant species being cultivated. Diagnosing plant health issues and adjusting environmental settings to maximize yields require greater experience that is generally learned over longer periods of time. Management of technological systems and daily routines of planting and harvesting are generally more readily accessible to entry-level workers. Figure 4 below depicts the primary competency categories involved:

Figure 4. Micro-credentialing framework for CEA operations

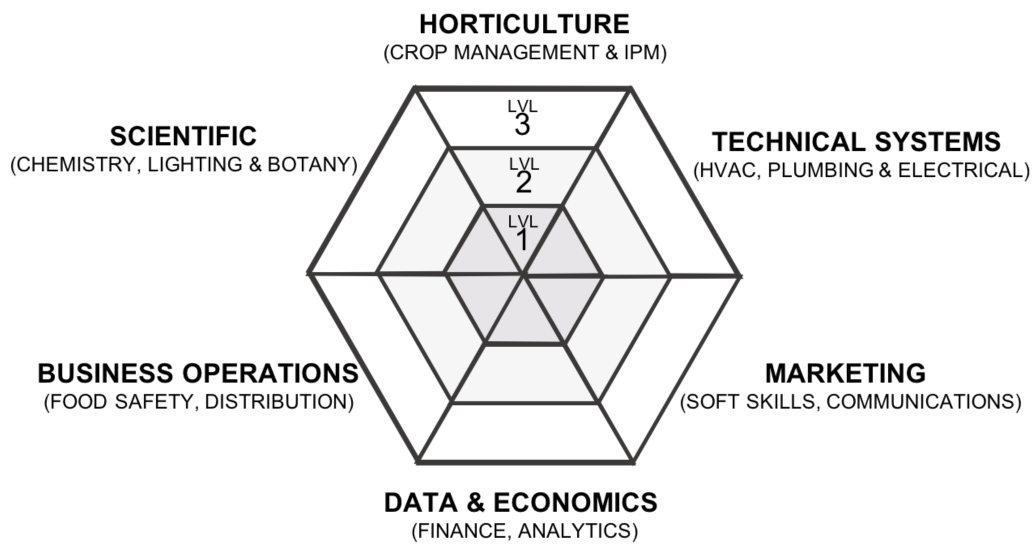


Figure 5. Example credentials in CEA by individual roles

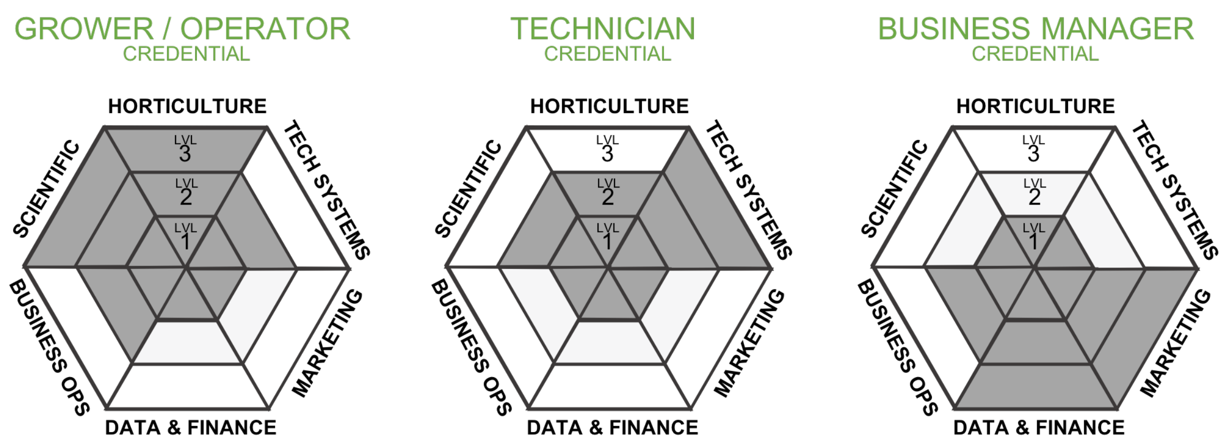


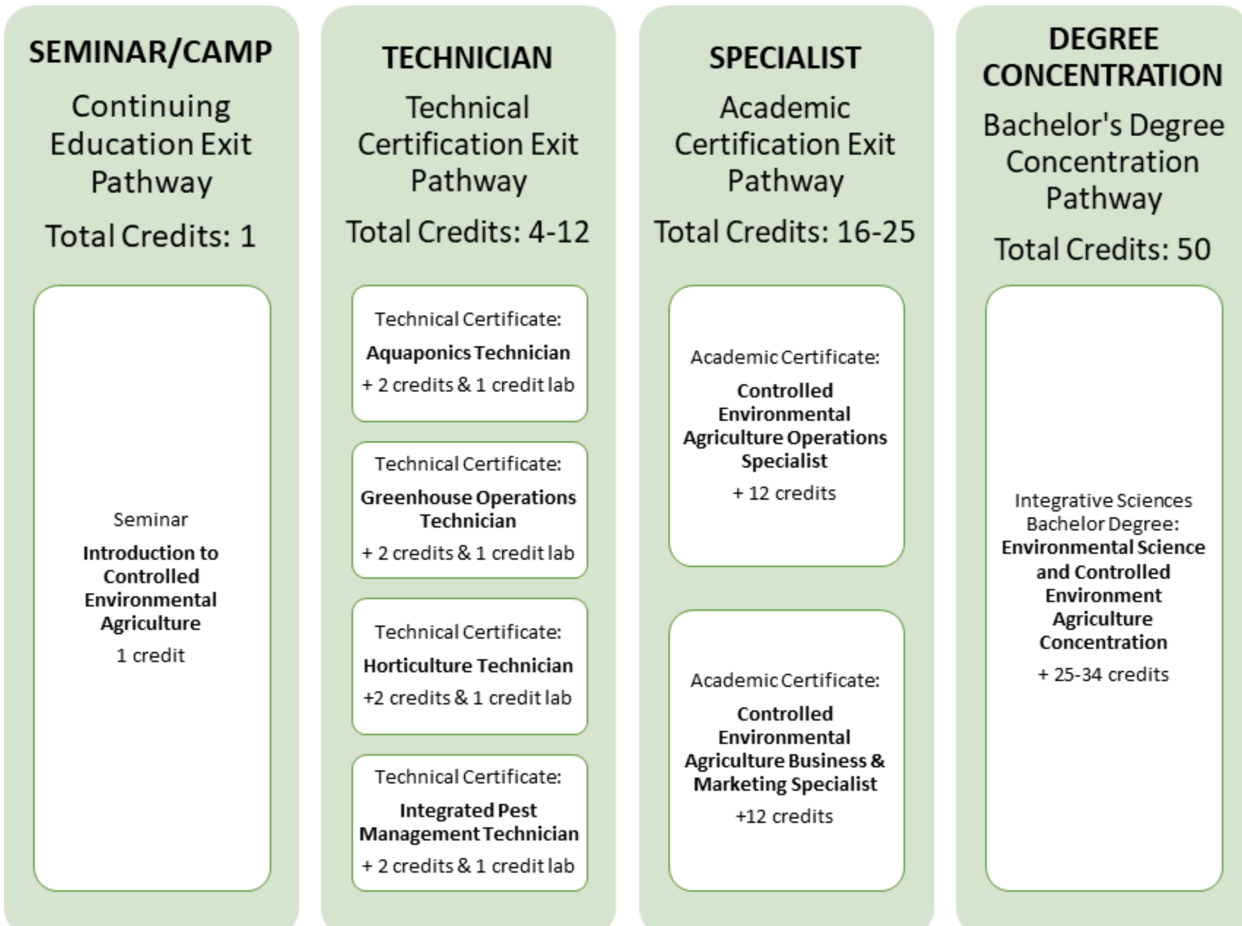
Figure 5 depicts competency groupings for three distinct example roles, overlayed on the micro-credentialing framework. Each of the three roles in this scenario require different skill profiles and proficiency levels, with the three roles achieving full coverage in needed competencies when functioning as a complete team.

INTEGRATION OF MICRO-CREDENTIALS INTO HIGHER EDUCATION DEGREE PROGRAMS

An effective micro-credentialing model, informed by industry needs and employer feedback, also creates new opportunities for educators in institutions of higher education to seamlessly integrate workforce development-level competencies into concentrations and four year degree programs.

The program shown below in Figure 6 is an example of how the industry-determined competency/badging model described above could be applied by institutions of higher education to develop a micro-credentialing pathway that meets the varied workforce needs of the CEA industry by giving students multiple exit pathways into career opportunities. The model is considered stackable because the credits in each pathway build on each other and count towards the next stage in the pathway.

Figure 6. Example of stackable micro-credentialing pathway for the CEA field[8]



The first exit pathway in this model is the **Continuing Education Pathway**. This pathway is meant as an opportunity to spark interest in the field with a short, low-commitment introductory course. This course could be offered in the form of a summer camp for K12 students or in the form of a seminar or professional development course for adults seeking new career opportunities.

The second exit pathway is the **Technical Certification Pathway**. This pathway is the backbone of the micro-credentialing concept. This is where entry-level workforce needs are met as industry-aligned competencies and skills are delivered in short courses targeted at specific technical roles in the field (ex. Aquaponics Operator). Students can take any combination of these micro-credentialing courses that suits their career goals.

[8] This example of a stackable micro-credentialing (Figure 5) for the field of Controlled Environmental Agriculture was designed by Harrisburg University of Science and Technology.

Multiple micro-credentials from the second exit pathway can be stacked together to align with the skills needed for broader or more complex roles in the industry, which leads us to the third exit pathway, the **Academic Certification Pathway**. As students reach this pathway they will have collected approximately 15 college credits related to the CEA industry, which constitutes an academic certification and will prepare them for broader, more skilled rolls in the field, depending on the options they selected to stack (ex. CEA Business Manager).

The final exit pathway is that of a traditional undergraduate **degree concentration** in CEA. Students who seek this pathway having come through each of the pathways before it will arrive at this stage with as many as 25 of the 50 credits needed for a degree concentration already completed. This pathway is where the students learn the in depth, academic concepts that they don't need to perform entry level roles but are necessary for success in more complex roles (ex. CEA System Engineer).

CEA FACILITIES AS LEARNING ENVIRONMENTS

Due to the diverse, interrelated disciplines involved in CEA, along with the flexibility of systems design, CEA systems configured for skills-oriented training and education create an ideal learning environment for a wide range of career pathways. Relevant career pathways that can be modelled in a CEA environment are also highly transferable beyond the CEA industry and across broader sectors within food, agriculture, renewable resources, environment and related technological and engineering fields. Learners can engage broad concepts in science, technology, engineering and math (STEM) fields, simultaneous to hands-on applications of those concepts through workplace activities relevant across the value chain of food, agriculture and supporting technologies — in an immersive and unusually interdisciplinary working environment.