Competencies for a United States Horticulture Undergraduate Major: A National Delphi Study

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ADDITIONAL INDEX WORDS. curriculum, degree program

SUMMARY. A competency-based curriculum involves defining set knowledge, skills, and values for a particular education. Many technical undergraduate majors have developed a list of competencies for evaluation, assessment, and improvement of higher education curriculum. This national Delphi study is the first concise list of competencies described for a horticulture curriculum. A sample of horticulture educators within the United States ($n = 22$) were selected as experts in horticulture education and curriculum improvement through an e-mail requirement letter sent to university chairs. Information on age, teaching position, and bachelor's degree earned by panel member and department size was collected and it was determined these factors did not impact the panel members' decision on ranking competencies. The three-round Delphi study results provide a list of competencies considered to be important or not important in the general horticulture education field. The final compilation of competencies describes a total of 108 specific learning outcomes, with 41 horticulture technical competencies, 34 life science technical competencies, and 33 professional competencies. Overall, this competency skills list may be useful for future assessment and development of horticulture curricula.

Evidence of a quality education is the primary agenda of accreditation agencies in their evaluation of American higher education institutions. The American academe is increasingly viewed as an economic service providing industry a competitive edge. Employers and financial backers of these institutions desire more than traditional evidence such as grades, certificates, and degrees to measure student's knowledge, skills, and abilities (Baker, 2004). In "Knowing What Students Know" (Pellegrino et al., 2001), one recommendation for institutions to improve quality is to use large-scale assessment to sample a broad range of competencies shared by teachers, students, and other education stakeholders. Pellegrino et al. (2001) goes on to say, "Knowledge and skills to be assessed and the criteria for judging the desired outcomes should be clearly specified and available to all potential examinees." Knowledge and skill can be measured by defined competencies, which are established behavior

requirements needed for students to be successful.

Competencies have been used in curriculum evaluation and reform to measure learning and to keep academic entities accountable for the growth of that learning. Many undergraduate majors have defined competencies assessing effectiveness of their degree programs. In the United States, the horticulture undergraduate major has no defined set of national competencies and currently does not have a nationwide accreditation organization that reviews these programs. In the 1980s, the American Society for Horticulture Science created a curriculum committee to review curricula for the major and to determine their relevancy (Hegwood and Merritt, 1987). From this committee, a summary of core requirements was established for a certified horticulturist designation. The requirements included required courses in the degree program as well as a minimum of five years of experience in the field. While addressing core requirements, these efforts and those of the committee that has updated this document fall short of setting specific course content and required skills needed within the horticulture field (American Society for Horticultural Science, 2008). Completion of a competency-based curriculum for the horticulture major

would facilitate unity in horticulture programs and provide assurance to industry professionals of the education potential employees have acquired. The purpose of this study was to develop a competency-based list for the horticulture undergraduate major using a national Delphi study to gather input from horticultural experts in academia. The Delphi method is based on a structured process for collecting and distilling knowledge from a group of experts by means of a series of questionnaires interspersed with controlled opinion feedback (Alder and Ziglio, 1996). This method of surveying individuals and collecting interactive comments provides a useful venue when creating a collaborative work.

Materials and methods

The research design consisted of a three-round Delphi method technique consisting of a sequential series of questionnaires sent to a panel of horticulture undergraduate educators involved in general horticulture. The population for this study was comprised of general horticulture leaders from specific horticulture professional organizations within the United States. Childers (1989) determined the total number of horticulture programs is approximately 100. A recruitment letter was emailed to the 68 identifiable department heads of horticulture programs within the United States. Individual department heads were requested to forward the e-mail to the horticultural curriculum expert within their department. These individuals became panel members when they sent an e-mail to the researcher accepting participation in the study. A second letter was then emailed to the newly identified panel members with a hyperlink to round 1 of the survey. Nonrespondents were contacted during round 1 by e-mail and then by phone. This recruitment increased the sample from 19 to 22 panel members. The sample size for the expert panel of horticulture educators was $n = 22$ (32%) for round 1, $n = 19$ (27.9%) for round 2, and $n = 17$ (25%) for round 3.

The instrument was a modified questionnaire using a list of competencies from Iowa State University's Horticulture Assessment Survey and "Making the Match Questionnaire on Skills" (Evers, 1998). Permission was gained to use a modification of

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the Iowa State Assessment Survey (A.M. VanDerZanden, personal communication). The response choices used a five-point Likert-type scale consisted of the following choices: 5 = very important, 4 = important, 3 = neutral, 2 = unimportant, and 1 = very unimportant. After the end of each section, a comment box was provided for any new competencies the panelist wished to add or suggestions for changing an existing competency (Bailey-Evans, 1994; Keech, 1998). The second section contained 13 demographic questions asking about the respondent's personal/professional characteristics, the university's characteristics, and the current assessment measures already in place. The demographic questions allowed the participant to respond by checking the appropriate boxes, as well as provided for open-ended responses.

The instrument was tested for face validity and reliability through a pilot survey. The pilot survey was administered to a selection of faculty from other universities to evaluate content, face validity, and clarity of the first round questionnaire. The sample of participants for the pilot test questionnaire ($n = 6$) contained horticulture educators from Texas Tech University, Texas A&M

University, University of Arkansas, Iowa State University, and Utah State University. The criterion for the participants was experience in horticulture education, higher education, or educational surveys. After the pilot survey, a total of 25 subdisciplines of horticulture and 97 competencies were added to round 1.

In round 1, panel members were asked to evaluate each competency listed concerning its importance to the horticulture undergraduate program. Each competency had to have 75% of the participants agree that it should be retained to remain on the list of competencies for the horticulture undergraduate major in the next round. Any competencies not receiving a ranking of 75% acceptance rate were removed from the questionnaire. Protocol for selecting the cutoff point for Delphi studies usually varies between a 65% and 75% acceptance rate. Round 2 consisted of new competencies added by the panel members, high-ranking scores from round 1, and a new section with ranking the main topics of the competencies. The round 3 questionnaire was the final round of ranking the competencies and did not include the option of adding any new competencies. Table 2 represents the

final revision of the questionnaire that was used to rank the competencies.

The Delphi study data were ordinal in nature; thus, nonparametric techniques were used (Siegel, 1956). The Kruskal-Wallis test was used to analyze differences in independent variables among groups. The significance level for determining statistical difference between groupings mean ranks was held at $P \leq 0.05$ throughout the study.

Results and discussion

Panel member locations and academic affiliations collected during round 1 are presented in Table 1. Eighteen states were represented in this national Delphi study. Characteristics of the panel members are described to show qualifications and homogeneity within the sample population. A small sample of 10 to 15 respondents is adequate for a sample when the group is homogeneous (Ferguson, 2000). In analyzing the highest education degree achieved, 19 of the panel members (86.3%) received their doctorate, with six continuing on with a postdoctorate. Three members' highest education level was a Masters degree (13.6%). Horticulture was the most frequent major for all three degree levels, with

Table 1. Locations and work areas for 22 participating Delphi study panel members identifying competencies with a U.S. horticulture baccalaureate degree.

Academic area ^a	University affiliation	Location
Plant Sciences	University of Arizona	Tucson, AZ
Horticulture and Crop Science	California State Polytechnic University	San Luis Obispo, CA
Environmental Horticulture (2)	University of California, Davis	Davis, CA
Plant and Soil Science	University of Delaware	Newark, DE
Horticultural Science	Florida Southern College	Lakeland, FL
Horticulture	University of Georgia	Athens, GA
Tropical Plant and Soil Science	University of Hawaii, Manoa	Honolulu, HI
Agriculture	Illinois State University	Normal, IL
Horticulture	Iowa State University	Ames, IA
Agriculture	Murray State University	Murray, KY
Plant and Soil Sciences	Mississippi State University	Mississippi State, MS
Agriculture, Biology, Chemistry, and Physics	Lincoln University	Jefferson City, MO
Plant Sciences and Plant Pathology	Montana State University	Bozeman, MT
Agronomy and Horticulture	University of Nebraska	Lincoln, NE
Horticulture	Cornell University	Ithaca, NY
Natural Resources and Experimental Design	North Carolina A&T University	Greensboro, NC
Horticulture	Pennsylvania State University	University Park, PA
Horticulture, Forestry, and Landscape Parks	South Dakota State University	Brookings, SD
Agriculture	Sam Houston State University	Huntsville, TX
Agriculture	Texas State University	San Marcos, TX
Plant and Soil Science	Texas Tech University	Lubbock, TX
Plants, Soils, and Climate	Utah State University	Logan, UT

^aAcademic unit housing the horticulture program at the participating institution.

Table 2. Delphi study topic area, round of acceptance, competency description, and percentage of acceptance after three rounds of panel members' surveys to determine the inclusion of specific competencies in an undergraduate horticulture curriculum.

Topic area that includes the competency	Delphi round no. when accepted	Competency description	Acceptance rate (%) ^z
Plant identification			100
	1	Identify plants commonly used in the discipline by scientific and common name	100
	1	Use fundamental knowledge of taxonomy	86
	1	Use dichotomous keys	89
	1	Understand basic plant morphology	100
	2	Identify geographic origin, ecology, and adaptability of common plants to environmental conditions	80
	2	Describe basic family characteristics	70
	2	Find and examine sources of information to identify plants	90
	2	Recognize visually common cultivars used in field of interest	70
	3	Identify geographic origin of common plants	82
	3	Identify adaptability of common plants to environmental conditions	94
			95
			100
Field and greenhouse management	1	Define and select planting methods for different horticulture crops	100
	1	Construct and manage different irrigation, fertilization, and pest management systems	95
	1	Understand formulations and manage soil-based, artificial substrates used in horticulture	91
	1	Identify strategies for efficient and abundant production, harvest, and storage of high-quality crops (food, flowers, and turf)	91
	1	Perform techniques in sexual and asexual propagation of plants	91
	2	Understand construction and maintenance of a greenhouse	95
	2	Know how to apply appropriate plant management involving pruning, training, plant growth regulators, and environment (light, nutrition, water, and soil)	95
	3	Demonstrate ability to produce a quality plant and turn a profit	76
	3	Understand basis for scheduling crops	94
	1	Understand hardscape and greenscape problems	96
	1	Identify source of the problem	96
	1	Apply different pruning techniques	73
	1	Design an appropriate irrigation schedule for a landscape	77
	1	Design an appropriate fertility schedule for a landscape	82
	1	Design an appropriate mowing schedule for a landscape	73
	2	Determine appropriate time management for task	70
	2	Understands landscape bidding	80
	2	Recognize appropriate placing for specific plants	90
	3	Understand how and why of planting a plant (size, depth of hole, backfill, and where the root collar or crown must be relative to grade)	100
	3	Recognize and solve root problems such as encircling roots	88
	1	Understand effects of pest control on environment	100
	1	Design and calculate appropriate application of agricultural compounds	96
	1	Identify and apply appropriate safety procedure regarding agricultural compounds	95
	2	Recognize governmental regulations that impact agricultural chemical application and use	90
	2	Design an appropriate chemical application schedule (time, rotation, and limitations)	90
	2	Calculate and make conversions for applying	90
	2	Be able to obtain a pesticide license	85
			95
	3	Understand the content of a pesticide label	100

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Table 2. (*Continued*) Delphi study topic area, round of acceptance, competency description, and percentage of acceptance after three rounds of panel members' surveys to determine the inclusion of specific competencies in an undergraduate horticulture curriculum.

Topic area that includes the competency	Delphi round no. when accepted	Competency description	Acceptance rate (%) ^z
	1	Understand new technologies within the horticulture discipline	100
	1	Operate typical horticulture equipment	82
	1	Operate common word processing software	91
	1	Operate common spreadsheet software	86
	1	Operate common presentation software	64
	1	Operate a computer to organize and interpret information	73
	1	Understand automation systems within a greenhouse environment	77
	3	Operate equipment such as a pH meter and light meter and apply data collected from it	94
Biological science			90
	1	Demonstrate fundamental knowledge of biological science	100
	1	Understand cellular structure and function	73
	1	Operate a microscope and locating structures on a slide	55
	2	Understand plant populations in ecology as well as agriculture	40
	3	Relate cropping relationships of horticulture crops to native relatives	18
Physical science			60
	1	Demonstrate fundamental knowledge of physical science	77
	1	Understand basic chemical reactions, pH, and metric measurements	91
	1	Use basic laboratory equipment and follow laboratory protocols	77
	1	Understand plant hormone influence	91
	1	Recognize how a plant responds to environmental stress	100
	2	Understand herbaceous and woody plant anatomy	95
	2	Understand plant nutrient uptake and use	100
	2	Understand plant responses to programming by means of light and temperature	90
	3	Manipulate plant management scheduling for greenhouse application, overwintering, etc.	76
	3	Select plants for interior and landscape plantings	68
	3	Understand plant physiology for postharvest handling of cuts (flowers/fruit) and whole plants	82
Plant genetic/biotechnology			65
	1	Understand the principles of genetics	82
	1	Identify how to use genetics for plant improvement	64
	1	Recognize the potential impact of biotechnology on the environment	64
	1	Understand the future of genetics through professional development	45
	2	Understand the relationship of genetics to plant improvement through plant breeding and selection	90
	2	Understand the bases for genetics and be able to extend that knowledge to understanding genetically modified organisms and plant breeding	70
	3	Understand the difference and similarities between classical plant breeding and modern genetic engineering approach	82
	3	Understand how mutations arise	71
Basic plant breeding			65
	1,3	Understand the fundamental principles of plant breeding	68, 82
	1	Recognize the potential impact plant breeding has on agriculture	91
Abiotic/biotic factors			
	1	Recognize the common biotic and abiotic stresses	100
	1	Understand potential effect of biotic/abiotic stress on plants at various stages of development	96
	1	Recognize options for stress reduction with minimal disturbance to environment and human beings	86
Principles of soils		Recognize the common biotic and abiotic stresses	100

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Table 2. (*Continued*) Delphi study topic area, round of acceptance, competency description, and percentage of acceptance after three rounds of panel members' surveys to determine the inclusion of specific competencies in an undergraduate horticulture curriculum.

Topic area that includes the competency	Delphi round no. when accepted	Competency description	Acceptance rate (%) ^z
Environmental awareness	1	Understand potential effect of biotic/abiotic stress on plants at various stages of development	96
		Recognize options for stress reduction with minimal disturbance to environment and human beings	86
	1	Identify the different soil textures	82
	1	Recognize the soil-water relationship involved with growing horticulture crops	100
	1	Understand the influences of soil pH on plants and fertilization methods	100
	1	Understand the movement of water through the soil-plant-air-continuum	86
	2	Apply knowledge of soils to field soils, displaced soils, and artificial substrates in containers	90
	2	Assess soil type in the irrigation management schedule	90
			75
	1	Understand the impact of human activities on the environment	96
	1	Recognize how societies are affected by environmental change	68
	1	Understand how physical and biological properties are interlinked in ecological systems	91
	2	Recognize governmental regulations concerning the environment and why they were enacted	70
	2	Understand the basis for integrated pest management and organic practices	90
	2	Recognize governmental regulations concerning the environment and why they were enacted	70
	2	Understand the basis for integrated pest management and organic practices	90
	2	Identify invasive species issues	75
	3	Identify and analyze solutions to specific environmental issues (air/water pollution, erosion, and microbial contamination)	77
			100
	1	Speak effectively on subject matter within a professional curriculum	96
Writing/ verbal skills	1	Write concisely on subject matter within a professional curriculum	95
	2	Apply critical thinking with respect to analyzing and interpreting available information	100
	2	Recognize governmental regulations concerning the environment and why they were enacted	70
	2	Understand the basis for integrated pest management and organic practices	90
	2	Identify invasive species issues	75
			50
Research skills	1	Summarize basic research data	73
	1	Analyze basic research data	45
	1	Interpret research data	68
	1	Understand the scientific method	96
	1	Conduct and implement a research hypothesis and controls	64
	2	Interpret graphical representation of data, environmental summaries, and flow charts	80
	2	Recognize the use of statistics and be able to interpret basic statistical concepts	85
	2	Present conclusions or recommendations and be able to support them	80
			95
Problem solving skills	1	Work effectively with others on complex issues	100
	1	Define a problem and identify resources and alternative solutions	91
Decision making skills			100
	1	Make effective decisions in a short time period	82
	1	Assess long-term effects of a decision	86
	1	Make decisions on the basis of thorough analysis of a situation	91
	1	Identify political implications of the decision to be made	46
	1	Knows ethical implications of the decisions to be made	82

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Table 2. (*Continued*) Delphi study topic area, round of acceptance, competency description, and percentage of acceptance after three rounds of panel members' surveys to determine the inclusion of specific competencies in an undergraduate horticulture curriculum.

Topic area that includes the competency	Delphi round no. when accepted	Competency description	Acceptance rate (%) ^z
Leadership/ collaborative skills	1	Recognize all those affected by the decision	82
	2	Express and defend decisions effectively	90
			90
	1	Motivate and organize a group of peers and subordinates in defining and solving a problem	50
	1	Work effectively in a team situation as a leader or a participant	91
	1	Demonstrate high standards of achievement	86
	2	Capability of recognizing alternative view points	85
	2	Implement a solution to a problem	90
	3	Conduct a professional meeting	47
	3	Summarize concisely a group's decision	77
Professionalism	3	Identify and lead a group through the decision-making process	53
			100
	1	Understand career opportunities in the horticulture discipline	86
	1	Be acquainted with major horticulture industries	86
	1	Develop industry connections within the field of interest	86
	1	Understand basic business management concepts	91
	1	Realize need for continuing education through short courses, seminars, and conferences	100
	2	Identify current trends and topics through current literature and media	60
	2	Obtain appropriate client skills	45
	3	Obtain experience in at least one internship	94
Ethical/professional judgment			90
	1	Understand ethical issues involved in the formation of professional judgments in horticulture	91
	1	Develops an ethical perspective and sense of moral responsibility and values	86
	1	Discuss contemporary ethical and moral issues in professional and private life	59
	1	Understand the responsibility of the individual in sustainable management of energy, soil, water, and plants	77
	1	Remain aware of changing legislation with regards to ethical and moral issues	55
Lifelong learning skills			85
	1	Stay updated on latest developments in horticulture	91
	1	Gain new knowledge from everyday experiences	77
	3	Use the internet to seek out new technologies, information, trends, and business management skills	77
Global perspective			55
	1,3	Demonstrate a global perspective on agricultural issues	60, 47
	1,3	Demonstrate a global perspective on environmental issues	73, 65
	1	Demonstrate a global perspective on economic issues	41
	1	Demonstrate a global perspective on natural resource issues	57
	1,3	Understanding of cultural diversity within the nation and around the world	64, 71
	1,3	Demonstrate understanding of different beliefs and practices	55, 65
	1	Apply fundamental concepts of economics and human interaction	23
	3	Understand the geopolitical and economic influence of the United States on global socioeconomic dynamics	48
Historical perspective	1,3	Appreciate a historical perspective to the role of science and technology in agriculture	45, 59
Literature and art Visioning	1,3	Appreciate and interpret work of literature and the arts - 36% cut	41, 35
	1	Understand the scope of horticulture and its relation to other disciplines	86
	1,3	Conceptualize the future of the industry	64, 65
	1,3	Provide innovative paths for related business to follow	36, 41
	1,3	Consider a holistic perspective of the rural and urban ecosystem	55, 47

^zPercentage of acceptance of the identified competency after three rounds of surveys. The minimum threshold for inclusion of the competency in the curriculum was 75%.

over 77% of the participants earning their B.S. and M.S. in horticulture, and more than 50% achieving their Ph.D. in horticulture. All doctoral degrees were obtained in a plant science-related field, with 12 of the 19 obtaining their doctorate specifically in horticulture.

The central tendency of the panel member showed that they typically: 1) had a Ph.D. in horticulture, 2) held a position of assistant professor or full professor, 3) were 51 to 60 years in age, and 4) had been teaching for 21 or more years. The average expert's institutional size was 15,000 to 25,000 students. The department size was between 50 and 200 students with the associated unit participating in six or more years of assessment. From these profile demographics, it was determined the targeted audience had been sampled. Kruskal-Wallis analysis did not detect a difference in the rankings of a panel member with respect to their baccalaureate degree, age, position, or department size.

In round 1, 25 horticulture sub-discipline areas were introduced in the study and 17 of these were approved in round 3. In addition, a total of 108 competencies were approved in the final round. Topics and competencies were placed into the following three categories: 1) horticulture technical competencies, 2) life science competencies, and 3) professional competencies. Horticulture technical competencies had 41 elements approved, which was the highest number of all the categories. Life science and professional competencies also maintained a high level of acceptance, with 34 and 33 competencies approved, respectively.

The following horticulture sub-disciplines received 95% to 100% importance rating for including in the horticulture curriculum: 1) plant identification, 2) field and greenhouse management, 3) landscape management, 4) agricultural chemicals, and 5) technology. The horticulture experts did not discuss the survey with anyone and still retained a uniform understanding of what the horticulture major should contain. Even

though there has not been a formal national competency curriculum, this uniformity reveals an equality of standards for the horticulture curriculum.

The following subdisciplines were approved for the life science competencies: 1) biological science, 2) plant physiology, 3) abiotic/biotic factors, 4) principles of soils, and 5) environmental awareness. Physical science, plant genetics/biotechnology, and plant breeding ranked lower than 75%; thus, they were eliminated from the horticulture curriculum. The low importance ranking of these subdisciplines may have been due to the trend to reduce the total required hours for a horticulture undergraduate degree. In addition, plant genetics/biotechnology, physical science, and plant breeding may have also been cut due to these courses being housed in separate departments at many institutions.

The professional disciplines approved are the following: 1) writing/verbal, 2) problem solving, 3) decision making, 4) leadership/collaborative, 5) professionalism, 6) ethical/professional judgment, and 7) lifelong learning. Professional disciplines eliminated were global perspective, historical perspective, literature and art, and visioning. These disciplines frequently fall under the general education curriculum of many institutions, thus they may not have been viewed as part of the horticulture major. Similarly, global perspectives may have been considered a multicultural class. Even though the visioning discipline was eliminated from the curriculum, the competency of "understand the scope of horticulture and its relation to other disciplines" had a high approval of 86%.

The main objective for this study was to describe a set of competencies necessary for the horticulture undergraduate major. This extensive horticulture competency curriculum list is available to aid horticulture departments in developing a competency curriculum that meets their individual needs. Assessment has not become an accepted part of scholarly activity; however, as long as the higher

education accrediting organizations require documentation of how these practices are implemented, horticulture departments across the nation will continue to be interested in this area of study.

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