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DESCRIPTION OF THE USE OF GREENHOUSE FACILITIES BY SECONDARY AGRICULTURAL EDUCATION INSTRUCTORS IN ARIZONA

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Abstract

The purpose of this study was to determine the status and use of greenhouse laboratory facilities by secondary agricultural education instructors in Arizona. Specific objectives were to determine the number of programs with operating greenhouses, types of operating systems, how the facilities are used in the local program, level of preparation of instructors to use greenhouses, use of greenhouse to meet science standards, and barriers to the use of greenhouses. Findings suggest that 75% of agricultural education programs in Arizona have a greenhouse. Teachers are more likely to use the greenhouse for classroom instruction, SAE, and fundraising and less likely to use it for CDE training and agriscience research. Teachers are likely to use a greenhouse to teach to state science standards. Most teachers have little or no postsecondary preparation or previous work experience in horticulture prior to entering teaching and are not satisfied with quantity or quality of use of their greenhouse. Teachers are supportive of a university-level course to prepare preservice teachers to use a greenhouse for education. Lack of funding and experience are perceived barriers to not having a greenhouse as part of the local agricultural education program.

Introduction/Theoretical Framework

The application stage of teaching is where the student engages in the psychomotor task to reinforce the connection of what was learned in a cognitive domain (Newcomb, McCracken, Warmbrod, & Whittington, 2004). McCormick (1994, p. 171) summarized the application of learning to assure a positive education experience: "Effective teachers stress the application of what was taught because they realize that application promotes learning effectiveness, and provides a more positive educational experience for the students."

Successful student performance requires the appropriate learning environment. In agricultural education, this environment may be a specialized laboratory such as an agricultural mechanics shop, school farm, biotechnology laboratory, computer technology center, or greenhouse laboratory facility. The purpose of laboratories is to provide organized and systematic instruction of two types: individualized instruction and group instruction (Newcomb et al., 2004). Newcomb et al. write, "Laboratories are a crucial component of the teaching-learning program for education in agriculture" (p. 214). The authors posit that much of the effectiveness of agricultural education instruction is lost without the use of a laboratory. Talbert, Vaughn and Croom (2005, p. 182) define an agriscience laboratory as "a facility used in teaching the science and math principles and concepts associated with agriculture." Use of a specialized laboratory can make a difference in student achievement and promote a positive attitude toward science (Rothenberger & Stewart, 1995). The theoretical framework for this study is tied to cognitive apprenticeship (Brown, Collins, & Duguid, 1989). "Cognitive apprenticeship supports learning in a domain by enabling students to acquire, develop, and use cognitive tools in authentic domain activity" (Brown et al., p. 30). The teacher verbalizes the activity while they are modeling (demonstrating) it and coaches the student during completion of the task or activity. The theory suggests that instructors teaching a skill often fail to take into account the

"implicit processes" involved in carrying out complex skills when they are teaching novices. According to Duncan (1996, p. 67), "the most appropriate instructional method is one that incorporates both (a) realistic presentation of the knowledge, procedures, and skills and (b) opportunities for students to apply the knowledge and practice the procedures and skills in a realistic context." Brown et al. found that when authentic situations are created during learning that are similar to the situations in which the knowledge will ultimately be applied, the closer the match between the learning situation and the ultimate workplace situation and the easier the transfer of learning will be. In this study, the presence and use of a greenhouse by teachers to teach hands-on activities related to concepts introduced in lecture is how teachers make use of contextualized learning and cognitive apprenticeship when effective demonstrations take place.

Laboratories in agricultural education programs serve as a means to provide the application of the instruction taught in the classroom (McCormick, 1994). Several researchers in agricultural education have reported findings that support the theory that students learn best when an application experience follows lecture and instruction (Enderlin & Osborne, 1992; Oen & Sweany, 1971; Rothenberger & Stewart, 1995).

With the exception of Rothenberger and Stewart's (1995) study of a greenhouse laboratory experience, few researchers have discussed the greenhouse facility as an effective teaching laboratory in agricultural education. In their 1995 study, Rothenburger and Stewart sought to determine the effectiveness of instruction in horticulture using a greenhouse combined with traditional classroom instruction. They found that students with a greenhouse laboratory experience scored significantly higher on a knowledge exam than students who were taught the same lessons but had no greenhouse laboratory experience.

In agricultural education, specialized facilities are used to provide students with necessary skills to prepare for specialized careers (McCormick, 1994). Understanding the local and state economy is important for determining the viability of teaching technical skills related to specific job titles.

Ornamental horticulture has emerged as one of the rapidly growing areas of production agriculture across the nation. In 2005, there were 10,563 growers in the United States using a total of 550 million square feet of greenhouse space (United States Department of Agriculture [USDA], 2002). According to the USDA, wholesale receipts of greenhouse and nursery crop producers edged up less than 1% to $15.7 billion in 2004, boosted by the 2% gain in floriculture sales from 2003. The total wholesale crop value of growers (with $10,000 or more in sales) was $5.36 billion.

Horticulture is one of the agriculture career areas with the greatest opportunity for jobs and future importance as perceived by students, stakeholders, and school administrators (Foster, Bell, & Erskine, 1995; White, Stewart, & Linhardt, 1991). According to the Arizona Nursery Association (ANA, 2006), sales of nursery products topped $1.2 billion. The number of jobs related to horticulture in Arizona exceeded 24,000. The number of commercial growers in Arizona with a reported gross value of sales between $50,000 and $99,999 increased from three in 2004 to nine in 2005 (ANA, 2006). In Arizona, nursery, greenhouse, floriculture and sod ranks sixth in the state in total market value (USDA, 2002). In the teacher preparation program at the land-grant University of Arizona, a course in the Department of Agricultural Education is offered that prepares students to teach psychomotor skills in laboratory sciences. Though the discussion of preparing effective demonstrations applies to all areas of agricultural education, the main emphasis of the course is on preparing students to teach in agriculture mechanics laboratories. Little emphasis is placed on other instructional laboratory facilities (i.e. greenhouses, nurseries, aquaculture, and biotechnology) that may be found at the local agricultural education program.

Purpose and Objectives

The purpose of this study was to describe the status of use of greenhouse

facilities by high school agricultural education programs in Arizona. This study provided information that facilitated direction of horticulture content knowledge and skills of preservice student teachers prepared by the University of Arizona. Specific objectives of the study were:

1. Determine the status of greenhouse facilities by agricultural education programs in Arizona.
2. Describe how teachers use greenhouse facilities in relation to their agricultural education program.
3. Determine the horticulture backgrounds and level of preparation of agricultural education teachers to teach with a greenhouse.
4. Determine barriers to the effective operation of greenhouses by agricultural education teachers.

Methods and Procedures

This research was descriptive in design and sought to establish baseline data for identifying how high school agriculture programs use their greenhouse laboratories. Because of limited funding, the focus of this study concentrated on agricultural education programs in Arizona.

Population

The target population for this study consisted of all agricultural education teachers currently working in 2005-2006 (N_T = 90) representing all Arizona high school agricultural education programs (N_P = 70). Names of teachers, their schools, and e-mail addresses were obtained from the *2005-06 Arizona Agricultural Education Directory.* Because the size of the total population was manageable with available resources, a census of the population was taken. At the time of the study, five teachers retired or left their teaching position (N_T = 85); this left four of the high school teaching positions vacant, so accessible information from these schools was not available. Therefore, data was to be collected from the accessible population of agricultural education programs of (N_P = 66).

Instrument

The survey questionnaire was developed based on a review of the literature and informal discussions with horticulture faculty from two universities. A web-based survey instrument was developed by the researcher and reviewed for face and content validity by a committee of community college and university faculty with expertise in plant science, controlled environmental agriculture, ornamental horticulture, and greenhouse operation and management. The instrument was composed of yes/no categorical questions, fixed-response, and Likert-type scale questions. The constructs measured using a greenhouse to teach state standards, confidence in managing greenhouse components, use of greenhouse in the total agriculture program, and perceived barriers. The instrument was piloted with 13 agricultural education teachers from a neighboring state known to manage greenhouse facilities. Instrument reliability was established using Cronbach's Coefficient Alpha. Reliability coefficients ranged from .72 to .96. Notes of clarification were returned on the questionnaire to the researcher. Noted problems were corrected by the researcher prior to administration to the target population.

Data Collection

An electronic cover letter explaining the purpose of the study with an active link to the online survey was e-mailed to 85 teachers on June 1, 2007. The first question requested the respondent to check off the name of their school from a drop-down list. This information would be used to track respondents by programs and responses by programs with multiple teachers. By the end of the 1st week, a total of 45 teachers representing 38 schools completed the survey instrument for a response rate of 53%. A second e-mail letter was sent out 1 week later. Ten additional electronic questionnaires were completed by teachers representing four additional schools for a response rate of 65%. A third e-mail follow-up yielded 14 additional responses for a response rate of 69 of 85 (81.1%) teachers representing 48 of 66 agricultural education programs. After 2 weeks, a paper and pencil version of the instrument with a self-addressed stamped return envelop was mailed to 19 teachers not responding to the

e-mail invitation. Eight complete and usable surveys were returned and were coded as "late responding."

Threat to external validity is common to survey researchers when less than a 100% response rate is obtained. To correct for non-response error, non-responding teachers (n = 11) were contacted by telephone and requested to complete the instrument with the aid of an interviewer. A total of 75 teachers representing 55 (83.3%) agricultural education programs completed the survey for a final response rate of 88.2%. According to Wiersma and Jurs (2005, p. 175), "when surveying a professional population, 70 percent is considered a minimum response rate." Because both teacher response rate and program response rate exceeded 70%, the acquired response rate for this study was deemed acceptable.

Because late respondents are similar to non-respondents, according to Ary, Jacobs, and Razavieh (1996, p. 461),

> If no significant differences are found between early and late respondents, and late respondents are believed typical of nonrespondents, then the researcher can assume that the respondents are an unbiased sample of the recipients and can thus generalize to the total group.

A comparison of early and late respondents was conducted to determine if significant differences occurred between the two groups. Summated Likert-scale scores for three constructs were examined using *t*-tests. No significant differences were found, suggesting that late respondents were no different than early respondents (Linder, Murphy & Briers, 2001).

Analysis

Descriptive statistics were used to analyze the data. Data were downloaded to an Excel spreadsheet and checked for errors. Responses were recoded and entered into the Statistical Package for the Social Sciences (SPSS v.14) for statistical analysis. Descriptive statistics were used to summarize and organize data. Frequencies, percentages, and measures of central tendency were used to describe data.

Findings

Objective 1: Determine the status of greenhouse facilities by agricultural education programs in Arizona.

To complete the first objective, respondents were asked to answer a series of yes/no categorical questions and closed response questions describing greenhouse facility use. Questions included the presence of a greenhouse, a plant nursery, duration of use, use of greenhouse in the total agricultural education program, use of greenhouse to teach curriculum, size of the greenhouse, and type of environmental systems and control systems found in the greenhouse. Of the 75 (100%) teachers responding to the question "*Does your agricultural education program have a greenhouse facility?*" 57 (76%) replied in the affirmative and 18 (24%) in the negative. Teachers responding "*no*" to the question were directed to complete the section of the questionnaire regarding perceived barriers to having a greenhouse facility as part of their local program. As a follow-up to the positive responders of the first question, a similar inquiry was made of the local agriculture program having a plant nursery facility. Fewer teachers responded in the affirmative. Only 17 teachers (28.8%) said a plant nursery was present; 42 (71.2%) said their program did not have a plant nursery facility. Teachers were asked to provide the square footage of their greenhouse. Responses ranged from 240 square feet to 3,600 square feet. The reported mean size was 1,300 square feet. The median response was 1,128 square feet. Teachers were asked to report the duration of use of their greenhouse. Choices provided ranged from *"All year long*" to "*Only when I/we teach a specific unit.*" Twenty (35.1%) teachers reported their greenhouse was used all year long; two teachers (3.5%) indicated using their facility only for specific units. Teachers were given an opportunity to check "*other*" and provide additional information (Table 1).

Table 1
Duration of Use of Greenhouses as Reported by Agriculture Teachers (n = 57)

Duration	*f*	%
All year long	20	35.1
Only when school is in session	18	31.6
Not in use at present time	6	10.5
Only during selective growing seasons	2	3.5
Only when I/we teach specific units	2	3.5
Other:	9	15.8
"*Not in use because it was not maintained"*		
"*The greenhouse is being built right now and has not been is use at this time"*		
"*Being overhauled not in use at this time"*		
"*All year long(a) lack in summer to lack of extended contract"*		

For agricultural education teacher education faculty to better understand the greenhouse facility needs of the secondary agriculture teachers, it was important to know what the typical greenhouse in the local agriculture program has in terms of equipment and operating systems. To determine the complexity of the typical greenhouse found in the agricultural education programs, teachers were asked to check which operating systems were found in their greenhouse. The majority of the teachers reporting their greenhouses are equipped with fans (94%), cooling systems (93%), ventilation (89%), heating (86%), and irrigation (68%). Over half the respondents indicate having misters (58%), sensor controls (55%), lighting (54%), and a fertilizer injection system (51%). Less than a quarter of the teachers said their greenhouses are equipped with retractable shade (24%) or bottom heat (20%). Figure 1 illustrates the findings.

Objective 2: Describe how teachers use greenhouse facilities in relation to their agricultural education program.

A set of questions focused directly on recently adopted plant science standards for agricultural education in Arizona was developed. Teachers were asked about their perception of their ability to teach specific plant science standards using a greenhouse. The question was phrased as "*I feel I am well prepared to teach the following curriculum standards using a greenhouse or nursery"* followed by a list of 12 curriculum standards related to plant sciences. A 5-point rating scale with descriptors of "*Strongly agree"* to *"Strongly disagree"* was provided. The highest mean response was 4.41 (*SD* = 0.57) and the lowest was 3.33 (*SD* = 0.97). All responses fell in the "*Agree*" category (Table 2).

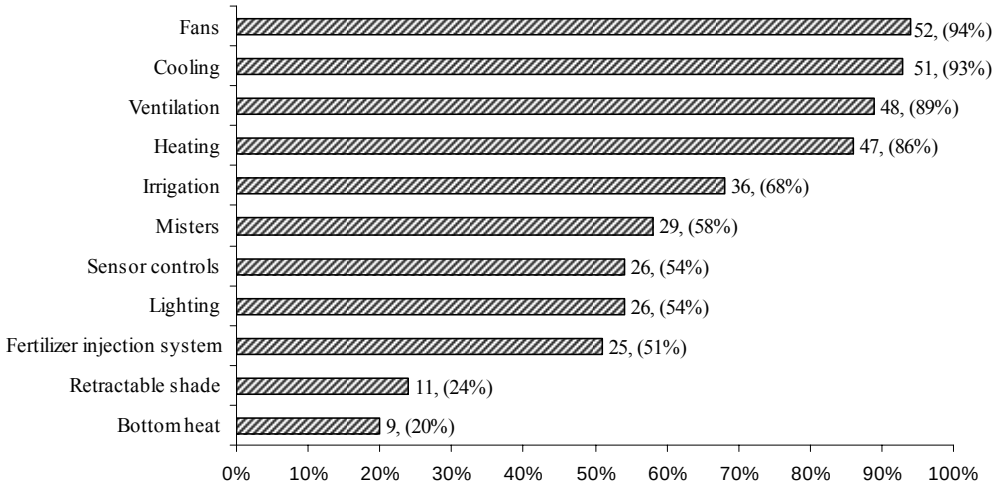

Figure 1. Percentage of greenhouses equipped with specific operating systems.

Table 2
Teacher's Perceptions of Use of Greenhouses to Teach Plant Science Standards

Curriculum Standard	*M*	*SD*
Demonstrate laboratory procedures and safety practices	4.41	0.57
Describe basic principles of nutrition	4.04	0.68
Describe principles of plant growth production	4.21	0.68
Analyze the relationships within living systems	3.85	0.88
Examine the interaction of biological systems within the environment	3.81	0.86
Apply fundamentals of production and harvesting to produce plants	3.80	0.90
Investigate approved nutritional practices	3.74	0.89
Analyze interaction among environmental and natural resource sciences	3.62	0.93
Address taxonomic or other classifications to explain basic plant anatomy and physiology	3.62	0.84
Apply principles of anatomy and physiology to produce and manage plants in both a domesticated and a natural environment	3.60	1.00
Investigate environmental and economical impacts of integrated pest management options	3.59	0.99
Investigate approved practices of disease control	3.33	0.97

Note: 1 = Strongly Disagree, 2 = Disagree, 3 = Undecided, 4 = Agree, 5 = Strongly Agree.

Another series of questions sought to determine the teachers' perceptions of use of their greenhouse in teaching horticulture and plant sciences. Teachers were in strong agreement with the statement, "*A specific college course in greenhouse use for education should be developed*" (M = 4.60, SD = 0.67). Teachers disagreed with statements that they could teach plant science standards without a greenhouse (M = 2.40, SD = 1.27). Teachers also disagreed that instruction in the use of greenhouses to teach plant sciences and horticulture was included in their teacher preparation program (M = 2.40, SD = 1.22). Teachers agreed that a greenhouse could be effective for teaching math and science, and they would receive administrative support for using a greenhouse for teaching hands-on instruction (Table 3).

Table 3.
Perception of Use of Greenhouses in Teaching Horticulture and Plant Science Concepts

Statement	*M*	*SD*
A specific college course in greenhouse use for education should be developed.	4.60	0.67
A greenhouse can be an effective tool in teaching math and science concepts to students.	4.57	0.61
My administration supports the use of a greenhouse as a tool for teaching hands-on instruction.	4.45	0.68
The greenhouse is an effective teaching tool used in my/our agricultural education program.	4.42	1.03
I need assistance in using a greenhouse to teach the state framework for horticulture and plant science.	3.75	0.97
I am able to effectively teach plant science without the use of a greenhouse.	2.68	1.30
I can teach the horticulture and plant science standards of the Arizona CTE curriculum framework without a greenhouse.	2.40	1.27
My teacher preparation program included instruction in the use of greenhouses to teach horticulture and plant science.	2.40	1.22

Note: 1 = Strongly Disagree, 2 = Disagree, 3 = Undecided, 4 = Agree, 5 = Strongly Agree.

A series of questions were developed to describe how teachers use the greenhouse laboratory in their agricultural education program. According to the National FFA Organization (2006), the complete or total agricultural education program includes classroom instruction, student leadership development activities (FFA), and experiential learning activities (Supervised Agriculture Experience [SAE]). Other areas may include Career Development Event (CDE) training, fundraising, recruitment/public relations, and agriscience fair/research activities. Respondents were asked to check from a list of all that apply. Most cited use of a greenhouse was for classroom instruction (n = 53, 95%), with student SAE ranking second (n = 44, 81%) and fundraising (n = 33, 73%) was third (Figure 2). According to teachers, greenhouses are less likely to be used for FFA activities, CDE training, and agriscience fair student projects/research (n = 17, 33%).

Lastly, teachers were asked about their level of satisfaction with the quantity and quality of use of their greenhouse in relation to their total agriculture program. Quantity of use was defined as the number of days of instruction using the facility, or the number of students served. Over one-third of respondents stated they were not satisfied with the quantity of use of their greenhouse (Figure 3), as opposed to 10% who cited they were "Very Satisfied" with quantity of use.

Quality of use was defined as the number plants produced, amount of money raised, or the number of classes using the facility. More than 40% of teachers expressed their level of dissatisfaction with the quality of use of their greenhouse, whereas less than 5% were very satisfied with the quality of use (Figure 4).

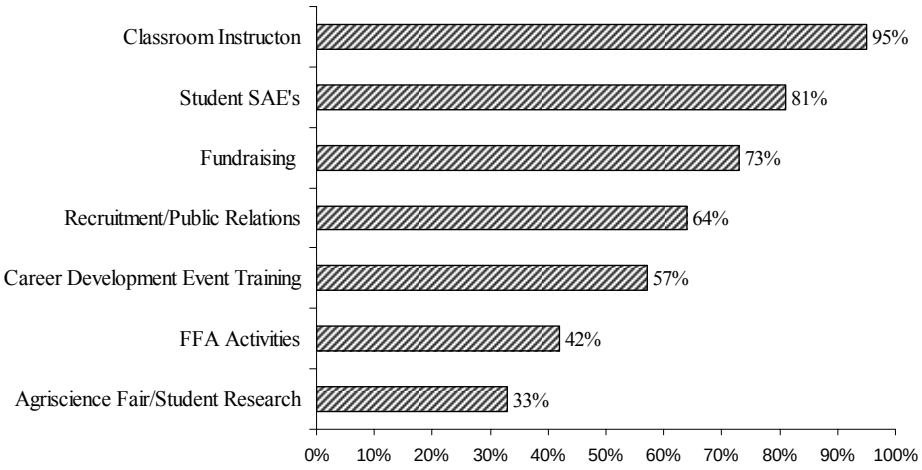

Figure 2. Percentage of use of greenhouse in total agricultural education program (n = 57).

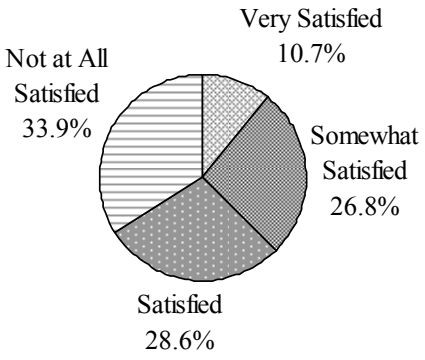

Figure 3. Level of satisfaction of quantity of use of greenhouse in agriculture program.

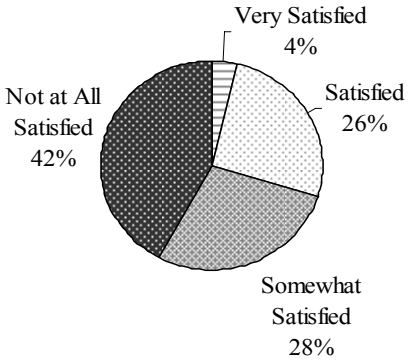

Figure 4. Level of satisfaction of quality of use of greenhouse in agriculture program.

Objective 3: Determine the horticulture backgrounds and level of preparation of agricultural education teachers.

Two questions were posed to measure the horticulture background and level of preparation of agricultural education teachers. These questions would serve to assist the researcher in determining the level of confidence teachers would have in working with greenhouses. Teachers were asked to indicate the number of hours/units in horticulture they completed in college (either community college or university-level). Over one-half (57.9%) of the teachers completed 6 or fewer hours of horticulture. Nearly 30% of responding teachers said they completed "0" hours of horticulture in college. Less than a quarter (22.8%) of teachers reported completing 7-12 hours. Approximately 10% completed 13-18 hours, 8% completed 19 or more hours, and two teachers reported having completed more than 25 hours/units (Figure 5).

To determine previous horticulture experience, teachers were asked to identify the number of years of horticulture work experience prior to teaching. Over half (54%) the respondents reported having no previous work experience in horticulture. Thirty-three percent reported from 1 to 5 years experience, and 7% said they worked between 6-10 years. One respondent claimed 11 or more years of experience prior to teaching (Figure 6)

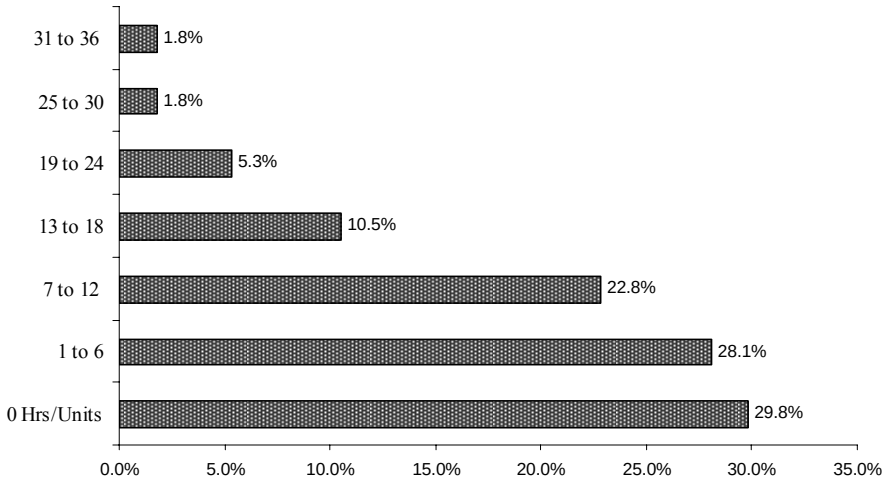

Figure 5. Postsecondary horticulture hours (units) teachers report completing (n = 57).

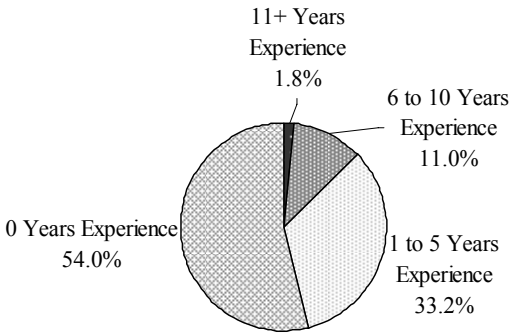

Figure 6. Reported years of horticulture work experience before teaching (*n* = 57).

Objective 4: Determine barriers to the effective operation of greenhouses by agricultural education teachers.

The survey questionnaire directed teachers who responded negatively to the question of whether or not their program included a greenhouse facility (*n* = 19, 25%), to complete the section of the questionnaire that asked respondents to check a list of existing barriers that prevented the program from operating a greenhouse. Funding associated with the cost to purchase a greenhouse (*f* = 8; 42.1%) was the most frequently cited barrier. Maintenance cost (26.7%) and a lack of knowledge or experience of the instructor (26.3%) were frequently cited barriers. Lesser named barriers included the perception that a greenhouse does not "fit" with the local program (15.8%), limited use in the local program (15.8%), and time required to operate and maintain (10.5%). One respondent cited "*cost to repair*" as barrier. No respondents indicated a lack of student interest as a possible barrier.

Conclusions

This study examined the status of use of greenhouse facilities by agricultural education teachers in Arizona. Greenhouse facilities are a common laboratory teaching facility in the majority of agricultural education programs in Arizona, but plant nurseries are not as common a horticulture feature. The typical greenhouse facility in an agricultural education program in Arizona is 1,300 square feet in size and is equipped with heating, cooling, ventilation, fans, and irrigation including misters. The facility is used primarily for classroom instruction, student SAEs, local program fundraising, and public relations or recruitment, and used by one to five class periods. Greenhouses are not typically used to train CDE teams or for agriscience fair research projects. Teachers agree they can use a greenhouse to effectively teach to 12 state plant science standards. Teachers agree a greenhouse can be an effective tool to teach math and science concepts to students and feel they have administrative support for using a greenhouse. Unfortunately, agricultural education teachers in Arizona have a limited horticulture background in terms of the number of college hours completed, and years of horticulture work experience obtained before they enter teaching. Also, they were not likely to receive instruction during their teacher preparation to use a greenhouse to teach horticulture and plant science. This may translate as to why they are not satisfied with quantity or quality of use of their greenhouses.

A lack of funding is the number one perceived barrier to existing agricultural education programs from constructing or operating a greenhouse, followed by maintenance costs, and a lack of knowledge and experience. This finding appears logical from the point that very few teachers have previous horticulture experience, and have completed few horticulture-related college courses. However, teachers at new agricultural education programs without a greenhouse indicate having plans to construct and operate a greenhouse as part of their local program.

Agricultural education instructors in Arizona use greenhouse facilities as a way to provide hands-on (psychomotor) instruction to apply plant science knowledge (cognitive) delivered in the classroom. Student's use of the specialized facility reinforces essential concepts taught in the classroom, making greater strides toward student achievement. This appears to support the theory of cognitive apprenticeship.

Implications

As the study of agricultural education grows beyond traditional production agriculture to include more diverse, highly technical instructional methodologies and sophisticated facilities, so will the need for university teacher preparation programs to update their coursework and training. Schlautman and Silletto (1992) believe teacher educators need to keep current with changes in agriculture technology (including horticulture) to better prepare future agriculture educators to be effective instructors. Findings from this study can better prepare future agriculture teachers in Arizona to use their existing greenhouse facilities, and assist teachers establish new greenhouse facilities to strengthen the teaching of plant science and horticulture competencies, and to prepare students for hands-on careers in ornamental horticulture. The use of greenhouses to provide hands-on instruction can be valuable in teaching plant science standards.

Recommendations

Based on the findings of this study, the following recommendations are offered for consideration:

1. University students pursuing a degree in agricultural education should receive instruction in the use of greenhouse laboratory facilities in their undergraduate experience. The instruction should include not only the components of a greenhouse, but should focus on how greenhouse facilities can be used for educational purposes, specifically teaching science and math standards. Agricultural education faculty should meet with plant science faculty to discuss ways of incorporating the use of greenhouses for teaching in existing courses or develop a short course designed to meet the needs of high school teaches with greenhouse facilities. Professional development in the form of short courses should be developed to provide assistance to teachers with existing facilities learn to become more proficient users.
2. University teacher educators need to include in their instruction of laboratory facilities to preservice student teachers, a unit which focuses on greenhouse facilities and their role in psychomotor development of secondary students. Preservice teachers should tour greenhouse facilities of effective local programs to observe and gain knowledge of how the laboratories "fit" the total agriculture program.
3. States leading in Ornamental Horticulture, Biotechnology, and Aquaculture should conduct similar studies to determine the level of preparation of teachers to use specialized facilities, and the impact it may have on teacher preparation.
4. National-level funding for a multi-state study of use of specialized instructional facilities in agricultural education should be made available to assist teacher preparation programs in universities and colleges to provide up-to-date, specialized, technical instruction to future teachers so they are better prepared to teach in newer, more advanced facilities.

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