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PEER-REVIEWED ARTICLE

A COMPARATIVE ANALYSIS OF UAS CREWMEMBER COLLEGIATE CURRICULA

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ABSTRACT

This research was a comparative analysis of undergraduate degree-granting collegiate curricula for unmanned aircraft system (UAS) crewmembers. To keep up with the civil and public-use UAS industry demand for competent unmanned aircraft crewmembers, collegiate curricula are being developed at a rapid pace. However, the absence of Federal Aviation Regulations for certification requirements of crewmembers of any UAS greater than 55 pounds, leads to concerns regarding the standardization of unmanned aviation crewmember curricula. Curricula are comprised of educational goals, educational experiences to meet those goals, how these educational experiences are organized, and how these goals are verified. This research focused on a comparative analysis of what academic topics are taught at 18 colleges offering Bachelor or Associate of Science degrees. All but four of the colleges required some sort of manned pilot certification, all offered hands-on training with sUAS or a simulator; however, two did not have any UAS-specific academic topics. Overall the largest relative variation was found in the UAS-specific topics, as measured by the coefficient of variation between topic-required credit hours. This variation raises concerns regarding student employability, matriculation, and workforce stability. Further research is recommended after the Federal Aviation Administration promulgates regulations for >55-pound UAS crewmember certification, using a larger sample set of colleges with more detailed course content descriptions.

Keywords: unmanned aviation, crewmember, education, standardization, collegiate curriculum

Key Terms (Definitions)

Crewmember	The FAA defines UAS crewmembers as pilots, sensor/payload operators, visual observers, and any people required for safe flight operations (Federal Aviation Administration, 2013).
Curriculum	Curriculum is comprised of four parts: (a) educational goals; (b) educational experiences to meet those goals, (c) organization of educational experiences; (d) and verification of elements to meet initially identified goals (Tyler, 1949). Curriculum is the singular form of curricula.
Education	Education is the cognitive capabilities garnered from learning theory and is primarily focused on understanding concepts (Cross, 1996). In short, it contributes to what you know.
Public Aircraft	In accordance with 49 U.S.C. 140102(a)(41) and 14CFR 1.1, public use aircraft are those performing noncommercial governmental functions such as national defense, intelligence missions, firefighting, search-and-rescue, law enforcement, aeronautical research, or biological or geological resource management.
Small Unmanned Aircraft	The term ‘‘small unmanned aircraft’’ means an unmanned aircraft weighing less than 55 pounds (112th Congress, 2012).
Training	“Training is measured by what you can do when you’ve completed it” and is primarily focused on attaining skills (Cross, 1996).
Unmanned Aircraft	An unmanned aircraft is any aircraft without the possibility of human intervention from onboard the vehicle (Federal Aviation Administration, 2015b).
Unmanned Aircraft System	An unmanned aircraft system is the unmanned aircraft and all associated equipment necessary to operate the system (Federal Aviation Administration, 2015c).

Introduction

By 2025, the projected economic growth in unmanned aviation will exceed $82.1 billion and result in over 100,000 new jobs being created, many of which will require unique education and certification (Association for Unmanned Vehicle Systems International, 2013). This requirement has resulted in a rapid effort to educate and train unmanned aircraft system (UAS) crewmembers to meet the expected demand. Undergraduate collegiate institutions that first establish academic dominance in the unmanned aviation crewmember field could derive significant economic benefit and become a boon to their local UAS economies (Barber, 2014).

In pursuit of these benefits, colleges across the country are developing curricula to provide Associate and Bachelor of Science degrees in unmanned aviation fields, like offerings from colleges that have provided hands-on aviation training and the accompanying degrees in aeronautics (Siebenmark, 2015). However, failure to provide UAS crewmember graduates that are accepted and recognized by the unmanned aircraft industry could have a negative impact on the continued economic health of these colleges. This research will focus on a comparative analysis of the unmanned aviation curricula of various institutions with the objective to characterize the level of standardization of unmanned aviation curricula and recommend areas for potential improvement.

Literature Review

Terwilliger (2013) characterized the growing UAS industry as a three-legged stool comprised of government, industry, and academia. Four aspects of academic involvement are outlined: (a) research and development (R&D); (b) public outreach; (c) addressing the disparity between the UAS fleet and infrastructure; and (d) identifying needs of the UAS community (Terwilliger, 2013). The most relevant need identified, in relation to this research, is for training and education opportunities to prepare the workforce and to provide professional development options. Academia is a stakeholder in the growth of UAS, and as such has much to either gain or lose depending on how the growth is managed.

Perrit and Sprague (2015) engaged in research regarding the ramifications of civil and public use UAS entitled "Drones". Of specific interest was their analysis of meeting UAS workforce demands. They concluded that UAS crewmember curricula appear to be outgrowths of established aviation curricula, whereby students attain FAA aircraft crewmember certifications, but also include courses specifically targeted at the UAS field (Perrit & Sprague, 2015).

Methodology

Quantitative data were gathered in the form of total credit hours required, the distribution of topics associated with the credit hours, and the proportion of hands-on or laboratory training credit hours. These data were obtained from publicly-available college course catalogs. Descriptive statistics of the credit counts for each topic were created with the online statistical package StatCrunch (Integrated Analytics LLC, 2015). The descriptive statistics were: (a) mean; (b) median; (c) standard deviation; and (d) coefficient of variation (CV).

Data obtained from the curricula were grouped into five areas: (a) overall credits required; (b) general education credits required; (c) aviation credits required; (d) unmanned aviation-centric credits required; and (e) hands-on training credits required. Aviation credits required were determined by the number of credits that have aviation-related topics in the course titles and course descriptions, and unmanned aviation-centric credits were determined from the classes that have UAS-related topics in the course titles and descriptions. Hands-on training credits were determined by examining the classes that have UAS lab or field work requirements. All other required credits were considered general education. All categories were mutually exclusive. Bachelor and Associate degrees were analyzed separately.

Unmanned Aircraft System Crewmember Associate of Applied Science Degrees Green River Community College

Program Summary. Green River Community College is a two-year undergraduate college in Auburn, Washington, and has an established manned aviation department (Green River College, 2015a). From this foundation, an Associate in Applied Science in UAS degree has been created (Green River College, 2015b). The curriculum requires that students attain their private pilot *Airplane Single Engine, Land* (ASEL) certificate.

Curriculum Distribution. The distribution of the curriculum between the four parts outlined in this research is as follows: (a) 35 quarter hours of general education credits, (b) 40 quarter hours of aviation credits, (c) 10 quarter hours of unmanned-centric credits, (d) five quarter hours of UAS hands-on or laboratory credits, and (e) 90 quarter hours total credits to complete the degree (Green River College, 2015b). Division of the academic calendar into quarters as opposed to semesters sets this institution apart from other colleges; hence a correction factor of 1.5 (The Best Schools, 2017) has been applied to the credits in Table 1.

Central Oregon Community College

Program Summary. The Associate of Applied Science in Aviation – UAS Operations from Central Oregon Community College (COCC) is an outgrowth of their manned aviation curriculum (Orcelletto, 2015). Students are required to obtain their FAA private pilot, instrument, and commercial ratings in manned airplanes (Central Oregon Community College, 2015).

Curriculum Distribution. The distribution of the curriculum is as follows: (a) 47 quarter hours of general education credits; (b) 32 quarter hours of aviation credits, (c) 13 quarter hours of unmanned-centric credits, (d) eight quarter hours of UAS hands-on or laboratory credits, and (e) 100 quarter hours total credits to complete the degree (Central Oregon Community College, 2015). Division of the academic calendar into quarters as opposed to semesters sets this institution apart from other colleges; hence a correction factor of 1.5 (The Best Schools, 2017) was applied to the credits in Table 1.

Community College of Beaver County

Program Summary. The Community College of Beaver County (CCBC) in western Pennsylvania has an established manned aviation curriculum with their UAS curriculum as a byproduct (Community College of Beaver County, 2015). Their unmanned aircraft degree is called Associate of Applied Science in Unmanned Aerial Vehicle (UAV).

Curriculum Distribution. The distribution of the curriculum is as follows: (a) 22 semester hours of general education credits, (b) 31 semester hours of aviation credits, (c) zero semester hours of unmanned-centric credits, (d) 12 semester hours of UAS hands-on or laboratory credits, and (e) 65 semester hours total credits to complete the degree (Community College of Beaver County, 2015). The four courses that comprise the hands-on portion of the curriculum consist of three flying classes and a class where the students build an unmanned aircraft (U. Matuszak, personal communication, December 9, 2015).

Northwestern Michigan College

Program Summary. The UAS degree at Northwestern Michigan College (NMC) is entitled Associate of Science in Aviation, but they have a UAS core of classes and hands-on training that can be selected as electives within the curriculum (Northwestern Michigan College, 2015).

Curriculum Distribution. The distribution of the curriculum is as follows (a) 18 semester hours of general education credits, (b) 37 semester hours of aviation credits, (c) zero semester hours of unmanned-centric credits, (d) 10 semester hours of UAS hands-on or laboratory credits, and (e) 65 semester hours total credits to complete the degree (Northwestern Michigan College, 2015).

Cochise College

Program Summary. The UAS crewmember degree offering at Cochise College is the Associate of Applied Science (AAS) in UAS. Cochise College offers a manned aviation curriculum that is FAA Part 141 certified, but the UAS degree is not an outgrowth of manned aircraft curricula, but rather from the college's collaborative relationship with U.S. Army UAS programs at Fort Huachuca, Arizona (Cochise College, 2015).

Curriculum Distribution. The distribution of the curriculum is as follows: (a) 23 semester hours of general education credits, (b) 27 semester hours of aviation credits, (c) six semester hours of unmanned-centric credits, (d) eight semester hours of UAS hands-on or laboratory credits, and (e) 64 semester hours total credits to complete the degree (Cochise College, 2015).

Sinclair Community College

Program Summary. The Sinclair Community College Associate of Applied Science in Unmanned Aerial Systems program is an outgrowth of the college's short term technical certificates which are, in turn, outgrowths of the college's established manned aviation curriculum (A. Shephard, personal communication, November 4, 2013). The process of starting with technical certificates and developing the curriculum to enable offering an Associate degree began in 2008 (Lambert, 2015).

Curriculum Distribution. The distribution of the curriculum is as follows: (a) 32 semester hours of general education credits, (b) 13 semester hours of aviation credits, (c) 14 semester hours of unmanned-centric credits, (d) three semester hours of UAS hands-on or laboratory credits, and (e) 62 semester hours of total credits to complete the degree (Sinclair UAS Training and Certification Center, 2015).

Hinds Community College

Program Summary. The UAS degree offering at Hinds Community College (HCC) is the Associate of Applied Science in Aviation Technology with a focus in UAS Technology (Hinds Community College, 2015a). The degree offering is three years old and is an outgrowth of the college's aviation maintenance and FAA Part 141 schools (D. Lott, personal communication, December 19, 2015). The students are not required to obtain their private pilot certification within the curriculum, but are encouraged to do so on their own or as part of their electives (D. Lott, personal communication, December 19, 2015).

Curriculum Distribution. The distribution of the curriculum is as follows: (a) 18 semester hours of general education credits, (b) 12 semester hours of aviation credits, (c) three semester hours of unmanned-centric credits, (d) 27 semester hours of UAS hands-on or laboratory credits, and (e) 60 semester hours of total credits to complete the degree. This distribution was determined by including the recommended private pilot courses into the elective positions.

Yavapai College

Program Summary. Yavapai College is in Prescott, Arizona and their UAS degree offering is called an Associate of Applied Science in Aviation Technology with a concentration in UAS (Yavapai College, 2015). The curriculum does not require the students to attain their manned airman certifications (Yavapai College, 2015).

Curriculum Distribution. The distribution of the curriculum is as follows: (a) 31 semester hours of general education credits, (b) three semester hours of aviation credits, (c) 18 semester hours of unmanned-centric credits, (d) eight semester hours of UAS hands-on or laboratory credits, and (e) 60 semester hours of total credits to complete the degree (Yavapai College, 2015).

Summary of Unmanned Aircraft System Crewmember Associate Degrees

Examination of multiple collegiate course catalogs and public information paired with phone calls and e-mails revealed how much of each curriculum was distributed between academic UAS material and hands-on material. Additionally, some colleges lacked any purely academic UAS curriculum and provided all their UAS related material in the hands-on regime, revealing a methodological limitation of making the two categories mutually exclusive. Two examples of this approach can be seen in Table 1 (CCBC and NMC). However, every college had some form of hands-on training.

Table 1
Credit Hours by College Institution and Topic for Associate Degrees

College Name	Abbrev.	General Education Credit hours	Aviation Education Credit hours	Unmanned Education Credit hours	Hands-on or lab credit hours	Total Credits to complete degree
Green River College	GRC	23.33(35)	26.66(40)	6.66(10)	3.33(5)	60(90)
Central Oregon Community College	COCC	31.33(47)	21.33(32)	8.66(13)	5.33(8)	66.66(100)
Community College of Beaver County	CCBC	22	31	0	12	65
Northwestern Michigan College	NMC	18	37	0	10	65
Cochise College		23	27	6	8	64
Sinclair Community College	SCC	32	13	14	3	62
Hinds Community College	HCC	18	12	3	27	60
Yavapai College		31	3	18	8	60

Note: ( ) parentheses indicate quarter credit hours

There was notable variation in the amount (e.g. private, commercial, instrument) of FAA manned pilot certificates required as part of the curriculum. Table 2 indicates that SCC, HCC, and Yavapai College did not have any required manned pilot certifications while Central Oregon Community College was the most demanding in this respect, requiring a commercial certificate. Although the FAA Part 107 (2016) regulations for sUAS do not require a manned pilot certificate, the job opportunities of graduates may be restricted for certain employers, such as the Customs and Border Protection which requires that their UAS pilots have a manned pilot commercial certificate (Border Patrol Edu, 2016). Furthermore, graduates without manned pilot certificates will likely be constrained to employment in the small UAS community.

Table 2
FAA Manned Certificates and Ratings Included in Associate Degree Curricula

College Name	Abbrev.	Private	Instrument	Commercial	Multi-Engine	Certified Flight Instructor
Green River College	GRC	Required	Optional			
Central Oregon Community College	COCC	Required	Required	Required		
Community College of Beaver County	CCBC	Required	Required			
Northwestern Michigan College	NMC	Required	Required	Optional	Optional	Optional
Cochise College		Required	Required			
Sinclair Community College	SCC					
Hinds Community College	HCC	Optional				
Yavapai College						

Note: Airplane or Helicopter rating not specified

Statistical Analysis of Unmanned Aircraft System Crewmember Associate Degrees

General education credit hours from Table 1 varied from 18 to 32 with a mean of 24.83 and a standard deviation of 5.84 (Table 3). Aviation credit hours from Table 1 varied from three to 37 with a mean of 21.37 and a standard deviation of 11.29, which was the highest of all topic areas (Table 3). Unmanned academic credit hours from Table 1 varied from zero to 18 credits hours with a mean of 7.04 and a standard deviation of 6.41 (Table 3). Unmanned hands-on training credit hours from Table 1 varied from three to 27 with a mean of 9.58 with a standard deviation of 7.70 (Table 3). Overall credits required for degree completion from Table 1 varied from 60 to 67 (100 quarter hours) with a mean of 62.83 and a standard deviation of 2.68 (Table 3).

Standard deviations are a good measure of how much variation there is in each category, but a ratio called the coefficient of variation (CV) allows relative levels of variance to be compared between categories enabling comparisons between Associate degrees and Bachelor degrees as well as their constituent topics. Lovie (2005) states that the CV is a measure of relative variability, independent of both the units of measurement and the magnitude of the data and is defined as the standard deviation (SD) divided by the mean.

Table 3 indicates that the area of the curriculum with the most variation is UAS education. UAS education's coefficient of .91 approaches 1.0 indicating a low level of standardization of the classroom education in UAS topics. The next most varied category was UAS hands-on training. These two topics (i.e. UAS education and UAS hands-on training) that comprise the UAS specific aspect of the curriculum vary more than the other topics and do raise concerns about the level of overall standardization from college to college.

Table 3
Summary Descriptive Statistics for Topics within UAS Associate Degrees

Curricula Topics	Mean	Median	Std. dev.	Coefficient of Variation
General Education Credit Hours	24.83	23.17	5.84	0.24
Aviation Education Credit Hours	21.37	24.00	11.29	0.53
UAS Education Credit Hours	7.04	6.33	6.41	0.91
UAS Training Credit Hours	9.58	8	7.70	0.80
Total Credits to Complete Degree	62.83	63	2.68	0.04

Unmanned Aircraft System Crewmember Bachelor Degrees

University of Louisiana at Monroe

Program Summary. The UAS crewmember degree offering at the University of Louisiana at Monroe (ULM) is called a Bachelor of Science in Aviation with a concentration in UAS (University of Louisiana at Monroe, 2015a). It is a development from the established manned aviation curriculum at ULM and the concentration in UAS was first offered in 2013 (University of Louisiana at Monroe, 2015b).

Curriculum Distribution. The distribution of the curriculum is as follows: (a) 78 semester hours of general education credits, (b) 30 semester hours of aviation credits, (c) nine semester hours of unmanned-centric credits, (d) three semester hours of UAS hands-on or laboratory credits, and (e) 120 semester hours of total credits to complete the degree (University of Louisiana at Monroe, 2015a).

Liberty University

Program Summary. The Bachelor of Science in Aeronautics with a concentration in Unmanned Aerial Systems is the most recent addition to their course offerings from the college of aeronautics, in which the students will attain both their private pilot certification and their instrument rating (Liberty University, 2015).

Curriculum Distribution. The distribution of the curriculum is as follows: (a) 60 semester hours of general education credits, (b) 39 semester hours of aviation credits, (c) six semester hours of unmanned-centric credits, (d) nine semester hours of UAS hands-on or laboratory credits, and (e) 120 semester hours of total credits to complete the degree (Liberty University, 2015).

Embry-Riddle Aeronautical University

Program Summary. Embry-Riddle Aeronautical University (ERAU) offers a Bachelor of Science in Unmanned Aircraft Systems Science degree at both of their residential campuses in Daytona Beach, Florida and Prescott, Arizona (Embry-Riddle Aeronautical University, 2015). There are two tracks within the degree: (a) Professional UAS Pilot, and (b) UAS Operations, with the difference being that instead of the FAA manned pilot certification courses as in the professional UAS Pilot track, the UAS Operations track has aviation specific electives (Embry-Riddle Aeronautical University, 2015).

Curriculum Distribution. The distribution of the curriculum is as follows: (a) 59 semester hours of general education credits, (b) 36 semester hours of aviation credits, (c) 18 semester hours of unmanned-centric credits, (d) nine semester hours of UAS hands-on or laboratory credits, and (e) 122 semester hours of total credits to complete the degree (Embry-Riddle Aeronautical University, 2015).

Kansas State University

Program Summary. Kansas State University's (KSU) UAS degree offering is the Bachelor of Science in Unmanned Aircraft Systems (Kansas State University, 2015a). The UAS department partners with the manned aviation department and the engineering department to leverage the UAS curriculum across a greater portion of the student body (M. Most, personal communication, December 17, 2015).

Curriculum Distribution. The distribution of the curriculum is as follows: (a) 72 semester hours of general education credits, (b) 40 semester hours of aviation credits, (c) nine semester hours of unmanned-centric credits, (d) six semester hours of UAS hands-on or laboratory credits, and (e) 127 semester hours of total credits to complete the degree (Kansas State University, 2015a).

University of North Dakota

Program Summary. The University of North Dakota was the first collegiate institution to offer a Bachelor's degree in unmanned aircraft (Defense and Aerospace Week, 2014). Their degree is called a Bachelor of Science in Aeronautics with a major in Unmanned Aircraft Systems Operation (University of North Dakota, 2015). North Dakota's designation as a FAA UAS Test Site along with their membership in ASSURE contribute to the strength of the UAS industry in the state (Federal Aviation Administration, 2014)(ASSURE, 2015).

Curriculum Distribution. The distribution of the curriculum is as follows: (a) 69 semester hours of general education credits, (b) 37 semester hours of aviation credits, (c) 15 semester hours of unmanned-centric credits, (d) four semester hours of UAS hands-on or laboratory credits, and (e) 125 semester hours of total credits to complete the degree (University of North Dakota, 2015).

Indiana State University

Program Summary. Indiana State University's (ISU) UAS degree offering is the Bachelor of Science in Aviation Technology with a major in Unmanned Systems (Indiana State University, 2015a). The degree does not require that students attain any manned pilot certifications, but they are encouraged to do so with their electives (Indiana State University, 2015a). The degree is part of the aviation technology department which is an established part of the college and contributes a large portion to the Unmanned Systems curriculum (Indiana State University, 2015a).

Curriculum Distribution. The distribution of the curriculum is as follows: (a) 62 semester hours of general education credits, (b) 40 semester hours of aviation credits, (c) 15 semester hours of unmanned-centric credits, (d) three semester hours of UAS hands-on or laboratory credits, and (e) 120 semester hours of total credits to complete the degree (Indiana State University, 2015b). This distribution was determined by selecting manned aircraft certifications as electives to include private pilot and instrument ratings.

Lewis University

Program Summary. The Lewis University UAS crewmember degree offering is the Bachelor of Science in Unmanned Aircraft Systems from the Aviation and Transportation Department (Lewis University, 2015a). Lewis University also offers a minor in UAS for any of their other degrees due to the broad relevance of the technology, which has the effect of increasing UAS class sizes (Lewis University, 2015b).

Curriculum Distribution. The distribution of the curriculum between the four parts outlined in this research is as follows: (a) 66 semester hours of general education credits, (b) 47 semester hours of aviation credits, (c) nine semester hours of unmanned-centric credits, (d) six semester hours of UAS hands-on or laboratory credits, and (e) 128 semester hours of total credits to complete the degree (Indiana State University, 2015b).

Middle Tennessee State University

Program Summary. Middle Tennessee State University (MTSU) is in Murfreesboro, Tennessee and brands their UAS crewmember degree offering a Bachelor of Science in Aerospace with a concentration in Unmanned Aircraft Systems (Middle Tennessee State University, 2015). Students are required to obtain their FAA Private Pilot certificate as part of their studies (Middle Tennessee State University, 2015).

Curriculum Distribution. The distribution of the curriculum is as follows: (a) 75 semester hours of general education credits, (b) 30 semester hours of aviation credits, (c) 12 semester hours of unmanned-centric credits, (d) three semester hours of UAS hands-on or laboratory credits, and (e) 120 semester hours of total credits to complete the degree (Middle Tennessee State University, 2015).

LeTourneau University

Program Summary. LeTourneau University is in Longview, Texas and has a UAS degree offering called the Bachelor of Science in Remotely Piloted Aircraft Systems with the pilot concentration (LeTourneau University, 2015). The pilot concentration requires a FAA manned pilot certificate (LeTourneau University, 2015).

Curriculum Distribution. The distribution of the curriculum is as follows: (a) 46 semester hours of general education credits, (b) 58 semester hours of aviation credits, (c) 17 semester hours of unmanned-centric credits, (d) five semester hours of UAS hands-on or laboratory credits, and (e) 126 semester hours of total credits to complete the degree (Liberty University, 2015).

Purdue University

Program Summary. Purdue University in West Lafayette, Indiana has the state's second UAS crewmember undergraduate college offering a Bachelor of Science in Unmanned Aerial Systems through the School of Aviation and Transportation Technology (Purdue Polytechnic, 2015).

Curriculum Distribution. The distribution of the curriculum is as follows (a) 62 semester hours of general education credits, (b) 24 semester hours of aviation credits, (c) 16 semester hours of unmanned-centric credits, (d) 18 semester hours of UAS hands-on or laboratory credits, and (e) 120 semester hours of total credits to complete the degree (Purdue Polytechnic, 2015).

Summary of Unmanned Aircraft System Crewmember Bachelor Degrees

Examination of multiple collegiate institutions course catalogs and public information paired with personal communications revealed the curriculum distribution between academic UAS material and hands-on material. Some colleges combined their hands-on training and classroom instruction and, in doing so, revealed a methodological limitation of making the two categories mutually exclusive for a comparative analysis. However; every college had some form of hands-on training with one exception that only used simulators for hands-on training. Table 4 summarizes the curriculum distributions of the 10 UAS crewmember Bachelor degree granting collegiate institutions.

Table 4
Credit Hours by College Institution and Topic for Bachelor Degrees

College Name	Abbrev.	General Education Credit hours	Aviation Education Credit hours	Unmanned Education Credit hours	Hands-on or lab credit hours	Total Credits to complete degree
University of Louisiana at Monroe	ULM	78	30	9	3	120
Liberty University		60	39	6	9	120
Embry-Riddle Aeronautical University	ERAU	59	36	18	9	122
Kansas State University	KSU	72	40	9	6	127
University of North Dakota	UND	69	37	15	4	125
Indiana State University	ISU	62	40	15	3	120
Lewis U niversity		66	47	9	6	128
Middle Tennessee State University	MTSU	75	30	12	3	120
LeTourneau University		46	58	17	5	126
Purdue University		62	24	16	18	120

There is less variation in the amount of FAA manned Certificates and ratings required in Bachelor degrees than in Associate degrees. Table 5 indicated that ISU had the least required manned pilot certifications while UND had the most, and that the combination of Private and Instrument were the most common.

Table 5
FAA Manned Certificates and Ratings Included in Bachelor Degree Curricula

College Name	Abbrev.	Private	Instrument	Commercial	Multi-Engine	Certified Flight Instructor
University of Louisiana at Monroe	ULM	Required	Required			
Liberty University		Required	Required			
Embry-Riddle Aeronautical University	ERAU	Required	Required	Required		
Kansas State University	KSU	Required	Required			
University of North Dakota	UND	Required	Required	Required	Required	
Indiana State University	ISU	Optional	Optional	Optional		
Lewis University		Required	Required			
Middle Tennessee State University	MTSU	Required				
LeTourneau University		Required	Required			
Purdue University		Required	Required			

Note: Airplane or Helicopter rating not specified

Statistical Analysis of Unmanned Aircraft System Crewmember Bachelor Degrees

General education credit hours from Table 4 varied from 46 to 78 with a mean of 64.9 and a standard deviation of 9.28 (Table 6). Aviation credit hours from Table 4 varied from 24 to 58 with a mean of 38.1 and a standard deviation of 9.54, which was the highest of all topic areas (Table 6). Unmanned academic credit hours from Table 4 varied from six to 18 credits hours with a mean of 12.6 and a standard deviation of 4.14 (Table 6). Unmanned hands-on training credit hours from Table 4 varied from three to 18 with a mean of 6.6 with a standard deviation of 4.60 (Table 6). Overall credits required for degree completion from Table 4 varied from 120 to 128 with a mean of 122.8 and a standard deviation of 3.33 (Table 6).

Table 6 indicates that the area of the curriculum with the most variance is UAS hands-on training. UAS hands-on training's coefficient of .70 for BS degrees indicated that the standard deviation is 70% of the mean, which was better than the UAS hands-on training CV of 0.80 for AS degrees. The next most varied category was UAS education credit hours with a CV of 0.33, which was far better than the UAS education CV of 0.91 for AS degrees. The two topics (i.e. UAS training and UAS education) that make up the UAS specific aspect of the curriculum vary more than any other topics and raise concerns about the level of overall standardization from college to college.

Table 6
Summary Descriptive Statistics for Topics within UAS Bachelor Degrees

Curricula Topics	Mean	Median	Std. dev.	Coefficient of Variation
General Education Credit Hours	64.9	64	9.28	0.14
Aviation Education Credit Hours	38.1	38	9.54	0.25
UAS Education Credit Hours	12.6	13.5	4.14	0.33
UAS Training Credit Hours	6.6	5.5	4.60	0.70
Total Credits to Complete Degree	122.8	121	3.33	0.03

Summary of Findings

Many of these curricula were derived from established manned aviation curricula with the UAS departments emerging as subsets or partners of the aviation departments to enable curriculum sharing and prevent duplication of efforts regarding instructional design. The UAS degrees are striving to meet the needs of their respective regions for competent UAS crewmembers to make economic gains. They are also doing so to draw potential economic gains away from their neighboring states. Some colleges distinguished themselves by their partnerships with local military operations and/or established civil UAS manufacturers that support their UAS programs by providing access to restricted or special use airspace and as subcontractors for UAS flight training.

Many of the sources in this research were news articles from local news outlets that are in the communities where the colleges reside. This is a manifestation of the colleges fulfilling Terwilliger's (2013) recommendation that academia engages in public outreach and education to improve social acceptance of UAS. It is not entirely a selfless act though, the colleges have an interest in drawing students and to do so, they must market their degree offerings as good choices for potential students; transforming the dialog about UAS to one about economic opportunity and revitalization.

The most credit hour variation in undergraduate UAS crewmember curricula was in the UAS-related topics, both academic and hands-on. Differences in the coefficients of variation between credit hours across topics were found in both Associate degrees and Bachelor degrees. Overall the Associate degrees had more variation in every topic than Bachelor degrees (Figure 1). The top two Associate degree topics with the most variation was UAS hands-on training and UAS academic education, which was also true for Bachelor degree curricula, although in the opposite order. Although the Bachelor degree curricula required nearly twice as many overall credit hours as the Associate degrees, the latter had a higher mean hands-on training credit hour requirement.

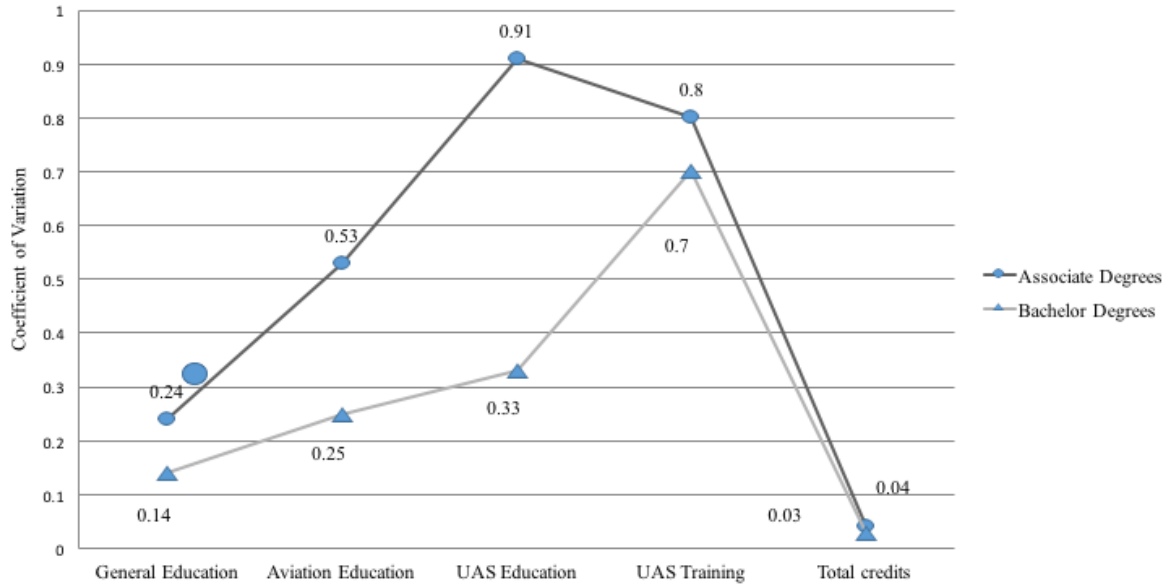

Figure 1. Coefficients of variation by curriculum topic and degree type.

FAA manned pilot certifications that were a part of the curriculum differed from institution to institution, but 78% of institutions included a requirement for at least a private pilot certification in the curriculum. Only one college offering a BS degree made a manned pilot certification optional, while three colleges offering AAS degrees made it either optional or not required.

Conclusions

Overall, BS degrees were more standardized than AAS degrees, with the UAS specific area within the curriculum (i.e. UAS academic topics and UAS hands-on training) showing the least standardization. Specifically; within Associate degrees, the UAS academic material was the least standardized and within Bachelor degrees, the UAS hands-on training was the least standardized. The mean for all the CVs of Associate degrees was 0.50 and the mean for all the CVs of Bachelor degrees was 0.29, illustrating that Bachelor degree curricula were more standardized than Associate degree curricula.

The large relative variability in required credit hours within topics or from degree to degree has ramifications for the growing industry. Graduates from different undergraduate colleges will have different strengths and weaknesses. Specifically, and most critically, graduates of Associate degree curricula are likely to have more variation in their level of UAS academic education than graduates of Bachelor degree curricula, which may result in graduates that do not understand the same breadth or depth of UAS topics. Despite the relative low variability in aviation and overall credit hours for graduates with Bachelor degrees, they still had a large variation in their level of UAS flight experience.

Employer awareness of non-standardized curricula could pose challenges for graduates in their job hunt as well as for colleges recruiting future students. Employers could be negatively impacted by lack of standardization where multiple employees with similar college degree credentials present differing skillsets, complicating human resource labor planning, professional development, and operational success. Additionally, the lack of standardization creates students that have trouble matriculating from Associate UAS degree curricula to Bachelor UAS degree curricula in pursuit of higher education.

Recommendations

Curriculum Standardization

In order in reduce the relative variability and improve the level of standardization within UAS crewmember undergraduate collegiate curricula, several aspects must be addressed; specifically, FAA manned pilot certifications, UAS academic credits, and UAS hands-on experiences. The following three recommendations require some manner of agreement between the involved schools.

FAA manned pilot certifications are one of the elements within the curriculums lacking standardization. To correct this, colleges should include minimum FAA pilot certification requirements for the completion of UAS crewmember curricula. Associate degrees should require a minimum of a sport pilot certificate, and Bachelor degrees should require a minimum of private pilot certificate in either a helicopter or airplane. This requirement would further elevate graduates from their peers with simply a Part 107 certificate. The inclusion of this material in the curriculum would add very little course work for the students' due to ground school already being part of curriculum and schools would be free to exceed this minimum requirement. In the future, when the regulatory environment matures and more types of unmanned FAA certificates exist, this recommendation could easily become outdated and fall to the wayside.

UAS academic topics should be included in the curriculum to provide the students a foundation of system knowledge regarding the different types of UAS as well as environmental, economic, and political aspects. Some of the colleges did not offer any UAS academic topics, while others either provided dedicated UAS academic classes or combined their UAS academic topics with their UAS hands-on training.

UAS hands-on experience should be increased so that curriculum standards for colleges are similar in scope to the aeronautical experience required for existing manned pilot certificates under 14CFR Part 61. Required UAS flight hours, not including simulator time, should have different criteria for Associate degrees and Bachelor degrees so that the graduates' unmanned flight experience exceeds their manned flight experience thus preventing graduates from unmanned centric curricula having hundreds of manned flight hours, but only a handful of unmanned fight hours. These unmanned flight hours should be comprised of a variety of UAS types, but the exact distribution will be determined by the nature of the region that the university is trying to support. These degrees should be viewed as unmanned aviation degrees with a seasoning of manned material rather than manned aviation degrees with an unmanned flavor.

Further Analysis

The goal of UAS crewmember undergraduate college curricula has been to meet the workforce demands of a growing industry, but how well that is being accomplished requires further research. This research only addressed how standardized the current paradigm is. Therefore; a longitudinal study is recommended to measure the work experiences and employability of graduates of these curricula, over the course of their careers. This recommended course of action could also measure how many students pursued higher UAS crewmember education and how many attained additional manned certifications.

Additionally; it would allow the effectiveness of the curricula to be compared against one another and to determine which curricula were superior to the others. This could form the basis of discovering a model curriculum. Further refining this model curriculum would be an industry study examining the qualifications employers' desire in graduates of UAS crewmember curricula. The result could then be used to design recommendations to academic institutions for the desired distribution and inclusion of topics within the curricula.

Recommendation to Improve this Analysis

The relative variability of curricula standardization should be investigated at a finer level by expanding from the top-level course descriptions provided in the college catalogs, down to the content of individual syllabi for each class. This would enhance the reliability of correct categorization of curricula topics as hands-on or academic in nature, and allow blended classes to be more accurately represented in the curriculum distribution. The limitation to this approach is that collegiate institutions may not be willing to share their individual course syllabi due to concerns about curriculum development costs and retaining their intellectual property.

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