

Technical Agriculture Courses and Course Content Required for Undergraduate Degree Completion in Agricultural Education: A Historical Review

Kristopher R. L. Rankin III¹
Christopher J. Eck²
John D. Tummons³
Nathan A. Smith⁴

Abstract

Teachers must possess a deep understanding of subject matter to effectively teach content. Historically, Agricultural Education degrees were technical agriculture degrees with a specialization in education. Degrees consisted of one-third technical content, with an additional one-third of the coursework in integrative studies, where students incorporated professional coursework with technical agricultural content. Analysis of the number of technical agriculture courses needed for degree completion in Agricultural Education teacher preparation has been done sparingly, and typically focused on only one particular agricultural career and content pathway. The purpose of this study was to explore the technical agriculture content course requirements at Agricultural Education teacher preparation institutions from 1980 to 2020, specifically the content and scope of these courses. Historical research methods were used to achieve the purpose of this study. From 1980 to 2020, the average total course credit hours in technical agriculture content courses had declined. Researchers examined six career and content pathways and found a negative trend in the number of courses required from 1980 to 2020. Required courses have decreased between 0.63 courses to 1.83 courses (approximately two – six credit hours) in the past 40 years. With technical agriculture courses being removed from degree requirements, researchers recommend further inquiry in teachers' needs for additional curriculum and content focused on specific agriculture sectors is a byproduct of these programmatic changes.

Introduction

Today's vast agricultural landscape provides an abundance of agricultural-based career opportunities for students enrolled in School-Based Agricultural Education (SBAE) programs. Today, SBAE teachers teach about agriculture, food, and natural resources, while incorporating science, math, communications, leadership, management, and technology (NAAE, 2023). In addition, SBAE is expected to deliver curriculum and co-curricular resources across a wide variety of agricultural content areas. From our origins in the Smith-Hughes Act, Agricultural Education was conceptualized to be comprehensive in coverage, scientific in nature, and practical in impact and focus (National Research Council, 1988).

¹ Kristopher R. L. Rankin III is an Assistant Professor of Agricultural Education in the Department of Agricultural & Extension Education at New Mexico State University, 112 Gerald Thomas Hall, Las Cruces, NM 88003, krankin3@nmsu.edu. ORCID# 0009-0009-6519-0478

² Christopher J. Eck is an Assistant Professor of Agricultural Education in the Department of Agricultural Education, Communications & Leadership at Oklahoma State University, 234 Agricultural Hall, Stillwater, OK 74078, chris.eck@okstate.edu. ORCID# 0000-0002-1645-3632

³ John D. Tummons is an Associate Professor of Agricultural Education in the Division of Applied Social Sciences at the University of Missouri, 127 Gentry Hall, Columbia, MO 65211, tummonsj@missouri.edu. ORCID# 0009-0006-4191-4564

⁴ Nathan A. Smith is an Instructor of Agricultural Education in the Department of Agricultural Education, Communications & Leadership at Oklahoma State University, 236 Agricultural Hall, Stillwater, OK 74078, nathan.smith@okstate.edu. ORCID# 0000-0002-3126-9083

Although secondary Agricultural Education retains much of our original purpose and philosophy from 1917, progressive agriculturists have transformed agriculture through advances in biological, mechanical, and information systems technologies. Rice and Kitchel (2017) found SBAE teachers have a growing concern for their teaching abilities in certain areas due to agriculture's vast array of career and content areas.

Teachers need a deep understanding of subject matter in order to effectively teach content (Bransford et al., 2000). Conceptually, an Agricultural Education degree has been structured as a degree in agriculture with an emphasis in teacher education (Barrick & Garton, 2010). In 1953, 35% of Agricultural Education teacher preparation programs required more than 60 hours of technical agricultural content (Torres et al., 2010). Cruickshank (1996) recommended one-third of teacher preparation curriculum to be technical content, with an additional third of the coursework in integrative studies incorporating professional coursework with technical agricultural content. Unfortunately, teacher performance assessments and student achievement reports in post-secondary courses may indicate a lack of desirable teacher performance sought by communities and employers (Edwards, 2004) Some of the lack in teacher performance could be linked to teacher preparation, particularly course offerings and self-efficacy to teach the desired content knowledge. This lack of performance and content knowledge may stem from the diminishing discipline-specific knowledge that has emerged as a common trend among secondary students preparing to enter post-secondary education (Omaish et al., 2022). Thus, are Agricultural Education teacher preparation programs identifying and addressing SBAE teacher aspirants' agricultural subject matter needs and deficits to be effective after graduation?

Analysis of the number of courses in technical agriculture needed for degree completion in Agricultural Education teacher preparation has been done sparingly and typically focused on a single agricultural career and content pathway (Byrd et al., 2015; Clark et al., 2021; Fritz & Brown, 1998; Rankin III et al., 2023; Saucier et al., 2012). In addition, Sanders et al. (2023) analyzed different content areas within laboratory-based courses related to different career and content pathways, yet a review of all technical agriculture course requirements and course topics has not been explored. Investigating the requirements related to technical agriculture within Agricultural Education, teacher preparation programs could help to identify content course trends over time, ultimately helping to inform key stakeholders of SBAE about current requirements in technical agricultural content and identify potential deficits and needs for the continual development and training of effective in-service SBAE teachers. This becomes increasingly important, considering the dissatisfaction of preservice SBAE teachers related to quantity, quality, and transferability of content of required technical agriculture courses during their teacher preparation program (Rice & Kitchel, 2017). In addition, Agricultural Education teacher preparation faculty have reported that SBAE teacher aspirants require technical content knowledge to be effective teachers, yet these opportunities are declining (Edwards & Thompson, 2010).

Purpose and Research Questions

The purpose of this study was to explore trends in technical agriculture course credit requirements of Agricultural Education teacher preparation programs from 1980 to 2020. To accomplish the purpose of this study, three research questions guided this inquiry:

1. What was the trend in technical agriculture course credit hour requirements for completion of Agricultural Education undergraduate degrees across institutions over time?
2. What was the trend in total course requirements related to technical agriculture courses for completion of Agricultural Education undergraduate degrees across institutions over time?
3. What course topics and content related to technical agriculture courses for completion of Agricultural Education, teacher education undergraduate degrees across institutions have changed from 1980-2020?

Conceptual Framework

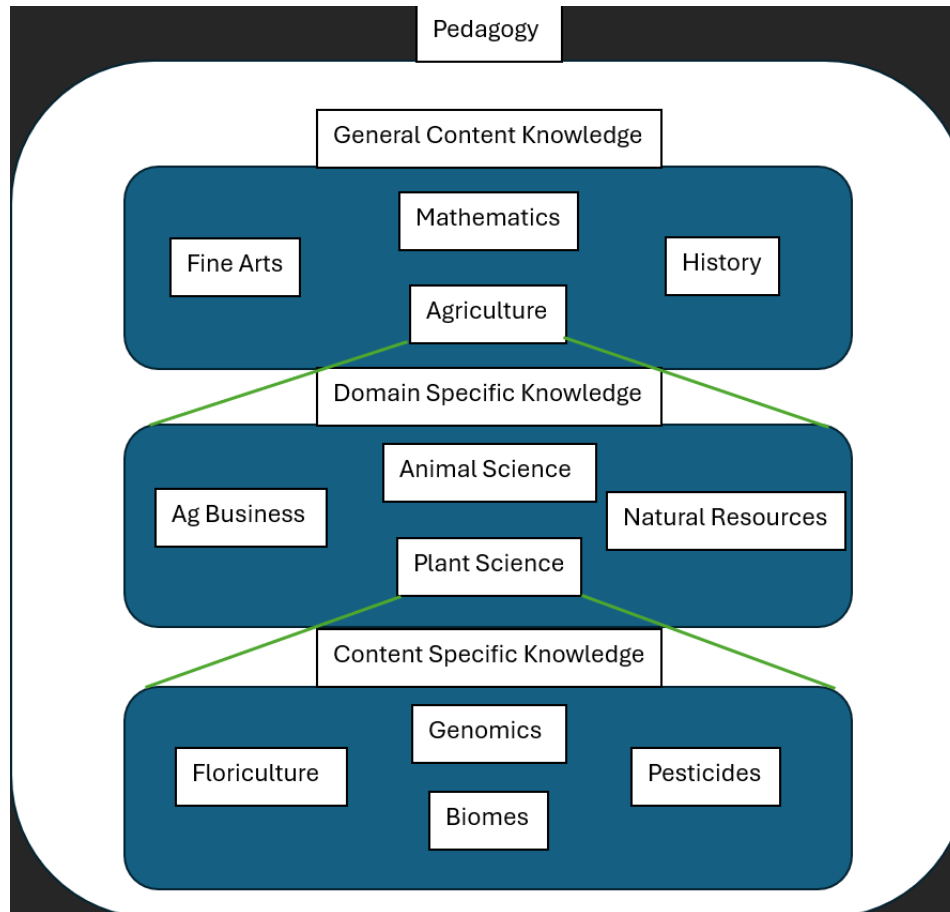
This study was framed by Shulman's (1986) teaching knowledge bases. Shulman (1986) deduced teachers need seven areas of knowledge to effectively teach (Shing et al., 2015). Of these seven, three paradigms of knowledge explain the growth of a teacher's mind: (a) subject matter content knowledge, (b) pedagogical content knowledge, and (c) curricular knowledge. Subject matter content knowledge refers to the organization and overall amount of knowledge about a particular content area a person contains (Shulman, 1986). Shulman (1986) further explained subject matter content knowledge as the understanding of *what* the content the teacher is being trained in, the *why* the content is such, and how it can be justified or potentially deemed wrong. The second knowledge base required of teachers regarding content is Pedagogical Content Knowledge (PCK), which refers to the knowledge of how to teach and effectively portray the subject matter content knowledge to an audience (Shulman, 1986). PCK includes the understanding of how individuals learn and in which ways the subject matter could most effectively be taught (Shulman, 1986). Through combining subject matter and pedagogical content knowledge, one can derive curricular content knowledge (Shulman, 1986). Shulman (1986) stated

The curriculum is represented by the full range of programs designed for the teaching of particular subjects and topics at a given level, the variety of instructional materials available in relation to those programs, and the set of characteristics that serve as both the indications and contradictions for the use of a particular curriculum or program materials in particular circumstances. (p. 10)

This study was framed using an adapted conceptual model (see Figure 1) developed by Veal and MaKinster (1999) to help focus and outline the courses and content areas surrounding agriculturally related courses involved in Agricultural Education, teacher preparation programs. The conceptual framework encompassed both subject matter content knowledge as well as pedagogical content knowledge (Veal & Makinster, 1999).

Figure 1

Conceptual Model of Subject Matter and Pedagogical Content Knowledge



Methods

Historical research methods (McDowell, 2002) were used to carry out this study. Data were collected by accessing primary and secondary sources of information for this historical inquiry (McDowell, 2002). Specifically, data collection investigated online databases and search engines, personal communications, and institutional libraries' resources. The 1980s were chosen as a starting point as the 1980s was a decade of great change in agricultural and vocational education overall. Both the 1983 report *A Nation at Risk* (Bell, 1983) and the Carl D. Perkins Act (Carl D. Perkins Vocational Education Act, 1984), called for renewed emphasis on academic coursework for secondary school students, emphasizing the impact of career and technical education in assisting to achieve that goal.

The population of interest for this study was college and university Agricultural Education teacher preparation programs nationwide ($N = 84$; NAAE, 2024). To reach this target population, a stratified sampling method (Privitera, 2020) was employed to determine a representative sample of institutions based on the American Association for Agricultural Education (AAAE) regions. The three AAAE regions were used to frame the sub-groups of the study: 1) North-Central, 2) Southern, and 3) Western. Each sub-group had all institutions alphabetized; such were numbered based on alphabetical order and a random number generator was used to select three institutions from each region. In addition to the nine randomly generated institutions, Oklahoma State University was added to the study due to the interest of the researching

institution team. Therefore, 10 institutions served as the representative sample (Privitera, 2020) for this study: Auburn University (AU), Oklahoma State University (OSU), South Dakota State University (SDSU), Texas A&M University (TAMU), University of Florida (UF), the University of Missouri (UM), Utah State University (USU), Virginia Tech (VT), Washington State University (WSU), and West Virginia University (WVU).

Primary sources (McDowell, 2002) included university records of degree completion requirements, or course-taking requirements, as set forth by the respective academic departments and their institutions. The key terms and phrases used to aid in finding the study's sources via online searches were 1) agricultural sciences degree requirements, 2) Agricultural Education degree requirements, 3) historical Agricultural Education university degree sheets, and 4) historical university course catalogs. Searching multiple terms allowed for a reduced possibility of *presentism* occurring if considering historical versus mere current-day naming conventions (Johnson & Christensen, 2012). Limitations of this study included unobtainable or incomplete institutional records in a few cases. A database collection detailing all documents received, identified, and examined for accuracy and authenticity was created to organize findings to answer the study's research questions (McDowell, 2002). The search, organization, and data analysis processes employed allowed the research team to address internal and external criticisms of the data (Johnson & Christensen, 2012).

Online searches using the ten universities' internal search engines and their respective websites yielded archived course catalogs and related information about undergraduate degree completion requirements, which included course titles, course topics, and requirements for undergraduate degrees in Agricultural Education. Technical agriculture credit hour requirements were organized by the eight National AFNR content pathways (The Council, 2023): 1) Animal Science (AS), 2) Agriculture Power, Structures & Technology (APT), 3) Plant Sciences (PS), 4) Natural Resources and Environmental Sciences (NRE), 5) Agribusiness (AB), 6) Agricultural Biotechnology Systems (ABS), and 7) Food Science and Preservation (FS). Natural Resources and Environmental Sciences were combined due to findings indicating both pathways covering similar or same course concepts and topics. Electives and total credit hours required for graduation were also identified. All data were compiled and analyzed using Microsoft Excel to report descriptive statistics (i.e., frequencies and mean).

Findings

Research Question 1: What was the trend in technical agriculture course credit hour requirements for completion of Agricultural Education undergraduate degrees across institutions over time?

The number of credit hours required for degree completion in Agricultural Education teacher preparation varied across findings that spanned institutions operating on both a semester and quarter system. Results displayed in Table 1 show an analysis by five-academic-year increments. Hyphenated credit hours indicate a range of course credit hour requirements based upon different offerings/requirements indicated in that academic year. For institutions which offered multiple degrees or ranges in Agricultural Education, an average was calculated. Agricultural Education program credit hours ranged from a low on 120 in 1980 to a high of 136 for semester long courses and a high of 190 for quarterly courses (See Table 1). Therefore, course credit requirements cannot be directly compared by adding semester credits and quarter credits due to the unequal waiting of hours, which is evident as credit hours fluctuated over the 20-year inquiry, with eight of 10 programs studied requiring 120 credit hours as of 2020. Electives for both general and agricultural specific courses were summated and reported in Table 1, as some institutions provided examples of both general and content specific electives, while other institutions did not.

Table 1

Course Credit Hour Requirements in Technical Agriculture Courses for Undergraduate Degree Completion in Agricultural Education from 1980 to 2020 at Ten Agricultural Education Teacher Preparation Institutions

Year	Course Content Area ^d	AU	OSU	SDSU	TAMU	UF	UM	USU	VT	WSU	WVU
1980	AS	b	b	15	9	5 ^a	11	17-19 ^a	c	3-6	3
	APT			12	8	9 ^a	10	12-21 ^a	c	8-22	0
	PS			12	10	13 ^a	10	14-21 ^a	c	13-20	6
	NRE			0	4	5 ^a	0	3 ^a	c	3-15	0
	AB			10	6	5 ^a	11	6-35 ^a	c	3-12	3
	ABS			0	0	0 ^a	0	0 ^a	c	0	0
	FS			0	0	0 ^a	0	0 ^a	c	0	0
	EL			c	15	18 ^a	7-18	21-51 ^a	c	10-18	68
	Total	b	b	136	132	184 ^a	128	186 ^a	c	120	136
1985	AS	b	b	15	9	4	11	17-19 ^a	c	6	3
	APT			12	8	6	10	12-21 ^a	c	18	0
	PS			12	10	10	10	14-21 ^a	c	18	6
	NRE			0	4	3	0	3 ^a	c	6	0
	AB			10	6	4	11	6-35 ^a	c	9	3
	ABS			0	0	0	0	0 ^a	c	0	0
	FS			0	0	0	0	0 ^a	c	0	0
	EL			c	15	9	7-18	21-51 ^a	c	11	68
	Total	b	b	136	132	128	128	186 ^a	190 ^a	130	136
1990	AS	b	b	6-12	9	4	9	17-19 ^a	c	6	3
	APT			13	8	3	10	12-21 ^a	c	18	0
	PS			5	7	14	12	14-21 ^a	c	15	6
	NRE			0-6	0	3	0	3 ^a	c	6	0
	AB			7	9	4	11	6-35 ^a	c	12	3
	ABS			0	0	0	0	0 ^a	c	0	0
	FS			0	0	0	0	0 ^a	c	0	0
	EL			c	19-21	9	3-7	21-51 ^a	c	11	66
	Total	b	b	129	132	128	128	186 ^a	190 ^a	130	136
1995	AS	b	b	9	9	4	8	0 ^a	c	3	3
	APT			10	8	3	7	20 ^a	c	6	0
	PS			9	7	15	11	17 ^a	c	16	6
	NRE			2	0	6	0	5 ^a	c	0	0
	AB			4	9	4	11	6 ^a	c	6	3
	ABS			0	0	0	0	0 ^a	c	0	0
	FS			0	0	3	0	0 ^a	c	0	0
	EL			9	17-19	5	8	c	c	15	66
	Total	b	b	128	132	128	128	186 ^a	130	134	136

Year	Course Content Area ^d	AU	OSU	SDSU	TAMU	UF	UM	USU	VT	WSU	WVU
2000	AS	4	b	9	9	4	9	3	3	3	4
	APT	6		10	9	3	6	3	9	6	5-8
	PS	15		9	7	14	12	3	9	16	8
	NRE	0		2	0	3	0	c	3	0	0
	AB	6		4	9	4	6	c	6	6	6
	ABS	0		0	0	0	0	c	0	0	0
	FS	0		0	0	4	0	c	0	0	0
	EL	5		7	16-18	19	15	50	c	15	62-65
	Total	120	b	128	132	120	128	120	130	134	136
2005	AS	4-7	4-7	9	10	1	6	4-7	3	3	4
	APT	6	5	14	10	0	6	5-23	9	9	5-8
	PS	11	10	9	9	7	6	7-28	9	16	8
	NRE	5-8	3	3	8	3	3	0-21	3	0	0
	AB	3	4	4	6	3	3	0-9	6	6	9
	ABS	0	0	0	0	0	0	0	0	0	0
	FS	0	0-3	0	0	0	3	0	0	0	0
	EL	12	19	5	11-12	18	12	c	c	18	59-62
	Total	125	124	128	120	120	128	120	120	137	136
2010	AS	4-7	4	10	10	4	6	4-10	3	3	4
	APT	6	5	8	10	3	6	5-26	6	15	3
	PS	11	10	6	9	7	6	4-31	6	9	8
	NRE	5-8	3	3	8	3	3	0-24	3	0	0
	AB	3	4	4	6	7	3	0-6	6	3	9
	ABS	0	0	0	0	0	0	0	0	0	0
	FS	0	3	0	0	0	3	0	0	0	0
	EL	12	19	5	9-10	27	15	c	c	9	64
	Total	125	124	128	120	120	128	120	120	127	136
2015	AS	4	4	13	10	4	5	7	c	3	4
	APT	6	5	5	10	3	6	9	c	12	6
	PS	11	10	6	9	7	10	8	c	9	8
	NRE	6	3	3	0	3	0	3	c	0	0
	AB	3	3	4	6	7	6	3	c	3	9
	ABS	0	0	0	0	0	0	0	c	0	0
	FS	0	3	0	0	0	0	0	c	0	0
	EL	12	19	6-9	14	18	18	11	c	12	64
	Total	129	124	120	120	120	120	120	120	129	136
2020	AS	4	4	7-13	10	4	6-8	9	0	3	4
	APT	6	5	4	4	3	6	6	7	9	8
	PS	11	10	9	9	7	10	14	0	9	8
	NRE	3	3	3	0	3	0	3	0	0	0
	AB	3	3	4-7	6	7	6	0	0	3	9

Year	Course Content Area ^d	AU	OSU	SDSU	TAMU	UF	UM	USU	VT	WSU	WVU
2020	ABS	0	0	0	0	0	0	0	0	0	0
	FS	0	3	0-3	0	0	0	3	0	0	0
	EL	12	17	^c	16	18	18	9	30	12	27
	Total	123	120	120	120	120	120	120	120	125	120

Note. ^a the institution participated in a four-quarter system. ^b course credit hour requirements were either not provided or found. ^c information was either unspecified or not stated in the data. ^dAS = Animal Science, APT = Agriculture Power, Structures & Technology (APT), PS = Plant Sciences, NRE = Natural Resources and Environmental Sciences, AB = Agribusiness, ABS = Agricultural Biotechnology Systems, FS = Food Science and Preservation, and EL = Elective coursework.

The average number of course credit hours in technical agriculture courses required for completion of degrees in Agricultural Education teacher preparation had declined from 1980 to 2020, from an average of 60.4 course credit hour requirements in 1980, to an average of 41.5 course credit hours required for degree completion in 2020. Total credit hours required for degree completion in Agricultural Education had also decreased from an average of 151.5 to 120.8 total credit hours from 1980 to 2020. During the span of this historical inquiry, the average total course credit hours in technical agriculture content courses also declined. That is, in 1980, the range of technical course credit hours across all content pathways, including electives (i.e., Animal Science [AS], Agriculture Power, Structures & Technology [APT], Plant Sciences [PS], Natural Resources and Environmental Sciences [NRE], Agribusiness [AB], Agricultural Biotechnology Systems [ABS], and Food Science and Preservation [FS]) was between 8.36 and 11.68 credit hours. However, in 2020 the range in technical course credit hours across all content pathways, including electives, was 5.21 to 5.46 credit hours. Biosystems was found to have no required course credit hours for degree completion in Agricultural Education.

Research Question 2: What was the trend in total course requirements related to technical agriculture courses for completion of Agricultural Education undergraduate degrees across institutions over time?

With regard to the total number of courses related to technical agriculture content, it can be difficult to firmly comprehend the scope of the total number of courses required for undergraduate degree completion based solely on the total course credit hours. This is attributed to the fact the universities and SBAE teacher preparation programs may assign different course credits to courses based upon a variety of factors (e.g., length of the course, amount of lecture and laboratory instruction time, etc.). Table 2 outlines each of the technical course content pathways by five-year span for each of the 10 Agricultural Education teacher preparation programs investigated.

Table 2

Total Course Requirements in Technical Agriculture Courses for Undergraduate Degree Completion in Agricultural Education from 1980 to 2020 at Ten Agricultural Education Teacher Preparation Institutions

Year	Course Content Area ^d	AU	OSU	SDSU	TAMU	UF	UM	USU	VT	WSU	WVU
1980	AS	^b	^b	5	3	1 ^a	3-4	4-5 ^a	^c	1-2	1
	APT			5	4	2 ^a	3-4	4-5 ^a	^c	3-9	0

Year	Course Content Area ^d	AU	OSU	SDSU	TAMU	UF	UM	USU	VT	WSU	WVU
1980	PS			4	3	3 ^a	3-4	3-5 ^a	^c	5-7	2
	NRE			0	1	1 ^a	0	1 ^a	^c	1-5	0
	AB			3	2	1 ^a	3-4	2-10 ^a	^c	1-4	1
	ABS			0	0	0 ^a	0	0 ^a	^c	0	0
	FS			0	0	0 ^a	0	0 ^a	^c	0	0
	EL			^c	5	6 ^a	2-6	5-15 ^a	^c	3-6	23
1985	AS	^b	^b	5	3	1	3-4	4-5 ^a	^c	2	1
	APT			5	4	2	3-4	4-5 ^a	^c	6	0
	PS			4	3	3	3-4	3-5 ^a	^c	6	2
	NRE			0	1	1	0	1 ^a	^c	2	0
	AB			3	2	1	3-4	2-10 ^a	^c	3	1
	ABS			0	0	0	0	0 ^a	^c	0	0
	FS			0	0	0	0	0 ^a	^c	0	0
	EL			^c	5	3	2-6	5-15 ^a	^c	4	23
1990	AS	^b	^b	2-4	3	1	3	4-5 ^a	^c	2	1
	APT			5	3	1	3-4	4-5 ^a	^c	6	0
	PS			5	2	4	4	3-5 ^a	^c	6	2
	NRE			0-2	0	1	0	1 ^a	^c	2	0
	AB			2	3	1	3-4	2-10 ^a	^c	3	1
	ABS			0	0	0	0	0 ^a	^c	0	0
	FS			0	0	0	0	0 ^a	^c	0	0
	EL			2-4	6-7	3	2-3	5-15 ^a	^c	4	22
1995	AS	^b	^b	3	3	1	3	0 ^a	^c	1	1
	APT			4	3	1	3	5 ^a	^c	2	0
	PS			3	2	4	4	4 ^a	^c	5	2
	NRE			1	0	2	0	1 ^a	^c	0	0
	AB			1	3	2	3	2 ^a	^c	2	1
	ABS			0	0	0	0	0 ^a	^c	0	0
	FS			0	0	1	0	0 ^a	^c	0	0
	EL			3	6-7	2	2-3	^c	^c	5	22
2000	AS	1	^b	3	3	1	3	1	1	1	1
	APT	2		4	3	1	2	1	3	2	2
	PS	4		3	2	4	3	1	3	5	2
	NRE	0		1	0	1	0	^c	1	0	0
	AB	2		1	3	2	2	^c	2	2	2
	ABS	0		0	0	0	0	^c	0	0	0
	FS	0		0	0	1	0	^c	0	0	0
	EL	2		3	5-6	6	5	15-20	^c	5	21-22
2005	AS	1-2	1-2	3	4	1	2	1-2	1	1	1
	APT	2	4	5	4	0	2	2-9	3	3	2
	PS	3	3	3	3	2	2	2-10	3	5	2
	NRE	2-3	1	1	3	1	1	0-7	1	0	0
	AB	1	1	1	2	1	1	0-3	2	2	3

2005	ABS	0	0	0	0	0	0	0	0	0	0
	FS	0	0-1	0	0	0	1	0	0	0	0
	EL	4	6-7	2	4-5	6	4	°	°	6	20-21
2010	AS	1-2	1	3	4	1	2	1-3	1	1	1
	APT	2	4	3	4	1	2	2-9	2	5	1
	PS	3	3	2	3	2	2	1-10	2	3	2
	NRE	2-3	1	1	3	1	1	0-7	1	0	0
	AB	1	1	1	2	2	1	0-2	2	1	3
	ABS	0	0	0	0	0	0	0	0	0	0
	FS	0	1	0	0	0	1	0	0	0	0
	EL	4	6-7	2	3-4	9	5	°	°	3	22
2015	AS	1	1	4	4	1	2	2	°	1	1
	APT	2	4	4	4	1	2	3	°	4	2
	PS	3	3	2	3	2	3	2	°	3	2
	NRE	2	1	1	1	1	0	1	°	0	0
	AB	1	1	1	2	2	2	1	°	1	3
	ABS	0	0	0	0	0	0	0	°	0	0
	FS	0	1	0	0	0	0	0	°	0	0
	EL	4	6-7	°	4-5	6	6	3-4	°	4	22
2020	AS	1	1	2-4	4	1	2	3	0	1	1
	APT	2	4	3	2	1	2	2	3	3	3
	PS	3	3	3	3	2	3	4	0	3	2
	NRE	1	1	1	0	1	0	1	0	0	0
	AB	1	1	1-2	2	2	2	0	0	1	3
	ABS	0	0	0	0	0	0	0	0	0	0
	FS	0	1	0-1	0	0	0	1	0	0	0
	EL	4	6-7	°	5-6	6	6	3	10	4	9

Note. ^a the institution participated in a four-quarter system. ^b course requirements were either not provided or found. ^c information was either unspecified or not stated in the data. ^dAS = Animal Science, APT = Agriculture Power, Structures & Technology (APT), PS = Plant Sciences, NRE = Natural Resources and Environmental Sciences, AB = Agribusiness, ABS = Agricultural Biotechnology Systems, FS = Food Science and Preservation, and EL = Elective coursework.

Research Question 3: What course topics and content related to technical agriculture courses for completion of Agricultural Education, teacher education undergraduate degrees across institutions have changed from 1980-2020?

The technical agriculture courses required for degree completion in Agricultural Education, teacher education varied greatly across both years analyzed and institutions. The number of different course topics and concentration areas had also diminished between 1980 and 2020. Results displayed in Table 3 show which technical agriculture courses were required for teacher certification by five-academic-year increments. In 1980, an average of 13 different technical agriculture career and content course topics were required for degree completion in Agricultural Education, teacher education. However, the average number of course topics declined to an average of 9.8 different technical agriculture career and content course topics required for degree completion in Agricultural Education, teacher education in 2020, a greater than three course content and topics reduction.

Table 3

Technical Agricultural Courses Required for Degree Completion in Agricultural Education, Teacher Education From 1980 – 2020

Year	Course Content Area	SDSU	WVU	UM	VT	UF	AU	WSU	USU	TAMU	OSU
1980	AS	1, 2, 5, 6	1	2, 3, 60	–	1	–	1, 2	1, 2, 60	1, 2, 4	–
	APT	27, 28, 29, 30, 31, 32, 33, 34	–	27, 30, 35, 60	–	36	–	26, 27, 28, 29, 30, 37, 60	27, 28, 29, 30, 60	27, 28, 36, 60	–
	PS	11, 12, 13, 14, 15	11, 13	13, 60	–	13, 14, 16	–	11, 12, 13, 14, 17	11, 13, 18	12, 13, 14,	–
	NR/Ev	–	–	–	–	46	–	42, 46, 47, 60	60	17	–
	AB	50, 51, 52	53	51, 53	–	51	–	51, 60	51, 53, 60	53, 60	–
	FS	–	–	–	–	–	–	–	–	–	–
	1985	AS	1, 2, 5, 6	1	2, 3, 60	–	1	–	1, 2	1, 2, 60	1, 2, 4
APT		27, 28, 29, 30, 31, 32, 33, 34	–	27, 30, 35, 60	–	36	–	26, 27, 28, 29, 37, 60	27, 28, 29, 30, 60	27, 28, 36, 60	–
PS		11, 12, 13, 14, 15	11, 13	13, 60	–	13, 14, 16	–	11, 12, 13, 17, 20	11, 13, 18, 60	12, 13, 14,	–
NR/Ev		–	–	–	–	46	–	46	60	17	–
AB		50, 51, 52	53	51, 53	–	51	–	51, 52, 53	51, 53, 54	53, 60	–
FS		–	–	–	–	–	–	–	–	–	–
1990		AS	1, 5, 60	1	6	–	1	–	2	1, 2, 60	2, 4, 60

Year	Course Content Area	SDSU	WVU	UM	VT	UF	AU	WSU	USU	TAMU	OSU
1990	APT	27, 28, 31	–	27, 30, 35, 60	–	29	–	60	27, 28, 29, 30, 60	60	–
	PS	11, 12, 13, 14, 15, 60	11, 13	13, 60	–	11, 13, 21, 22	–	15, 17, 20	11, 13, 18, 60	11, 13	–
	NR/Ev	60	–	–	–	46	–	46	60	–	–
	AB	50, 51, 52	53	51, 53	–	51	–	53, 60	51, 53, 54	51, 53, 54	–
	FS	–	–	–	–	–	–	–	–	–	–
1995	AS	1, 5, 7	1	6, 60	–	1	–	1	60	2, 4, 60	–
	APT	27, 28, 31	–	26, 39, 60	–	29	–	26, 27	27, 29, 30	60	–
	PS	11, 12, 13	11, 13	11, 13, 18, 61	–	11, 13, 21, 22	–	11, 13, 14, 15, 18	12, 13, 15	11, 13	–
	NR/Ev	42, 43	–	–	–	42, 46	–	–	49	–	–
	AB	51	53	52, 53, 56	–	51, 54	–	51, 52, 55	53, 55	51, 53, 54	–
FS	–	–	–	–	57	–	–	–	–	–	
2000	AS	1, 5, 7	1	8, 9, 61	60	1	1, 10	1	1	2, 4, 60	–
	APT	27, 28, 31	26, 28	26, 39	26, 27, 60	29	27, 28, 30	26, 27	29	60	–
	PS	11, 12, 13	11, 13	11, 13, 18	13, 60	11, 13, 21, 22	12, 13, 23, 24	11, 13, 14, 15, 18	13	11, 13	–
	NR/Ev	42, 43	–	–	47	46	–	–	–	–	–
	AB	51	51, 55	56, 60	55, 60	51, 54	52, 55	51, 52, 55	–	51, 53, 54	–

Year	Course Content Area	SDSU	WVU	UM	VT	UF	AU	WSU	USU	TAMU	OSU
2000	FS	–	–	–	–	57	–	–	–	–	–
2005	AS	1, 5, 7	1	8, 9	60	1	1, 10	1	1, 4	2, 4, 60, 61,	1, 5
	APT	27, 28, 31, 35, 60	26, 28	26, 27	26, 27, 60	–	27, 28, 30	26, 27, 30	26, 27, 29, 30, 40, 41, 60	26, 60	27, 28, 29, 31
	PS	11, 12, 13	11, 13	11, 17	13, 60	11, 13	12, 13, 16	11, 13, 15, 60	13, 14, 15, 18, 60	11, 60	11, 13, 18
	NR/Ev	42, 43	–	13	47	46	43, 45	–	42, 43, 47, 60	60	47
	AB	51	51, 55, 56	52	55, 60	53	51	51, 52, 55	51, 53	53, 60	52
	FS	–	–	58	–	–	–	–	–	–	57
2010	AS	1, 5, 7	1	8, 9	60	1	1, 10	1	1, 4, 60	2, 4, 60, 61,	1
	APT	28, 31, 35	26	26, 27	26, 28	28	27, 28, 30	27, 36, 37, 38, 41	26, 27, 29, 30, 40, 41, 60	26, 60	27, 28, 29, 31
	PS	11, 12	11, 13	11, 17	13, 60	11, 13	12, 13, 16	13, 18, 25	13, 14, 15, 18, 60	11, 60	11, 13, 18
	NR/Ev	42, 43	–	13	47	46	43, 45	–	42, 43, 47, 60	60	47
2010	AB	51	51, 55, 56	52	55, 60	51, 53	51, 52	51	51, 53	53, 60	52
	FS	–	–	5	–	–	–	–	–	–	57

Year	Course Content Area	SDSU	WVU	UM	VT	UF	AU	WSU	USU	TAMU	OSU
2015	AS	1, 5, 7, 10	1	60, 61	–	1	1	1	1, 3, 4	2, 4, 60, 61,	1
	APT	27, 28, 29, 30, 31	26	26, 27	–	28	27, 28, 30	27, 36, 37, 39	27, 28, 29	26, 60	27, 28, 29, 31
	PS	11, 12	11, 13	11, 13, 18	–	11, 13	12, 13, 16	13, 18, 25	12, 13, 18	11, 60	11, 13, 18
	NR/Ev	42, 43	–	–	–	46	44, 45	–	42 or 19	60	47
	AB	51	51, 55, 56	52, 56, 60	–	51, 53	51, 52	51	53 or 56	53, 60	52
FS	–	–	–	–	–	–	–	–	–	–	57
2020	AS	1, 5, 7, 10	1	1, 8, 9	–	1	1	1	1, 60	1, 2, 60, 61	1
	APT	27, 28, 29, 30, 31	26, 28, 39	26, 27	26, 27, 29	28	27, 28, 30	27, 36, 37, 39	27, 29	26, 60	27, 28, 29, 31
	PS	11, 12, 13, 18	11, 13	11, 13, 18	–	11, 13	12, 13, 16	13, 18, 25	11, 12, 13, 18, 60	11, 60	11, 13, 18
	NR/Ev	42, 43	–	–	–	46	44	–	60	–	47
	AB	51, 52	51, 55, 56	52, 56, 60	–	51, 53	51, 52	51	–	53, 60	52
FS	–	–	–	–	–	–	–	–	59	–	53

Agricultural power, structures, and technology was found to have the greatest amount of different course topics offered and required across the study's timeframe with 16 different technical agricultural career and content topics taught. Plant systems had the second greatest offering of different course content and topics at 15. Interestingly, agricultural biotechnology systems was never a required technical agriculture content course for any of the studied institutions across the 40-year span (see Table 1). Food science and preparation was the only technical agriculture career and content pathway to have courses be added to the requirements of degree completion, in which it had no requirements in 1980 but did have requirements starting in 1995 and continuing through 2020.

Table 4 displays the technical agriculture career and content pathways, the associated course numbers, and the names of the associated course topic/concentration area relating to Table 1.

Table 4

Technical Agricultural Course Topics Required for Degree Completion in Agricultural Education, Teacher Education Descriptions

Career and Content Pathway	Course Number	Course Topic Concentration	Number of years course appears as requirement
Animal Systems	1	Intro to Animal Sciences	9
	2	Animal Nutrition	9
	3	Animal Genetics	3
	4	Animal Reproduction	8
	5	Meat Animal Production	9
	6	Livestock Management	4
	7	Livestock Evaluation	6
	8	Ruminant Production	4
	9	Monogastric Production	4
	10	Dairy Food Science	4
Plant Systems	11	Intro to Plant Sciences/Horticulture	9
	12	Crop Production	9
	13	Soil Science	9
	14	Field and Forage Crop Science	7
Plant Systems	15	Weed Plant Management	7
	16	Intro to Landscaping	6
	17	Soil Management	5
	18	Plant Growth, Development, Cultivation, & Greenhouse	9
	19	Range Management	1
	20	Pest Management	2
	21	Intro to Agronomy	2
	22	Vegetable & Fruit Production	2
	23	Turfgrass Management	1
	24	Intro to Gardening	1
	25	World Ag Systems	2
Agricultural Power, Structures, and Technology Systems	26	Intro to Agriculture Mechanics	6

Career and Content Pathway	Course Number	Course Topic Concentration	Number of years course appears as requirement
	27	Welding	9
	28	Agricultural Structures	9
	29	Small Gas Engine Repair	9
	30	Farm Power/Tractor & Machinery Repair	9
	31	Agricultural Electricity	9
	32	Processing Equipment	2
	33	Agricultural Waste Management	2
	34	Industrial Structures	2
	35	Shop Processes	5
	36	General Mechanical Systems Operation	5
	37	Materials Handling & Organization	4
	38	Shop Safety	2
	39	Advanced Shop Projects	3
	40	Irrigation	2
	41	Electrical Controls/Precision Agriculture	2
Natural Resources/ Environmental Science	42	Intro to Conservation/Natural Resource Management	7
	43	Intro to Wildlife & Fisheries Management	6
	44	Aquaculture	2
	45	Environmental Sciences	3
	46	Entomology	9
	47	Forestry	6
	48	Soil & Water Conservation	0
Agribusiness Systems	49	Principles of Accounting	1
	50	Farm & Ranch Management/Farm Business Planning	3
	51	Agricultural Marketing & Prices	9
	52	Intro to Agricultural Economics/Food & Resource Economics	9
	53	Computer Applications in Agriculture	9
	54	Microcomputers in Agriculture	4
	55	Agricultural Sales	6
	56	Communicating in Agriculture	6
Food Systems	57	Intro to Food Science	5
	58	Food Science & Nutrition	1
	59	Food Ethics & Economics	1
General Courses	60	Elective Specific to Content Area	9
	61	Lab Course in Specific Content Area	6

Fifty-nine different technical agriculture course topics were identified to have been required across the 40-year span of this study. Two additional general course topics were identified as some Agricultural Education, teacher education preparation programs put requirements in specific technical agriculture content pathways. These additional general course topics, which could not be defined due to the variability with each institution, were technical agriculture content specific electives and lab courses in specific technical agriculture content pathways (see Table 4). Table 5 shows the number of different technical classes required by year.

Table 5*Frequency of unique technical agriculture content course offerings by subject and year*

Course pathway	1980	1985	1990	1995	2000	2005	2010	2015	2020
Animal Sciences	6	6	5	6	7	8	8	7	7
Plant Sciences	8	9	10	6	10	8	9	6	6
Agricultural Power, Structures, and Technology Systems	13	11	6	6	5	9	12	9	9
Natural Resources/ Environmental Science	1	0	0	0	1	1	1	1	1
Agribusiness Systems	4	5	5	7	6	5	5	5	5
Food Systems	0	0	0	1	2	1	1	1	1
Electives specific to content area	1	1	1	0	1	1	1	1	1
Lab course in specific content area	0	0	0	1	1	1	1	1	1
Total unique content requirements	35	33	28	31	35	39	42	36	35

Note. The 40-year span mean was calculated from adding all courses required in each five-year increment analyzed from each university, then divided by the number of data points. For institutions which offered multiple degrees or provided ranges in Agricultural Education courses, an average was calculated. ^aAS = Animal Science, APT = Agriculture Power, Structures & Technology (APT), PS = Plant Sciences, NRE = Natural Resources and Environmental Sciences, AB = Agribusiness, ABS = Agricultural Biotechnology Systems, FS = Food Science and Preservation, and EL = Elective coursework.

Conclusions, Discussion, and Recommendations

The purpose of this study was to explore the course requirements at Agricultural Education, teacher preparation institutions from 1980 to 2020 regarding technical agriculture content courses. By the year 2000, all ten institutions operated on a three-semester academic year. This change in academic calendar year operations could have been due to legislative changes connected to federal student loans and funding for different programs over time. This decline in technical course credit hours aligns with previous studies associated with specific agriculture content areas (Albritton & Roberts, 2020; Saucier et al., 2012).

Total course requirements in six of the eight technical agriculture career and content areas analyzed decreased from 1980 to 2020. With the total number of courses and course credit hours in technical agriculture content courses being reduced over time from 1980 to 2020, we conclude the reduction of

overall degree hours has played a role in the reduction of agricultural content specific courses and course credit hours required. We acknowledge an increase in other degree requirements may have also contributed to the reduction in technical content courses. These conclusions raise important questions about how teacher preparation has evolved over time. Are SBAE teacher preparation programs still preparing sufficient SBAE teachers? Or is an increase in more streamlined purposeful professional development in the hope of developing the shortfalls of technical agriculturally literate and competent SBAE teachers? These are the questions that must be asked if evaluation and change is to be implemented within SBAE teacher preparation programs, regardless of state lines or affiliations. Perhaps an emergence of increased teacher education and pedagogy courses were implemented to increase preservice teacher self-efficacy and knowledge regarding teaching or to meet state teacher certification requirements in certain programs, while others experienced an increase in general education requirements. With technical agriculture courses being removed from degree requirements, feasible research indicating teacher's needs for additional curriculum and content focused on specific agriculture sectors is a byproduct of these programmatic changes. While less emphasis or room within a degree plan for technical agriculture content is concerning, the number of teachers in SBAE programs is increasing (Foster et al, 2024), potentially allowing teachers to be more specialized. Allowing SBAE teacher aspirants to further specialize in a specific agriculture pathway/content area could further their preparedness to teach effectively, likely increasing secondary student achievement and career preparedness (Edwards, 2004). If SBAE teacher preparation programs were more flexible in their agriculture content requirements (i.e., more agriculture electives), could the concern of teacher aspirants related to their ability to teach all content areas (Rice & Kitchel, 2017; Roberts & Ball, 2009) be reduced? Implementing a more flexible content curriculum using micro-credentialing of specific content areas would allow teacher aspirants to develop a deeper understanding of specific agriculture subject matter to effectively teach content (Bransford et al., 2000; Tummons et al., 2024). Additionally, are the courses that are being taken and/or required by SBAE teacher preparation programs providing the necessary content and hands-on experiences for SBAE teacher aspirants?

This change in course content focus could be due to the increased pressure from federal government legislation such as the No Child Left Behind Act (P.L. 107-110 , 2001-2002), which put an increased emphasis on student testing and teaching core educational courses in all aspects of non-core classes. More needs to be understood about the total number of courses, the course topics and the changes made to the SBAE teacher preparation programs across this timeline. As courses at different university programs can have a range of credit hours given, it is important to look at the total number of courses across university programs to give a more accurate depiction of the difference in pre-service teacher preparation programs. We recommend that the changes made to the specific course topics requirements be analyzed to identify potential patterns across programs. This could allow for potential analysis to identify conceivable correlations between the identified teacher technical skill needs in agricultural content pathways (Albritton & Roberts, 2020; Blackburn et al., 2015; Hainline & Wells, 2019; Peake et al., 2007; Solomonson et al., 2022) and the courses currently offered in SBAE teacher preparation programs.

Agricultural Biotechnology Systems was found to have not been required by any of the institutions sampled in this study. This could imply that either agricultural biotechnology courses do not currently exist, or, are not viewed as necessary for degree completion by the institutions. Possibly the prevalence, or lack thereof, of biotechnology courses in SBAE programs also impacts this coursework. We recommend that The Council's (2023) eight Agricultural Career and Content Pathway areas be re-assessed to see if agricultural biotechnology systems should continue to be its own area, or merged with the other career and content pathways. Similarly, with many institutions having nearly identical courses and course topics in Natural Resources and Environmental Systems, we inferred that these two career and content pathways may need to be merged into one pathway. Further analysis is necessary to understand the extent to which natural resources and environmental systems are considered alike or similar at other institutions and within SBAE programs.

When accounting for only the required courses in specific agriculture content courses, SDSU (39 course credit hours) was the closest to Cruickshank's (1996) recommendation of having one-third of all post-secondary coursework be related to the specific field in which pre-service teachers are preparing to teach. Having SBAE teacher aspirants complete approximately one-third of their degree, or more, in agriculture content has the potential to better prepare SBAE teachers for entry into the teaching profession (Cruickshank, 1996). Because electives were not specified in many instances, we recommend that university faculty work closely with pre-service teachers to enroll them in agriculture content courses in which they may have little experience with the content knowledge and skills, thus, allowing the pre-service teachers to increase their breadth of knowledge (Bransford et al., 2000) within the scope of agriculture. The unknown related to specific coursework taken for general electives in degree programs serves as a limitation within this study, as some programs and advisors regularly recommend agriculture content courses to be taken as electives, yet others may not. Analysis of general education requirements identified by university administration could potentially be substituted for agriculturally related courses. Specifically, course topics such as fine arts, humanities, chemistry, and biology have potential to be course content areas in which colleges of agriculture may be able to provide and meet similar, if not the same, curriculum standards outlined by general education requirements. Thus, by offering these courses in an agricultural context for general education requirements, pre-service SBAE teachers could be exposed to additional agriculture content, providing them an opportunity to increase their knowledge base within their specific degree field and further their development of pedagogical content knowledge. This becomes increasingly important considering the diminishing level of agricultural experience that pre-service teacher aspirants have prior to their university coursework and the student teaching experience (Houck & Kitchel, 2010).

It is also recommended that comparisons between land-grant and non-land-grant institutions be conducted to ascertain the emphasis placed on technical agriculture content courses for degree completion in Agricultural Education. As certain land-grant and non-land grant universities contain SBAE pre-service preparation programs, ascertaining the similarities and differences between the two types of institutions may allow comparisons to be drawn between self-efficacy in agricultural content, motivation to teach agricultural content, and overall preservice preparation comparisons on like or similar courses. Agricultural Education teacher preparation faculty and administrators should consider the findings of this study when advocating for degree requirements, the development of new courses, and general education requirements. With continued teacher shortages and the proliferation of online and alternative pathways, the authors challenge teacher education programs and state staff to make intentional decisions regarding the minimum content requirements necessary for Agricultural Education teachers and consider how these changes might impact the future of agricultural education as a career and technical education program.

References

- Albritton, M. C., & Roberts, T. G. (2020). Agricultural technical skills needed by entry level agriculture teachers: A modified Delphi study. *Journal of Agricultural Education, 61*(1), 140–151. <https://doi.org/10.5032/jae.2020.01140>
- Auburn University. (1998 – 2020). *Auburn University bulletin*. Author. <https://bulletin.auburn.edu/archivedbulletins/>
- Barrick, R. K., & Garton, B. L. (2010). Frameworks for agriculture teacher education. In Torres, R. M., Kitchel, T., & Ball, A. L. (Eds.), *Preparing and advancing teachers in agricultural education*. Curriculum Materials Service.
- Bell, T. H. (1983). A nation at risk: The imperative for educational reform. *The Elementary School Journal, 84*(2), 113–130. <https://doi.org/10.1086/461348>

- Blackburn, J. J., Robinson, J. S., & Field, H. (2015). Preservice agriculture teachers' perceived level of readiness in an Agricultural Mechanics Course. *Journal of Agricultural Education, 56*(1), 172–187. <https://doi.org/10.5032/jae.2015.01172>
- Bransford, J. D., Brown, A. L., & Cocking, R. R. (2000). *How people learn* (Vol. 11). National academy press.
- Byrd, A. P., Anderson, R. G., Paulsen, T. H., & Shultz, M. J. (2015). Does the number of post-secondary agricultural mechanics courses completed affect teacher competence? *Journal of Agricultural Education, 56*(1), 20–31. <https://doi.org/10.5032/jae.2015.01020>
- Carl D. Perkins Vocational Education Act* (1984). 20, U.S.C. § 2301. <https://www.govinfo.gov/content/pkg/STATUTE-98/pdf/STATUTE-98-Pg2435.pdf>
- Clark, T. K., Anderson, R., & Paulsen, T. H. (2021). Agricultural mechanics preparation: How much do school based agricultural education teachers receive? *Journal of Agricultural Education, 62*(1), 17–28. <https://doi.org/10.5032/jae.2021.01017>
- Cruikshank, D. R. (1996). *Preparing America's Teachers*. Phi Delta Kappa International, PO Box 789, Bloomington, IN 47402-0789.
- Edwards, M. C. (2004). Cognitive learning, student achievement, and instructional approach in secondary agricultural education: A review of literature with implications for future research. *Journal of Vocational Education Research, 29*(3), 225–244. <https://doi.org/10.5328/jver29.3.225>
- Edwards, M. C., & Thompson, G. (2010). Designing technical agriculture curriculum. In R. M. Torres, T. Kitchel, & A. L. Ball (Eds.), *Preparing and advancing teachers in agricultural education* (pp. 113–128). Curriculum Materials Service.
- Foster, D. D., Smith, A. R., Lawver, R. G., & Spiess, M. (2024). National Agricultural Education Supply and Demand Project [data set]. *American Association for Agricultural Education*. <http://nsd.aaaeonline.org>.
- Fritz, S. M., & Brown, F. W. (1998). Leadership education courses and programs in departments of agricultural education. *Journal of Agricultural Education, 39*(3), 57–62. <https://doi.org/10.5032/jae.1998.03057>
- Hainline, M., & Wells, T. (2019). Identifying the agricultural mechanics knowledge and skills needed by Iowa school-based agricultural education teachers. *Journal of Agricultural Education, 60*(1), 59–79. <https://doi.org/10.5032/jae.2019.01059>
- Houck, A., & Kitchel, T. (2010). Assessing Preservice Agriculture Teachers' Content Preparation and Content Knowledge. *Journal of Assessment and Accountability in Educator Preparation, 1*(1), 29–36. https://www.researchgate.net/publication/348153082_Assessing_pre-service_teachers'_content_preparation_and_content_knowledge
- Johnson, B., & Christensen, L. B. (2012). *Educational research* (4th ed.). SAGE
- McDowell, W. H. (2002). *Historical research: A guide*. Longman.

- National Association of Agricultural Educators. (2023). *What is agricultural education?*. Author.
<https://www.naae.org/whatisaged/>
- National Association of Agricultural Educators (NAAE). (2024). *Find a college*. Author.
<https://www.naae.org/teachag/college.cfm>
- National Research Council. (1988). *Understanding agriculture: New directions for education*. National Academy Press.
- Oklahoma State University. (2005 – 2020). *Oklahoma State University bulletin*. Author.
https://registrar.okstate.edu/catalog_archives.html
- Omaish, H. A., Sennuo, A., Alymany, G., Abdullah, M. U., AlNakib, S., Divan, A., & Dionigi, F. (2022). Knowledge gaps amongst students entering higher education in the non-regime north of Syria: Causes and possible solutions. *International Journal of Educational Research Open*, 3, 1–8.
<https://doi.org/10.1016/j.ijedro.2022.100129>
- P.L. 107-110 – 107th Congress (2001–2002). No child left behind act of 2001. (2002, January 08).
<https://www.congress.gov/bill/107th-congress/house-bill/1/text>
- Peake, J. B., Duncan, D. W., & Ricketts, J. C. (2007). Identifying technical content training needs of Georgia Agriculture Teachers. *Journal of Career and Technical Education*, 23(1), 44–54.
<https://doi.org/10.21061/jcte.v23i1.442>
- Privitera, G. J. (2020). *Research Methods for the Behavioral Sciences* (3rd ed.). SAGE
- Rankin III, K. R. L., Tummons, J. D., Eck, C. J., & Smith, N. A. (2023, September, 27–29). *Technical Agriculture Content Courses Required for Undergraduate Degree Completion in Agricultural Education: A Historical Review* [Poster Presentation]. 2023 North Central Agricultural Education Conference and National Conference on Learner-Centered Teaching, Brookings, SD.
<https://shorturl.at/liXH8>
- Rice, A., & Kitchel, T. (2017). Teachers' beliefs about the purpose of agricultural education and its influence on their pedagogical content knowledge. *Journal of Agricultural Education*, 58(2), 198–213. <https://doi.org/10.5032/jae.2017.02198>
- Roberts, T. G., & Ball, A. L. (2009). Secondary agricultural science as content and context for teaching. *Journal of Agricultural Education*, 50(1), 81–91. <https://doi.org/10.5032/jae.2009.01081>
- Sanders, K., Smalley, S., & Hainline, M. (2023). Evaluating the preparation of pre-service school-based agricultural education teachers in laboratory-based courses. *Journal of Agricultural Education*, 64(2), 11–29. <https://doi.org/10.5032/jae.v64i2.71>
- Saucier, R., McKim, B., & Tummons, J. (2012). A Delphi approach to the preparation of early-career agricultural educators in the curriculum area of agricultural mechanics: Fully qualified and highly motivated or status quo? *Journal of Agricultural Education*, 53(1), 136–149.
<https://doi.org/10.5032/jae.2012.01136>
- Shing, C. L., Saat, R. Mohd., & Loke, S. H. (2015). The knowledge of teaching – Pedagogical content knowledge (PCK). *The Malaysian Online Journal of Educational Science*, 3(3), 40–55.
<https://mojes.um.edu.my/index.php/MOJES/issue/view/1378>

- Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4. <https://doi.org/10.2307/1175860>
- Solomonson, J. K., Wells, T., Hainline, M. S., Rank, B. D., Wilson, M., Rinker, S. P., & Chumbley, S. B. (2022). Technical agriculture skills teachers need to teach courses in the plant systems pathway. *Journal of Agricultural Education*, 63(3), 100–116. <https://doi.org/10.5032/jae.2022.03100>
- South Dakota State University. (1980 – 2020). *South Dakota State University general catalog*. Author. <https://catalog.sdstate.edu/content.php?catoid=32&navoid=4236>
- Texas A&M University. (1980 – 2005). *Texas A&M University undergraduate catalog*. Author. <https://library.tamu.edu/collections/digital-library/course-catalogs>
- Texas A&M University. (2010 – 2020). *Texas A&M University undergraduate catalog*. Author. <https://catalog.tamu.edu/archives/>
- The National Council for Agricultural Education. (2023). *AFNR standards*. The National Council for Agricultural Education. <https://thecouncil.ffa.org/afnr/>
- Torres, R. M., Kitchel, T. J., & Ball, A. L. (Eds.). (2010). *Preparing and advancing teachers of agricultural education*. Curriculum Materials Service, the Ohio State University.
- Tummons, J. D., Mott, R., & Bagnell, R. (2024). "The Lost Boys": A Case Study of Male Agricultural Education Teacher Certification Students Who Changed Their Career Trajectories. *Journal of Agricultural Education*, 65(3), 276–291. <https://doi.org/10.5032/jae.v65i3.2499>
- Utah State University. (1980 – 2020). *Utah State University general catalog*. Author. <https://digitalcommons.usu.edu/universitycatalogs/>
- University of Florida. (1980 – 1995). *University of Florida undergraduate catalog*. Author. <https://original-ufdc.uflib.ufl.edu/UF00075594/00001/allvolumes>
- University of Florida. (2000 – 2020). *University of Florida undergraduate catalog*. Author. <https://catalog.ufl.edu/UGRD/previous-catalogs/>
- University of Missouri. (1980 – 2020). *University of Missouri college catalog*. Author. <https://catalog.sdstate.edu/content.php?catoid=32&navoid=4236>
- Veal, W. R., & MaKinster, J. G. (1999). Pedagogical content knowledge taxonomies. *The Electronic Journal for Research in Science & Mathematics Education*, 3(4). <https://ejrsme.icrsme.com/article/view/7615>
- Virginia Polytechnic Institute and State University. (1980 – 2020). *Virginia Tech catalog*. Author. <https://digitalsc.lib.vt.edu/collections/show/243>
- Washington State University. (1980 – 2020). *Washington State University college catalog*. Author. <https://research.libraries.wsu.edu/xmlui/handle/2376/5781/recent-submissions>
- West Virginia University. (1980 – 2020). *West Virginia University bulletin undergraduate catalog*. Author. <http://catalog.wvu.edu/archivedcatalog/>