Assessment of Controlled Environment Agriculture Workforce Needs and UMKC Student Interest in Controlled Environment Agriculture Education

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Executive Summary

Controlled environment agriculture (CEA) systems integrate technology to optimize crop performance via environmental control. There is an urgent need to train the future workforce to meet the needs of the CEA industry as these systems become more technology driven. Therefore, the goal of this project was to inform the development of CEA curriculum by gauging student interest at the University of Missouri – Kansas City (UMKC) and understanding the knowledge, skills, and degrees desired for different job hierarchies in the CEA industry. A survey was sent to individuals in the CEA industry (academics, growers, and service/technology providers) to determine the knowledge and skills needed for different CEA job positions and the degree that certifies competency for said positions. Another survey was sent to UMKC students to gauge their knowledge of – and interest in – a CEA educational program. Responses from the CEA industry were separated in two groups based on the role of respondents in CEA: roles directly involved in growing crops and support roles (academics and service/technology providers). There was consensus between both industry groups on the top ranked skills, knowledge, and degree programs for job positions in CEA. The top five positions in demand by the CEA industry are, from highest to lowest ranked: (1) farm manager, (2) farm worker, (3) research & development director, (4) food safety coordinator, and (5) research technicians. The top degrees for the positions listed above are: (a) apprenticeship, (b) two-year associate, (c) graduate, (d) bachelor, and (e) bachelor programs, respectively. Eighty-nine percent of UMKC students are interested in a lab or greenhouse where they can participate in growing crops. Fifty-three percent of UMKC students are interested, or would consider participating in, an academic minor for Controlled Environment Agriculture. We anticipate that our observations will inform the development of curriculum and degrees that meet the needs of the CEA industry. Individuals utilizing the results from this project should consider which responses are relevant for their own curricular development needs.

Keywords: *hydroponic, vertical farm, urban agriculture, food deserts, controlled environments*

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Background

Controlled Environment Agriculture (CEA) implements technology to optimize the plant growth environment which results in higher crop yields, greater adaptability to grow crops beyond traditional field farming methods, and a built-in resiliency to adapt to climate change and events capable of disrupting traditional food distributions networks. Because of its adaptability, CEA farms become a potential farming system to address food insecurity in urban areas [1]. Produce attributes such as fresh, local, pesticide free, year-round, safety, and community agriculture initiatives can influence consumer perceptions and demand for produce sourced from CEA farms [2].

As the United States (US) shifts to local CEA production, billions of dollars will be injected into production capacity to increase local/state revenue. Local CEA production seeks to reduce our national need for fruit and vegetable imports, increase the nutritional value to consumers, and reduce the environmental footprint of farming due to the minimization food haul and food waste [3]. The CEA market is projected to expand to over $170 billion by 2025 and grow five times in US market share over the next 10 years [4]. Notable examples of investments in the US include over $200 million in Plenty (as of 2017), over $238 million in AeroFarms (as of 2020), and over $167 million in Bowery Farms (as of 2020).

The University of Missouri – Kansas City (UMKC) lacks the educational capacity in agriculture – leaving students with no exposure to any agricultural programs yet has nationally competitive programs in science and engineering. As an urban institution, UMKC is ripe to create a CEA educational program to directly serve metropolitan and regional needs. Surveys to assess CEA industry workforce needs and UMKC student interest in CEA educational programs were the primary research components of this study.

Methodology

The purpose of the project was to identify CEA industry workforce training needs, measure UMKC's student interest in CEA educational programs, and assess UMKC's infrastructure needs to deliver on CEA education. The CEA workforce training needs were identified by asking the CEA industry what skills, knowledge, and degrees are needed for individuals working in different job hierarchies. A survey to UMKC students to measure their experience with agriculture and their interest in a CEA program was also administered.

Industry Survey: A survey was administered to individuals in the mailing lists for the Indoor-Ag Con and the US CEA Network. The Indoor Ag-Con has approximately 6,500 contacts in their mailing list representing growers, investors, real estate developers, technical leaders, produce buyers, academics, policymakers, industry suppliers, and advocates for the CEA industry. The US CEA Network mailing list has approximately 112 contacts from faculty members and USDA officials with research and extension programs tied to CEA.

For the industry study, researchers grouped responses from participants based on the role they have within a CEA farm operation due to lower response rates. Two categories were created depending on which roles had a *direct involvement* in growing and selling crops and which roles offer *support* to a CEA farm operation. The *Directly Involved* category includes participants who indicated having roles as owner, farm manager, R&D director, R&D staff, sales, marketing specialists, integrated pest management specialist, food safety coordinator, farm worker, and gardener. The *Support* category includes participants who indicated having roles as investor, logistics, accounting, human resources, administrator, academic researcher, and academic instructor.

Industry participants were asked to select the skills and knowledge they thought were needed for different job positions in a CEA operation (Figure 1). Participants were then asked to indicate the appropriate educational degree they felt would certify an individual is fit for such position (Figure 1). Each position included a short description of activities and expectations.

Positions:

1. Farm worker
2. Farm manager
3. R&D Technician
4. R&D Lead/Director
5. Marketing specialist
6. Food safety coordinator
7. CEA Entrepreneur/Investor
8. CEA Farm owner

Degrees:

- High school degree
- Apprenticeship program
- Career certificate program
- Two-year associate degree
- Minor degree of an established Bachelor's degree
- Bachelor's degree
- Graduate education
- Other (please specify)

Knowledge & skills:

- Food safety
- Integrated pest management
- Programming and coding
- Basic chemistry
- Basic plant physiology
- Advanced plant physiology
- Statistics
- Experimental design and data analysis
- Leadership
- Logistics
- Financing
- Accounting
- Marketing
- Quality Assurance
- Quality Control
- Microbiology
- Human Resource Management
- Economics
- Conflict Management
- Empathy
- Critical listening
- Advertising
- Other (please specify)

Figure 1. *Participants from the CEA industry had to select the knowledge & skills and the degree needed to certify competency for each of the listed positions.*

Industry participants then ranked the positions that are most needed currently and in the future. The participants were asked to indicate if internships or apprenticeships were necessary for each of the positions and if they were willing to host an internship program.

Student Survey: The student survey was sent to 11,290 UMKC undergraduate and graduate students. The survey was not sent to students that invoked their FERPA rights, high school students taking advanced credits, and any student under 18 years of age.

UMKC students were asked to indicate if they had any experience in agriculture. Students were then asked if they would like to see a UMKC greenhouse or laboratory where they could grow crops. Students were provided with the CEA definition and then asked if they were familiar with CEA farming. Students had to indicate if they would be interested in a UMKC CEA minor if it was offered and what knowledge and skills they would be interested in gaining from the minor.

Frequency statistics were performed for both student and industry survey questions that asked about skills and degrees of a particular job position to determine consensus between participants in the *Directly Involved* or *Support* role categories. Hypothesis testing was done using chi-square at $p<0.05$ using IBM SPSS

Statistics. Significance between groups is indicated by cells highlighted in yellow with bold, italicized, and underlined font (Tables 2 and 3).

Results and Discussion

CEA Industry Survey

Industry Respondent Description. The industry survey totaled 54 responses resulting in less than 1% response rate. The following observations describe the CEA industry survey respondents:

- Role in the CEA industry: 40% in support industries, 38% directly involved with the growth and sale of crops, and 19% in academic positions.
- 81% were from companies/farms headquartered in the United States.
- 34% belonged to a CEA company/farm that is growing and selling crops.
- Crops were grown using 52% vertical farms, 24% greenhouses, 16% high tunnels, and 8% plant factories.
- Leafy greens, herbs, microgreens, and tomatoes were mentioned the most when asked which crops were grown.

CEA Workforce Needs Assessment. The CEA industry indicated that job positions related to growing crops, managing the farm, food safety and research and development were the most needed (Table 1). There was no significant change to the rankings when asked about the job positions needed in the future.

Table 1. Ranking of positions that are most needed in CEA operations (1 least needed and 9 most needed):

Job position	**Current need rank mean**	**Future need rank mean**	**Rank position current→future**
Farm manager	7.30	7.08	=[z]
Farm worker	6.87	6.79	=
R&D lead/director	6.09	6.35	↓
Food safety coordinator	6.00	6.56	↑
R&D technician	5.41	5.88	=
Marketing specialist	4.9	5.21	=
Human resources	3.17	2.90	=
Accountant	3.07	2.74	=

[z] ↓↑ indicate change in the ranking position and = indicates no change in the ranking position

Overall, there was consensus between respondents in the *Directly Involved* and *Support* categories when asked about the degree program that certifies competency for each position in CEA farm operations (Table 2). However, respondents with support roles disagree on the following (↓↑ indicate change in the ranking position):

- Farm worker: 38.9% ↑ for two-year associate degree
- Farm manager: 55.6% ↑ for bachelor's degree, making it the top degree endorsed by the support industry
- Marketing specialist: 77.8% ↑ for bachelor's degree
- Food safety coordinator: 66.7% ↑ for bachelor's degree

Table 2. *Ranking of educational programs for each job positions in CEA farms according to individuals with roles involved with growing and selling crops. The highlighted cells indicate significant difference between the respondents with roles* Directly Involved *with growing and selling crops and respondents with* Support Roles *(chi-square at p≤0.05). Values represent the percentage of participants that endorsed that educational program.*

Educational program	Farm worker	Farm manager	Research & development technician	Research & development lead/director	Marketing specialist	Food safety coordinator	CEA entrepreneur /investor	CEA farm owner
Apprenticeship	41.2	17.6	11.8	0.0	11.8	11.8	0.0	17.6
Career certificate	29.4	35.3	0.0	0.0	11.8	11.8	11.8	23.5
Two-year associate degree	***11.8***	47.1	29.4	5.9	23.5	29.4	5.9	17.6
Minor degree of an established Bachelor's degree	0.0	11.8	41.2	5.9	29.4	17.6	5.9	23.5
Bachelor's degree	5.9	***23.5***	52.9	41.2	***47.1***	***35.3***	35.3	58.8
Graduate education	11.8	5.9	17.6	58.8	5.9	11.8	17.6	11.8
High school education	23.5	0.0	---	---	---	---	---	---
Other	17.6	5.9	0.0	0.0	5.9	0.0	29.4	23.5

Overall, industry respondents that are directly involved with growing crops and the respondents in support roles agree on the skills and knowledge needed for positions in a CEA farm operation (Table 3). However, respondents with support roles disagree on the following (↓↑ indicate change in the ranking position):

- Farm worker: 30.6% ↑ for basic chemistry and 41.7% ↑ for logistics
- Farm manager: 55.6% ↑ for advanced plant physiology
- R&D technician: 36.1% ↑ for logistics
- Marketing specialist: 0% ↓ for microbiology and 58.3% ↑ for conflict management
- Food safety coordinator: 0% ↓ for programming and coding and 66.7% ↑ for conflict management
- CEA entrepreneur: 91.7% ↑ for leadership
- CEA farm owner: 100% ↑ for leadership

Table 3. *Ranking of skills and knowledge needed for each job position in CEA farms according to individuals with roles involved with growing and selling crops. The highlighted cells indicate significant difference between the respondents with roles* Directly Involved *with growing and selling crops and respondents with* Support *roles (chi-square at p≤0.05). Values represent the percentage of participants that endorsed that knowledge and skill.*

Skills & Knowledge	Farm worker	Farm manager	Research & development technician	Research & development lead/director	Marketing specialist	Food safety coordinator	CEA entrepreneur /investor	CEA farm owner
Food safety	82.4	82.4	47.1	58.8	64.7	88.2	35.3	64.7
Integrated pest management	64.7	64.7	41.2	52.9	23.5	52.9	23.5	58.8
Programming and coding	0.0	0.0	23.5	29.4	11.8	***11.8***	0.0	11.8
Basic chemistry	***5.9***	23.5	82.4	64.7	11.8	41.2	11.8	41.2
Basic plant physiology	76.5	88.2	76.5	58.8	29.4	58.8	29.4	76.5
Advanced plant physiology	5.9	***23.5***	58.8	76.5	5.9	29.4	11.8	17.6
Statistics	0.0	5.9	70.6	76.5	41.2	23.5	41.2	35.3
Experimental design and data analysis	11.8	5.9	82.4	88.2	17.6	23.5	11.8	29.4
Leadership	29.4	82.4	11.8	82.4	58.8	70.6	***70.6***	***88.2***
Logistics	***5.9***	52.9	***5.9***	58.8	58.8	29.4	35.3	58.8
Finances	0.0	17.6	5.9	47.1	64.7	5.9	76.5	88.2
Accounting	5.9	5.9	5.9	23.5	29.4	5.9	70.6	70.6
Marketing	0.0	0.0	5.9	23.5	82.4	5.9	47.1	76.5
Quality assurance	41.2	70.6	35.3	41.2	35.3	76.5	35.3	58.8
Quality control	47.1	76.5	35.3	47.1	35.3	76.5	29.4	52.9
Microbiology	5.9	23.5	52.9	58.8	***11.8***	47.1	11.8	23.5
Human resource management	5.9	58.8	0.0	47.1	35.3	41.2	35.3	70.6
Economics	0.0	23.5	5.9	52.9	52.9	11.8	76.5	70.6
Conflict management	23.5	88.2	11.8	35.3	***23.5***	***35.3***	35.3	76.5
Empathy	17.6	58.8	11.8	35.3	35.3	41.2	41.2	64.7
Critical listening	35.3	70.6	47.1	76.5	58.8	58.8	70.6	88.2
Advertising	0.0	0.0	0.0	5.9	70.6	5.9	35.3	58.8
Other	11.8	5.9	0.0	0.0	5.9	0.0	5.9	17.6

The statistical differences observed in the degree program and skills and knowledge responses do not significantly affect the overall rankings. Institutions utilizing the results from this project should consider which responses are relevant for their own curricular development needs.

CEA industry respondents perceive that the top three roles that need an internships or apprenticeships prior to hiring are R&D director, farm manager, and food safety coordinator (Table 4). When asked about their willingness to host internships, 37% are not willing to host an internship program, 45% would offer a paid internship, and 18% would offer an unpaid internship. One respondent indicated that they provide job training due to the lack of trained workforce in the CEA sector and that they were open to developing an internship program.

Table 4. *CEA industry respondents' perception on the need of internships for different positions in a CEA operation from 1 least needed to 5 most needed.*

Position	**Apprenticeship Rank Mean**	**Rank**
R&D lead/director	3.89	1
Farm manager	3.85	2
Food safety coordinator	3.65	3
R&D technician	3.36	4
Accountant	3.16	5
Human resources	3.12	6
Farm worker	3.00	7
Marketing specialist	2.9	8

Two respondents indicated that engineering roles were not included in the survey, and that engineering curriculum is critical as CEA farms become more automated and technology driven. One respondent suggested the inclusion of networking roles focused on managing collaborations while addressing intellectual property issues.

Student Survey

Student Description. The student survey had 556 responses resulting in a 5% response rate. The students identified as 57.2% undergraduate, 41.7% graduate, and 1.1% as other. The top three academic units represented in the survey were: 23% School of Science and Engineering, 16% the Henry W. Bloch School of Management, and the 13% School of Education, Social Work, and Psychological Sciences.

Student Experience in Agriculture and Interest in CEA. UKMC students had limited experience in agriculture (3.15 experience on a 0 - no experience to 10 - highly experienced scale). This indicator could be used as the baseline to evaluate the success of any agriculture related program at UMKC.

Only 1.6% of students were familiar with the concept of CEA while 51.3% heard about it and 47.1% had never heard of CEA. Only 2% of the students indicated that they participated in the UMKC Gardening Club. Despite the lack of experience and engagement in agriculture, 89% of students would like to see a greenhouse or laboratory at UMKC where students participate in growing crops and 58% are interested or would consider participating in a minor in CEA. Ninety-four percent of students interested would consider in participating in CEA internships as part of a CEA curriculum.

Students that would consider a CEA minor expressed that the top 10 skills and topics they wish to learn include: 22% plant physiology, 11% food safety, 9% quality control, 8% experimental design & data

analysis, 7% integrated pest management, 6% basic chemistry, 5% leadership, 4% logistics, 4% entrepreneurship, and 4% economics.

Conclusion

The observations from the CEA industry survey allowed us to identify critical workforce needs in terms of professional positions and training needs (degree programs and curriculum content). The survey revealed that the top five job positions needed by the CEA industry are farm manager, farm worker, R&D director, food safety coordinator, and R&D technician. Tables 2 and 3 summarize the knowledge and skills needed in degree programs that certify competency of the workforce for positions in a CEA operation. Overall, there was a consensus between individuals that are directly involved with growing and selling crops and individuals in roles that support CEA operations. These observations will inform educators on which content to include in degree programs focused on CEA education.

The industry survey observations are limited to the <1% of the targeted audience. Feedback from participants raised awareness that the survey lacked questions to assess the knowledge and skills needed for engineering job positions. Feedback from open ended questions showed a lack of consensus. For example, in the farm worker position, several individuals indicated that no formal education or experience is needed, while other respondents indicated the need for some plant science and digital insight education as the CEA industry develops. For the CEA investor, some comments state that the investor only needs funds and an interest in the industry, while others indicated that a business or ag business background is a must.

The student survey revealed that UMKC students are interested in a program that will expose them to CEA. The data generated from the student survey also serves as the basis for evaluating the impact of any future projects as we develop UMKC's CEA educational capacity.

Through this project, we assessed the workforce training needs for different jobs in the CEA industry. We anticipate that our observations will inform the development of curriculum and degrees that meet the needs of the CEA industry. Individuals using the results from this work should weigh on which responses are more relevant as they develop curriculum that meet their needs, especially since we received a limited response rate from the CEA industry survey. We recommend that institutions developing CEA curriculum should engage with local CEA stakeholders to refine the content and priorities of their curriculum. Following this work, we will host a workshop with local farmers, educators, and industry suppliers to further develop our curriculum and identify infrastructure needs to deliver on said CEA curriculum.

Recommendations

The degree and the top five skills and knowledge needed for each job position are summarized in Table 5. We anticipate that institutions will use this summary to assess the infrastructure and teaching resources needed to develop educational programs in CEA. Additionally, we anticipate that the CEA industry will utilize this summary to assist in developing roles and responsibilities for future workforce development activities.

Table 5. Summary of top five skills needed and the appropriate degree for the listed CEA job positions.

Knowledge & Skill	Farm worker	Farm manager	R & D technician	R & D director	Marketing specialist	Food safety coordinator	CEA investor	CEA farm owner
Food safety	•	•	×	×	•	•	×	×
Basic plant physiology	•	•	•	×	×	×	×	×
Integrated pest management	•	×	×	×	×	×	×	×
Quality control	•	•	×	×	×	•	×	×
Quality assurance	•	×	×	×	×	•	×	×
Conflict management	×	•	×	×	×	×	×	•
Leadership	×	•	×	•	×	•	•	•
Basic chemistry	×	×	•	×	×	×	×	×
Experimental design and data analysis	×	×	•	•	×	×	×	×
Statistics	×	×	•	•	×	×	×	×
Advanced plant physiology	×	×	•	•	×	×	×	×
Critical listening	×	×	×	•	×	•	•	•
Marketing	×	×	×	×	•	×	×	•
Advertising	×	×	×	×	•	×	×	×
Finances	×	×	×	×	•	×	•	•
Economics	×	×	×	×	×	×	•	×
Accounting	×	×	×	×	×	×	•	×
Degree	**Apprenticeship**	**Two-Year Associate**	**Bachelor**	**Graduate**	**Bachelor**	**Bachelor**	**Bachelor**	**Bachelor**

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