

Development of an Associates in Science (AS) with Geospatial Technologies at Arizona Western College (Yuma, AZ).

By

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A practicum submitted in partial fulfillment of the requirements
for a Master of Science in Applied Geospatial Sciences

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Northern Arizona University

November 2017

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Acknowledgements

I would like to give special thanks to my wife Jodi, and Dr. Linda Elliot-Nelson of Arizona Western College. Both of their amazing and continual support, and willingness to encourage excellence and maximum efforts in my academic endeavor, made this practicum project entirely possible. I would also like to thank Mark Manone, Dr. Jessica Barnes and Dr. Eric Schiefer, for their excellent guidance and direction in the master's degree program at NAU. All are excellent mentors for future graduate students. In addition, gratitude to the entire GIS advisory committee during the planning stages, most importantly to the extended hours provided by Brian Brady, Jonathan Gholson, Bridgette Johanning, and the agencies they represent. And lastly, to my supervisors, colleagues and support staff during this project at Arizona Western College, thank you! This has always been a team effort, with a student benefit as the final goal. Joann Chang, Fred Croxen, Monica Ketchum, Elaine Grogett, and Reetika Dhawan, it has been a pleasure to work on this project with each of you. Your exceptional work ethic and stellar professionalism, is to be modeled by all others.

Abstract

This study focused on geographic programs at the community college level with the integration of geographic information systems, currently termed Geospatial Technology GST. One of the major objectives is the creation and empowerment of the community college to expand spatial education programs to meet the demands of the growing geospatial workforce. To fulfill this main objective, we must identify the skills and competencies required in the present geospatial occupations. With a known skill set, we can develop curriculum guidelines and build model courses and certification programs. Evaluation and accommodations will be taken into account for all stakeholders to include the students, the faculty, the institution, and the workplace agencies. We must understand the power of GIS education lies not in the technology itself, but in its potential to foster a change and introduction of spatial thinking. Therefore allowing the scientific practice to continue with the advances of technology and student skills in 21st century.

Letter of Significant Contribution

November 7, 2017

Re: Todd Pinnt

To whom it may concern,

I have worked with Professor Todd Pinnt for many years at Arizona Western College and continue to interact with him frequently in my current role as Vice President for Learning Services. In particular, Professor Pinnt has worked closely with my office on curriculum that he has written regarding Unmanned Aerial Systems.

Professor Pinnt's study through the process of completing his Master's degree in Applied Geospatial Sciences has been one our college has been engaged with and has encouraged. His focus in his practicum has been the creation and empowerment of the community college to expand spatial education program to meet the demands of the growing geospatial workforce.

The curriculum that Professor Pinnt has written has been very impressive since it encompasses an associate's degree as well as three stackable certificates that enable our students to focus on areas of emphasis within the discipline of geospatial technologies. The courses within this program enable the students to build upon their foundations of knowledge and their skill abilities to prepare them for additional knowledge and/or employment in the workforce for the unique needs of our district area.

The work Professor Pinnt has engaged in has also included the process of requesting a Certificate of Authorization (COA) that not only involves significant contact with different community stakeholders, but also added knowledge in the process of working with government entities in this specialized field.

In my opinion, Professor Pinnt has gone above and beyond in his application of learning within his Master's in Science in Applied Geospatial Sciences to add knowledge and skills to our community and to his portfolio.

If further information is required, please contact me at (928) 344-7516.

Sincerely,

Dr. Linda Elliott-Nelson

Vice President for Learning Services

List of Abbreviations

AGI - American Geosciences Institute
AGO - Arc GIS Online
COA - Certificate of Authorization
FAA - Federal Aviation Administration
GIS - Geographic Information Systems
HSI - Hispanic Serving Institution
K-12 - Kindergarten to Twelfth grade
NCES - National Center for Education Statistics
RTOP - Reformed Teaching Observation Protocol
UAS - Unmanned Aerial Systems

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Introduction

The role of community colleges has been largely overlooked in GIS educational literature. The increasingly diverse student populations must be prepared for the ever changing spatial technology that will be found in the new digital century. Students will be facing new expectations and new challenges presented in educational delivery. At a time when public education has faltered in support of the geospatial sciences and several states have removed earth science from the K-8 curriculum during the 2002-2007 timeframe, these educational institutions must evaluate the services presently offered. According to the American Geosciences Institute, the spatial sciences are not included in the high school programs, and only 25 states include earth science in the recommended high school curriculum. Within these states, 65 percent reported a decline in the earth science enrollments. In the past 18 years there have been fewer geospatial teachers, in high school, than any other science teacher. The national community college statistics fared significantly lower. The total number of community colleges per state to offer core geosciences programs was merely 5 percent. To include the geographic distribution of community colleges that offer programs in geosciences technology programs, geographic information systems , most are located in the western states. However, the total numbers are very low, with only six programs available nationally.

Keywords

Geospatial, Geographic Information Systems, Spatial Analysis, Geography, Geoscience, Geo Spatial Technologies, Unmanned Aerial Systems, Community College.

Purpose

Arizona Western College must develop a strategic plan to foster spatial literacy across the geographic curriculum, establish departmental programs to embed geospatial skills, support the K-12 geospatial educational system, and fortify the relationships with the professional workplace environments. Infusing geospatial technologies and spatial literacy can have long-term impacts on the individual, institutions, and society. Geography is not important, it is essential. As stated by Brian Brady, GIS-P certified professional in city government, in a recent interview he confirmed the educational community is the important piece that will train and develop individuals in the skills sets that are required for all city job positions. From the city manager to the field employee on the street, GIS skills and applications are increasing daily (Brady, 2016). GIS, as a spatial tool, is requiring abilities in a foundation of software to digitize the physical world to a finished deliverable. From the products produced by GIS tools, multiple career fields are now leading to an increased demand for fundamental knowledge and occupational perspectives found in data acquisition, analysis and modeling, and spatial application development and delivery. According to the Status of Recent Geoscience Graduate 2015, by the U.S. Department of Labor Employment and Training Administration, The skills required of GIS are leading to occupational demand far greater than the average growth in similar fields. GIS projected growth will be from 7 percent to greater than 20 percent leading into the year 2018 (Table 1).

Table 1 Geospatial Occupations (U.S. Dept. of Labor)

Geospatial Occupations Defined by the U.S. Department of Labor Employment and Training Administration

Occupation	Estimated Employment (2008)	Projected Growth (2008–2018)	Projected Growth Rate (2008–2018)
Geospatial Information Scientists and Technologists*	209,000	72,600	Average (7% to 13%)
Geographic Information Systems Technicians*	209,000	72,600	Average (7% to 13%)
Remote sensing Scientists and Technologists*	27,000	10,100	Average (7% to 13%)
Remote sensing Technicians*	65,000	36,400	Average (7% to 13%)
Precision Agriculture Technicians*	65,000	36,400	Average (7% to 13%)
Geodetic Surveyors*	58,000	23,300	Faster than average (14% to 19%)
Surveyors	58,000	23,300	Faster than average (14% to 19%)
Surveying Technicians	77,000	29,400	Much faster than average (≥ 20%)
Mapping Technicians	77,000	29,400	Much faster than average (≥ 20%)
Cartographers and Photogrammetrists	12,000	6,400	Much faster than average (≥ 20%)
Totals	857,000	339,9000	

*New occupations established late 2009.

Note: Employment and growth estimates do not include geospatial software programmers and application developers.

Source: U.S. Department of Labor Employment and Training Administration, O*NET Online, <http://online.onetcenter.org/>, September 6, 2010

Research Questions

- What is the level of knowledge and skill necessary for the successful and appropriate use of geospatial technologies at each academic echelon? What is age-appropriate in pedagogy and content?
- What dynamic approaches can be utilized to articulate improved educational training and outcomes in the geospatial sciences from K-12 educational system provided by the community college?
- What are the new challenges for students, faculty, and institutions, in considering the creation of non-traditional and online programs in geospatial sciences, focusing on the design criteria and institutional readiness?
- A wider range of industries, including agriculture, energy services, environmental technology, health, national security, resource management, and transportation rely on it geospatial technology. How can the community college incorporate spatial sciences within diversified departments on campus?

- How to align the geospatial curriculum with national workforce competency standards?
- How can employers and educators work to develop strategies to reduce the gap between geospatial workforce demand and supply?
- What constitutes a well developed strategic plan to contract a geospatial program in a community college with professional accreditation?

Study Site

Why select Arizona Western College and the educational community of Yuma, AZ for this project? Arizona Western College has significant variables of importance to justify the creation of a geography program that will serve and support GIS education. The most significant factor for the college is the lacking of a geography degree or certification program. At present time there is no program of study to fulfill all associate course level requirements that articulate to the state universities, of whom offer geography and GIS degrees. Additionally, Arizona Western College has a growing diversity of student populations that includes a high percentage of Hispanic (70 percent) and female (52 percent) populations (Arizona Western College, 2016). In a study conducted by the US Department of Education in 2016, minority students are highly underrepresented in the undergraduate geography programs across the United States. Less than 5 percent are reported as Hispanic or Latino in geographic studies. According to the same report, the female population was slightly over 30 percent of those same undergraduate students (U.S. Department of Education, 2016). Arizona Western College is a Hispanic serving institution (HSI) established by the standards of the United States Department of Education. The significance of HSI is the ability to qualify and receive grants under title III and title V for Federal funding in education. This future funding potential can lead to geospatial educational programs. This additional funding can provide support and opportunity in achievement of an associate degree. As found in a study by the Arizona Community Colleges, the 2015 student population at Arizona Western College has completed associate degrees at a higher rate than any other

Arizona community college, or the national and state average (Arizona Community Colleges, 2016). In a study conducted by the National Center for Education Statistics (NCES) Digest Of Education Statistics in 2014, reference by the American Geosciences Institute (AGI) Geoscience Workforce Program, the Hispanic percentage of associate degrees awarded surpassed other underrepresented minorities. From 1977 to the year 2013 Hispanic degree awarded increased from 4 to nearly 16 percent (National Center for Education Statistics NCES, 2015). This data presents a trend that AWC will be in situation to provide educational services for a demographic of high proximity. As stated previously, Arizona Western College shows a considerable deficiency in geographic course offerings, a highly diverse student population, high rates of success by students in academia, and the necessity to meet the demand of the students and community, with geographic and GIS educational opportunities. The higher educational institution of Arizona Western College is a high priority site for the establishment of spatial education.

Project Scope

Develop worthwhile institutional programs to foster spatial thinking and learning to fulfill future demands of the community and the requirements of the university bound student populations. In a Hispanic Serving Institution (HSI), Arizona Western College will be in a prime location to embrace improved learning strategies to implement and integrate geospatial thinking across the entire campus in both teaching and research.

Justification

Justification falls into four main areas of concern: 1) the K-12 geography environment, 2) the community college geography environment, 3) the institutional geospatial programs, 4) the workplace demands for the geospatial subset of skills.

In a study by the AGI, Geoscience Workplace Program, earth science and spatial education is required in 7 of the 50 states, as shown in Figure 1. Earth science is the core study of Earth and the many sphere of influence, such as atmosphere, lithosphere, and hydrosphere. While spatial education is the study of location information describing the Earth, with the application of geographic information systems (GIS), global positioning system (GPS), remote sensing, surveying, and cartography . A recent increase is taking place from spatial education growth, but is slow in the process of reaching a majority of states.

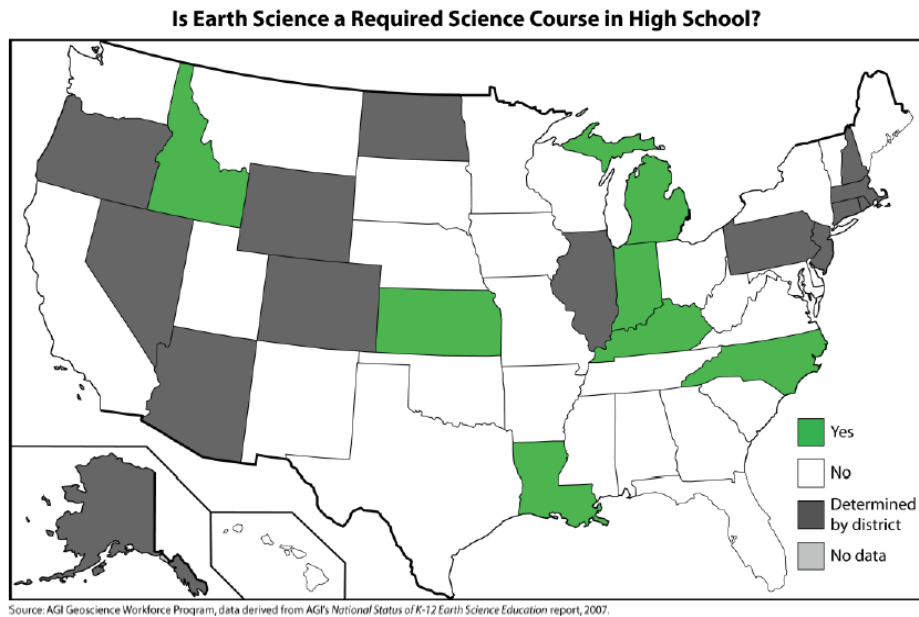


Figure 1 Earth Science in High School (American Geosciences Institute AGI)

Trends in the quantities of science courses taken by US high school graduates, found that geology/earth science related courses returned the lowest percentage of all measured science curriculums (Figure 2). The highest return of competition was biology with 95 percent of graduates, while earth science was 27 percent of graduates (American Geosciences Institute, 2016).

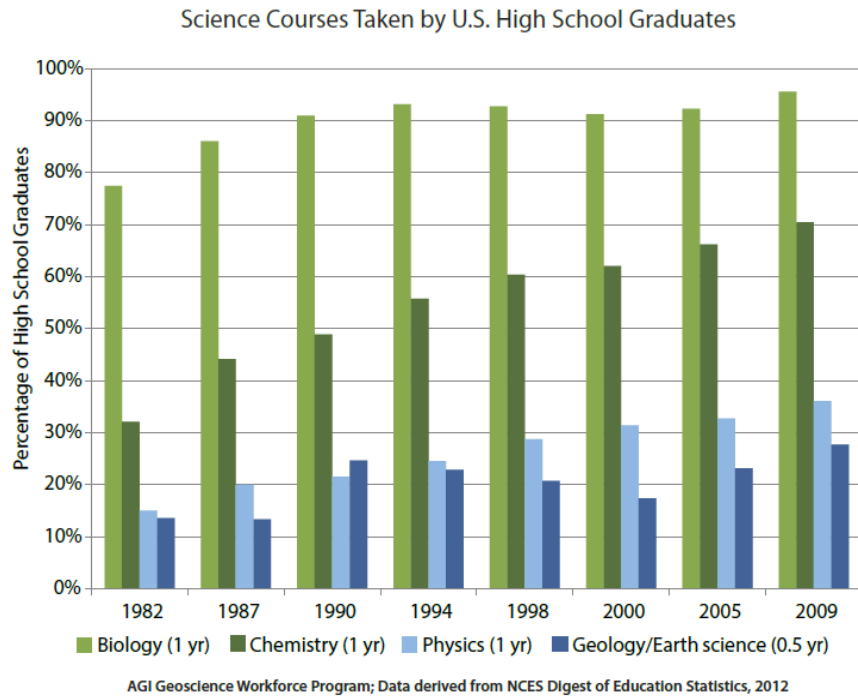


Figure 2 Science Classes by HS Graduates (American Geosciences Institute AGI)

A community college with GIS can be the bridge between the K-12 environment and the universities. With geospatial programs established at the community college, educational outreach and teacher training in the K-12 environment can be highly beneficial to increasing student exposure to the educational benefit of spatial education. Therefore, increasing the total number of graduates taking geographic sciences.

The second area for justification is found in the concept of geospatial education offered at the community college level. By having a established degree and certification program, students will be exposed to the academic and professional fields of GIS earlier in their academic and professional careers. Supporting this call for early exposure to GIS education, the Status of Recent Geoscience Graduates of 2015, showed a majority of bachelor degree awarded students had decided on their major after the community college time frame in their education. Nearly 90 percent selected the geography degree pathway after the completion of their two-year community college experience. Arizona Western College will need to review the established GIS programs across the country for early establishment at the community college level.

The third justification is the need to establish geospatial programs within the geography curriculum at the community college. Where in the academic programs will GIS fit? Research from Karen Kemp, Professor of the Practice of Spatial Sciences University of Southern California (USC), found GIS needs to be within a complete geography program. This format of operation will build upon the educational foundations, thought processes, and methodologies taught in introductory geography courses. This approach will improve the reasoning in spatial analysis beyond the technical tools of operation in the software. In a geography program, the general issues of geographical information science appears much more important than the specifics of a given geographic information system (Kemp, Karen U. 2016). This project will derive models demonstrated by institutions with successful transition to implement GIS education beyond technical skills.

The fourth component, the workplace and employer demands for spatially trained individuals, justifies not only the needs of society, but the needs of the individual for improved employability. Following the Geospatial Technology Competency Model (Figure 3), published by the US Department of Labor, this project will focus on the academic competencies found in tier 2, leading to the industrial related skills and occupational requirements found in tier 4 & 5. The importance of a strong base in subject specific geographic knowledge, added with geographic information systems and field methods, will increase depth of understanding when student approach spatial thinking and global perspectives.

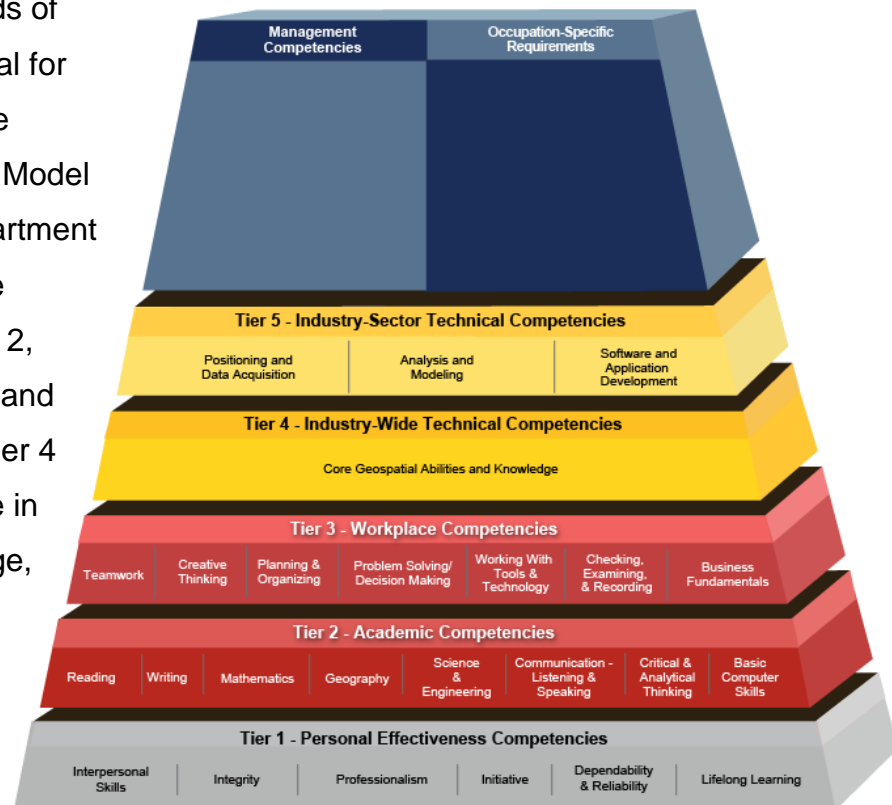
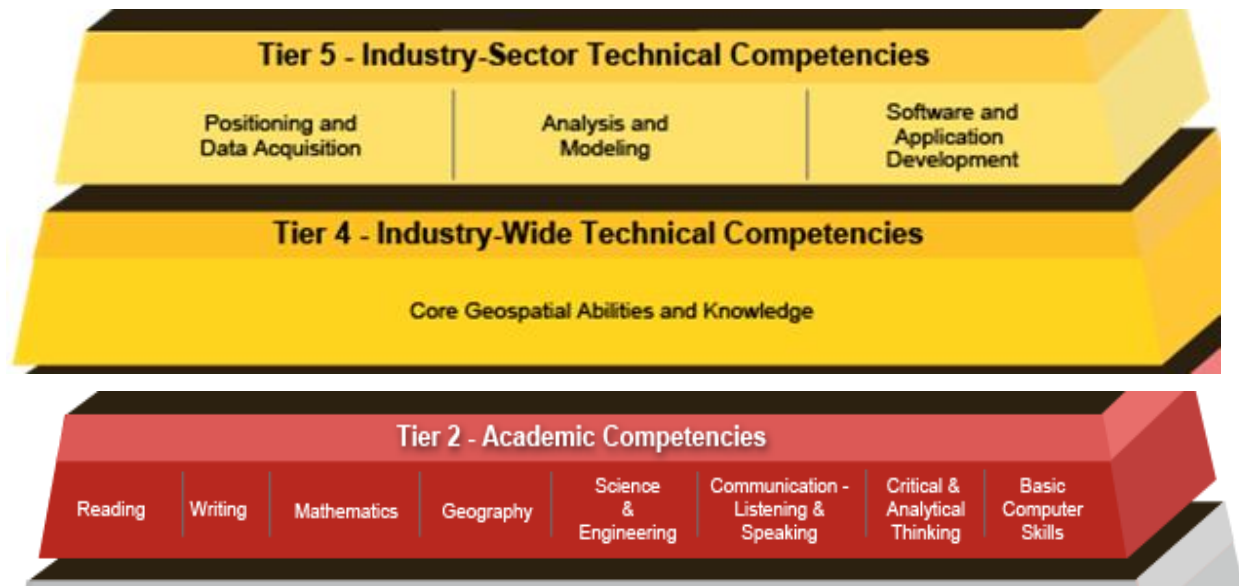


Figure 3 Geospatial Technology Competency Model (U.S. Dept. of Labor)



(Enlargement from figure above)

Literary Analysis

At the present time, spatial thinking has become something every educated person needs to be able to do, utilize, and apply. Spatial thinking is a form of reasoning and refers to the ability to use logic in the three dimensions, drawing a conclusion from limited data. In a growing digital world, with global based experiences, one is taxed with the ability to use spatial thinking as a personal resource. In contrast, at the same time a situation facing low public awareness of geospatial technologies is occurring. Community colleges and four-year Universities are facing increased growth of online GIS instruction that corresponds with a heavy demand for a geospatial workforce requiring highly skilled individuals. To fully understand the situation facing higher educational institutions one must address four essential stakeholder groups. First the students, the individual most affected and has the highest direct benefits, second the faculty with involvement in the creation of content and teaching of courses, third the academic institution with the accreditation and articulation concerns, and finally the employers with indirect benefits from the graduates of new knowledge and skill sets (Wikle, 2016).

The Student

"How They Learn"

The student is the most significant variable in this complex equation. Current geography courses will need to have additional pedagogies to address the adult learning styles found at the community college level. The Active Learning Approach will utilize key factors of discussion and reflection by the student, to focus on the learning of the objective, more importantly then only learning from the process of operation (Regina, 2008). This theory allows for GIS situational analysis to improve conceptual comprehension beyond simple technology operation. Problem based instruction (PBI) is also reinforced by the use of GIS applications (ESRI, 2016). PBI allows for critical thinking to analyze and evaluate the objective in order to form judgment, a skill set required in many GIS occupations. Spatial analysis, from the constructivist point of view, allows the student to develop and construct their own understanding and knowledge of the world through their experiences and reflecting on those experiences. Building upon this concept, Kolb's Experiential Learning theory shows how experience is translated through reflection into concepts, which in turn, are used as guides for active experimentation and the selection of new experiences (Healey, 2000). The four stages found in Experiential Learning: do, observe, think, and plan, are cyclical in design. A similar perspective in geospatial analysis, where data outcomes often lead to additional assessments and future experimentation.

Two Northern Arizona University programs will be observed to understand student learning patterns utilizing several pedagogies of GIS applications, The Power Of Data (POD) and GeoCache. The Power Of Data project is to build a continuity of experiences to improve learning for a diverse audience through geospatial data and hands on inquiry (Rubino-Hare, 2016). GeoCache utilizing the International Society for Technology Education Model to assess student skills and abilities utilizing geospatial technology. Both programs employ spatial thinking to develop comprehension in the student's learning process to understand spatial patterns and relationships.

The Faculty "How They Teach"

The need to identify the methods by which college faculty assess undergraduate knowledge, skills, and abilities in spatial education is growing exponentially. According to Michael Solem and Kenneth Foote in 2009, instructors must challenge and stimulate students with spatial concepts presented in a logical manner, addressing practical problems and promoting critical-thinking and problem-solving. With the use of GIS to visualize quantitative data, students will be challenged to deeper levels of learning and understanding of the potential and limitation found in GIS (Solem & Foote, 2009). In addition, what approach should be taken in teaching teachers and faculty how to engage spatial thinking? How should geospatial education look? In reference to this geospatial education question, a study conducted by Marian Blankman in 2016, focused on the need to develop a "conscientiously teaching geography" in a cohort of pre-service teachers. The goal for the project was to develop future primary school teachers (the cohort), with the ability to improve their pedagogical content knowledge, based primarily on the principles of good geography teaching practices (Table 2).

Table 2 Characteristics of Good Geography Teaching (Blankman, 2016)

<i>Geographic characteristics (What)</i>	
1. Where is it?	Describe what you see where, preferably using, e.g., a map, an atlas, a globe etc.
2. Why is it there?	Explain what you see (through the relationship man – nature)
3. What do I see if I zoom in or out?	At other levels of scale you may see different things/ Zooming provides a different picture
4. How does it change?	Describe the situation in the past and/or in the future.
5. What are the consequences, advantages and disadvantages?	The effects (or pros and cons) are viewed from different angles.
<i>Instructional characteristics (How)</i>	
6. How can I start the lesson in a motivating way?	The lesson starts in a way that pupils are challenged to participate in class. (<i>Everyday spatial problem</i>)
7. How can I end the lesson in a way transfer takes place? (Talking about 'the special and the general')	At the end of the lesson there is a discussion about the usefulness of knowing something about the subject of the lesson.

In the initial phase, applying short intervention and design principles to including modeling and reflection of geographic methods, the student teachers did show substantial and contextual knowledge improvement in the geographic content (Blankman, 2016). However, after a long term review, unsurprisingly the effects of the improvement diminished without continued support. Early teaching professionals must be provided opportunities to become familiar with new scientific insights found in geographic instruction. This research demonstrated the opportunity to improve pre-service educational programs with geographic foundations. However, larger scale challenges and barriers presented by society and institutions still limit the feasibility of complete program success. Student teachers enter college with a wide variety of knowledge sets, often lacking of a focus on the geographic subject matter. With limited number of teaching hours devoted to the subject of geography, this task of change will continue to limit positive outcomes in the long run. Teacher training institutes must provide extended opportunities (Table 3) to integrate in-depth spatial applications of geographic curriculum to become more proficient and experienced in utilizing good geographic teaching methods (Table 2).

Table 3 Guiding Questions for Reflection on GIS Opportunities (Jo, 2016)

Topic	Guiding Question for Reflection
The importance of spatial thinking What is GIS? GIS for spatial thinking education	What would be potential of using GIS to facilitate geographic and/or spatial thinking?
Getting to know <u>ArcGIS Online</u>	How do you feel about basic features of AGO? What did you like or dislike?
Learning geographic inquiry with AGO (1): A physical geography example	What would be benefits of using GIS in this physical geography lesson for students to achieve the learning objectives?
Learning geographic inquiry with AGO (2): A human geography example	What would be benefits of using GIS in this human geography lesson for students to achieve the learning objectives?

The implementation of geospatial technologies in pre-service teacher programs and supporting research on the facilitating process is still limited and inadequate (Jo, 2016).

Beyond the pre-service teacher educational programs, what can be cited for geospatial curriculum approaches to promote specific scientific situations? A study conducted by Bodzin on three hundred 8th grade middle school students and their teachers, focused primarily on this question of scientific situations. Can a geospatial curriculum approach promote understanding in climate change? Additionally, what factors related to the student and teacher populations, may account for improved knowledge achievement? The results and findings from the study revealed that not only the geospatial curriculum improved understanding of specific scientific events, but also improved overall effectiveness in science curriculum (Bodzin, 2014). The primary goal of the study successfully addressed the idea that geospatial curriculum improved climate change comprehension. The use of technology integrated science curriculum, provided higher order thinking skills and improved depth of understanding with the use of authentic scientific inquiry. Minimal differences on subject variability were found between students and teachers from pre- and post-test evaluations. Additionally, several research situations prohibited valid results to be conclusive in addressing the secondary goal. The limited number of schools selected, the presence of class tracking, and non-random subject mixture, establish a setting with measurable differences that were inconclusive to support the use of student or teacher data effects on the outcome.

An overall change in attitude on the significance of spatial skills, will allow adoption to new technologies, improve the process, and increase teacher attempts to try new methods and pedagogies. An improved disposition and paradigm shift to implement GIS into existing curriculum, by modeling and demonstration, will increase the value of spatial education. Improving future teachers personal capabilities, in a positive experience, can lead to successful teaching and learning conditions.

The Institution

"How They Implement"

With a focus of influential funding provided from the National Science Foundation, national efforts to focus on geospatial technology education and workforce

development has progressed significantly since 1988. Improvements include the development of core curriculum, the establishment of accreditation criteria, and continual focus and revision to develop competency models on program designs and workforce needs (Johnson, 2010). The institutional program review and implementation extends beyond the geoscience departments and into other areas, such as career, technical, and education departments for designing pre-service teacher programs. From the pre-service teacher training, elementary and middle school science programs, high school geospatial pathways, and the community colleges, all are tasked in building a 21st century workforce with spatial abilities.

A study in the Spanish universities reflected on what geography should be taught, how geography should be taught and why geography should be taught. Large amounts of research have focused on why geography matters, where as higher education should focus on the usefulness of geography (de Miguel González, 2016). The Spanish study confirmed that certification and degree programs must focus on specialization and more applied connected career opportunities. GIS and spatial analysis on environmental and social problems must be a focus of student projects. The community college must develop the student's skills and competencies to analyze and provide solutions to current problems. The Spanish study found of all professional profiles, ranging from urban planning, environment, GIS, or local development, the area of geographical information technology systems was the only profile field with consistent growth and the fastest growth perspective in the upcoming years.

There is a growing interest in the geosciences among community college students, particularly in states with strong geoscience industries, and they tend to encourage students to transfer to four-year institutions to complete their geoscience education. Therefore, the community college student population is an ideal target for recruitment of geoscience majors for the four-year institutions (Wilson, Status Geoscience Workforce, 2016) . With a spotlight on community college students, one primary question still remains for the educational institutions to address. Where will GIS fit in academic programs? This question becomes even more challenging at the community colleges whom have smaller student enrollments, smaller facilities, less full-

time faculty and limited budgets. Research by Karen Kemp, Professor of the Practice of Spatial Sciences, found the greatest student outcomes came from GIS as a spatial analysis device within the educational programs of a full Geography department (Kemp, 2016). Conversely, shown Figure 4, we see the harsh reality from the Geo Tech Center research findings in 2015, that a mere 17 percent have this academically rewarding environment for GIS existence.

Departmental Location of GIS Courses in 2015

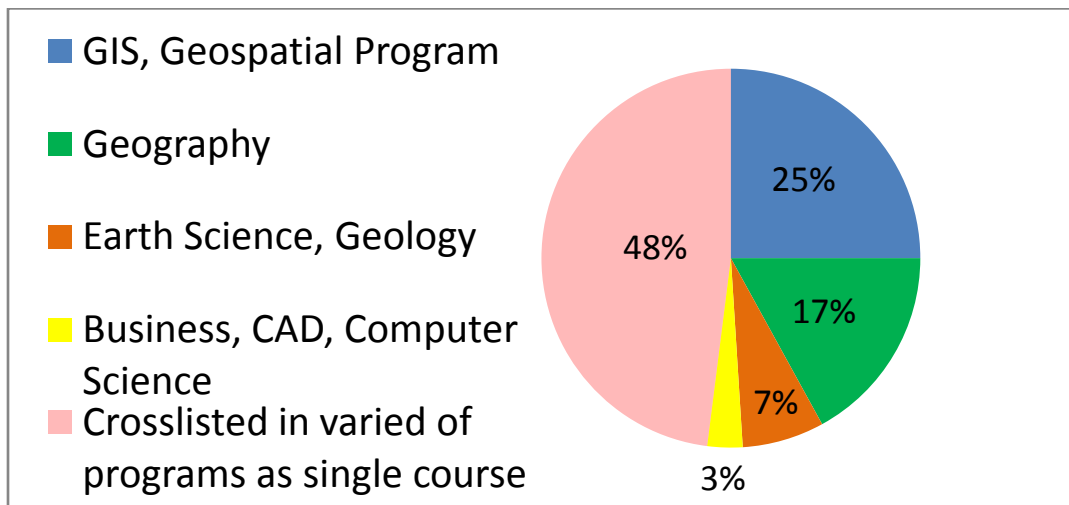


Figure 4 Where will GIS fit in academic programs (Geo Tech Center, 2015)

Spatial thinking is a methodical shift towards practical approaches in applied geography. Geography in higher education is in a current process of conceptual and instrumental reconstruction. A focus to discover the requirements of the community employer, and observe if the community college is meeting the competency demands with relevant educational program delivery is presently the current direction of thought.

The Employers

"Who They Hire"

For centuries paper maps and primitive use of data collection processes have been successful. But with the improved technologies over the last few decades, we have seen data collection and spatial mapping become more efficient and effective with the use of computerize geographic information systems. Commercial businesses,

academic, governments and militaries have all become more reliant on information and location characteristics of resources and individuals. GIS and many other spatial technologies are becoming more widely used by all stakeholders in our communities. The demand for improved technologies has increased with a wider diversity of GIS applications and improved data collection methods. With this increase in technology, there has been an equal increase in the field concerned with the development and use of these technologies. In a study by the American Association of Geographers, the geospatial revolution can be separated into three domains. Geographic Information Science, Geospatial Technology, and Applications of GIS&T (American Association of Geographers, 2016). Domain one, Geographic Information Science, is a multidisciplinary research entity that applies spatial information and technologies to basic scientific questions. Domain two, Geospatial Technology, is a focused and specialized set of technologies to handle information and geo-referenced data for manipulation, analysis and display output. Domain three, Applications of GIS&T, covers the increasing diverse application of geospatial technology in industry, government and education. Examples are numerous, but include real-time analysis of electrical grids, military intelligence, facilities, environmental assessment, land ownership and traffic flows. As represented in the Figure 5, all three domains interact in a two-way system, yet have multiple relationships with diversified fields. As this concept demonstrates, there will be a challenge in academia to supply individuals educated and trained in the multi faceted requirements of spatial applications. As we stated previously, the students are the most crucial variable. However, the employer yields the demand for the educational supply of students. Community colleges must focus on what attributes, within which domains, will successively fulfill the demand in the local community, higher academia at the universities, and final hiring agencies.

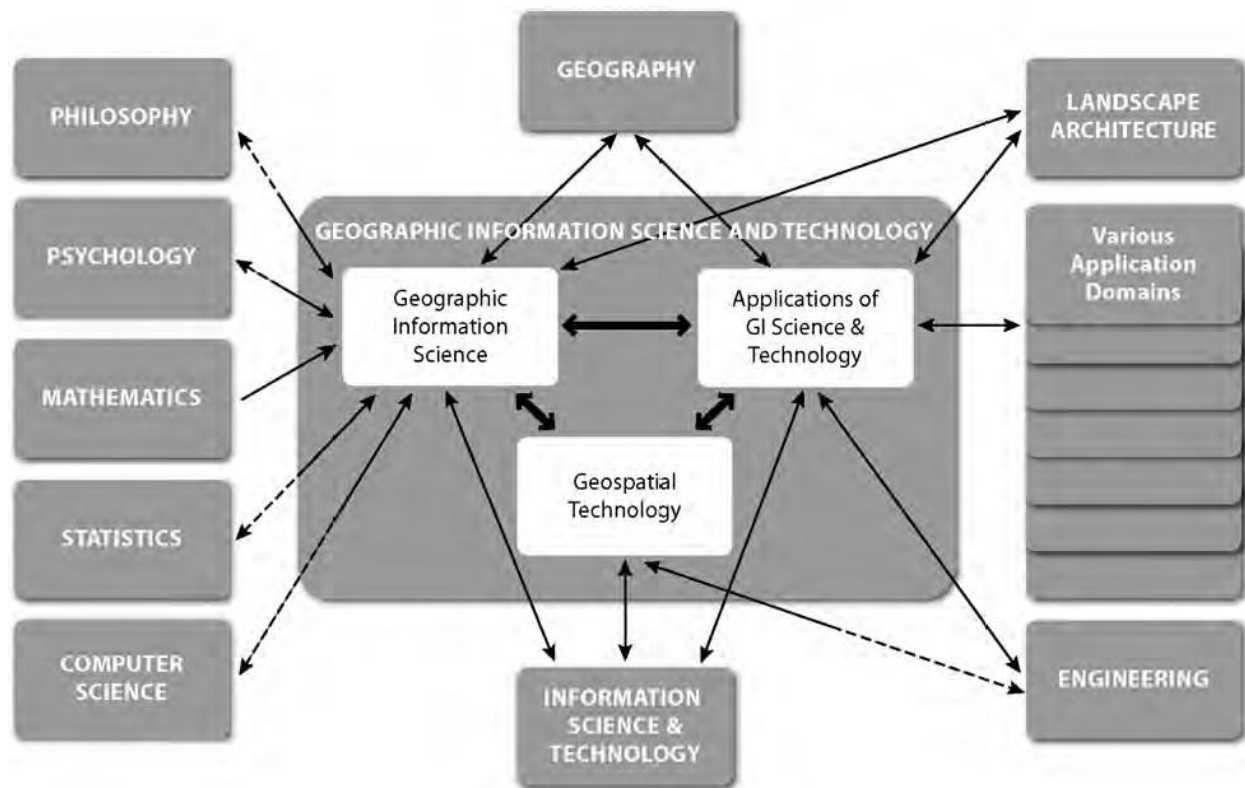


Figure 5 Various application domains (American Association of Geographers, 2006)

The three sub-domains comprising the GIS&T domain, in relation to allied fields. Two-way relations that are half-dashed represent asymmetrical contributions between allied fields. The number and variety of fields that apply geospatial technologies is suggested by the stack of "various application domains."

Methodology

A conceptual framework was utilizing by the Leibnizian approach by following two ideas, the concept of relationships within regions, and the ideology of the analysis of the complex. The Leibnizian philosophy is comparable to the concepts of spatial science methods applied with GIS tools. Leibnizian review of the complex is by the assessment of the composition of the many elements of the complex subject, down to their simplest form, referenced as monads (Kulstad & Carlin, 1997). The basic foundation of GIS is the representation of spatial data in their simplest level of attributes, very similar to the Leibnizian monad concept. GIS potential, as a device, is in displaying layered

relationships and running spatial analysis on attributes in selected fields; therefore explaining the complex from the simplest form, the subject's spatial attributes.

The concept of relationships within regions, merges with the idea of the connections between the professional GIS career fields and the educational institutions. How are they different and how are they interconnected? Educational institutes must take note of the demand of the career field, create measurable goals, then develop the methods of instruction to obtain the required skills towards comprehension of the proposed goals. GIS career fields are the origin of demand, and end product of the supply of the educational institutions. They are the driving force for scientific advancements in education. Therefore, education is the process of understanding, while GIS, as a tool, is the learning instrument of application.

In addition to the Leibnizian philosophy, GIS education epistemology can be evaluated in both the realism and humanistic standpoints. The realism approach in social science, as a science without concepts, is completely blind. The critical realist view, as stated by Andrew Sayer, "...must acknowledge that the world can only be known under particular descriptions, in terms of available discourses, though it does not follow from this that no description or explanation is better than any other" (Sayer, 2004). Geospatial education must take into account the varied standpoints of realism in this context of present scientific truth and accurate causation.

The humanistic approach, the need of empathic understanding of human experiences, is mute without the physical environment. The lack of characteristic and crucial questions of human meaning, is often lacking in the positivism perspective when only focusing on the fundamentals of the materialistic physical world (Spence & Owens, 2011). A detached and neutral view with a logical way of thought, of order, external reality, reliability and generality are required in the research of possible impacts, or lack of impacts, from GIS educational programs. Positivism is an appropriate methodology for the world of physical geography, however, it can be seen as inappropriate for a human geographer. It can lack sensitivity to the particular meaning of people and place, and therefore require an employment of qualitative methods.

GIS education calls upon the subfield of geography entitled, spatial analysis. Spatial analysis is using quantitative methods to process spatial data for the purpose of making calculations, models, and inferences about space, spatial patterns, and spatial relationships (American Association of Geographers, 2016). This study will employ a qualitative case study approach on institutions, and the impacts on instructors and students from spatial analysis. Spatial analysis, as an academic discipline, is underserved and absent in many K-12 and community college science programs (Wilson, 2016). As stated in Northern Arizona University educational outreach programs, the objective in geospatial programs should not be to create an experimental science in search of laws, but to focus more on meaning through interpretation of the methods employed. A call for case studies, that will evaluate the variety of more qualitative methods employed, such as discourse analysis, semiotics, interviewing and ethnography to provide measurable outcomes will be desirable (Rubino-Hare, 2016). A common view that much of geography is 'science' and that being a science means that specific objectives and method have to be adhered to, although variations in approaches are significant. Science does not tell us everything we want to know, it does not tell us what is relevant or of practical value. The implications for more qualitative methods (as opposed to quantitative), will become apparent with each case study reviewed. Realism, according to Andrew Sayer professor of social theory, is the approach between pessimistic views identifying no one interpretation is better than any other, and positivistic views can be missing the point to be questioned (Spence, 2011). Each case study must carefully judge the situation and stay to the objective, avoiding bias viewpoints and promoting a realist view.

The unit of analysis for the practicum project will be the community college, community employers, instructors and student outcomes. The goal will be to develop student populations to have the competencies required of the geospatial community workforce. Followed by the creation of entry level courses and curriculum to meet this demand. The basic order of operation is as follows:

1. Body of knowledge (Academic foundation and the domain of GIS)
2. Skills Competency Model (Geospatial Competency Model/Department of Labor Model)
3. Job analysis (Fielding of experts)
4. Apply Methodology (DACUM "Developing a Curriculum", from list to curriculum)
5. Validation (Community College educational delivery assessment)
6. Alignment (Curriculum to established State and National standards)

The academic enterprise is continually evolving to match students' acquired skills with workforce demand (Houlton, 2015). We must understand the power of GIS education lies not in the technology itself, but in its potential to foster a change and introduction of spatial thinking. Therefore allowing the scientific practice to continue with the advances of technology and student skills in 21st century.

Developing a Geospatial Program

As observed in the Arizona Western College programs, geospatial studies existed in limited quantities, as one single course within the physical sciences. Occasionally, taken from many campus interviews with faculty, varied instructors would engage single course assignments, utilizing the tools and skills of geographic information. Absent was the degree or certification programs needed to fulfill job skills in the workplace. Many students obtained completed degrees and domain expertise above the state and national level, however many are lacking the skills and competencies to enter a geospatial field or position (Figures 6, 7 & 8).

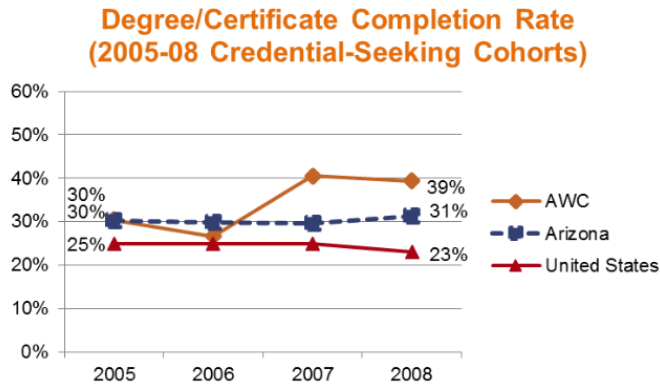


Figure 6 AWC Degree/Cert. Completion Rate (Arizona Western College, 2016)

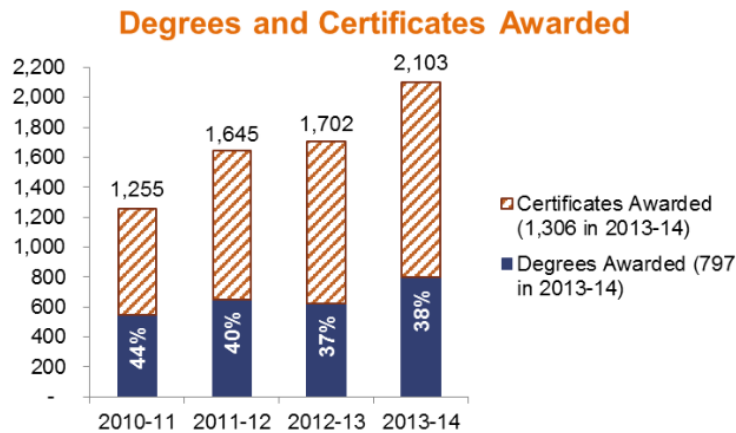


Figure 7 AWC Degree and Cert. Awarded (Arizona Western College, 2016)

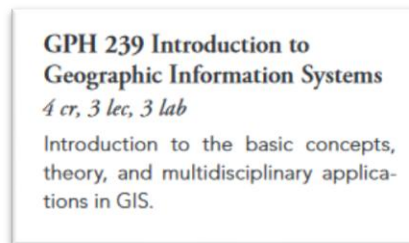


Figure 8 Single GIS Course at AWC (Arizona Western College, 2016)

As suggested by the GeoTechCenter in 2016, one of the simplest approaches to a successful program design is to begin with a visionary and an influential administrator. The two visionary individuals, who see the value of promoting improved geographical

technology with the assistance of a larger advisory committee support, can carry out the task of new program placement. In Arizona Western College's case, the practicum proposal was successful from the start. The proposal was initially formed first with a community GIS users group, then gained the two administrative visionaries with the foresight and funding resources to establish a new program. With community GIS professionals supporting the proposal design, and providing research showing the growth in the geospatial field, administration was quick to see the gains and potentials of the program. Both administrators had significant contributions to the design and direction for further growth and possible community growth impacts. Examples include the addition of remote-sensing using unmanned aerial systems, and the addition to embrace several career fields in existing college and university programs. Motivated by the initial administrative support, the original practicum proposal was modified to include the new college request for improved remote sensing programs, thus the additions of the unmanned aerial systems certification (UAS), found within geospatial technologies (See Appendices F, G and H).

To improve the needs assessment for the new proposed community college program, a sample population of teachers and students in a local area high school was initiated to measure geospatial knowledge and usage in the classroom. This student population is ideal, as they will be the future students for the pilot geospatial program set to open in Fall 2018. Concurrently, a sample population of GIS professionals were assessed to provide career and skills assessment for the current geospatial workplace environment. The responses of the GIS professionals would assist in the development of the new proposed program goals and curriculum.

Planning Phase

In the present age of digital information, geographic information systems (GIS), has become the mainstay and expected commonality for spatial data usage. As a national goal and awareness, The American Geosciences Organization has drafted a recommendation for the new governmental leadership to recognize geospatial

contributions. Supporting this directive is the informing the population that GIS consist of more than just computerized mapping, it is the power to link data to maps, allowing the user to create dynamic analysis and final visual displays. The use of complex map algebra to quarry and analyze data into visual components, exceeds far beyond any previous traditional spreadsheet formats. The geoscience community has gone to great lengths to demonstrate the significance to invest in the knowledge and technology towards education in Science, Technology, Engineering, and Math (STEM). STEM ties directly into the science of spatial assessment and the technology as a tool of research and delivery found in GIS. As shown in the selected passages below, the geosciences have projected growth, the need to develop educational programs directed towards spatial analysis, and the formation of revolutionary careers that will be competitive on a global scale.

Geoscience Policy Recommendations for the New Administration and the 115th Congress

Growing a dynamic workforce

1. Support strong federal investments in basic geoscience research to train and develop future geoscientists.
2. **Invest in a vibrant and dynamic STEM-focused workforce to increase our global competitiveness.**
3. Establish infrastructure to support robust aquaculture systems to create new jobs and business opportunities.

“The economic demand for geoscientists will continue to grow within the United States and worldwide, yet increasing numbers of U.S. geoscientists are reaching retirement age. AGI estimates a shortage of 135,000 geoscientists within the U.S. economy by 2022.²The nation’s schools, colleges, and universities must be ready to educate and train this next generation of geoscientists.” (American Geosciences Institute, n.d.)

Sustain and grow programs to educate a diverse group of students in science, technology, engineering, and math (STEM). Geoscience educators ensure that students across the U.S. at all levels have opportunities to learn about the Earth. They recruit, teach, and retain talented students and encourage them to pursue careers in geoscience and related STEM disciplines.

Source: www.americangeosciences.org

Significant questions for educational design to address:

- What dynamic approaches can be utilized to articulate improved educational training and outcomes in the geospatial sciences from K-12 educational system provided by the community college?
- What are the new challenges for students, faculty, and institutions, in considering the creation of non-traditional and online programs in geospatial sciences, focusing on the design criteria and institutional readiness?

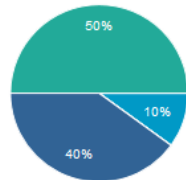
Analysis Stage

The Geographical Information Systems (GIS) and Unmanned Aerial Systems (UAS) informational survey was given to gain the thoughts and opinions of GIS professionals to develop a core curriculum (Figure 9). Instructional content was presented to better serve the government agencies, private industries and the greater community near Arizona Western College. The initial goal was to emphasize the foundation of GIS concepts for certificate, associate degree, university transfer, and extend geospatial sciences throughout Arizona Western College academic programs. However, the survey can provide a very detailed account of the career requirements necessary even prior to post-secondary education. Below you will find a summary of the survey results and selected statistics to support GIS education.

GIS Advisory Panel Survey Results

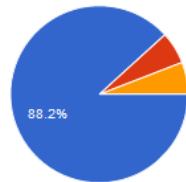
Employee dataset:

Current Job Title (Select from the drop down list "Choose"):



GIS Analyst	0	0%
GIS Technician	0	0%
GIS Data Specialist	0	0%
GIS Specialist	0	0%
GIS Mapping Technician	0	0%
Engineering Technician	1	10%
GIS Mapping Assistant	0	0%
GIS Application Specialist	0	0%
Engineering Aide	0	0%
Supervision or Management	4	40%
Training and Education	0	0%
Other	5	50%

Work Category?



Government (Public)	15	88.2%
Industry (Private)	1	5.9%
Education	1	5.9%

Figure 9 GIS Advisory Panel Survey - Job Title

The overarching responses presented "advanced GIS usage" as a significant priority in the field, with a 70 percent responding of "very high" in personal interest (Figure 10). Additionally, supported with 30 percent of respondents noting positive growth will be observed in advanced GIS. Unmanned aerial systems showed a lower rate of usage with 41 percent noting "not used in the workplace". Countered with 47 percent "high interest of usage in the field" (Figure 11). Overall, according to the respondents, we must continue with the focus of Advanced GIS, but address the need of a growing interest in unmanned aerial systems (UAS).

Personal interest in using advanced GIS?

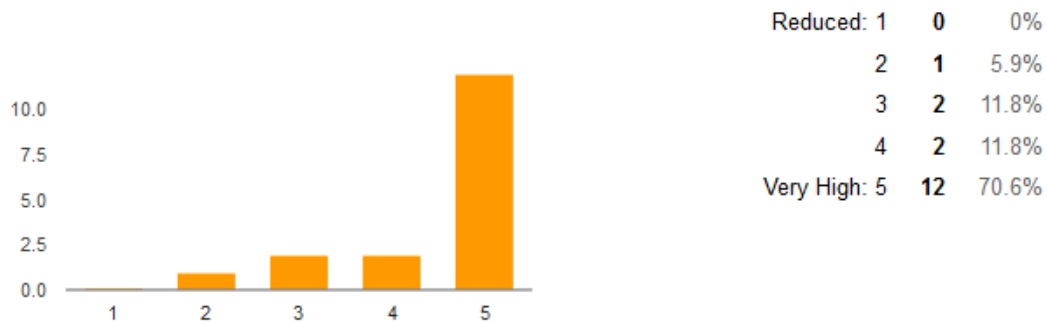


Figure 10 GIS Advisory Panel Survey - Personal Interest GIS

Personal interest in using advanced UAS?

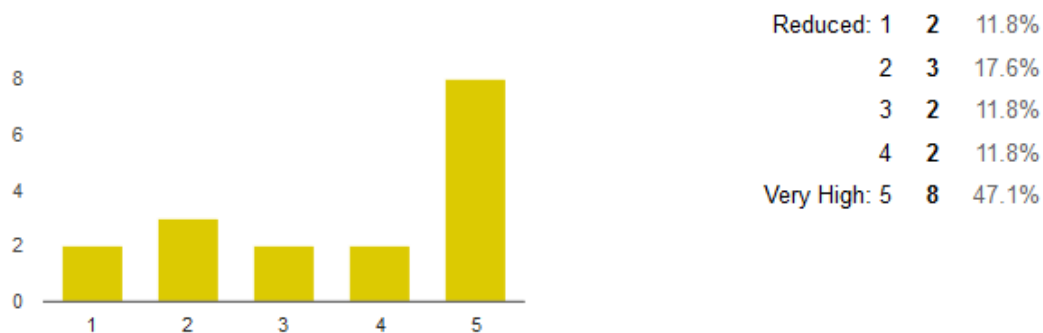
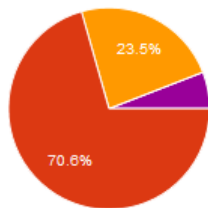


Figure 11 GIS Advisory Panel Survey - Personal Interest UAS

Agency dataset:

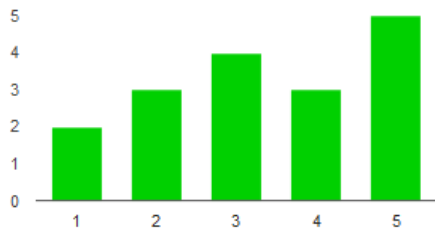
Many current positions, utilizing GIS, fall within governmental fields. Most agencies have current positions utilizing GIS with less than 10 individuals (Figure 12). Advanced GIS applications showed from respondents, less than five. Even with the low number of positions per agency, within the Yuma Geographic area, several agencies exist providing for opportunities of future employment. Professionals in the occupational field are reporting positive predictions. Nearly 58 percent of respondents provided "very high" expectations for future advanced GIS and unmanned aerial systems growth rates.

Number of current positions producing, creating, and designing with basic entry level GIS/UAS tools?



0	0	0%
1-5	12	70.6%
6-10	4	23.5%
11-15	0	0%
16+	1	5.9%

Growth projections of basic entry level GIS/UAS in agency?



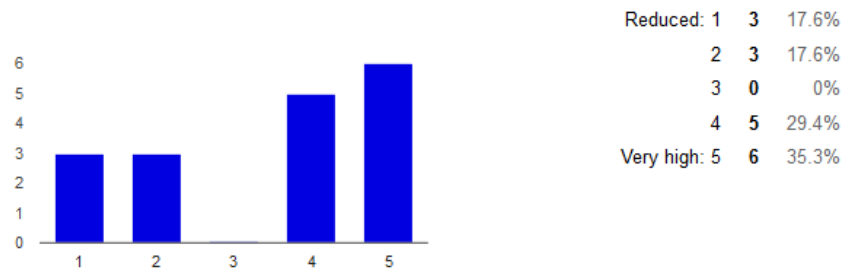
Reduced: 1	2	11.8%
2	3	17.6%
3	4	23.5%
4	3	17.6%
Very high: 5	5	29.4%

Figure 12 GIS Advisory Panel Survey - Positions & Growth

Program design:

The receiving of training for employees in spatial skills within GIS and UAS was highly supportive with 94 percent (Figure 13). A smaller rate of 77 percent respondents supported college credit and certification programs. A key factor, being addressed by multiple college departments, is the embedding of geospatial skills within their degree programs. This action will provide a greater impact on a larger student population, beyond only the smaller population of geography degree seeking students.

Growth projections of interpreting and managing from GIS/UAS output?



Program design: Interest in agency-wide staff receiving the following:

Employee training in spatial skill sets (GIS/UAS)?

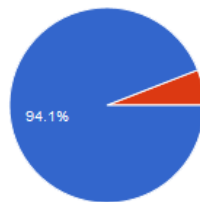


Figure 13 GIS Advisory Panel Survey - Program Design

Competencies training and educational outreach:

Utilizing the geospatial technology competency model (GTCM), feedback was provided by the respondents with a 82 percent support of improving academic content in the sciences, geography, and computer skills (Figure 14).

Academic content (science, engineering, geographic, computer skills)

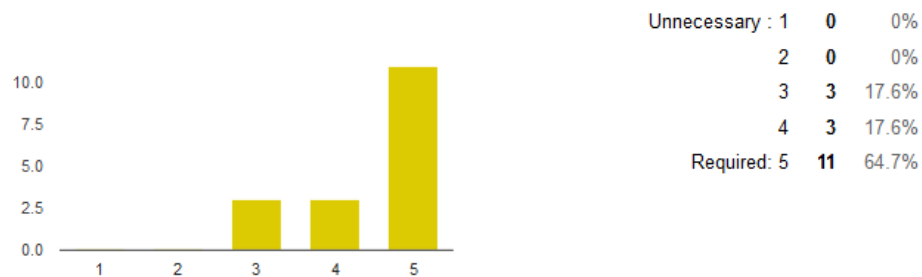


Figure 14 GIS Advisory Panel Survey - Academic Content

Additionally, an interesting secondary supported area of competencies (76 percent) fell within the "workplace problem solving and technology tools" of the model. A component of solving with technology tools can be addressed by the embedded GIS coursework within multiple curriculum areas of the community college. This newly designed coursework can address cartographic and visualization task, with problem-solving towards applied spatial analysis (Figure 15).

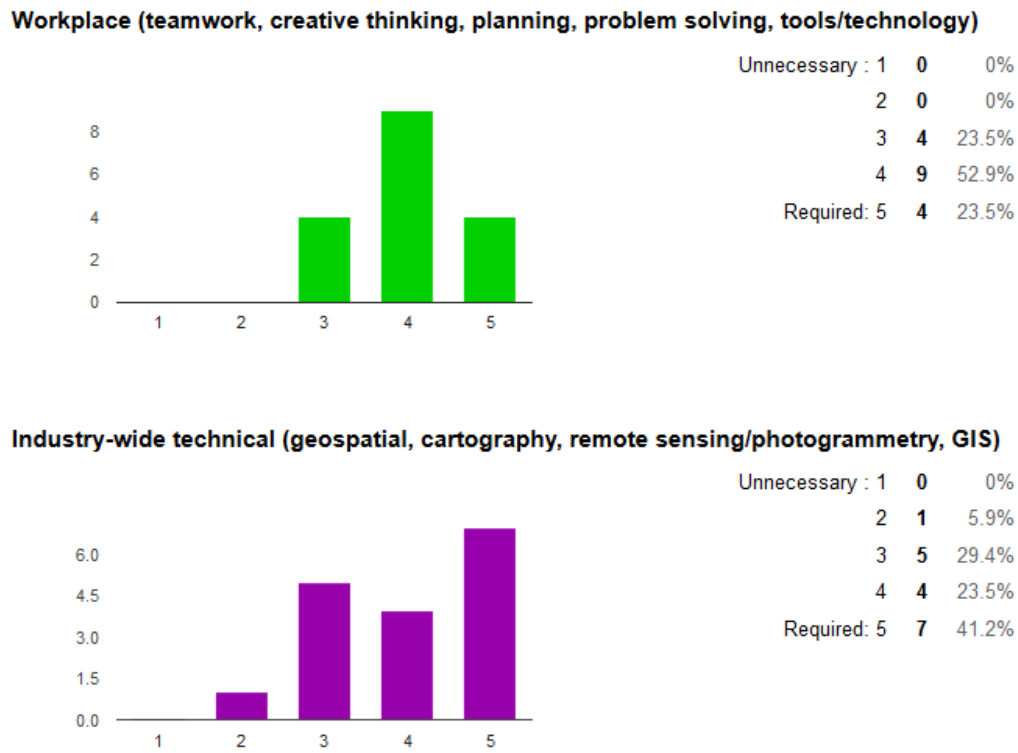


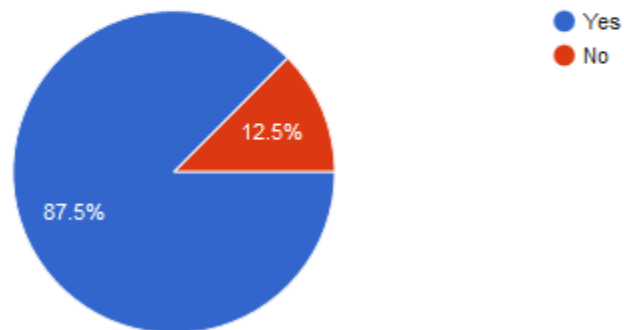
Figure 15 GIS Advisory Panel Survey - Workplace Competencies

With the need to have relevant field experience for the community college students 87 percent of respondents supported student survey experiences and internships, an excellent level of support by the professional in the community. A lower percentage of 73 and 65 percent supported capstone projects and the potential to serve as adjunct professors (Figure 16). With the adoption of an academic GIS/UAS program at the community college, select individuals within the professional community will not only be required, but essential for the successful outcome. The program must not only

foster future academic candidates, but promote the excellent, experienced, and knowledgeable professionals in the local community.

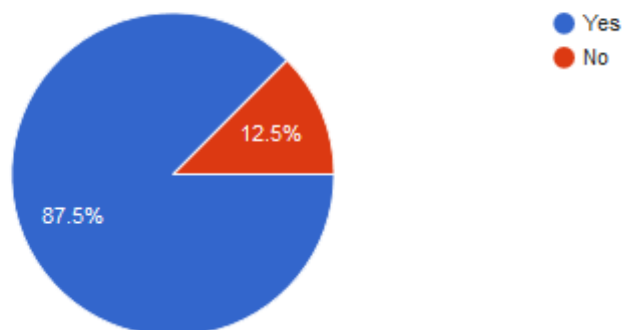
Interest in providing student survey experience on the job?

16 responses



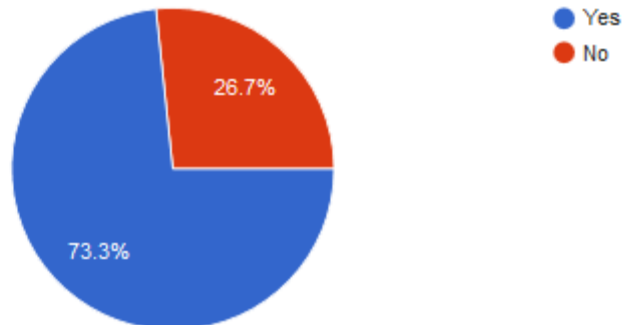
Interest in facilitating a student internship?

16 responses



Interest in hosting a student capstone project?

15 responses



Interest in becoming an adjunct professor for geospatial studies in higher educational courses?

17 responses

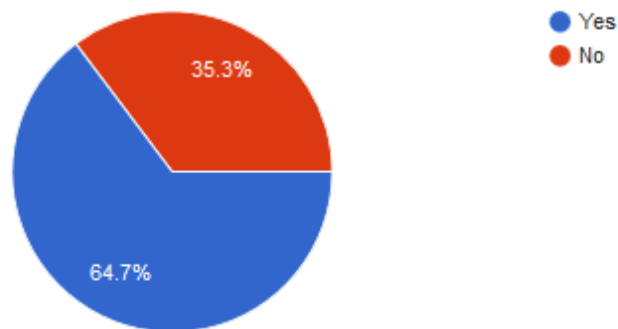


Figure 16 Advisory Panel Survey - Provide Field Experiences

GIS Educator Survey Results

In the forefront of determining educational needs, within the realm of GIS applications, one must determine the needs of the educator and the curriculum for which they teach. Several personal surveys were conducted with a variety of teachers within several disciplines. Two high schools science and social studies teachers self-reported the frequency of use, given a range scale from "never" (1) to "always" (5) for each question series. A majority of teachers stated the need for instructional training

with the use of GIS tools. Most importantly the need to assist in the introduction and location of data as a reliable source, and implementing the process for student's ability to enter data based on their research or fieldwork. Beyond the teacher and student skill set required, review and analysis of hardware availability and access must take place. The typical classrooms, including science classrooms, have limited computer access within their labs. The use of handheld devices and the availability of cloud-based online software would be essential. Teachers reported over 93 percentage to the response "never use GIS to acquire, manage, analyze or display spatial data". After the question prompts had been seen by the teachers, feedback was similar with the requested for training on how to employ GIS applications in the classroom. The teacher survey results, from several questions related to spatial skills and GIS applications, are available in complete form, with results in Appendix A.

Geo Spatial Technology Curriculum K-12 (GST)

Assess teacher's level of GIS understanding and needs of use, along with students interest and abilities in a K-12 environment.

Task verification (Feb 2017)

With a focus on introducing the fundamental concepts of GIS and technology skills in the spatial parameters, a goal was established to introduce, not only GIS, but cartography and spatial analysis. Exploration of how geospatial technologies are used in addressing human and environmental issues was the thematic content delivery.

Standards alignment (Feb 2017)

With a variety of academic areas to address for standard alignment, I elected to utilize the geographic information science and technology's body of knowledge to establish a foundation of competencies towards standards. The following are the five

areas to be addressed utilized within the standards: analytical methods, conceptual foundations, cartography and visualization, design aspects, and data modeling.

Overview



Teacher Training Workshops (Image source: esri.com)

In five lessons, teachers will be learning how to make maps in ArcGIS Online. They will get acquainted with volcanoes and geology spatial data as they explore a map, make their own map, and work with its symbols and pop-ups. They will turn table data from a CSV file into spatial information, and package a web map as a professional-looking app.

Statement and Purpose of Study

Goal: Introduction to the fundamental concepts of Geographic Information Science and Technology (GIS&T) including Geographic Information Systems (GIS), cartography, and spatial analysis. Exploration of how geospatial technologies are used in addressing human and environmental issues.

Design (Mar 2017)

Determine training approach

In the educational program there can be two arenas of concerns for determining the training approach, both for students and for the teacher educator in the classroom.

Concerns of access to technology, data, training, and curricular materials in conjunction with limitation of institutional support and professional goals incentives, as stated by the GIS&T body of knowledge, have been an ongoing issue facing the challenge of teacher development. We cannot expect to modify student development without first embracing teacher programs.

Develop learning objectives (Mar 2017)

Student Learning Outcomes for Teachers (SLO's):

1. The student will describe the fundamental concepts and applications of Geographic Information Science and Technology (GIS&T), including the problems and challenges of representing change over space and time.
2. The student will demonstrate the use of web mapping tools to study and develop possible solutions to real world problems.
3. The student will demonstrate basic proficiency in map reading, interpretation, and design principles, including map projections and the geographic grid.
4. The student will describe and demonstrate how to access different sources of data, describe the process of creating data, and discuss the fundamental concepts of data quality.
5. The student will identify, explain, and interpret spatial patterns and relationships.

Develop performance measures (Mar 2017)

Build skills in the following areas:

- Adding layers to a map
- Adding data stored as spreadsheet or file data to a map
- Changing map symbols
- Configuring pop-ups
- Sharing the map as a web app

What you need:

- Internet connection
- User, Publisher, or Administrator role in an ArcGIS organization
- Video " The Power of Maps.mp4"-ESRI
- Video "Geospatial Revolution Trailer" -Penn State
- Video " ArcGIS Online Overview"- ESRI

Reformed Teaching Observation Protocol (RTOP) training guide

An additional focus of GIS applications, modeled within the Reformed Teaching Observation Protocol RTOP training guide, were reflected upon to include the customizing and focus of section IV parts 10 & 11 (Table 4). The classroom observation tool found in part four "content" contains direct strategies in GIS use of real world data, to solve real world problems. By the use of display outputs derived from GIS models and tools, one can present data in a logical and commonly understood format.

Table 4 Reformed Teaching Observation Protocol (Piburn & Sawada, 2000)

Reformed Teaching Observation Protocol (RTOP).	
IV. CONTENT	
10) Connections with other content disciplines and/or real world phenomena were explored and valued.	
Connecting mathematical and scientific content across the disciplines and with real world applications tends to generalize it and make it more coherent. A physics lesson on electricity might connect with the role of electricity in biological systems, or with the wiring systems of a house. A mathematics lesson on	

proportionality might connect with the nature of light, and refer to the relationship between the height of an object and the length of its shadow

11) Students used a variety of means (models, drawings, graphs, symbols, concrete materials, manipulative, etc.) to represent phenomena.

Multiple forms of representation allow students to use a variety of mental processes to articulate their ideas, analyze information and to critique their ideas. A “variety” implies that at least two different means were used. Variety also occurs within a given means. For example, several different kinds of graphs could be used, not just one kind.

Develop training plan (Mar 2017)

Overall the training plan for education should be to establish tools that allow students and teachers to explore data, create, save, and share projects internally and external to other institutions.

Development (Mar 2017)

Competency and learning modules

A great depth of skill levels can be developed using GIS and ArcGIS online (resource: ESRI) to create modules for both students and teachers. Several areas include:

- maps as investigation of spatial situations
- collective and collaborative data management designs
- web applications to share content in a public forum
- analysis tools to solve spatial problems
- global collections within Living Atlas
- advanced 3D scene viewer

Develop lesson plans (Mar 2017)

A basic beginner approach was used with the first time GIS teachers. A need to build a foundation of understanding about taking data to spatial placement. With time to explore and discover, create and modify existing data, teachers will be provided a guide with step-by-step instructions to take a single layer of data, to a finished complex multiple dataset pop-up window web map.

Lesson Matrix

Title	Description	Time
Explore a map	Learn about volcanoes and lava flow risk on the island of Hawaii.	10 minutes
Create a map	Make your own map by adding layers to a basemap.	20 minutes
Add a layer from a CSV file	Turn a table of address information into spatial data in your web map.	20 minutes
Configure pop-ups	Configure pop-ups to make your map features informative.	20 minutes
Make an app	Present your map with a finished look and a nice user experience.	20 minutes

Screen shots showing the data set, map, and pop-up displays (resource ESRI):

	A	B	C	D	E	F	G	H
1	OBJECTID	NAME	ADDRESS	CITY	STATE	ZIP	PHONE	
2	1	Hilo High	556 Waian	Hilo	HI	96720	(808) 974-4021	
3	2	Holualoa	76-5957 M	Holualoa	HI	96725	(808) 322-4800	
4	3	Honaunau	83-5360 M	Captain C	HI	96704	(808) 328-2727	
5	4	Hookena	86-4355 M	Captain C	HI	96704	(808) 328-2710	
6	5	Kau High	96-3150 P	Pahala	HI	96777	(808) 313-4100	
7	6	Kaumana	1710 Kaun	Hilo	HI	96720	(808) 974-4190	
8	7	Kohala Ele	54-3609 A	Kapaau	HI	96755	(808) 889-7100	

Figure 17 Screen shot showing the Data Set (ESRI, 2016)

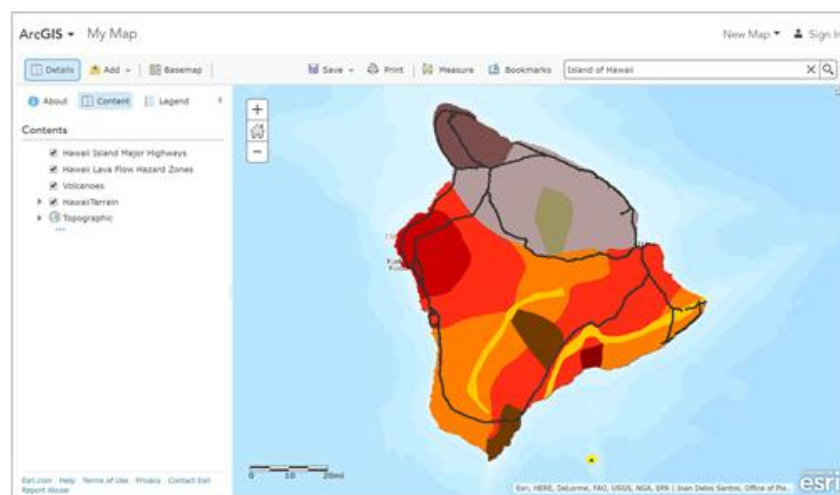


Figure 18 Screen shot showing the Map Interface (ESRI, 2016)

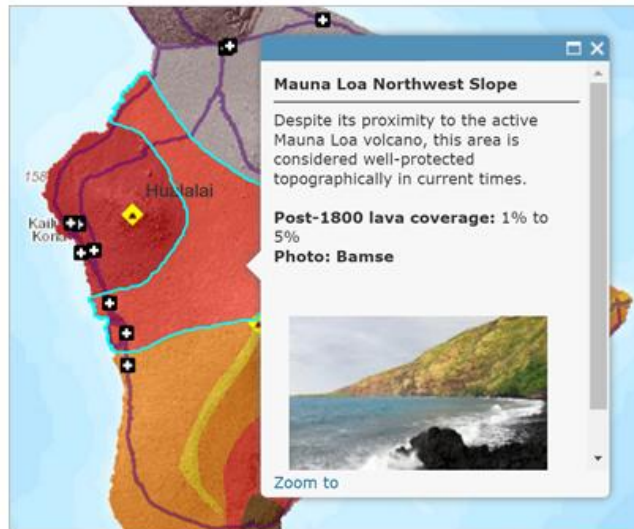


Figure 19 Screen shot showing the Pop-up Window (ESRI, 2016)

Final step:

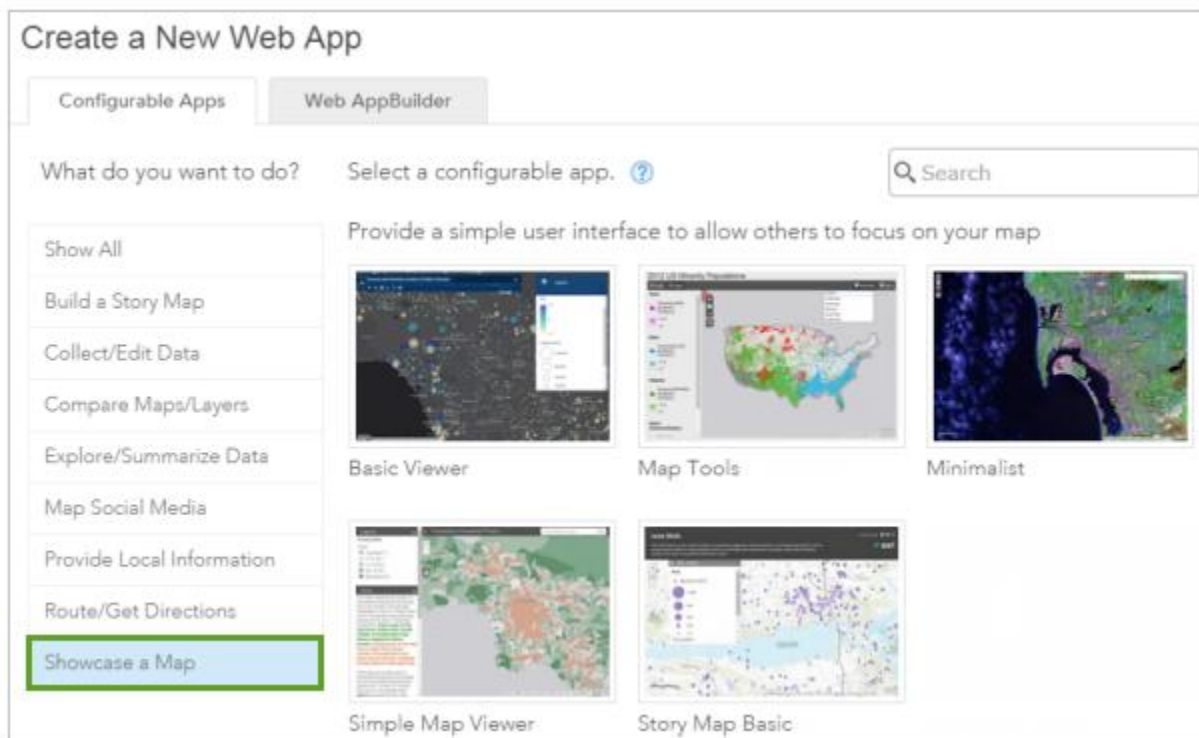


Figure 20 Screen shot showing the Web App. (ESRI, 2016)

GIS use in the classroom:

In application of previously stated GIS lesson plan design, two teachers educating twelfth grade students, used the approach for a focused water resource study within an economic course. With supporting articles from public and private sources, websites, and the Aral Sea case study, 300+ students were tasked to research, evaluate and present water resource concerns of the Lower Colorado River. Below is the lesson plan along with student and teacher feedback.

Explore the impact of human activities on water resources.

Focus on Lower Colorado River

Statement and Purpose of Study

Goal: Introduction to the fundamentals of Geospatial Technology, including Geographic Information Systems (GIS), cartography, and spatial analysis through a series of hands-on computer-based exercises. Participants will learn how to utilize geospatial technology to address social and environmental issues. This course is designed to complement other disciplines or as an entry into geospatial thinking.

Science Standards:

APES: I. C. Global water resources and Use

APES: II. E. Natural Biogeochemical Cycles: water cycle

NGSS: HS-ESS3. Earth and Human Impacts

Student Learning Outcomes (SLOs):

1. The student will describe the fundamental concepts of Geographic Information Science and Technology.

2. The student will demonstrate proficiency in the basic functions of geospatial software and hardware.
3. The student will demonstrate awareness of fundamental spatial analysis techniques.
4. The student will demonstrate basic proficiency in map creation and design principles.
5. The student will demonstrate proficiency in the creation and acquisition of spatial data.
6. The student will demonstrate how to access different sources of data, demonstrate the process of creating data, and discuss the fundamental concepts of data quality.

Student Resources:

Article: Shrinking Colorado River is a growing concern for Yuma farmers. -LA Times

Research Brief: AZ Senate State Brief on Water Supplies - AZ Senate

Website: Colorado River Management. -AZ Dept. of Water Resources

Current water levels (Charts, maps and graphs)

Website: Yuma County Water Users Association

Interactive Website: Drought in the lower Colorado River basin_

Map of water allocations (found at end of interactive website)

ArcGIS data observations of Colorado River Basin (Link to ArcGIS):

Watershed. waterway flow rates, canals, dams, precipitation, population urban growth, water usage rates, vegetation, and reservoir and lake levels.

Evaluate: What are some similarities and differences between the effects of human alterations on the Colorado River and the Aral Sea?

Application of learning (Project):

Explore consequences of human actions on water resources.

Examine the health impacts of availability to clean water.

Examine how has human alteration affected the Colorado River?

"Using GIS as a decision-making tool is a smart way of gathering all the things you already know and placing them in a single spot so you can see the entire picture." -Tom McCaffrey, GIS coordinator, University of Calgary

ArcGIS: Create an online student user account

Problem-based Model: What priorities are of concern for water scarcity, salinity, and security, when planning future water allocations and water rights? Produce a map showing patterns, or distributions, of significant data of interest, towards future sustainability of the Lower Colorado River Basin.

Submit the Map URL you have created to share.

Students demonstrated higher levels of classroom engagement and interest in their local community. An increase in the volume of questions with a higher level thinking order of evaluation and analysis of the local Yuma area water usage were observed over four days, within eight classrooms. Three groups of students made external efforts beyond the classroom to educate local community groups within their family members. Additionally, students had a vast improvements in ownership of their map deliverable, focusing on having meaningful content and possible human impacts of change. The greatest feedback provided by both students and teachers, is the comment

from Dan Olsen, a teacher in high school, that he and his students will continue to use GIS tools and assignments well into the future.

Develop supporting material and media (Apr 2017)

EDcommunity.ESRI.COM

Education community portal

Www.esri.com/schools

K – 12 education website

Www.esri.com/arclessons

Searchable lesson database

Pilot test and revise material (Apr 2017)

One does not need to look far, to see the connection and use of problem based learning (PBL) with GIS in the spatial sciences. Many institutions and online resource websites use PBL with case studies, from small local scale references, to wide global impacting databases. The need to bring together unrelated fields of study, to complete basic investigation, is a basis of PBL. However, a revision and adjustment to the approach style of PBL can be supported by Audet and Ludwig in their publication “GIS in Schools”. One must base all projects on carefully selected and complex problems and allow the modification of student teacher roles in the classroom. “Students become project planners, collaborators, producers, and decision makers” (Audet& Ludwig, 2003). The importance of the teacher in a PBL-GIS classroom transitions frequently in the concept of researcher, conceptual inquirer, coach and guide. In crafting the PBL scenario the teacher can address in two approaches, unstructured and structured. The unstructured design is the missing element in my present methodology. All previous

work, and tooling of this project, followed a basic structured approach, an approach that sets the student in more of an organized setting with far less autonomy. The unstructured approach is based on four stages:

1. Clarify topic
2. Identify problem(s)
3. Plan Inquiry
4. Investigate and report

Judging from quick observation towards the project experience at hand, one can plan on developing GIS learning beginning with a structured approach, and progress student learning environments to an unstructured approach building organization and analytical skills. Supporting this concept and approach, “real learning happens when students analyze their data and report results” (Audet & Ludwig, 2003).

Implementation (Apr 2017)

- Distribute introduction survey to all 9-12 grade teachers.
- Conduct standard task analysis of the interested participating teachers.
- Focus on two teacher population sets
 - social sciences
 - physical sciences
- Build problem based learning modules that are:
 - recent or current
 - of local community importance (or have local impacts)
 - relevant to the student (and of personal interest)

Sample case studies (source ESRI):

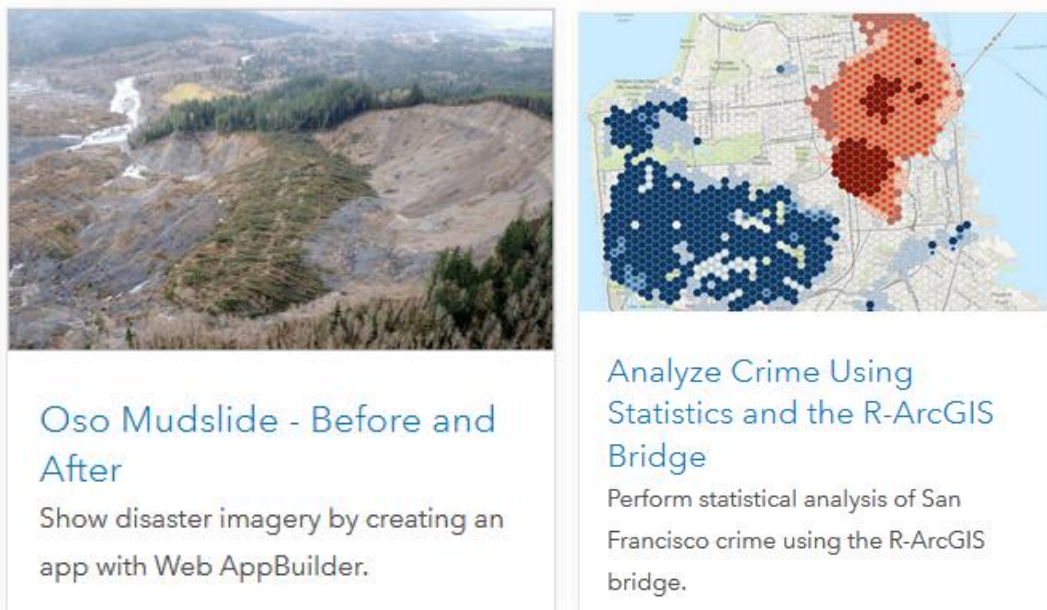


Figure 21 Sample Case Studies with GIS (ESRI, 2016)

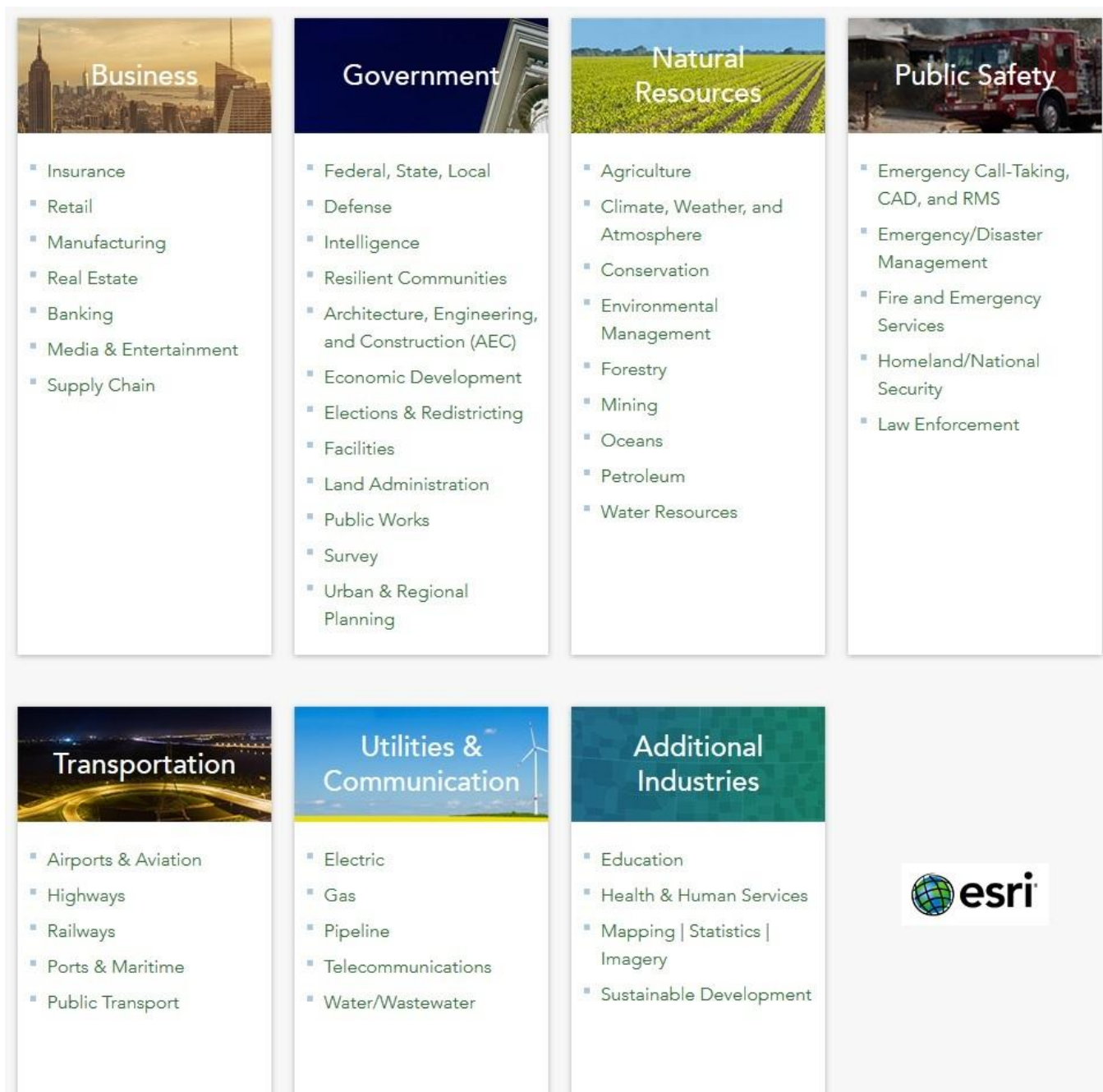


Figure 22 Career Fields Utilizing GIS (ESRI, 2016)

Teacher instruction and education must include the demonstration of the numerous career fields utilizing GIS (Figure 22). One must present the importance and relevance of data deliverables to a finished end product with significant impact for all stakeholders. The chart that follows, provides a graphical display of the ideas behind the countless applications that can be found in the employment of GIS tools.

ESRI provides additional online teacher courses for professional development and self-improvement. Course formats include instructor-led, web-based and seminars (Figure 23),. Many of the courses will lead to certifications and academic recognition. Sample courses and seminars shown here:

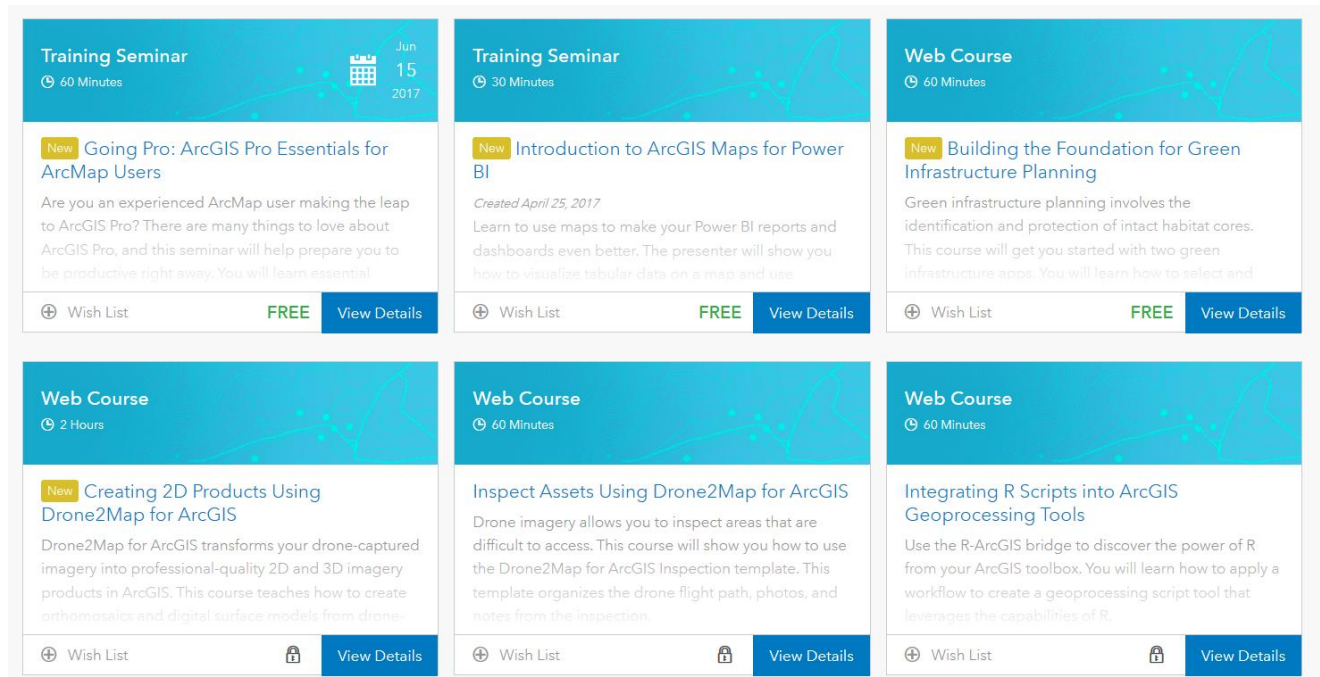


Figure 23 Online Teacher Courses (ESRI, 2016)

Evaluation stage (Apr 2017)

First initiative steps must be to prepare teachers and allow them time, training and skills to explore and become innovators within your own classrooms with the use of GIS in their curriculum. Second, to advance these innovators and their training in Geo spatial analysis and Geo statistical analysis. In other words, providing a broad range of powerful spatial and analysis tools that will provide the teacher and student a multitude of strategies to explore data, identification of anomalies, making predictions and valuation of said productions.

Outreach concept

A proposal for the Arizona Western College Geospatial Department is currently pending on departmental and faculty review. A primary concern for successful program design of curriculum is the outreach to early education to embrace the spatial learner at all academic levels in K-12. By building K-12 classroom learning experiences with college students and faculty, demonstrating the ease and increasing access to data and information, students will form a well-rounded community and global perspective. (see the green area of the following flow chart, Figure 24)

Level

Elementary (K-6)

Middle School (7-8)

High School (9-12)

Applications

Storymap, Arcmap, AZ Geo Bee

Storymap, Arcmap, AZ Geo Bee, ArcAnalysis

Storymap, Arcmap, ArcAnalysis, APHG, APGIST

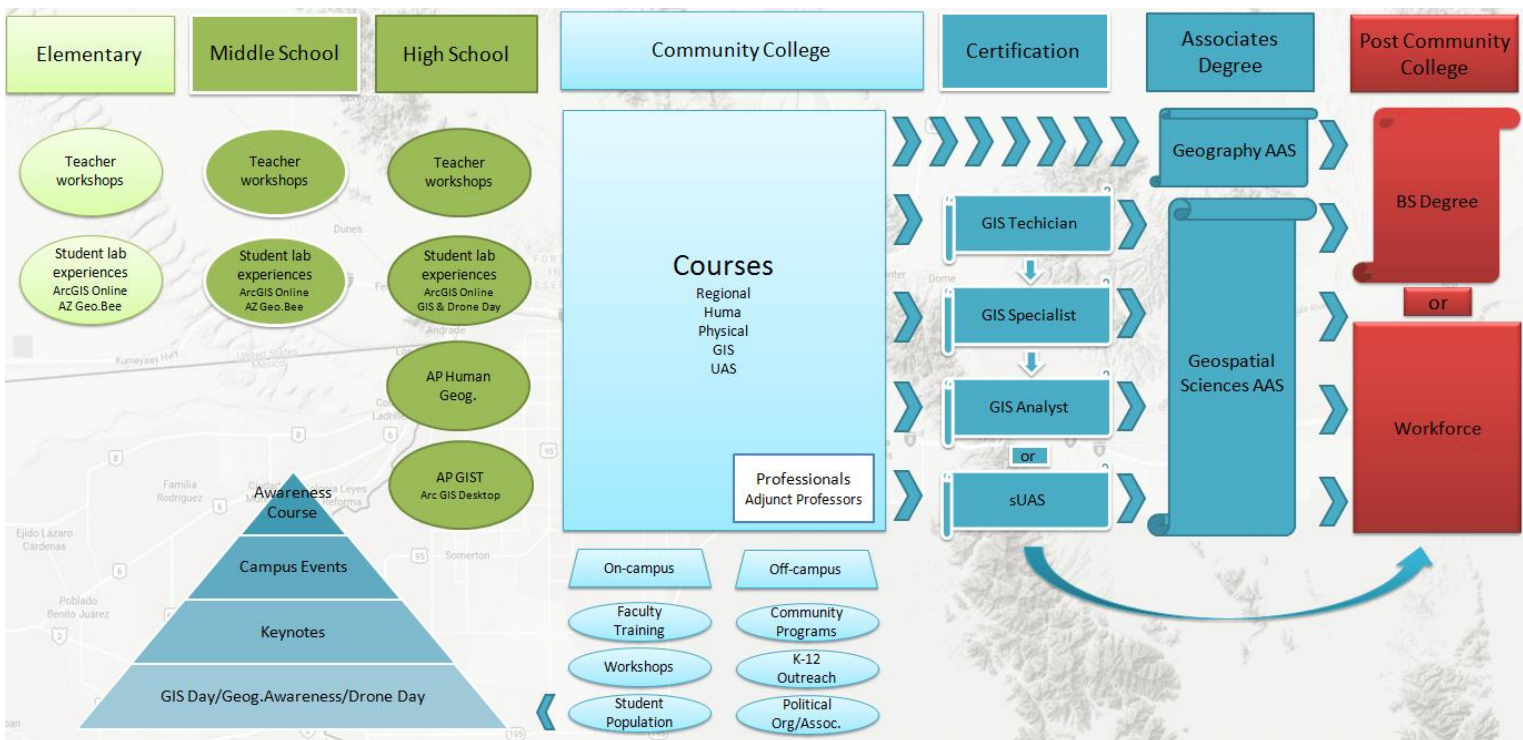


Figure 24 Proposal Outreach & Concept Map (Pinnt, 2017)

As we have seen from our initial assessment of the GIS professionals in the advisory committee, the need to foster technical skills and the application of spatial analysis, is of significant importance. To meet the demands of tomorrow's workforce a planned approach to embed spatial analysis, across the curriculum, must be addressed. In the early stages of program design, teacher feedback and evaluation showed limited GIS usage with very high interest in the process and knowledge required for spatial analysis. Teachers were very successful at understanding the concept of utilizing spatial data after completing the ESRI lesson experiences. Many focused on the question of: How do I use this tool in my subject area? Followed by the very important question: How do I derive and locate needed data? Most teachers were in need of procedural assistance, but once they discovered the methods, they were very successful at placing ideas and projection of future uses within their own content area. Looking back on the survey data from the teachers (Appendix A), one can observe very low levels of exposure and experience, by both the social science and physical science educators. After the learning experience for the educators, many began asking how can I find more information within my content? This brings to mind the importance of problem based learning to provide a structured approach in the beginning, thus setting the form and procedure for a successful GIS project. Realizing this key fact, after the project was presented, now requires new modification to include a well-planned workflow, as often utilized in GIS projects. Those familiar with problem-solving techniques, will see the similarities in addressing and analyzing problems, as used in a GIS structured approach.

GIS workflow

1. define the problem,
2. identify the deliverables required for support,
3. identify collect and examine the data needed to solve the problem,
4. document your work,
5. prepare your data,
6. create a location or base map,
7. perform geospatial analysis,

8. produce the deliverables, draw conclusions, and present your findings

By using this approach we are certain to provide solutions that develop educators and students, whom can produce results successfully and of value to be accepted by a broad audience. Therefore, preparing citizens who can proudly state:

"GIS in my community, my country, my world."

In regards to the need of implementation, please review the ideas of GIS K12 education and the online tools and learning experiences, as presented by the ESRI company - a leader in geospatial software development.

Why GIS for K12 teaching?

- Interactive maps, unlimited topics, global to local
- Usable in science, social studies, math, English/ language arts, technology, engineering, careers, health, service, outdoor/active learning, clubs
- Use for background content + skills
- Rich media – maps, tables, charts, images, video, text
- Representational environment (e.g. thematic map, pop-ups with characteristics, graphs, etc) helps users grasp patterns and relationships but also detail

Why ArcGIS Online for K12 teaching?

- Online = no installs = any connected device (computer, tablet, smartphone) anywhere
- Explore, analyze, modify, save, and share content built by others ("professional") or by oneself
- Ease of use = engagement

Source: ESRI.com

Educational and Community Outreach

To foster community connection between GIS professionals, educators and students, two GIS DAY's and one GEOSPATIAL DAY were conducted during the practicum time frame. Cibola High School (CHS) hosted the GIS Day's, with the largest presentation provided to nearly 50 classes and static displays across the campus during lunch hours (Figure 25). Over one thousand five hundred students were directly engaged in their understanding on how geographic information systems can be applied in a variety of situations, careers and the benefit society gains. Over two thousand five hundred students were shown the physical tool of operation for geospatial analysis during the lunch hour from over 20 private and government agencies. Additionally, an evening community event was hosted and completed by the High School Geography Club at the downtown shopping mall area. Providing videos and maps of GIS content, online samples of local government GIS web-based tools, a map with push-pins for visitors to place their origin, and educational games and prizes for the children on geographic knowledge. Below is the schedule of classroom presentations during GIS DAY.

Teacher	Room	502-XXXX	1st 7:30-8:24	2nd 8:30-9:30	3rd 9:36-10:30	4th 10:36-11:30	4th 11:06-12:00	5th 12:06-1:00	6th 1:36-2:30
Barrios	102 X 6019		Cam Enviro Sci Jonahan Ghoulson Natural Resource Specialist / GIS Manager MCAS A/S	Cam Enviro Sci: Jonahan Ghoulson Natural Resource Specialist / GIS Manager MCAS A/S	Cam Enviro Sci: Jonahan Ghoulson Natural Resource Specialist / GIS Manager MCAS A/S			Cam Enviro Sci: Terry Staggs, Cartographic Technician (GIS), BOR A/S	Cam Enviro Sci: Terry Staggs, Cartographic Technician (GIS), BOR A/S
Fritz, S	101 X 6018						Engineering: Jim Condit, Chief (Supervisory General Engineer) BOR		
Norton	506	5926	Digital Design:	Digital Technology Brian Brady	Digital Technology Brian Brady	Business Leadership: Owen Fulsone, Chief, Administrative Support Office, BOR			
Fontanes	504	5922			Digital Photo: Joe Oddi Technical Trainer Pictometry.com			Digital Photo: Joe Oddi Technical Trainer Pictometry.com	Digital Photo: Joe Oddi Technical Trainer Pictometry.com
Freytag	613	5967		Horticulture: Stacey Bealmear- Jones U of A 726-3904				App Bio Systems (Ag): Dr. Kurt Nolte U of A	
Moore	724	6005			Government: Felicia Frausto Human Resources Director for Yuma County 373-1171				
Stiger	206	5875					US History: Brandon Zimmerman BLM Anza trail/ history	US History: Brandon Zimmerman BLM Anza trail/ history	US History: Brandon Zimmerman BLM Anza trail/ history
McLean	207	5876	US History: Tina Clark, Historian, Archaeologist, Curator, Yuma Crossing National Heritage Area (928) 210-3328	US History: Tina Clark, Historian, Archaeologist, Curator, Yuma Crossing National Heritage Area (928) 210-3328	US History: Tina Clark, Historian, Archaeologist, Curator, Yuma Crossing National Heritage Area (928) 210-3328				
Groth	202	5871			Economics:		Economics:	Economics:	
Garcia	103	6020						Science Research: Jay Nemeth, Civil Engineer, Bureau of Reclamation, (928) 343-8137	
Davignon	735	5751	Biology: Nate Caswell/Vance Wolf Fish & Wildlife Service (928) 783- 3371	Biology: Nate Caswell/Vance Wolf Fish & Wildlife Service, (928) 783-3371	Biology: Nate Caswell/Vance Wolf Fish & Wildlife Service, (928) 783-3371		Biology: Nick Heatwole, Environmental Protection Specialist, Bureau of Reclamation, (928) 343- 8111		Biology: Nick Heatwole, Environmental Protection Specialist, Bureau of Reclamation, (928) 343-8111
Echols	100	6017	Biology: Tom Plicka- MCAS & Maria Guzman-City of Yuma	Biology: Tom Plicka-MCAS & Maria Guzman-City of Yuma	Biology: Tom Plicka-MCAS & Maria Guzman-City of Yuma		Biology : Betsy Bowman City of Yuma		Biology: Betsy Bowman City of Yuma
Guthrie	104	6021					Environmental Science: Daniel Cruz, GIS Manager Yuma County GIS/IT Department, (928) 817- 5151	Environmental Science: Daniel Cruz, GIS Manager, Yuma County GIS/IT Department, (928) 817- 5151	Environmental Science: Chris Bedinger Arizona Game & Fish Department 928-341-4045
Keller	104	6021	Environmental Science: Fred Croxen, Geologist, Bureau of Reclamation/AWC (928) 343-8281	Environmental Science Fred Croxen, Geologist, Bureau of Reclamation/AWC, (928) 343- 8281	Environmental Science Fred Croxen, Geologist, Bureau of Reclamation/AWC, (928) 343- 8281				
McClellan	105	6022	Biology: Espy Matlock & Richard Stamp City of Yuma	Biology: Espy Matlock & Richard Stamp City of Yuma	Biology: Espy Matlock & Richard Stamp City of Yuma		Biology: Jay Nemeth, Civil Engineer, Bureau of Reclamation, (928) 343- 8137		Biology: Jay Nemeth, Civil Engineer, Bureau of Reclamation, (928) 343-8137

Impact: 47 sessions @ 35 students = 1645

1645

Figure 25 GIS Day Schedule (Brady & Johanning, 2016)

Arizona Western College Geospatial Day

To gain connections with geoscience professionals and the higher educational community, a Geospatial Day was designed and created to be hosted at the local community college (Figure 26). Arizona Western College sponsored the facility requirements, staffing and provided food for all presenters during the post meeting luncheon. The post meeting doubled as the foundation of the advisory committee for the newly proposed Geospatial Programs at the community college. Students in attendance for the classroom presentations were of a wider age range than the prior held GIS DAY events. In attendance, a sixth grade honor science academy, a seventh and eighth grade science core (with ownership of seven unmanned aerial vehicles via a science grant), and the high school science research cadre whom are working on field projects requiring GIS additions. Below is the GST DAY information and schedule.



Goal of the AWC Geospatial Day?

Improve awareness of, and interest in, careers that utilize geospatial technologies.

What is GIS?

A geographic information system (GIS) lets us visualize, question, analyze, and interpret data to understand relationships, patterns, and trends.

What is UAS?

Remote Sensing & Imagery Analysis describes the knowledge necessary to generate products and/or presentations of any natural or man-made feature

through satellites, airborne platforms, unmanned aerial vehicles (UAS), terrestrially based sensors, or other similar means. Most recent trends and innovations have been established using UAS applications.

Labor Trends?

Rapid adoption of geospatial technologies (GST) by government and industry makes them among the top high growth industries identified by the U.S.

Department of Labor, accounting for approximately 27,600 new jobs by 2018, a faster than average job growth (<http://www.bls.gov/oco/ocos040.htm>).

When and Where?

November 2nd, 2017. AWC Main Campus, Science and Engineering Buildings.

Presenters for the student workshops included:

Marine Corps Air Station Yuma GIS Department, Bureau of Reclamation GIS Department, City of Yuma GIS Department, VMU-1 Squadron Marine Corps (UAV), Bureau of Reclamation Civil Engineering, University of Arizona - Yuma Center of Excellence for Desert Agriculture (YCEDA).

Arizona Western College

GEOSPATIAL DAY 2017

GUZMAN	AS-111	15	<p>PRESENTATION TITLE:</p> <p>DAISY GUZMAN, MCAS KEVIN LOBERG, MCAS</p>
JOHANNING	AS-103	30	<p>PRESENTATION TITLE:</p> <p>PRESENTATION TITLE: BUILDING A RECREATION GUIDE MAP USING GIS</p> <p>BRIDGET JOHANNING: MRS. JOHANNING IS A CARTOGRAPHIC TECHNICIAN WITH THE BUREAU OF RECLAMATION FOR THE PAST 5 YEARS. SHE IS A CURRENT CERTIFIED FAA PART 107 REMOTE PILOT WITH A SMALL UNMANNED AIRCRAFT SYSTEMS RATING.</p> <p>MRS. JOHANNING HAS 23 YEARS PRIOR TO BOR WITH THE BUREAU OF LAND MANAGEMENT AS A GIS/COMPUTER SPECIALIST. HER PASSION IS OUTREACH TO SPARK JUST ONE YOUTH INTO AN INNOVATIVE CAREER LIKE MAPPING AND DRONES.</p>
BRADY/ BRADY	AS-110	30	<p>PRESENTATION TITLE: APPLICATIONS OF GEOGRAPHIC INFORMATION SYSTEMS IN LOCAL GOVERNMENT.</p> <p>KENT BRADY GRADUATED FROM UTAH STATE UNIVERSITY WITH A BACHELOR'S DEGREE IN GEOGRAPHY IN 2004. SINCE THEN HE HAS WORKED IN THE PRIVATE SECTOR WITH ENVIRONMENTAL CONSULTING FIRMS, AND IN THE PUBLIC SECTOR AT THE STATE AND LOCAL LEVEL. HE HAS BEEN WITH THE CITY OF YUMA'S GIS DIVISION FOR THE PAST YEAR.</p> <p>BRIAN BRADY GRADUATED FROM FLORIDA EASTERN STATE COLLEGE WITH AN AS DEGREE IN GEOGRAPHIC INFORMATION SYSTEMS (GIS) IN THE MID 80'S AND TAUGHT INTRO AND ADVANCED GIS COURSES AT THE COLLEGE LEVEL AND HAS BUILT ENTERPRISE CLASS GEOSPATIAL SYSTEMS FOR NASA, THE MILITARY AND LOCAL GOVERNMENT FOR TWENTY-EIGHT YEARS. BRIAN IS ALSO A COUNCIL MEMBER OF THE ARIZONA GEOGRAPHIC INFORMATION COUNCIL AND CO-CHAIRS THE COUNCIL'S SMALL UNMANNED AERIAL SYSTEMS (sUAS) WORKGROUP AS WELL AS AN FAA LICENSED 107 PILOT.</p>
GIBSON/ PITTMAN	EB-130	25	<p>PRESENTATION TITLE: UAS IN SUPPORT OF DISASTER RELIEF</p> <p>THIS PRESENTATION WILL GIVE AN OVERVIEW OF WHAT UNMANNED AIRCRAFT CAN BE USED FOR HUMANITARIAN SCENARIOS.</p> <p>SERGEANT GIBSON CURRENTLY SERVES AS A FULL MOTION VIDEO ANALYST AT MARINE UNMANNED AERIAL VEHICLE UNIT 1 IN YUMA, ARIZONA. SERGEANT GIBSON'S PERSONAL DECORATIONS INCLUDE: NAVY AND MARINE CORPS ACHIEVEMENT MEDAL (1ST AWARD) AND THE GOOD CONDUCT MEDAL (2ND AWARD).</p> <p>SERGEANT PITTMAN CURRENTLY SERVES AS A FULL MOTION VIDEO ANALYST AT VMU-1 IN YUMA, ARIZONA. SERGEANT PITTMAN'S PERSONAL DECORATIONS INCLUDE: NAVY AND MARINE CORPS ACHIEVEMENT MEDAL AND GOOD CONDUCT MEDAL.</p>
NEMETH/ MILLER	EB-133	25	<p>PRESENTATION TITLE: 'GEOSPATIAL DATA USE AT THE BUREAU OF RECLAMATION'.</p> <p>THIS PRESENTATION WILL PROVIDE AN OVERVIEW OF HOW GEOSPATIAL DATA IS DEVELOPED AND USED, AS WELL AS HOW THAT INFORMATION IS UTILIZED IN APPLICATIONS THAT ARE FAMILIAR TO ALL. ADDITIONALLY, THE PRESENTATION WILL COVER HOW GEOSPATIAL INFORMATION IS USEFUL TO ENGINEERS. LASTLY, HOW GEOSPATIAL DATA IS USED AT THE BUREAU OF RECLAMATION WILL BE DISCUSSED; INCLUDING A REVIEW OF THE DIFFERENT CAREERS THAT RELY ON THIS INFORMATION.</p> <p>MR. NEMETH IS A CIVIL ENGINEER WITH THE BUREAU OF RECLAMATION, YUMA AREA OFFICE. HE HAS OVER TWENTY YEARS OF PROFESSIONAL EXPERIENCE IN WATER RESOURCES, HYDROLOGY, HYDRAULICS, AND CIVIL SITE DEVELOPMENT. AS AN ENGINEER, MR. NEMETH REGULARLY USES GEOSPATIAL DATA IN THE DESIGN AND ANALYSIS OF WATER RESOURCES CIVIL ENGINEERING PROJECTS.</p> <p>MR. JAN MILLER IS A PROFESSIONAL CIVIL ENGINEER WITH BACHELOR AND MASTER DEGREES IN WATER RESOURCES ENGINEERING WITH AN EMPHASIS IN HYDRAULICS. JAN MOVED HIS FAMILY HERE TO YUMA 2 1/2 YEARS AGO TO BEGIN WORKING WITH THE U.S. BUREAU OF RECLAMATION AND LOVES IT. JAN TYPICALLY USES GEOSPATIAL TOOLS LIKE ArcGIS AS A RESOURCE FOR IMAGERY AND ENGINEERING ANALYSIS.</p>
BEVINGTON	EB-132	25	<p>PRESENTATION TITLE: REMOTE PILOT OPERATIONS WITH UAS</p> <p>ROSA BEVINGTON IS A MEDIA SPECIALIST AND DRONE OPERATOR, YUMA CENTER OF DESERT EXCELLENCE FOR DESERT AGRICULTURE (YCEDA).</p>

Figure 26 Arizona Western College GeoSpatial Day (Croxen, 2017)

Higher Education GST Program and Curriculum Design

As stated earlier the Arizona Western College geospatial curriculum existed as a single course (Figure 8). The new direction of the program required the establishment of goals and objectives. Based on the previous discussed needs assessment, completed by geospatial professionals and educational feeder schools, Arizona Western College can fulfill the demand by establishing geospatial degrees and certifications. The need to foster cooperation and communication between departments, to improve Geospatial skills and link their existing programs for future growth, had become the primary goal. Several department presentations, and many faculty interviews, lead to presentations to explain the geospatial proposal and intentions for the college. The physical sciences, career and technology, and public safety departments all were provided the details of objectives and student learning outcomes developed by the advisory committee of GIS professionals for course and program design. Faculty members were provided details of geospatial technology, how it is useful and the many methods and ways of implementation. All departments provided positive feedback, echoing the significant advantage of technology skills, identifying direct applications within their content area, and the personal request on how they can be directly involved.

Many efforts were taken to include all departments and individuals (campus-wide) in the curriculum development. The geospatial program and course proposals were shared within many departments, allowing time for review and the opportunity to provide feedback. With the use of the previously discussed, Department of Labor (DOL) Geospatial Technology Competency Model (GTCM), curriculum was established to address industry requirements and then reviewed by the GIS advisory committee, prior to faculty revision.

After minor revisions and additions, the departments voted on the approval with nearly 100 percent passing rates. Entry and submission into the online curriculum platform Arizona Curriculum Review and Evaluation System (ACRES) was completed for the fourteen new courses, three new certifications, and one new degree. Once in the

system the campus curriculum committee reviewed, suggested modifications, and once adjusted, voted on approval. Presently the status is pending the Vice President of Learning Services approval, then presented to the President of the college. Presidential review is a requirement, as greater than fifty percent of the program consist of new courses. From that point, the program is presented to the Governing Board of the College for final approval prior to catalog entry and course public listings.

In the following pages, you will observe a graphic diagram of course content planned for each degree and certification. Additionally, you will see the goal and objective established for each program, along with course and credit requirements.

A.S. in Geography (Appendix B)

Additional resources utilized for the design of A.S Geography Degree: Arizona State University, Northern Arizona University, and University of Arizona.

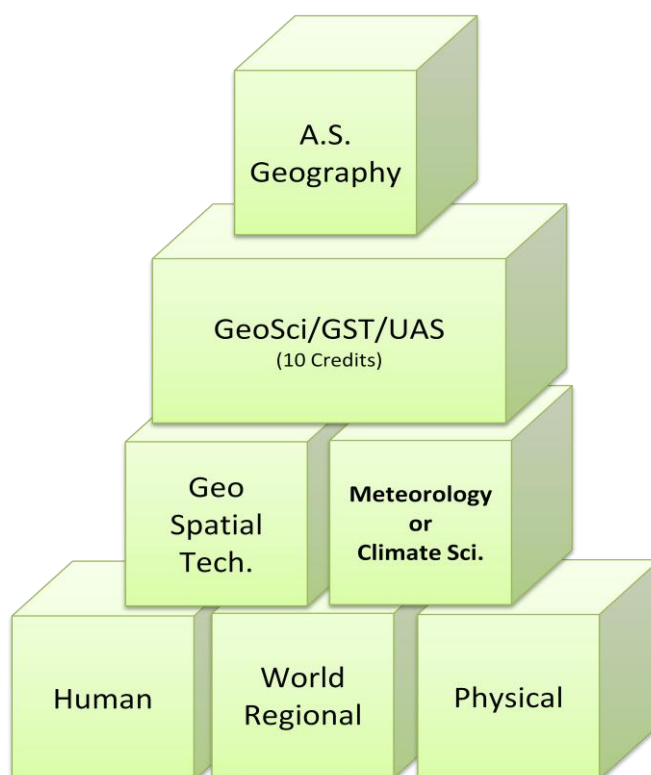


Figure 27 A.S. in Geography

Certifications in GeoSpatial Technologies (GST) (Appendix C)

Additional resources utilized for the design of Certificate in GST: Arizona State University, Big Bend Community College, Del Mar College, Mesa Community College, Penn. State University, Redlands University, Scottsdale Community College, South Western Community College, University of Maryland, University of California Los Angeles, United States Air Force Academy, University of South Carolina, Weber State University, and West Valley College.

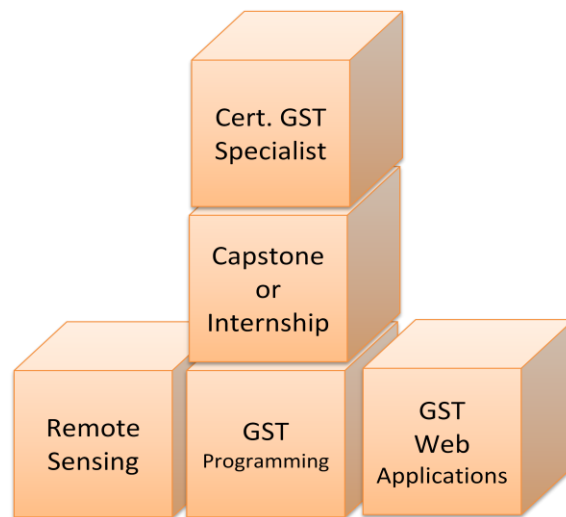


Figure 28 Certifications in GeoSpatial Technologies - Specialist

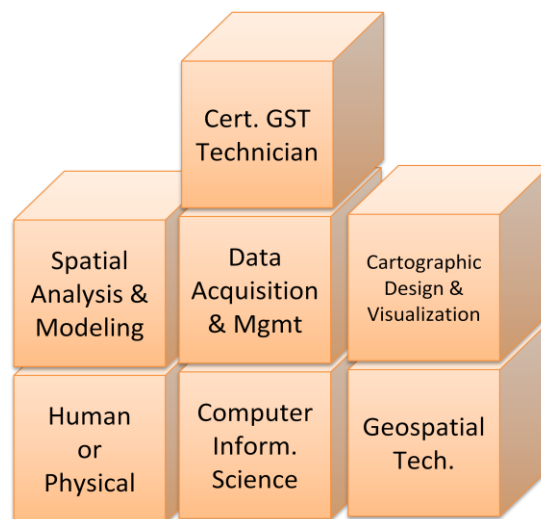


Figure 29 Certifications in GeoSpatial Technologies - Technician

Certifications in Unmanned Aerial Systems (UAS) (Appendix D)

Additional resources utilized for the design of Certificate in UAS: Arizona State University-PolyTech, Indiana State University, Kansas State University, Lorain County Community College, Nicholls State University, New Mexico State University, Ohio University, Oregon State University, Sinclair Community College, University of Florida, and University of Wyoming,

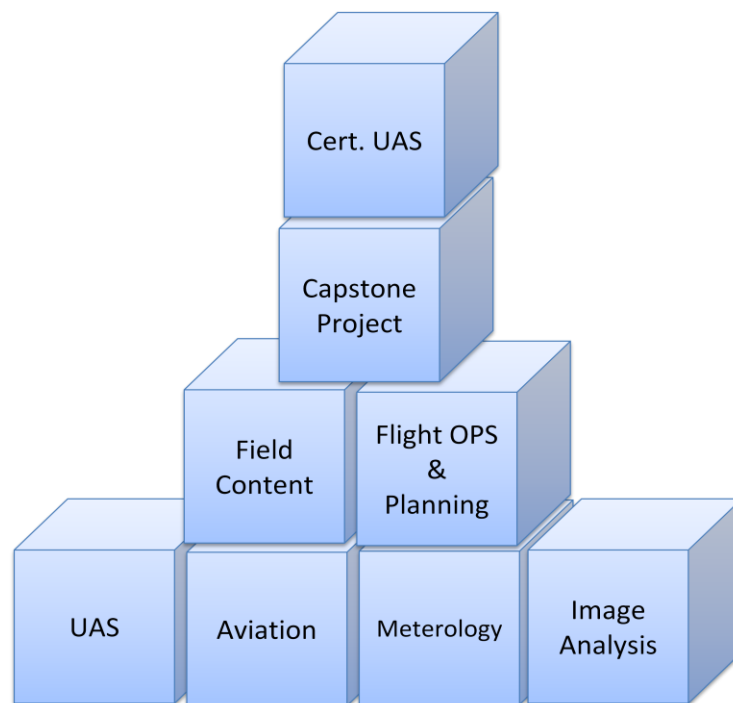


Figure 30 Certifications in Unmanned Aerial Systems

Geography Program

The curriculum is designed to produce graduates with a well-rounded general geography degree where students are exposed to the practice and experience of human and physical geography, within the contexts of space, place and process. The development of specialist, conceptual spatial analytical and fieldwork skills are central to the subject, as is the need to develop problem-oriented, inquiring minds. By providing a diversity of human and physical geography courses, students acquire a range of

cognitive, general and transferable skills which will contribute to their professional and personal skills and career development beyond Higher Education.

Required Core Courses: 13 units

Course	Units
GEO 102 Introduction Human Geography	3
GEO 105 World Regional Geography	3
GST 101 Introduction to Geospatial Technology	3
GPH 110 Introduction to Physical Geography	4
Other Department Required Courses (14 units)	
GPH 171 Introduction to Meteorology	4
<or>	
GPH 213 Introduction to Climate Science	4
Select additional courses from Geography, Geospatial Sciences, Physics, Chemistry, or Geology	10
General Education Requirements (37 Credits)	
Total Major Units	27
GE Units	37

Total Degree Units 64

Geo Spatial Technologies (GST) - Geographical Information Systems (GIS)

Earning the GIS Certificate requires completing 8 three unit courses in GIS and 2 courses in the related fields of Geography and Computer Science. All courses are to be in review as transferable credit at Arizona State Universities in 2018. (Appendix E)

Occupational Certificate - Applications in Geospatial Technologies

'Technician'

Required Core Courses: 15-16 units

Course	Units
GEO 102 Introduction Human Geography	3
<or>	
GPH 110 Introduction to Physical Geography	4
GST 101 Introduction to Geospatial Technology	3
GST 102 Spatial Analysis and Modeling	3
GST 103 Data Acquisition and Management	3
GST 104 Cartographic Design and Visualization	3

Other Department Required Courses (3 units)

CIS 120 Survey of Computer Information Systems	3
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Total Certificate Units 18-19

'Specialist'

Required Core Courses: 9 units

Course	Units
GST 105 Introduction to Remote Sensing	3
GST 106 Intro. to Programming for Geospatial Tech.	3
GST 107 Geospatial Web Applications and Development	3

Other Department Required Courses (3 units)

GST 108 Capstone in Geospatial Technology	1-2
<or>	
GST 109 Internship	1-3
Total Certificate Units	10-12

Schedule Concept:

Technician

<u>Fall 2018</u>	<u>Spring 2019</u>
CIS-120	GST-103
GEO-102 <or> GPH-110	GST-104
GST-101	
GST-102	

Specialist

<u>Fall 2018</u>	<u>Spring 2019</u>
GST-105	GST-108 <or> GST-109
GST-106	
GST-107	

Geo Spatial Technologies (GST) - Unmanned Aerial Systems (UAS)

Earning the UAS Certificate requires completing 4 three unit courses in Unmanned Aerial Systems and 3 courses in the related fields of Math, Geography and Geospatial Sciences. All courses are to be in review as transferable credit at Arizona State Universities in 2018. (Appendix F)

Required Core Courses: 12 units

Course	Units
UAS 100 Introduction to UAS	3
UAS 101 Aviation UAS Pilot Ground School	3

UAS 102 UAS Image Analysis and Visualization	3
UAS 103 UAS Flight Operations and Planning	3

Other Department Required Courses (9 units)

MAT 151 College Algebra	3
GPH 171 Introduction to Meteorology	4
GST 108 Capstone Project	2

Required Minor Courses - Select within one department (6-8 Units)

Total Degree Units **29-31**

Schedule Concept:

UAS

Fall 2018

UAS-100
UAS-101
MAT-151
GPH-171

Spring 2019

UAS-102
UAS-103
Elective Area Course
Elective Area Course
GST-108

Sustainability

There are several factors necessary to sustain a college program. Relevancy, funding, marketing, college and faculty buy in, community connection, student placement, departmental conflicts, and university articulation to name a few. The continual and frequent analysis of program and curriculum content is a mandatory requirement, if expected to meet the present and future industry needs. Use of the GeoSpatial Model from 2013, presented by the GeoTechCenter, was very

accommodating in initial setup. However, this design will be outdated in time. Improved course design can lead to increased student interest and student enrollment. Creating university and high school articulation connects leads to improved program design and student transferability. To improve college and faculty buy-in, make geospatial part of their course and increase the number of disciplines offering some form of spatial analysis. Improve certification programs with job placement skills as the top priority, thus, giving options to many students or working professionals looking to advance themselves. An additional improvement for sustainability was modeled by Northern Arizona University in 2017, as student projects and capstones utilizing geospatial technologies for college and administrative support and improvements. Examples included, 3-D visualization of campus buildings for facilities and management support, to the GIS online mobile device displays of the campus bus location and availability for student support and safety. All present a required and sustainable use in a positive and productive manner for all in the community to observe. To address student workforce placement, a plan of action must be established early in the program to survey and connect with outgoing students. Information must be reviewed to improve the quality of programs and build a stronger successful preparation for the workforce.

Conclusion

As originally set forth in the proposal of a geographic program creation at the community college, the goal has always remained to be a focus on introducing spatial thinking. Everything has a place, and every place has meaning. How we incorporate spatial thinking into the curriculum will continually change with advances in science and technology. It will continue to be a challenge to successfully build and implement geospatial programs. Arizona Western College has embraced the idea of a cross curriculum design to implement geospatial technologies. With improved course offerings within several existing programs, independent certifications, and providing student educational pathways into university programs, the Yuma area students will finally be provided geospatial career opportunities.

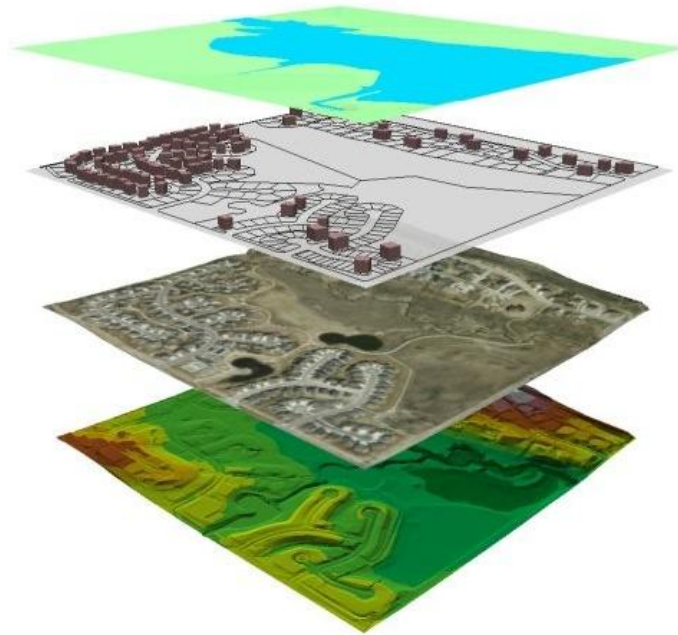
Future challenges, yet to be determined, include how the community workplace will be impacted by student completion, and how successful articulation of certification courses will directly equate into upper division university degree programs. Much will be possible, if we continue to adjust and adapt to the needs of the workforce, and strive for program and individual improvement.

Appendices

Appendix A - Geospatial Survey for Educators

Geospatial Survey (Educators)

Rate how you use the following in the classroom setting.



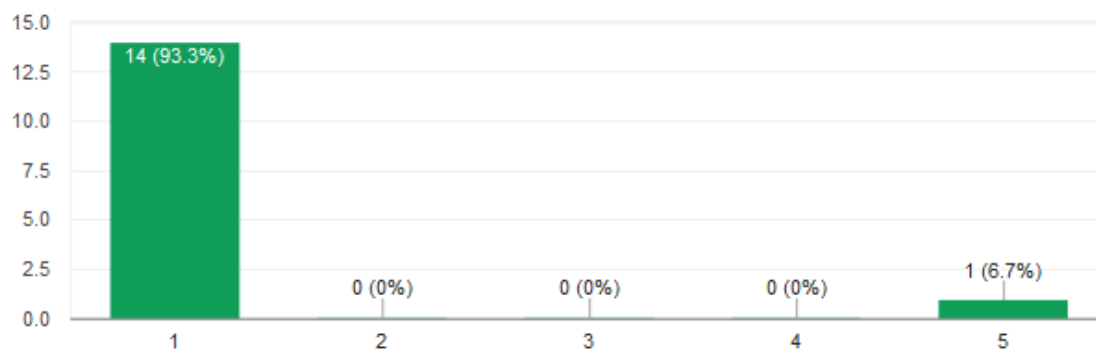
	1	2	3	4	5	
Never	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Always

Bar scale for **AVERAGE** in the Science and Social Science Departments

Use GIS to acquire, manage, display, and analyze spatial data in digital form



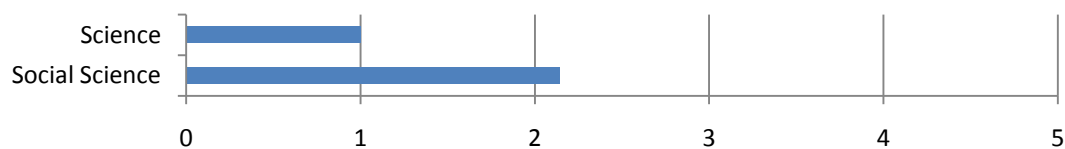
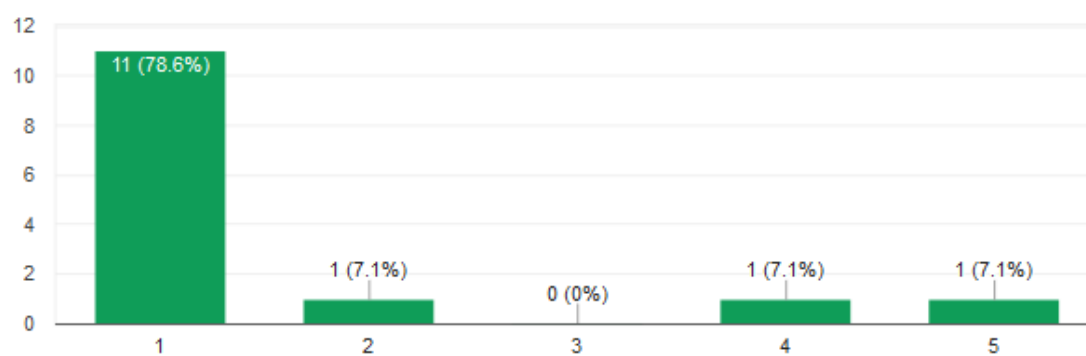
15 responses



Producing, creating, and designing paper or digital maps

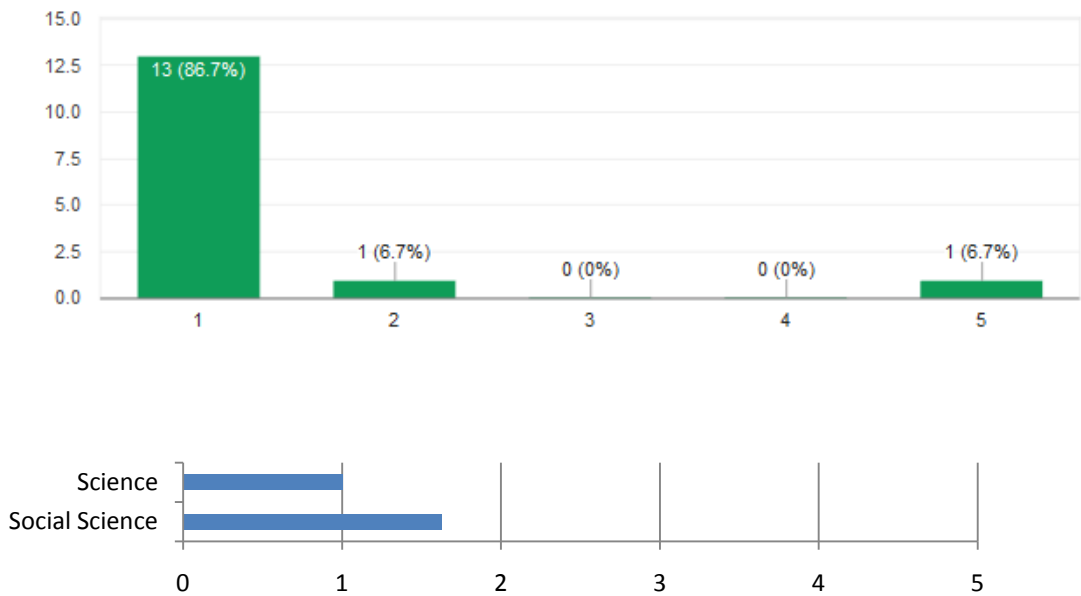


14 responses



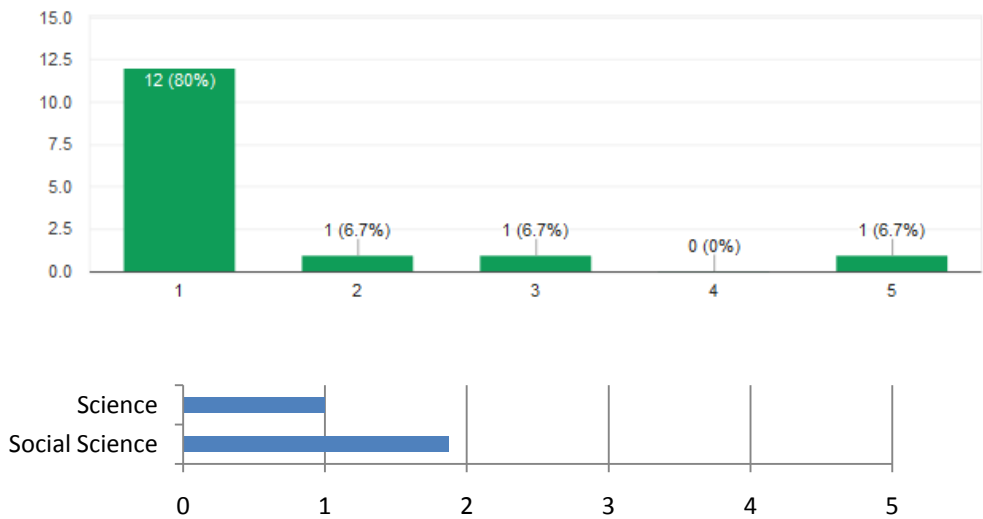
Use interviews, questionnaires, observations, photography, maps, GPS, GIS, and other techniques to measure geographic information in the field

15 responses



Use quantitative methods to process spatial data for the purpose of making calculations, models, and inferences about space, spatial patterns, and spatial relationships

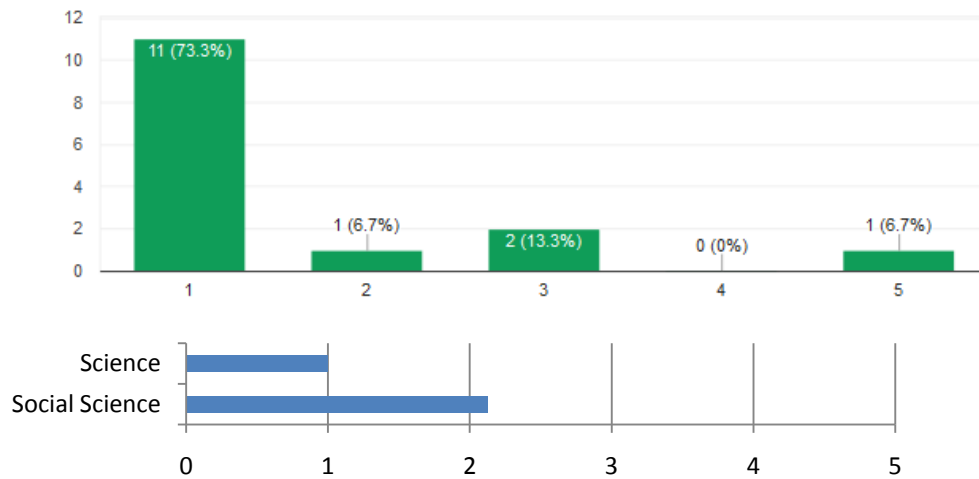
15 responses



Identify, explain, and find meaning in spatial patterns and relationships, such as site conditions, how places are similar and different, the influence of a land feature on its neighbors, the nature of transitions between places, how places are linked at local, regional, and/or global scales

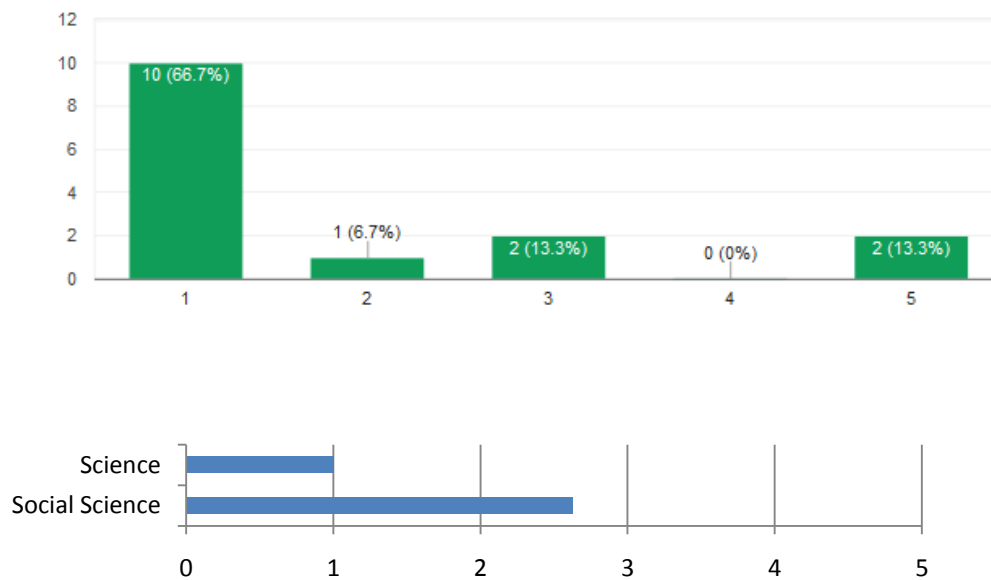


15 responses



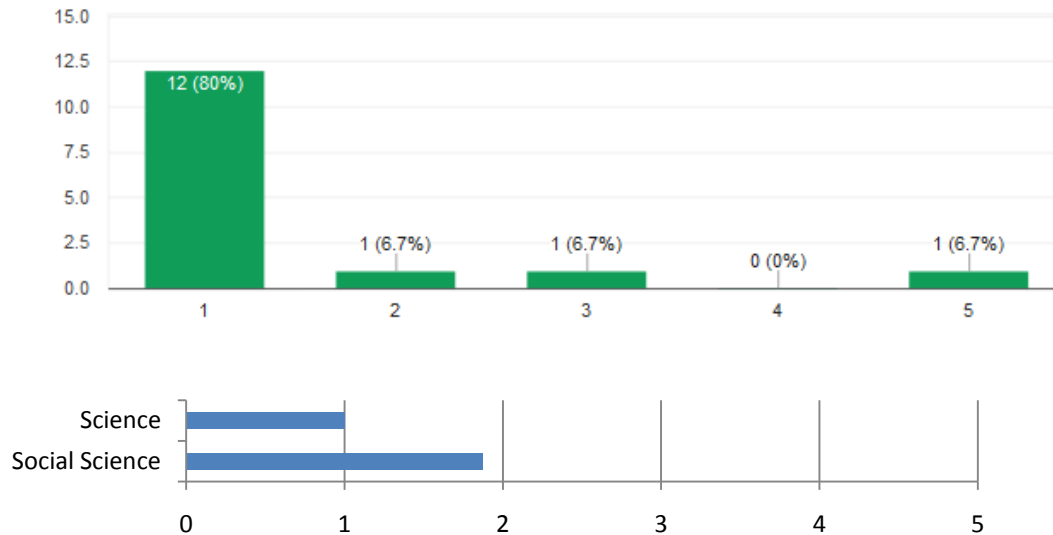
Possess and apply knowledge of how people, places, and regions are linked by global networks and processes (e.g., globalization, international trade, immigration, Internet technology, global climate system)

15 responses



Draw on and synthesize the information, concepts, and methods of the natural and social sciences for geographic research and applications

15 responses






Appendix B - Geography AS Degree (Proposed)

ASSOCIATE IN SCIENCE (A.S) AWC ADVISEMENT CHECK SHEET

To help you decide upon which courses to include in both the major and elective blocks, you and your Academic Advisor should consult the university transfer guides for specific required and recommended courses; the university transfer guides can be found at www.aztransfer.com.

GEOGRAPHY						
Student Name	ID #	Advisor	Major Code: AS.XXX Credits: 64			
ENTER PROGRAM DESCRIPTION HERE						
Required Major Courses (13 Credits)		C r	G r	Se m	App*	Notes
GEO 102	Introduction Human Geography	3			<input type="checkbox"/>	
GEO 105	World Regional Geography	3			<input type="checkbox"/>	
GST 101	Introduction to Geospatial Technology	3			<input type="checkbox"/>	

GPH 110	Introduction to Physical Geography	4				
Other Departmental Requirements (14 Credits)		C	G	Se	App*	Notes
Select at least one of the two following courses (4 credits)						
GPH 171	Introduction to Meteorology	4				
GPH 213	Introduction to Climate Science	4				
Select additional courses from Geography, Geospatial Sciences, Physics, Chemistry, or Geology (10 credits)						
General Education Requirements (37 Credits)		C	G	Se	App*	Notes
See the AGECS course list in the current catalog for selection of courses.						
English Composition (6 credits)						
ENG 101	 Freshman Composition ENG 1101	3				
ENG 102	 Freshman Composition ENG 1102	3				
Mathematics (5 credits)						
MAT 220	 Calculus I with Analytic Geometry MAT 2220 OR approved higher level math	5				
Arts/Humanities - Select at least one course from the Arts list and at least one course from the Humanities list. (6 credits)						
	Arts:					
	Humanities:					
Social and Behavioral Sciences (6 credits)						

Physical and Biological Sciences (8 credits)					
GLG 101	Introduction to Geology	4			
BIO 181	General Biology	4			
Options (6-8 credits)					

***Dual Application of Courses** is the sharing of coursework between the AGECE and major or program requirements which allows the student to meet both requirements with a single course. Students must still meet the required number of credits to satisfy the program or degree. This dual application of courses gives students the opportunity to include additional course work under general electives.

List any courses used to satisfy program or degree credits due to dual application:	C r	G r	Se m	App*	Notes

Appendix C - Certifications in GST (Proposed)

OCCUPATIONAL CERTIFICATE (CERT) AWC ADVISEMENT CHECK SHEET

To help you decide upon which courses to include in both the major and elective blocks, you and your Academic Advisor should consult the university transfer guides for specific required and recommended courses; the university transfer guides can be found at www.aztransfer.com.

Applications in Geospatial Technologies			
Student Name	ID #	Advisor	Major Code: CERT.XXX Credits: 18-19

The certificate program provides students with the knowledge and skills necessary to develop and manage geospatial technology projects and to implement GIS as a dynamic system for decision making and establishment of policies. The geospatial curriculum, with course offerings within the discipline, represent a broad cross-section of the key geospatial science sub-fields including physical, human and regional geography, as well as state-of-the-art geographic information processing methods such as digital image processing and geographic information systems.

Required Major Courses 'Technician' (15-16 Credits)		Cr	Gr	Sem	Notes
GEO 102	Introduction to Human Geography <OR>	3			
GPH 111	Introduction to Physical Geography	4			
GST 101	Introduction to Geospatial Technology	3			
GST 102	Spatial Analysis and Modeling	3			
GST 103	Data Acquisition and Management	3			
GST 104	Cartographic Design and Visualization	3			
Other Departmental Requirements (3 Credits)		Cr	Gr	Sem	Notes
CIS 120	Survey of Computer Information Systems	3			

OCCUPATIONAL CERTIFICATE (CERT) AWC ADVISEMENT CHECK SHEET

To help you decide upon which courses to include in both the major and elective blocks, you and your Academic Advisor should consult the university transfer guides for specific required and recommended courses; the university transfer guides can be found at www.aztransfer.com.

Applications in Geospatial Technologies					
Student Name	ID #	Advisor	Major Code: CERT.XXX Credits: 10-12		
The certificate program provides students with the knowledge and skills necessary to develop and manage geospatial technology projects and to implement GIS as a dynamic system for decision making and establishment of policies. The geospatial curriculum, with course offerings within the discipline, represent a broad cross-section of the key geospatial science sub-fields including physical, human and regional geography, as well as state-of-the-art geographic information processing methods such as digital image processing and geographic information systems.					
Required Major Courses 'Specialist' (Technician Cert. or Equivalent + 9 Credits)		Cr	Gr	Sem	Notes
GST 105	Introduction to Remote Sensing	3			
GST 106	Introduction to Programming for Geospatial Technologies	3			
GST 107	Geospatial Web Applications and Development	3			
Required Major Courses (1-3 Credits)		Cr	Gr	S	Notes

			e m	
GST 108	Capstone in Geospatial Technology (OR)	1-2		
GST 109	Internship	1-3		

Appendix D - Certification in UAS (Proposed)

OCCUPATIONAL CERTIFICATE (CERT) AWC ADVISEMENT CHECK SHEET

To help you decide upon which courses to include in both the major and elective blocks, you and your Academic Advisor should consult the university transfer guides for specific required and recommended courses; the university transfer guides can be found at www.aztransfer.com.

Applications in Geospatial sUAS					
Student Name		ID #	Advisor		Major Code: CERT.XXX Credits: 29-31
A certificate program to prepare students for careers in the field of Unmanned Aerial Systems (UAS). The operations of UAS have a variety of research and commercial uses, with rapid growth and continually evolving applications. A flexible curriculum has been carefully designed to permit either an in-depth or cross-disciplinary approach to the study of geospatial science and aviation, maximizing a student's ability to design his/her academic program beyond the core disciplinary requirements of a degree program. The UAS program emphasizes remote observation with aviation fundamentals and complete knowledge on aviation safety and FAA regulations.					
Required Major Courses (12 Credits)		Cr	Gr	Sem	Notes
UAS 100	Introduction to UAS	3			
UAS 101	Aviation sUAS Pilot Ground School	3			
UAS 102	UAS Image Analysis and Visualization	3			
UAS 103	UAS Flight Operations and Planning	3			
Other Departmental Requirements (9 Credits)		Cr	Gr	Sem	Notes
MAT 151	College Algebra	3			
GPH 171	Introduction to Meteorology	4			
GST 108	Capstone Project	2			
Required Minor Courses - Select within one department below (6-8 Credits)		Cr	Gr	Sem	Notes
Sciences		Cr	Gr	Sem	Notes

AGS 110	Introduction to Food Safety	1			
AGS 240	Environmental Effects on Food Safety	3			
BIO 181	General Biology I	4			
BIO 182	General Biology II	4			
ENV 101	Environmental Science	3			
ENV 230	Foundations of Environmental Science: Human and the Environment	3			
GLG 101	Introduction to Geology	4			
GLG 110	Environmental Geology	4			
GST 101	Introduction to Geospatial Technology	3			
GST 102	Spatial Analysis and Modeling	3			
GST 105	Introduction to Remote Sensing	3			
OCN 110	Oceanography	4			
PLS 100	Plant Science	4			
PLS 120	Agricultural Entomology	3			
Public Safety		Cr	Gr	Sem	Notes
AJS 191	Terrorism and Counter Terrorism	3			
AJS 230	Police Function	3			
EDM 101	Introduction to Emergency Management	3			
EDM 140	Disaster Response and Recovery	3			
FSC 108	Occupational Safety and Health for Emergency Services	3			
FSC 151	Principles of Emergency Services	3			
HLS 101	Introduction to Homeland Security	3			
HLS 103	Introduction to Fire and Emergency Services	3			
HLS 215	Critical Incident Management for Public Safety	3			
Engineering, Technology & Math		Cr	Gr	Sem	Notes
CIS 154	Introduction to E-Commerce/E-Business	3			
CIS 171	Computer Forensics and Investigations	3			
CIS 175	Computer Security	3			
CSC 127A	Introduction to Computer Science 1	4			
CSC 210	Human Computer Interaction	4			Pre:CSC 127A or programming experience
DFT 100	AutoCAD I - Drafting	3			
DFT 101	AutoCAD II - Drafting	4			

EGR 150	Introduction to Environmental Engineering	3			Pre:Either MAT 187 or both MAT 151 and MAT 182
EGR 270	Plane Surveying	3			Pre:Either MAT 187 or both MAT 151 and MAT 183
MAT 270	Applied Statistics	3			
Media, Marketing & Business		Cr	Gr	Sem	Notes
BUA 220	Legal Environment of Business	3			
GRA 101	Graphic Communications I	3			
GRA 104	Digital Imaging I	4			
JRN 135	Introduction to Photojournalism	3			
JRN 235	Advanced Photojournalism	3			
MKT 110	Principles of Marketing	3			
MKT 230	Principles of Advertising	3			
TVP 125	Television Production 1	3			
TVP 225	Television Production 2	3			
QBA 211	Quantitative Analysis	3			

Appendix E - GST Courses (Proposed)

GST 101 INTRODUCTION TO GEOSPATIAL TECHNOLOGY NEW: 9/17 Page 1	GST 101 INTRODUCTION TO GEOSPATIAL TECHNOLOGY NEW: 9/17 Page 2
<p style="text-align: center;">ARIZONA WESTERN COLLEGE SYLLABUS</p> <p>GST 101 Introduction to Geospatial Technology</p> <p>Credit Hours: <u>3</u> Lec <u>3</u></p> <p>PREREQUISITE: None</p> <p><u>COURSE DESCRIPTION</u> Introduction to the fundamentals of Geospatial Technology, including Geographic Information Systems (GIS), Global Positioning Systems (GPS), cartography, remote sensing, and spatial analysis through a series of hands-on computer-based exercises. Participants will learn how to utilize geospatial technology to address social and environmental issues. This course is designed to be used as a stand-alone course to complement other disciplines or as an entry-level course into a geospatial program. Course content is based upon the United States Department of Labor's Geospatial Technology Competency Model for entry level geospatial occupations including Geospatial or GIS Technicians and Technologists.</p> <ol style="list-style-type: none"> <u>COURSE GOAL</u> <ol style="list-style-type: none"> Provides an introduction to Geographic Information Systems (GIS), cartography, and spatial analysis. Assessment of vector and raster systems, scale, resolution, map projection, coordinate systems, georeferencing, and Global Positioning Systems (GPS) <u>OUTCOMES</u> Upon satisfactory completion of this course, students will be able to: <ol style="list-style-type: none"> describe the fundamental concepts of Geographic Information Science and Technology. demonstrate proficiency in the basic functions of geospatial software and hardware. demonstrate awareness of fundamental remote sensing and spatial analysis techniques. demonstrate basic proficiency in map creation and design principles, including thematic map display, employment of map projections and cartographic design. demonstrate proficiency in the creation and acquisition of spatial data including the use of the Global Position System. demonstrate how to access different sources of data, demonstrate the process of creating data, and discuss the fundamental concepts of data quality. <u>METHODS OF INSTRUCTION</u> <ol style="list-style-type: none"> Lecture Discussion Learning Modules Audio-Visual Collaborative Learning Lecture-Lab Combination Computer Assisted Instruction <u>LEARNING ACTIVITIES</u> <ol style="list-style-type: none"> Complete assigned readings 	<ol style="list-style-type: none"> <ol style="list-style-type: none"> Do hands-on analysis in lab activities Participate in examinations Participate in weekly group discussion boards Complete weekly critical thinking essays <u>EVALUATION</u> <ol style="list-style-type: none"> Locally developed test: can be pre/post-test Lab Exercises Written exercise Exams Final Project <u>STUDENT RESPONSIBILITIES</u> <ol style="list-style-type: none"> Under AWC Policy, students are expected to attend every session of class in which they are enrolled. If a student is unable to attend the course or must drop the course for any reason, it will be the responsibility of the student to withdraw from the course. Students who are not attending as of the 45th day of the course may be withdrawn by the instructor. If the student does not withdraw from the course and fails to complete the requirements of the course, the student will receive a failing grade. Americans with Disabilities Act Accommodations: Arizona Western College provides academic accommodations to students with disabilities through AccessABILITY Resource Services (ARS). ARS provides reasonable and appropriate accommodations to students who have documented disabilities. It is the responsibility of the student to make the ARS Coordinator aware of the need for accommodations in the classroom prior to the beginning of the semester. Students should follow up with their instructors once the semester begins. To make an appointment call the ARS front desk at (928) 344-7674 or ARS Coordinator at (928) 344-7629, in the College Community Center (3C) building, next to Advising. Academic Integrity: Any student participating in acts of academic dishonesty—including, but not limited to, copying the work of other students, using unauthorized "crib notes", plagiarism, stealing tests, or forging an instructor's signature—will be subject to the procedures and consequences outlined in AWC's Student Code of Conduct. Texts and Notebooks: Students are required to obtain the class materials for the course]

<p style="text-align: center;">GST 102 SPATIAL ANALYSIS New: 9/17 Page 1</p> <p style="text-align: center;">ARIZONA WESTERN COLLEGE SYLLABUS</p> <p>GST 102 Spatial Analysis</p> <p>Credit Hours: 3 Lec 3</p> <p>PREREQUISITE: GST-101, or co-enrollment of GST-101</p> <p>COURSE DESCRIPTION This course introduces students to problem-solving and decision making using geospatial analysis techniques, applicable to a range of disciplines.</p> <ol style="list-style-type: none"> COURSE GOAL <ol style="list-style-type: none"> Introduces fundamental concepts of geospatial analysis and map interpretation. Explores how geospatial technologies and tools are used in data collection, analysis, presentation, and problem solving. OUTCOMES Upon satisfactory completion of this course, students will be able to: <ol style="list-style-type: none"> prepare data for use in analysis. determine an appropriate approach to solving a problem or answering a question using geospatial tools and methods. run geoprocessing tools individually and implement a model to run several tools in sequence. organize the data sets resulting from analysis. present the results of a geospatial analysis using appropriate terminology and visualizations. METHODS OF INSTRUCTION <ol style="list-style-type: none"> Lecture Discussion Learning Modules Audio-Visual Collaborative Learning Lecture-Lab Combination Computer Assisted Instruction LEARNING ACTIVITIES <ol style="list-style-type: none"> Complete assigned readings Do hands-on analysis in lab activities Participate in examinations Participate in weekly group discussion boards Complete weekly critical thinking essays EVALUATION 	<p style="text-align: center;">GST 102 SPATIAL ANALYSIS New: 9/17 Page 2</p> <ol style="list-style-type: none"> Locally developed test: can be pre/post-test Lab Exercises Written exercise Exams Final Project <ol style="list-style-type: none"> STUDENT RESPONSIBILITIES <ol style="list-style-type: none"> Under AWC Policy, students are expected to attend every session of class in which they are enrolled. If a student is unable to attend the course or must drop the course for any reason, it will be the responsibility of the student to withdraw from the course. Students who are not attending as of the 45th day of the course may be withdrawn by the instructor. If the student does not withdraw from the course and fails to complete the requirements of the course, the student will receive a failing grade. Americans with Disabilities Act Accommodations: Arizona Western College provides academic accommodations to students with disabilities through AccessABILITY Resource Services (ARS). ARS provides reasonable and appropriate accommodations to students who have documented disabilities. It is the responsibility of the student to make the ARS Coordinator aware of the need for accommodations in the classroom prior to the beginning of the semester. Students should follow up with their instructors once the semester begins. To make an appointment call the ARS front desk at (928) 344-7674 or ARS Coordinator at (928) 344-7629, in the College Community Center (3C) building, next to Advising. Academic Integrity: Any student participating in acts of academic dishonesty—including but not limited to, copying the work of other students, using unauthorized "crib notes", plagiarism, stealing tests, or forging an instructor's signature—will be subject to the procedures and consequences outlined in AWC's Student Code of Conduct. Texts and Notebooks: Students are required to obtain the class materials for the course.
<p style="text-align: center;">GST 103 DATA ACQUISITION AND MANAGEMENT New: 9/17 Page 1</p> <p style="text-align: center;">ARIZONA WESTERN COLLEGE SYLLABUS</p> <p>GST 103 Data Acquisition and Management</p> <p>Credit Hours: 3 Lec 3</p> <p>PREREQUISITE: GST-102, or co-enrollment of GST-102</p> <p>COURSE DESCRIPTION This course addresses the interpretation and understanding of a variety of data formats available in GIS. It introduces the fundamental concepts of primary GIS data creation and discusses quantitative techniques for collection, classification, and management of geographical data.</p> <ol style="list-style-type: none"> COURSE GOAL <ol style="list-style-type: none"> Compile, analyze, and present geospatial data while emphasizing the value of visual communication. Understanding of the methods and theories of spatial analysis that will allowing application of GIS knowledge and skills to everyday life and career. OUTCOMES Upon satisfactory completion of this course, students will be able to: <ol style="list-style-type: none"> describe the collection of field data, digital conversion of existing hardcopy maps, and the construction of spatial data from known locations demonstrate basic proficiency to collect, record, and utilize spatial data and databases. demonstrate an ability to collect, create, and process spatial data within a variety of environments. describe and explain the similarities and differences between data models as well as how data is treated differently within each format, to include the conversion of data between different formats. describe the concepts and applications of remote sensing, GPS, and affiliated data capture technologies. demonstrate an understanding of the fundamentals of GIS data storage and interoperability. METHODS OF INSTRUCTION <ol style="list-style-type: none"> Lecture Discussion Learning Modules Audio-Visual Collaborative Learning Lecture-Lab Combination Computer Assisted Instruction LEARNING ACTIVITIES 	<p style="text-align: center;">GST 103 DATA ACQUISITION AND MANAGEMENT New: 9/17 Page 2</p> <ol style="list-style-type: none"> Complete assigned readings Do hands-on analysis in lab activities Participate in examinations Participate in weekly group discussion boards Complete weekly critical thinking essays <ol style="list-style-type: none"> EVALUATION <ol style="list-style-type: none"> Locally developed test: can be pre/post-test Lab Exercises Written exercise Exams Final Project STUDENT RESPONSIBILITIES <ol style="list-style-type: none"> Under AWC Policy, students are expected to attend every session of class in which they are enrolled. If a student is unable to attend the course or must drop the course for any reason, it will be the responsibility of the student to withdraw from the course. Students who are not attending as of the 45th day of the course may be withdrawn by the instructor. If the student does not withdraw from the course and fails to complete the requirements of the course, the student will receive a failing grade. Americans with Disabilities Act Accommodations: Arizona Western College provides academic accommodations to students with disabilities through AccessABILITY Resource Services (ARS). ARS provides reasonable and appropriate accommodations to students who have documented disabilities. It is the responsibility of the student to make the ARS Coordinator aware of the need for accommodations in the classroom prior to the beginning of the semester. Students should follow up with their instructors once the semester begins. To make an appointment call the ARS front desk at (928) 344-7674 or ARS Coordinator at (928) 344-7629, in the College Community Center (3C) building, next to Advising. Academic Integrity: Any student participating in acts of academic dishonesty—including but not limited to, copying the work of other students, using unauthorized "crib notes", plagiarism, stealing tests, or forging an instructor's signature—will be subject to the procedures and consequences outlined in AWC's Student Code of Conduct. Texts and Notebooks: Students are required to obtain the class materials for the course.

<p style="text-align: center;">GST 104 CARTOGRAPHIC DESIGN New: 9/17 Page 1</p> <p style="text-align: center;">ARIZONA WESTERN COLLEGE SYLLABUS</p> <p>GST 104 Cartographic Design</p> <p>Credit Hours: 3 Lec 3</p> <p>PREREQUISITE: GST-103, or co-enrollment of GST-103</p> <p>COURSE DESCRIPTION This course introduces fundamental cartographic concepts. Successful students will be able to employ design principles to create and edit effective visual representations of data (e.g. maps, graphs and diagrams) in different formats (e.g. hardcopy, digital, web). Specific topics include the ethical and appropriate application of map scale, map projections, generalization and symbolization. Course content is based upon the United States Department of Labor's Geospatial Technology Competency Model for entry level geospatial occupations including Geospatial or GIS Technicians and Technologists.</p> <ol style="list-style-type: none"> COURSE GOAL <ol style="list-style-type: none"> Acquaint students with basic concepts of cartography as graphical means of communication Develop skills in map design, reading, analysis and interpretation Promote the principles of cartographic ethics and use acquired knowledge and skills adequately and responsibly in private, professional, and public life. OUTCOMES Upon satisfactory completion of this course, students will be able to: <ol style="list-style-type: none"> categorize and describe different types of maps (thematic, reference...) and be able to give examples of how they are used. describe the components of a map (map elements). employ an appropriate geographic referencing system (datum, projection, coordinate system) for a given purpose. select and apply ethical and appropriate data model, map scale, map elements, symbolization and color to produce maps that effectively communicate quantitative and qualitative geographic data. design professional quality maps, including map elements such as text, graphs, charts and diagrams, employing cartographic principles. produce maps and related products in a variety of formats (hardcopy, digital and web). critique maps for appropriate use of cartographic design principles. METHODS OF INSTRUCTION <ol style="list-style-type: none"> Lecture Discussion Learning Modules 	<p style="text-align: center;">GST 104 CARTOGRAPHIC DESIGN New: 9/17 Page 2</p> <ol style="list-style-type: none"> <ol style="list-style-type: none"> Audio-Visual Collaborative Learning Lecture-Lab Combination Computer Assisted Instruction LEARNING ACTIVITIES <ol style="list-style-type: none"> Complete assigned readings Do hands-on analysis in lab activities Participate in examinations Participate in weekly group discussion boards Complete weekly critical thinking essays EVALUATION <ol style="list-style-type: none"> Locally developed test: can be pre/post-test Lab Exercises Written exercise Exams Final Project STUDENT RESPONSIBILITIES <ol style="list-style-type: none"> Under AWC Policy, students are expected to attend every session of class in which they are enrolled. If a student is unable to attend the course or must drop the course for any reason, it will be the responsibility of the student to withdraw from the course. Students who are not attending as of the 45th day of the course may be withdrawn by the instructor. If the student does not withdraw from the course and fails to complete the requirements of the course, the student will receive a failing grade. Americans with Disabilities Act Accommodations: Arizona Western College provides academic accommodations to students with disabilities through AccessABILITY Resource Services (ARS). ARS provides reasonable and appropriate accommodations to students who have documented disabilities. It is the responsibility of the student to make the ARS Coordinator aware of the need for accommodations in the classroom prior to the beginning of the semester. Students should follow up with their instructors once the semester begins. To make an appointment call the ARS front desk at (928) 344-7674 or ARS Coordinator at (928) 344-7629, in the College Community Center (3C) building, next to Advising. Academic Integrity: Any student participating in acts of academic dishonesty—including, but not limited to, copying the work of other students, using unauthorized "crib notes", plagiarism, stealing tests, or forging an instructor's signature—will be subject to the procedures and consequences outlined in AWC's Student Code of Conduct. Texts and Notebooks: Students are required to obtain the class materials for the course.
<p style="text-align: center;">GST 105 INTRODUCTION TO REMOTE SENSING New: 9/17 Page 1</p> <p style="text-align: center;">ARIZONA WESTERN COLLEGE SYLLABUS</p> <p>GST 105 Introduction to Remote Sensing</p> <p>Credit Hours: 3 Lec 3</p> <p>PREREQUISITE: GST-104, or co-enrollment of GST-104</p> <p>COURSE DESCRIPTION This course is an introduction to remote sensing of the Earth. Topics include the physical principles on which remote sensing is based, history and future trends, sensors and their characteristics, image data sources, and image classification, interpretation and analysis techniques.</p> <ol style="list-style-type: none"> COURSE GOAL <ol style="list-style-type: none"> Introduces fundamental concepts of electromagnetic radiation and its interactions with various media. Explores commonly used sensors and techniques of remote sensing. OUTCOMES Upon satisfactory completion of this course, students will be able to: <ol style="list-style-type: none"> describe basic physics concepts on which remote sensing is based (i.e. Electromagnetic Spectrum, etc.) describe the fundamentals of Photogrammetry select appropriate data set for remote sensing application based on spectral, temporal, radiometric and spatial resolution. describe characteristics of passive and active remote sensing systems (such as multispectral, LiDAR and Radar). perform basic remote sensing workflows to solve problems (such as acquiring data, feature extraction, change detection, pre- and post-processing, create composite images and image classification). describe future trends in remote sensing. apply basic concepts, methods and uses of accuracy assessment and ground truthing to the results of remote sensing workflows. interpret, analyze and summarize results of a remote sensing workflow. METHODS OF INSTRUCTION <ol style="list-style-type: none"> Lecture Discussion Learning Modules Audio-Visual Collaborative Learning Lecture-Lab Combination Computer Assisted Instruction 	<p style="text-align: center;">GST 105 INTRODUCTION TO REMOTE SENSING New: 9/17 Page 2</p> <ol style="list-style-type: none"> <ol style="list-style-type: none"> Complete assigned readings Do hands-on analysis in lab activities Participate in examinations Participate in weekly group discussion boards Complete weekly critical thinking essays EVALUATION <ol style="list-style-type: none"> Locally developed test: can be pre/post-test Lab Exercises Written exercise Exams Final Project STUDENT RESPONSIBILITIES <ol style="list-style-type: none"> Under AWC Policy, students are expected to attend every session of class in which they are enrolled. If a student is unable to attend the course or must drop the course for any reason, it will be the responsibility of the student to withdraw from the course. Students who are not attending as of the 45th day of the course may be withdrawn by the instructor. If the student does not withdraw from the course and fails to complete the requirements of the course, the student will receive a failing grade. Americans with Disabilities Act Accommodations: Arizona Western College provides academic accommodations to students with disabilities through AccessABILITY Resource Services (ARS). ARS provides reasonable and appropriate accommodations to students who have documented disabilities. It is the responsibility of the student to make the ARS Coordinator aware of the need for accommodations in the classroom prior to the beginning of the semester. Students should follow up with their instructors once the semester begins. To make an appointment call the ARS front desk at (928) 344-7674 or ARS Coordinator at (928) 344-7629, in the College Community Center (3C) building, next to Advising. Academic Integrity: Any student participating in acts of academic dishonesty—including, but not limited to, copying the work of other students, using unauthorized "crib notes", plagiarism, stealing tests, or forging an instructor's signature—will be subject to the procedures and consequences outlined in AWC's Student Code of Conduct. Texts and Notebooks: Students are required to obtain the class materials for the course.

<p style="text-align: center;">GST 106 INTRODUCTION TO GEOSPATIAL PROGRAMMING New: 9/17 Page 1</p> <p style="text-align: center;">ARIZONA WESTERN COLLEGE SYLLABUS</p> <p>GST 106 Introduction to Geospatial Programming</p> <p>Credit Hours: 3 Lec 3</p> <p>PREREQUISITE: GST-105, or co-enrollment of GST-105</p> <p>COURSE DESCRIPTION The course provides an understanding of how to customize GIS software applications by way of modified toolbars, menus, and buttons. Topics include the theory and implementation of the various scripting languages currently in use. Upon completion, students will be able to solve geospatial problems and streamline GIS workflows through the creation and modification of scripts.</p> <ol style="list-style-type: none"> COURSE GOAL Introduce students to relevant scripting languages, application programming interface(s), techniques used in geoprocessing/automated mapping and application interface modification and management. OUTCOMES Upon satisfactory completion of this course, students will be able to: <ol style="list-style-type: none"> produce solutions to automate geoprocessing functions using a variety of programming methods, structures, and data sources. use a scripting language to modify and create geoprocessing scripts construct, compile, and troubleshoot computer code according to best practices solve geospatial problems and streamline GIS workflows through the design and development of custom GIS applications. modify user interfaces to increase productivity METHODS OF INSTRUCTION <ol style="list-style-type: none"> Lecture Discussion Learning Modules Audio-Visual Collaborative Learning Lecture-Lab Combination Computer Assisted Instruction LEARNING ACTIVITIES <ol style="list-style-type: none"> Complete assigned readings Do hands-on analysis in lab activities Participate in examinations Participate in weekly group discussion boards Complete weekly critical thinking essays 	<p style="text-align: right;">GST 106 INTRODUCTION TO GEOSPATIAL PROGRAMMING New: 9/17 Page 2</p> <ol style="list-style-type: none"> EVALUATION <ol style="list-style-type: none"> Locally developed test: can be pre/post-test Lab Exercises Written exercise Exams Final Project STUDENT RESPONSIBILITIES <ol style="list-style-type: none"> Under AWC Policy, students are expected to attend every session of class in which they are enrolled. If a student is unable to attend the course or must drop the course for any reason, it will be the responsibility of the student to withdraw from the course. Students who are not attending as of the 45th day of the course may be withdrawn by the instructor. If the student does not withdraw from the course and fails to complete the requirements of the course, the student will receive a failing grade. Americans with Disabilities Act Accommodations: Arizona Western College provides academic accommodations to students with disabilities through AccessABILITY Resource Services (ARS). ARS provides reasonable and appropriate accommodations to students who have documented disabilities. It is the responsibility of the student to make the ARS Coordinator aware of the need for accommodations in the classroom prior to the beginning of the semester. Students should follow up with their instructors once the semester begins. To make an appointment call the ARS front desk at (928) 344-7674 or ARS Coordinator at (928) 344-7629, in the College Community Center (3C) building, next to Advising. Academic Integrity: Any student participating in acts of academic dishonesty—including, but not limited to, copying the work of other students, using unauthorized "crib notes", plagiarism, stealing tests, or forging an instructor's signature—will be subject to the procedures and consequences outlined in AWC's Student Code of Conduct. Texts and Notebooks: Students are required to obtain the class materials for the course.
<p style="text-align: center;">GST 107 GEOSPATIAL WEB APPLICATIONS AND DEVELOPMENT New: 9/17 Page 1</p> <p style="text-align: center;">ARIZONA WESTERN COLLEGE SYLLABUS</p> <p>GST 107 Geospatial Web Applications and Development</p> <p>Credit Hours: 3 Lec 3</p> <p>PREREQUISITE: GST-106, or co-enrollment of GST-106</p> <p>COURSE DESCRIPTION The course involves the design, creation, configuration, optimization of geospatial servers and applications to deliver content across the Internet. The student will construct application to be developed as services with a variety of user interfaces.</p> <ol style="list-style-type: none"> COURSE GOAL Expose and educate students to map, feature and ancillary server services publication, rest end-point interaction and application design for client and mobile applications. OUTCOMES Upon satisfactory completion of this course, students will be able to: <ol style="list-style-type: none"> build a basic Web-based geospatial application perform basic customization of a Web-based geospatial application create and/or modify a basic interactive Web-based geospatial user interface publish geospatial resources to a web service design, configure, optimize, and maintain Internet mapping and application servers explain the use of SDKs in the development of mobile mapping applications METHODS OF INSTRUCTION <ol style="list-style-type: none"> Lecture Discussion Learning Modules Audio-Visual Collaborative Learning Lecture-Lab Combination Computer Assisted Instruction LEARNING ACTIVITIES <ol style="list-style-type: none"> Complete assigned readings Do hands-on analysis in lab activities Participate in examinations Participate in weekly group discussion boards Complete weekly critical thinking essays EVALUATION <ol style="list-style-type: none"> Locally developed test: can be pre/post-test 	<p style="text-align: right;">GST 107 GEOSPATIAL WEB APPLICATIONS AND DEVELOPMENT New: 9/17 Page 2</p> <ol style="list-style-type: none"> Lab Exercises Written exercise Exams Final Project STUDENT RESPONSIBILITIES <ol style="list-style-type: none"> Under AWC Policy, students are expected to attend every session of class in which they are enrolled. If a student is unable to attend the course or must drop the course for any reason, it will be the responsibility of the student to withdraw from the course. Students who are not attending as of the 45th day of the course may be withdrawn by the instructor. If the student does not withdraw from the course and fails to complete the requirements of the course, the student will receive a failing grade. Americans with Disabilities Act Accommodations: Arizona Western College provides academic accommodations to students with disabilities through AccessABILITY Resource Services (ARS). ARS provides reasonable and appropriate accommodations to students who have documented disabilities. It is the responsibility of the student to make the ARS Coordinator aware of the need for accommodations in the classroom prior to the beginning of the semester. Students should follow up with their instructors once the semester begins. To make an appointment call the ARS front desk at (928) 344-7674 or ARS Coordinator at (928) 344-7629, in the College Community Center (3C) building, next to Advising. Academic Integrity: Any student participating in acts of academic dishonesty—including, but not limited to, copying the work of other students, using unauthorized "crib notes", plagiarism, stealing tests, or forging an instructor's signature—will be subject to the procedures and consequences outlined in AWC's Student Code of Conduct. Texts and Notebooks: Students are required to obtain the class materials for the course.

<p style="text-align: center;">GST 108 CAPSTONE IN GEOSPATIAL TECHNOLOGY New: 9/17 Page 1</p> <p style="text-align: center;">ARIZONA WESTERN COLLEGE SYLLABUS</p> <p>GST 108 Capstone in Geospatial Technology</p> <p>Credit Hours: <u>1-2</u> <u>Lec 1-2</u></p> <p>PREREQUISITE: GST-107, or co-enrollment of GST-107</p> <p>COURSE DESCRIPTION The capstone is a learning experience resulting in a consolidation of a student's educational experience and certifies mastery of entry-level workplace geospatial competencies. The capstone experience should occur during the last semester of the student's educational program. Methods of providing a capstone experience include:</p> <ul style="list-style-type: none"> A final learning experience that allows a student to apply broad knowledge of the discipline. A comprehensive examination prepared by the faculty of the geospatial education program and administered at the conclusion of the program. A course involving simulation of the workplace, case studies, portfolios, and employment scenarios. A summative project involving the integration of various teams of students performing activities to simulate the situations which may occur in the workplace. Students will learn how to compile, analyze, and present geospatial data while emphasizing the value of visual communication. <ol style="list-style-type: none"> COURSE GOAL Demonstrate accumulated geospatial skills and expertise by developing and communicating the solution to a complex geospatial problem through a capstone project. OUTCOMES Upon satisfactory completion of this course, students will be able to: <ol style="list-style-type: none"> apply critical-thinking skills to solve problems by generating, evaluating, and implementing geospatial solutions. demonstrate knowledge of professional code of ethics, such as the GISCI GISP or ASPRS. demonstrate knowledge of standard professional practices and organizations (URISA, ASPRS, GITA, USGIF, resumes). develop, manage, complete, and evaluate a comprehensive geospatial project. demonstrate ability to work collaboratively in a team setting. present data and project results in a meaningful format (i.e., digital, written, verbal, graphical). METHODS OF INSTRUCTION <ol style="list-style-type: none"> Lecture Discussion 	<p style="text-align: center;">GST 108 CAPSTONE IN GEOSPATIAL TECHNOLOGY New: 9/17 Page 2</p> <ol style="list-style-type: none"> Learning Modules Audio-Visual Collaborative Learning Lecture-Lab Combination Computer Assisted Instruction <ol style="list-style-type: none"> LEARNING ACTIVITIES <ol style="list-style-type: none"> Complete assigned readings Do hands-on analysis in lab activities Participate in examinations Participate in weekly group discussion boards Complete weekly critical thinking essays EVALUATION <ol style="list-style-type: none"> Locally developed test: can be pre/post-test Lab Exercises Written exercise Exams Final Project STUDENT RESPONSIBILITIES <ol style="list-style-type: none"> Under AWC Policy, students are expected to attend every session of class in which they are enrolled. If a student is unable to attend the course or must drop the course for any reason, it will be the responsibility of the student to withdraw from the course. Students who are not attending as of the 45th day of the course may be withdrawn by the instructor. If the student does not withdraw from the course and fails to complete the requirements of the course, the student will receive a failing grade. Americans with Disabilities Act Accommodations: Arizona Western College provides academic accommodations to students with disabilities through AccessABILITY Resource Services (ARS). ARS provides reasonable and appropriate accommodations to students who have documented disabilities. It is the responsibility of the student to make the ARS Coordinator aware of the need for accommodations in the classroom prior to the beginning of the semester. Students should follow up with their instructors once the semester begins. To make an appointment call the ARS front desk at (928) 344-7674 or ARS Coordinator at (928) 344-7629, in the College Community Center (3C) building, next to Advising. Academic Integrity: Any student participating in acts of academic dishonesty—including, but not limited to, copying the work of other students, using unauthorized "crib notes", plagiarism, stealing tests, or forging an instructor's signature—will be subject to the procedures and consequences outlined in AWC's Student Code of Conduct. Texts and Notebooks: Students are required to obtain the class materials for the course.
<p style="text-align: center;">GST 109 INTERNSHIP IN GEOSPATIAL TECHNOLOGY New: 9/17 Page 1</p> <p style="text-align: center;">ARIZONA WESTERN COLLEGE SYLLABUS</p> <p>GST 109 Internship in Geospatial Technology</p> <p>Credit Hours: <u>1-3</u> <u>Lec 1-3</u></p> <p>PREREQUISITE: GST-107, or co-enrollment of GST-107</p> <p>COURSE DESCRIPTION A structured experience in a supervised setting that is related to the student's major and career interests. Practical experience is under the guidance of faculty and the internship supervisor. Students will work under the direction of a qualified professional with a focus on geospatial technology. The internship provides students with an overview of procedural, professional, and ethical issues faced by a geospatial technician on the job. Students will prepare a summary presentation.</p> <ol style="list-style-type: none"> COURSE GOAL Provides students with the opportunity to apply classroom instruction to real-world GIS problem-solving by working with a government or private agency. OUTCOMES Upon satisfactory completion of this course, students will be able to: <ol style="list-style-type: none"> apply critical-thinking skills to solve problems by generating, evaluating, and implementing geospatial solutions. demonstrate geospatial skills associated with professional, competent, and ethical behaviors associated sound project management. demonstrate soft skills that are needed in the geospatial technology workplace. write an effective resume and demonstrate successful job interview skills. evaluate and assess how organizational structure and culture impacts relationships, production, and communication among team members. evaluate professional interest through reflection on the internship experience through knowledge and awareness of range of various geospatial occupations. METHODS OF INSTRUCTION <ol style="list-style-type: none"> Lecture Discussion Learning Modules Audio-Visual Collaborative Learning Lecture-Lab Combination Computer Assisted Instruction LEARNING ACTIVITIES <ol style="list-style-type: none"> Complete assigned readings Do hands-on analysis in lab activities 	<p style="text-align: center;">GST 109 INTERNSHIP IN GEOSPATIAL TECHNOLOGY New: 9/17 Page 2</p> <ol style="list-style-type: none"> Participate in examinations Participate in weekly group discussion boards Complete weekly critical thinking essays <ol style="list-style-type: none"> EVALUATION <ol style="list-style-type: none"> Locally developed test: can be pre/post-test Lab Exercises Written exercise Exams Final Project STUDENT RESPONSIBILITIES <ol style="list-style-type: none"> Under AWC Policy, students are expected to attend every session of class in which they are enrolled. If a student is unable to attend the course or must drop the course for any reason, it will be the responsibility of the student to withdraw from the course. Students who are not attending as of the 45th day of the course may be withdrawn by the instructor. If the student does not withdraw from the course and fails to complete the requirements of the course, the student will receive a failing grade. Americans with Disabilities Act Accommodations: Arizona Western College provides academic accommodations to students with disabilities through AccessABILITY Resource Services (ARS). ARS provides reasonable and appropriate accommodations to students who have documented disabilities. It is the responsibility of the student to make the ARS Coordinator aware of the need for accommodations in the classroom prior to the beginning of the semester. Students should follow up with their instructors once the semester begins. To make an appointment call the ARS front desk at (928) 344-7674 or ARS Coordinator at (928) 344-7629, in the College Community Center (3C) building, next to Advising. Academic Integrity: Any student participating in acts of academic dishonesty—including, but not limited to, copying the work of other students, using unauthorized "crib notes", plagiarism, stealing tests, or forging an instructor's signature—will be subject to the procedures and consequences outlined in AWC's Student Code of Conduct. Texts and Notebooks: Students are required to obtain the class materials for the course.

Appendix F - UAS Courses (Proposed)

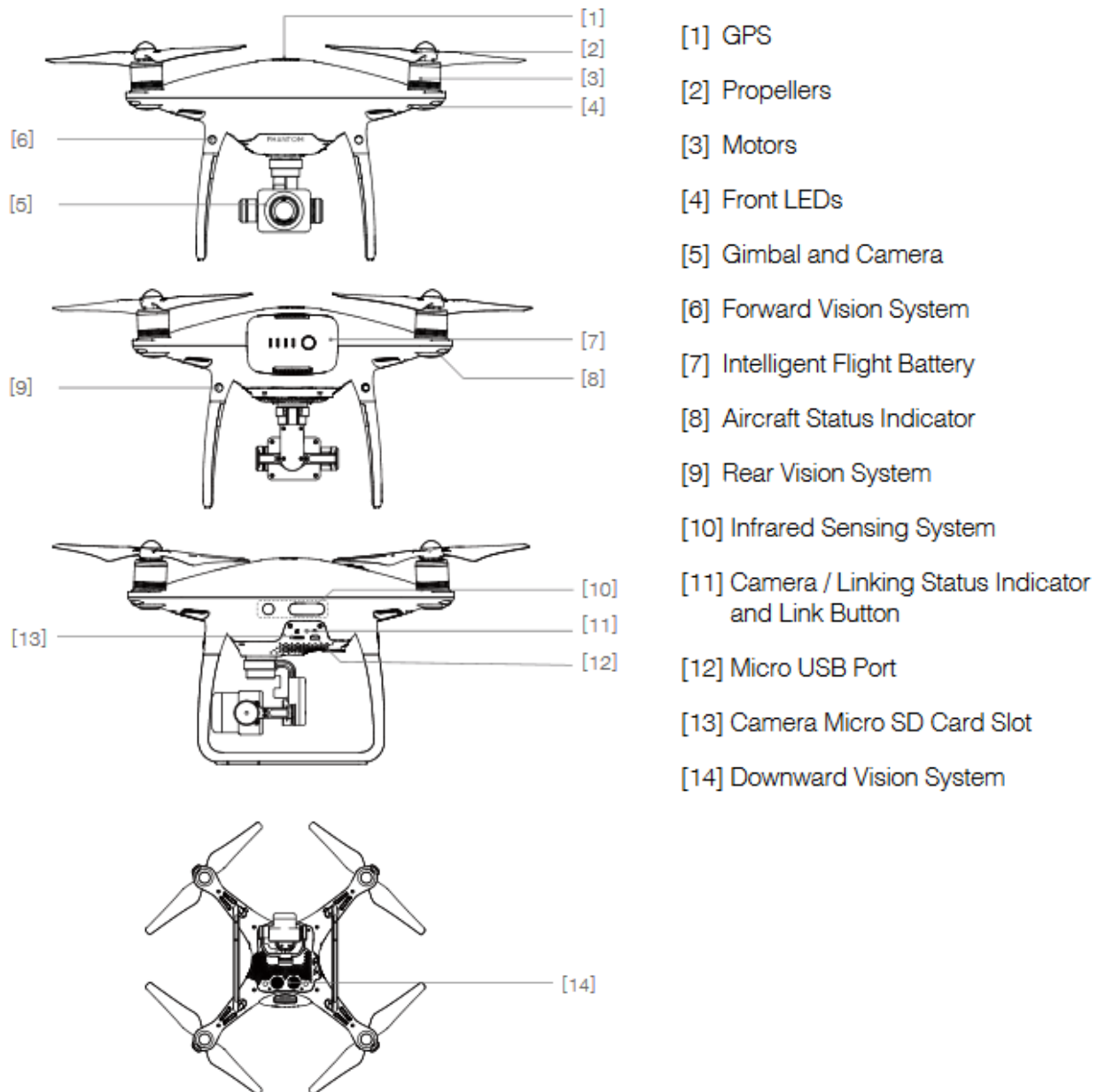
<p style="text-align: right;">UAS 100 INTRODUCTION TO UAS New: 9/17 Page 1</p> <p style="text-align: center;">ARIZONA WESTERN COLLEGE SYLLABUS</p> <p>UAS 100 Introduction to UAS</p> <p>Credit Hours: <u>3</u> Lec <u>3</u></p> <p>PREREQUISITE: None</p> <p>COURSE DESCRIPTION This course is a survey of unmanned aircraft systems (UAS), covering the foundations of unmanned aerial systems, including history, UAS systems, payloads, data links, ground support equipment, classes of UAS systems, categories, applications, mission planning and control and recovery systems. The course will include basic acquisition, use, and operation of UASs with an emphasis on operations.</p> <ol style="list-style-type: none"> COURSE GOAL <ol style="list-style-type: none"> Introduction to unmanned aircraft systems (UAS), including UAS types, system operations, current legal and ethical issues, the flight authorization process, safety of flight, sense and avoid technologies, sensors and payloads, human factors, and UAS simulator operation. Prepare the student operator for real-world safe operation of Small UAV and to provide basic study in preparation for Remote Pilot Certification under FAR Part §107. OUTCOMES Upon satisfactory completion of this course, students will be able to: <ol style="list-style-type: none"> describe the major types/groups/categories of UAS. recall key aspects of the UAS flight approval authorization process. recognize legal/ethical considerations for specific types of UAS operations. list the primary types of sensors used for data collection. compare and contrast types of detect, sense and avoid systems. differentiate the various levels of UAS automation and autonomy. demonstrate proper UAS safety procedures. METHODS OF INSTRUCTION <ol style="list-style-type: none"> Lecture Discussion Learning Modules Audio-Visual Collaborative Learning Lecture-Lab Combination Computer Assisted Instruction LEARNING ACTIVITIES <ol style="list-style-type: none"> Complete assigned readings Do hands-on analysis in lab activities 	<p style="text-align: right;">UAS 100 INTRODUCTION TO UAS New: 9/17 Page 2</p> <ol style="list-style-type: none"> <ol style="list-style-type: none"> Participate in examinations Participate in weekly group discussion boards Complete weekly critical thinking essays EVALUATION <ol style="list-style-type: none"> Locally developed test: can be pre/post-test Lab Exercises Written exercise Exams Final Project STUDENT RESPONSIBILITIES <ol style="list-style-type: none"> Under AWC Policy, students are expected to attend every session of class in which they are enrolled. If a student is unable to attend the course or must drop the course for any reason, it will be the responsibility of the student to withdraw from the course. Students who are not attending as of the 45th day of the course may be withdrawn by the instructor. If the student does not withdraw from the course and fails to complete the requirements of the course, the student will receive a failing grade. Americans with Disabilities Act Accommodations: Arizona Western College provides academic accommodations to students with disabilities through AccessABILITY Resource Services (ARS). ARS provides reasonable and appropriate accommodations to students who have documented disabilities. It is the responsibility of the student to make the ARS Coordinator aware of the need for accommodations in the classroom prior to the beginning of the semester. Students should follow up with their instructors once the semester begins. To make an appointment call the ARS front desk at (928) 344-7674 or ARS Coordinator at (928) 344-7629, in the College Community Center (3C) building, next to Advising. Academic Integrity: Any student participating in acts of academic dishonesty—including, but not limited to, copying the work of other students, using unauthorized "crib notes", plagiarism, stealing tests, or forging an instructor's signature—will be subject to the procedures and consequences outlined in AWC's Student Code of Conduct. Texts and Notebooks: Students are required to obtain the class materials for the course.
<p style="text-align: right;">UAS 101 AVIATION sUAS PILOT GROUND SCHOOL New: 9/17 Page 1</p> <p style="text-align: center;">ARIZONA WESTERN COLLEGE SYLLABUS</p> <p>UAS 101 Aviation sUAS Pilot Ground School</p> <p>Credit Hours: <u>3</u> Lec <u>3</u></p> <p>PREREQUISITE: None.</p> <p>COURSE DESCRIPTION The course provides the background required by the FAA in subject areas including: aerodynamics, aircraft performance, navigation, weather, and aviation regulations leading to pilot certification. Ground school preparation towards the Private Pilot and UAS 107 Certificates. Topics include, aerodynamics, navigation, performance, and regulations.</p> <ol style="list-style-type: none"> COURSE GOAL Produce competent, safety conscious aviation professionals who are knowledgeable in UAS operations. OUTCOMES Upon satisfactory completion of this course, students will be able to: <ol style="list-style-type: none"> explain the basics of airplane systems and understanding of aerodynamic principles identify information you need to know about the environment in which you fly such as airport facilities, air traffic control services, communication procedures, and sources of flight information. demonstrate understanding of the variable atmosphere and its effect on aircraft operations, how to maximize safety by minimizing your exposure to weather-related aviation hazards. justify aircraft capabilities and limitations in terms of performance parameters execute the basics of navigation using charts and radio aids. demonstrate the application of aeronautical decision-making principles and flight-related physiological factors. METHODS OF INSTRUCTION <ol style="list-style-type: none"> Lecture Discussion Learning Modules Audio-Visual Collaborative Learning Lecture-Lab Combination Computer Assisted Instruction LEARNING ACTIVITIES <ol style="list-style-type: none"> Complete assigned readings Do hands-on analysis in lab activities Participate in examinations 	<p style="text-align: right;">UAS 101 AVIATION sUAS PILOT GROUND SCHOOL New: 9/17 Page 2</p> <ol style="list-style-type: none"> <ol style="list-style-type: none"> Participate in weekly group discussion boards Complete weekly critical thinking essays EVALUATION <ol style="list-style-type: none"> Locally developed test: can be pre/post-test Lab Exercises Written exercise Exams Final Project STUDENT RESPONSIBILITIES <ol style="list-style-type: none"> Under AWC Policy, students are expected to attend every session of class in which they are enrolled. If a student is unable to attend the course or must drop the course for any reason, it will be the responsibility of the student to withdraw from the course. Students who are not attending as of the 45th day of the course may be withdrawn by the instructor. If the student does not withdraw from the course and fails to complete the requirements of the course, the student will receive a failing grade. Americans with Disabilities Act Accommodations: Arizona Western College provides academic accommodations to students with disabilities through AccessABILITY Resource Services (ARS). ARS provides reasonable and appropriate accommodations to students who have documented disabilities. It is the responsibility of the student to make the ARS Coordinator aware of the need for accommodations in the classroom prior to the beginning of the semester. Students should follow up with their instructors once the semester begins. To make an appointment call the ARS front desk at (928) 344-7674 or ARS Coordinator at (928) 344-7629, in the College Community Center (3C) building, next to Advising. Academic Integrity: Any student participating in acts of academic dishonesty—including, but not limited to, copying the work of other students, using unauthorized "crib notes", plagiarism, stealing tests, or forging an instructor's signature—will be subject to the procedures and consequences outlined in AWC's Student Code of Conduct. Texts and Notebooks: Students are required to obtain the class materials for the course.

<p style="text-align: center;">UAS 102 UAS IMAGE ANALYSIS AND VISUALIZATION New: 9/17 Page 1</p> <p style="text-align: center;">ARIZONA WESTERN COLLEGE SYLLABUS</p> <p>UAS 102 UAS Image Analysis and Visualization</p> <p>Credit Hours: 3 Lec 3</p> <p>PREREQUISITE: UAS-100.</p> <p>COURSE DESCRIPTION This course is designed to develop image analysis skills to allow for the student to create 3-D visualizations for 3-D modeling. These visualizations are to be used to analyze the subjects of the imagery acquired through use of Unmanned Aircraft.</p> <ol style="list-style-type: none"> COURSE GOAL Demonstrate knowledge of image acquisition and analysis from image acquired by small Unmanned Aircraft Systems. OUTCOMES Upon satisfactory completion of this course, students will be able to: <ol style="list-style-type: none"> describe the different types of imaging systems and sensors. describe the use and mounting of a gimbal on an unmanned aircraft system. identify the different applications that the imagery can be used for. process imagery acquired from UAS and conduct analysis of the location. identify the different types of software that can be used for image processing. METHODS OF INSTRUCTION <ol style="list-style-type: none"> Lecture Discussion Learning Modules Audio-Visual Collaborative Learning Lecture-Lab Combination Computer Assisted Instruction LEARNING ACTIVITIES <ol style="list-style-type: none"> Complete assigned readings Do hands-on analysis in lab activities Participate in examinations Participate in weekly group discussion boards Complete weekly critical thinking essays EVALUATION <ol style="list-style-type: none"> Locally developed test: can be pre/post-test Lab Exercises Written exercise Exams 	<p style="text-align: center;">UAS 102 UAS IMAGE ANALYSIS AND VISUALIZATION New: 9/17 Page 2</p> <p>5.5 Final Project</p> <ol style="list-style-type: none"> STUDENT RESPONSIBILITIES <ol style="list-style-type: none"> Under AWC Policy, students are expected to attend every session of class in which they are enrolled. If a student is unable to attend the course or must drop the course for any reason, it will be the responsibility of the student to withdraw from the course. Students who are not attending as of the 45th day of the course may be withdrawn by the instructor. If the student does not withdraw from the course and fails to complete the requirements of the course, the student will receive a failing grade. Americans with Disabilities Act Accommodations: Arizona Western College provides academic accommodations to students with disabilities through AccessABILITY Resource Services (ARS). ARS provides reasonable and appropriate accommodations to students who have documented disabilities. It is the responsibility of the student to make the ARS Coordinator aware of the need for accommodations in the classroom prior to the beginning of the semester. Students should follow up with their instructors once the semester begins. To make an appointment call the ARS front desk at (928) 344-7674 or ARS Coordinator at (928) 344-7629, in the College Community Center (3C) building, next to Advising. Academic Integrity: Any student participating in acts of academic dishonesty—including, but not limited to, copying the work of other students, using unauthorized "crib notes", plagiarism, stealing tests, or forging an instructor's signature—will be subject to the procedures and consequences outlined in AWC's Student Code of Conduct. Texts and Notebooks: Students are required to obtain the class materials for the course.
<p style="text-align: center;">UAS 103 UAS FLIGHT OPERATIONS AND PLANNING New: 9/17 Page 1</p> <p style="text-align: center;">ARIZONA WESTERN COLLEGE SYLLABUS</p> <p>UAS 103 UAS Flight Operations and Planning</p> <p>Credit Hours: 3 Lec 3</p> <p>PREREQUISITE: UAS-100.</p> <p>COURSE DESCRIPTION This course instructs the student in the operations and flight planning to include both fixed wing and rotor wing UAS aircraft.</p> <ol style="list-style-type: none"> COURSE GOAL Operational procedures for best practices and internal processes for safe and effective flight operations. OUTCOMES Upon satisfactory completion of this course, students will be able to: <ol style="list-style-type: none"> complete preflight activities, to include inspection of the aircraft, assessment of the operating location, briefing crew members involved in the operation, and equipment checkouts complete during flight operations, to include launch, operate, and recover from preset locations, observation locations, adhere to flight plan, permitted UAS flight operation and hazard notifications. complete post-flight operations, to include shut down procedures, aircraft inspection, flight plan review, mission data transfer, and logbook entry. complete emergency procedures, to include proficiency of the aircraft and all operational manual procedures and checklists, before any flight operations are conducted. complete flight area perimeter management, to include selection of launch and landing sites on safety, flight operations are within the FAA-issued airspace authorization parameters and UAS flight limits. complete accident/incident reporting, to include time requirement, location of contact and authority of reporting. complete flight crew communications, to include knowledge of flight management process flows, and coordinate flight operations in an organized and effective manner. complete external communications, to include waivers obtained before flight operations are conducted in Class B, C, D, and E airspace METHODS OF INSTRUCTION <ol style="list-style-type: none"> Lecture Discussion Learning Modules Audio-Visual Collaborative Learning Lecture-Lab Combination 	<p style="text-align: center;">UAS 103 UAS FLIGHT OPERATIONS AND PLANNING New: 9/17 Page 2</p> <p>3.6 Computer Assisted Instruction</p> <ol style="list-style-type: none"> LEARNING ACTIVITIES <ol style="list-style-type: none"> Complete assigned readings Do hands-on analysis in lab activities Participate in examinations Participate in weekly group discussion boards Complete weekly critical thinking essays EVALUATION <ol style="list-style-type: none"> Locally developed test: can be pre/post-test Lab Exercises Written exercise Exams Final Project STUDENT RESPONSIBILITIES <ol style="list-style-type: none"> Under AWC Policy, students are expected to attend every session of class in which they are enrolled. If a student is unable to attend the course or must drop the course for any reason, it will be the responsibility of the student to withdraw from the course. Students who are not attending as of the 45th day of the course may be withdrawn by the instructor. If the student does not withdraw from the course and fails to complete the requirements of the course, the student will receive a failing grade. Americans with Disabilities Act Accommodations: Arizona Western College provides academic accommodations to students with disabilities through AccessABILITY Resource Services (ARS). ARS provides reasonable and appropriate accommodations to students who have documented disabilities. It is the responsibility of the student to make the ARS Coordinator aware of the need for accommodations in the classroom prior to the beginning of the semester. Students should follow up with their instructors once the semester begins. To make an appointment call the ARS front desk at (928) 344-7674 or ARS Coordinator at (928) 344-7629, in the College Community Center (3C) building, next to Advising. Academic Integrity: Any student participating in acts of academic dishonesty—including, but not limited to, copying the work of other students, using unauthorized "crib notes", plagiarism, stealing tests, or forging an instructor's signature—will be subject to the procedures and consequences outlined in AWC's Student Code of Conduct. Texts and Notebooks: Students are required to obtain the class materials for the course.

Appendix G - Federal Aviation Administration Certificate of Authorization (Proposed)

Aircraft System

Aircraft Diagram



Flight Controller

The Phantom 4 Pro / Pro+ flight controller features several important upgrades. Safety modes include Failsafe and Return-to-Home. These features ensure the safe return of your aircraft if the control signal is lost. The flight controller can also save critical flight data from each flight to the on-board storage device. The new flight controller also provides increased stability and a new air braking feature.

Flight Mode

Three flight modes are available. The details of each flight mode are found below:

P-mode (Positioning): P-mode works best when the GPS signal is strong. The aircraft utilizes GPS, stereo Vision System and Infrared Sensing System to stabilize, avoid obstacles or track moving subjects. Advanced features such as TapFly and ActiveTrack are enabled in this mode.

S-mode (Sport): The handling gain values of the aircraft are adjusted to enhance aircraft maneuverability. The maximum flight speed of the aircraft is increased to 45mph (72kph). Note that Obstacle Sensing systems are disabled in this mode.

A-mode (Attitude): When neither the GPS nor the Vision System is available, the aircraft will only use its barometer for positioning to control the altitude.

Aircraft	
Weight (Battery & Propellers Included)	1388 g
Diagonal Size (Excluding Propellers)	350 mm
Max Ascent Speed	Sport mode: 19.7ft/s(6 m/s); GPS mode: 16.4ft/s(5 m/s)
Max Descent Speed	Sport mode: 13.1ft/s(4 m/s); GPS mode: 9.8ft/s (3 m/s)
Max Speed	45 mph (72 kph) (S-mode); 36mph (58 kph) (A-mode); 31 mph (50 kph) (P-mode)
Max Tilt Angle	42° (Sport mode); 35° (Attitude mode); 25° (GPS mode)
Max Angular Speed	250°/s (Sport mode); 150°/s (Attitude mode)
Max Service Ceiling Above Sea Level	19685 ft (6000 m)
Max Flight Time	Approx. 30 minutes
Operating Temperature Range	32° to 104° F (0° to 40° C)
Satellite Systems	GPS/GLONASS
GPS Hover Accuracy Range	Vertical: ±0.1 m (With Vision Positioning); ±0.5 m (With GPS Positioning) Horizontal: ±0.3 m (With Vision Positioning); ±1.5 m (With GPS Positioning)
Gimbal	
Stabilization	3-axis (pitch, roll, yaw)
Controllable Range	Pitch: - 90° to + 30°
Max Controllable Angular Speed	Pitch: 90°/s
Angular Control Accuracy	±0.01°
Vision System	
Velocity Range	≤31 mph (50 kph) at 6.6 ft (2 m) above ground
Altitude Range	0 - 33 feet (0 - 10 m)
Operating Range	0 - 33 feet (0 - 10 m)
Obstacle Sensory Range	2 - 98 ft (0.7 - 30 m)
FOV	60°(Horizontal), ±27°(Vertical)
Measuring Frequency	10 Hz
Operating Environment	Surface with clear pattern and adequate lighting (lux > 15)
Infrared Sensing System	
Obstacle Sensory Range	0.6 - 23 ft (0.2 - 7 m)
FOV	70°(Horizontal), ±10°(Vertical)
Measuring Frequency	10 Hz
Operating Environment	Surface with diffuse reflection material, and reflectivity > 8% (such as wall, trees, humans, etc.)

Camera	
Sensor	1" CMOS; Effective pixels: 20 M
Lens	FOV (Field of View) 84°, 8.8 mm (35 mm format equivalent: 24 mm), f/2.8 - f/11, auto focus at 1 m - ∞
ISO Range	Video: 100 – 3200 (Auto); 100 - 6400 (Manual) Photo: 100 - 3200 (Auto); 100 - 12800 (Manual)
Mechanical Shutter	8 - 1/2000 s
Electronic Shutter	1/2000 - 1/8000 s
Image Size	3:2 Aspect Ratio: 5472×3648 4:3 Aspect Ratio: 4864×3648 16:9 Aspect Ratio: 5472×3078
PIV Image Size	4096×2160 (4096×2160 24/25/30/48/50p) 3840×2160 (3840×2160 24/25/30/48/50/60p) 2720×1530 (2720×1530 24/25/30/48/50/60p) 1920×1080 (1920×1080 24/25/30/48/50/60/120p) 1280×720 (1280×720 24/25/30/48/50/60/120p)
Still Photography Modes	Single shot Burst shooting: 3/5/7/10/14 frames Auto Exposure Bracketing (AEB): 3/5 Bracketed frames at 0.7EV Bias Interval: 2/3/5/7/10/15/30/60 s

Video Recording Modes	H.265
	<ul style="list-style-type: none"> • C4K: 4096×2160 24/25/30p @100Mbps • 4K: 3840×2160 24/25/30p @100Mbps • 2.7K: 2720×1530 24/25/30p @65Mbps 2720×1530 48/50/60p @80Mbps • FHD: 1920×1080 24/25/30p @50Mbps 1920×1080 48/50/60p @65Mbps 1920×1080 120p @100Mbps • HD: 1280×720 24/25/30p @25Mbps 1280×720 48/50/60p @35Mbps 1280×720 120p @60Mbps
	H.264
	<ul style="list-style-type: none"> • C4K: 4096×2160 24/25/30/48/50/60p @100Mbps • 4K: 3840×2160 24/25/30/48/50/60p @100Mbps • 2.7K: 2720×1530 24/25/30p @80Mbps 2720×1530 48/50/60p @100Mbps • FHD: 1920×1080 24/25/30p @60Mbps 1920×1080 48/50/60p @80Mbps 1920×1080 120p @100Mbps • HD: 1280×720 24/25/30p @30Mbps 1280×720 48/50/60p @45Mbps 1280×720 120p @80Mbps
Max. Bitrate Of Video	100 Mbps
Supported File Systems	FAT32 (≤ 32 GB); exFAT (> 32 GB)
Photo	JPEG, DNG (RAW), JPEG + DNG
Video	MP4/MOV (AVC/H.264; HEVC/H.265)
Supported SD Cards	Micro SD, Max Capacity: 128GB. Write speed ≥15MB/s, class 10 or UHS-1 rating required
Operating Temperature Range	32° to 104° F (0° to 40° C)

Charger	
Voltage	17.4 V
Rated Power	100 W
Intelligent Flight Battery (PH4-5870mAh-15.2V)	
Capacity	5870 mAh
Voltage	15.2 V
Battery Type	LiPo 4S
Energy	89.2 Wh
Net Weight	468 g
Operating Temperature	14° to 104° F (-10° to 40° C)
Max. Charging Power	100 W

COA Special Circumstance

Arizona Western College operates Unmanned Aerial Systems (UAS) under FAA approved Certificate of Authorization and regulations. These UAS are operated for the purpose of operator training and proficiency, and research and development within academic curriculum. All flight operations utilize command and control data links with sensor and payload data links under unlicensed frequency bands of the FCC.

Letter of Authorization (LOA) with FAA, Yuma Airport Authority, and MCAS Yuma pending.

COA System Image



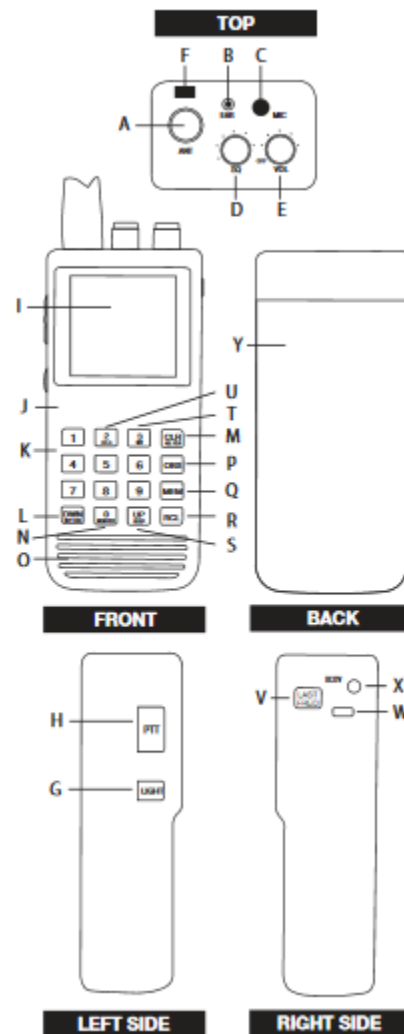
(Image source: dji.com)



Sporty's® SP-400 Hand-held NAV/COM

**sporty's®
pilot shop**

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Controls

This section serves only to identify and briefly describe the SP-400's external features. Please see the Operating Instructions section for detailed instructions on the use of the SP-400.

Top View

(A) Antenna Connector

The flexible rubber antenna or an external antenna may be attached to this BNC connector.

(B) Earphone Jack

Using the optional Headset Adapter (#8635A) the earphone of a standard aviation noise attenuating headset may be plugged into this jack. The internal speaker is disabled when this jack is used.

(C) Microphone Jack

Using the optional Headset Adapter (#8635A) the microphone of a standard aviation noise attenuating headset may be plugged into this jack. The internal microphone is disabled when this jack is used.

(D) Squelch

Rotate clockwise to increase squelch and counterclockwise to decrease squelch.

(E) On/Off and Volume Control

Combination on/off and volume control. Turn the knob clockwise from the OFF position to turn the unit on and to increase volume. Turn the knob counterclockwise to decrease volume and to turn the unit off.

(F) Wrist Strap Pin

The wrist strap (included as standard equipment) attaches to this location.

Left Side View

(G) Light Button

This button activates the back lighting for the screen and keypad.

This key is also used in combination with the Clear Key to enable/disable the auto-light feature.

(H) Push-To-Talk Button

This button activates the internal microphone or an external microphone when using the optional headset adapter.

Front View

(I) Screen

This LCD displays the current frequency, last frequency, Course Deviation Indicator (CDI) and other information to the operator.

(J) Internal Microphone

(K) Numeric Keypad

These keys are used whenever the SP-400 requires a numeric input such as setting the frequency or Omni Bearing Selector (OBS).

(L) Down Key/Key Lock

This key is used to select the next lower frequency, select the next lower OBS setting or to initiate search and scan functions. This key is also used in combination with the Clear Key to lock out all inputs to the keyboard.

(M) Memory Clear Key

This key is used to delete a selected memory channel.

(N) Clear Key/ALL CLR

This key is used to clear erroneous key entries and to exit functions such as search, scan, and memory storage and recall. This key is used in combination with the Down Key to lock out all inputs to the keyboard. It is used in combination with the Light Button to enable/disable the backlight feature. It is used in combination with the UP Key to enable/disable the BEEP function. This Key is also used in combination with the ON/OFF Volume Control to clear all memory channels.

(O) Internal Speaker

(P) Omni Bearing Selector Key

This key is used to change the Omni Bearing Selector (OBS) function for the Course Deviation Indicator (CDI).

(Q) Memory Key

This key is used while storing frequencies in one of the 20 memory channels.

(R) Recall Key

This key is used to recall stored frequencies from the 20 memory channels.

Front View (continued)

(S) Up Key/BEEP

This key is used to select the next higher frequency, select the next higher OBS setting or to initiate search and scan functions. This key is also used in combination with the Clear Key to enable/disable the beep feature.

(T) 3 Key WX

This key is used to select the NOAA Weather Radio Band.

(U) 2 Key 121.5 Emergency

This key is used to select 121.5 emergency frequency.

Right Side View

(V) Last Frequency

This switch is used to flip flop between your current and last frequency.

(W) Battery Pack Release

Pushing this button releases the battery pack for removal.

(X) External Power Jack

The SP-400 may be powered externally, with or without a battery pack attached by plugging the optional 12/24 Volt Cigarette Lighter Power Adapter (#8634A) or the 115 Volt Wall Power Adapter (#8633A) into this location.

Back View

(Y) Battery Pack

Specifications

General

Communication Frequencies:

2,280 Frequencies from 118.000 MHz to 136.975 MHz
(8.33 KHz steps)

Receive Only Frequencies

720 Frequencies from 137.000 MHz to 142.975 MHz
(8.33 KHz steps)

Navigation Frequencies

200 Frequencies from 108.000 MHz to 117.950 MHz
(50 KHz steps)

Memory Channels

20 channels numbered 00 to 19

NOAA Weather Band

10 channels numbered 0 to 9

Weight with Alkaline Battery Pack (including antenna)

1.83 lb. (469 grams)

Weight with NiMH Battery Pack (including antenna)

1.14 lb. (517 grams)

Weight without battery pack (including antenna)

.53 lb. (239 grams)

Dimensions with either battery pack

Height	5.68 in. (144.2 mm)
Width	2.5 in. (63.5 mm)
Depth	1.625 in. (41 mm)

Operating Temperature Range

-22°F to 122°F (-30°C to 50°C)

Frequency Stability

± 10 PPM (0.001%) at 25C

Battery Pack Power

NiMH Battery Pack	9.6 VDC / 2,200 mAH
Alkaline Battery Pack	12.0 VDC (8 AA batteries x 1.5 VDC each)

Receiver**Audio Output**

350 mW into 8 Ohms, 10%

Adjacent Channel Rejection

-60 dB

Sensitivity

AM 6 dB (S+N)/N at 1 µV soft

Selectivity

-6 dB ± 7 KHz

Band Width

± 25 KHz at 60 dB down

Power Consumption

68 mA (on; no reception, no noise)

380 mA (max at voice output)

Transmitter**Transmitter Power**

1.5 Watts ± 20%, 5 Watt (PEP) at 85% modulation

Antenna Impedance

50 Ohms

Spurious Radiation

-60 dB below carrier

Unnecessary Emissions

-60 dB or less

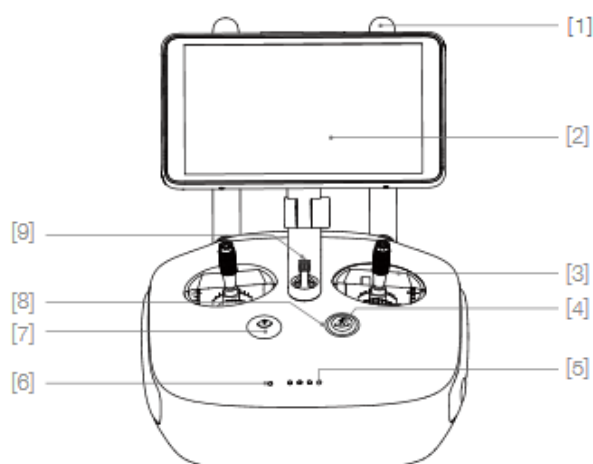
Power Consumption

1 A (max)

Remote Controller Profile

The Phantom 4 Pro / Pro+ remote controller is a multi-function wireless communication device that integrates a dual frequency video downlink system and the aircraft remote control system. The 5.8 GHz video downlink is recommended for urban areas to resist interference, 2.4 GHz is good for long transmission distances in open areas. The remote controller features a number of camera control functions, including photo/video capture and playback as well as gimbal control. The battery level is displayed via LED indicators on the front panel of the remote controller.

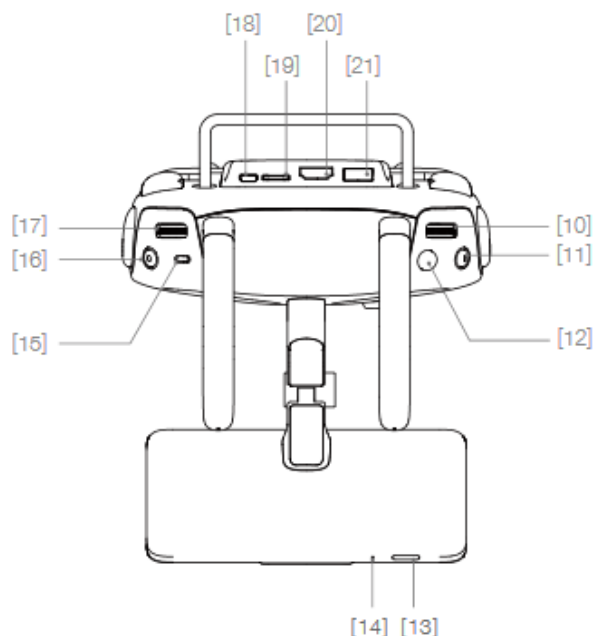
Phantom 4 Pro+ (Model: GL300E)



- [1] **Antennas**
Relays aircraft control and video signal.
- [2] **Display Screen**
Display device with Android system to run DJI GO 4 app.
- [3] **Control Stick**
Controls the orientation and movement of the aircraft.
- [4] **Return Home (RTH) Button**
Press and hold the button to initiate Return to Home (RTH).

- [5] **Battery Level LEDs**
Displays the battery level of the Remote Controller.
- [6] **Status LED**
Displays the Remote Controller's system status.
- [7] **Power Button**
Used to turn the Remote Controller on and off.

- [8] **RTH LED**
Circular LED around the RTH button displays RTH status.
- [9] **Speaker**
Audio output.

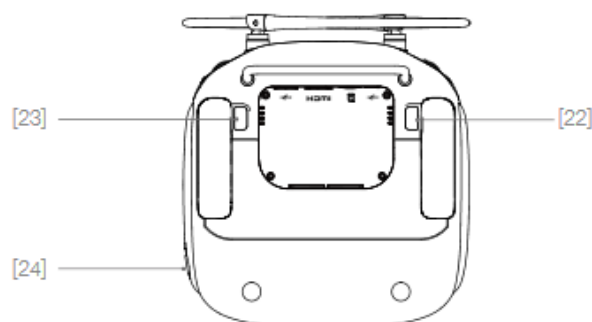


- [12] Shutter Button**
Two-stage button, press to take a photo.
- [13] Sleep/Wake Button**
Press to sleep/wake the screen, press and hold to restart.
- [14] Microphone**
- [15] Flight Mode Switch**
Switch between P-mode, S-mode, and A-mode.
- [16] Video Recording Button**
Press to start recording video. Press again to stop recording.
- [17] Gimbal Dial**
Use this dial to control the tilt of the gimbal.
- [18] Micro USB Port**
Upgrading the aircraft by connecting to the remote controller using the USB OTG cable.

- [10] Camera Settings Dial**
Turn the dial to adjust camera settings.
(Only functions when the Remote Controller is connected to a mobile device running the DJI GO 4 app.)
- [11] Intelligent Flight Pause Button**
Press once to allow the aircraft to exit from TapFly, ActiveTrack and Advanced mode.

- [19] Micro SD Card Slot**
Provide extra storage space for the display device, maximum supporting 128 GB.
- [20] HDMI Port**
Output HDMI video signal.
- [21] USB Port**
USB device support.

- [22] C1 Button**
Customizable through the DJI GO 4 app.
- [23] C2 Button**
Customizable through the DJI GO 4 app.
- [24] Power Port**
Connect to the Charger to charge the battery of the Remote Controller.



Remote Controller	
Operating Frequency	2.400 - 2.483 GHz and 5.725 - 5.825 GHz
	2.400 - 2.483 GHz (Unobstructed, free of interference)
Max Transmission Distance	FCC: 4.3 mi (7 km); CE: 2.2 mi (3.5 km); SRRC: 2.5 mi (4 km)
	5.725 - 5.825 GHz (Unobstructed, free of interference)
	FCC: 4.3 mi (7 km); CE: 1.2 mi (2 km); SRRC: 2.5 mi (4 km)
Operating Temperature	32° to 104° F (0° to 40° C)
Battery	6000 mAh LiPo 2S
	2.400 - 2.483 GHz
Transmitter Power (EIRP)	FCC: 26 dBm; CE: 17 dBm; SRRC: 20 dBm
	5.725 - 5.825 GHz
	FCC: 28 dBm; CE: 14 dBm; SRRC: 20 dBm
Operating Voltage	1.2 A @7.4 V
Video Output Port	GL300E: HDMI, USB
	GL300F: USB
Mobile Device Holder	GL300E: Built-in Display device (5.5 inch screen, 1920×1080, 1000 cd/m ² , Android system, 4G RAM+16G ROM)
	GL300F: Tablets and smartphones

(Image source: dl.djicdn.com)

Data Link

The Phantom 4 utilizes the 2.4 MHz Unlicensed ISM and 5.7-5.8 GHz Unlicensed ISM for data and Command and Control.

Declaration Exemption

AZ Attorney General letter on file.

Emergency Procedure

Phantom 4 Emergency & Abnormal Procedure Summary:

MOTOR REDUCED PERFORMANCE

- A. AIRSPEED – SET MIN – Predetermined at Flight Readiness Review
- B. SAFE HEADING - EST (Return To Base)- Predetermined at Flight Readiness Review
- C. Land – As Soon As Safely Possible
- D. If Unable to safely return to base:
 - 1. Conduct Ditching Procedure

LOW FLIGHT BATTERY

- A. AIRSPEED – SET MIN - Predetermined at Flight Readiness Review
- B. SAFE HEADING - EST (Return To Base)
- C. Land – As Soon As Safely Possible
- D. If Unable to safely return to base:
 - 1. Conduct Ditching Procedure

PC LOCK-UP

- A. BACK-UP PC - SWITCH
- B. Land - As Required

AP FAIL / UNCONTROLLED FLIGHT

A. IN VISUAL RANGE

1. MANUAL PILOT – HANDOFF
2. SAFE HEADING – EST (Return To Base) - Predetermined at Flight Readiness Review
3. Land – As Soon As Safely Possible

B. BEYOND VISUAL RANGE

1. AIRSPEED – SET - Predetermined at Flight Readiness Review
2. SAFE HEADING – EST (Return To Base)- Predetermined at Flight Readiness Review
3. Land – As Soon As Safely Possible

C. If Unable to safely return to base:

1. Conduct Ditching Procedure

GPS FAIL

A. SAFE HEADING – (Return to Base) - Predetermined at Flight Readiness Review B.
ATC – Notify

C. Last Known location – Identify

D. Map/Video or Payload Correlation – Perform (if available)

E. Radar Vectors – Request (if available)

F. Land – As Soon As Safely Possible

G. If Unable to safely return to base:

1. Conduct Ditching Procedure

GCS POWER FAIL

A. POWER SOURCE – VERIFY

B. BACK- UP STATION - SWITCH

C. Land – As Required

DITCHING Procedure

A. ATC – Notify

B. Safe Heading – Est

C. Ditch Site – Select known or calculated safe area

D. Airspeed – Set Minimum

E. Payload – Stow

F. Payload – Off

G. Engine – Cut

H. Last Known Position – Record

INTERMITTENT COMMUNICATIONS

- A. Safe Heading – Est (RTB)
- B. Radio Settings - Verify
- C. Antenna – Verify/Switch
- D. RF Attenuation/Line Of Sight – Verify
- E. Back-up Station - Switch
- F. Land – As Required

LOST COMMUNICATIONS

- A. Radio Settings - Verify
- B. Antenna – Verify/Switch
- C. RF Attenuation/Line Of Sight – Verify
- D. Back-up Station - Switch

IF COMMUNICATIONS NOT RE-ESTABLISHED

1. Last Known Position – Record
2. ATC – Notify
3. Time to Base – Estimate

REPEAT AS NECESSARY

E. Land – As Required

MANUAL CONSOLE FAIL

A. Pilot Address - Verify

B. Console Cable - Check

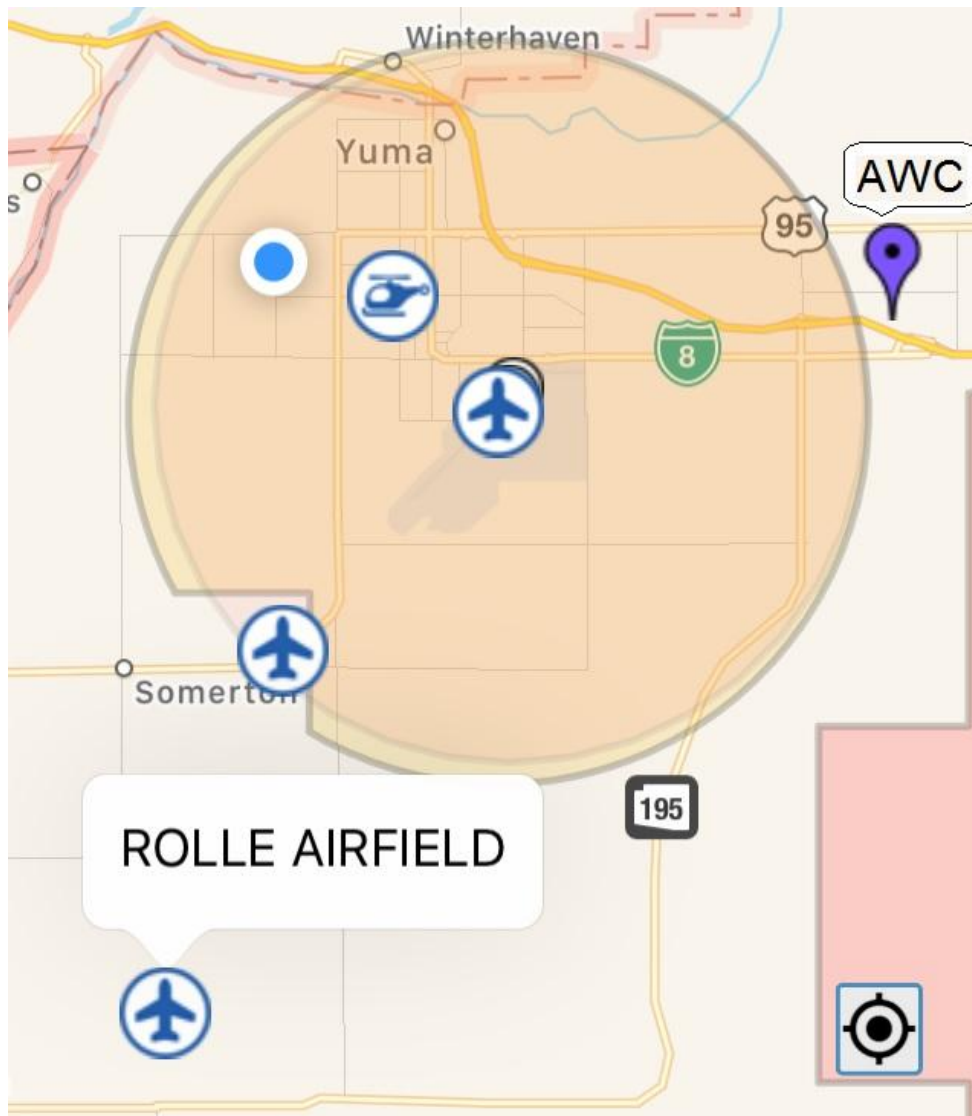
C. Back-up Console – Switch

E. Land – As Soon As Practical

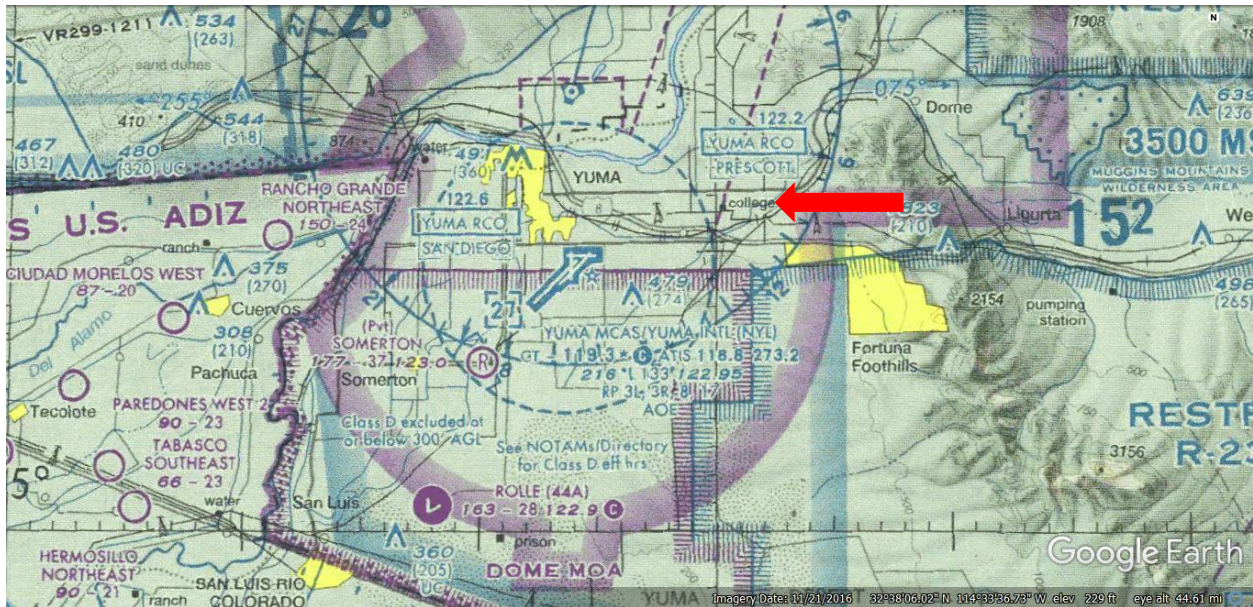
F. If Unable to safely return to base:

1. Conduct Ditching Procedure

Flight Operations Map



(Image source: B4UFly)



(Image source: FAA PHX Sectional/GoogleEarth)



(Image source: GoogleEarth)

Operations will be conducted in remotely populated areas in Class G airspace on the West and South sides of the college campus. The roughly rectangular area bounded by the following:

West of campus

Lat 32° 41' 21.83"N and Long 114° 30' 14.57" W; by Lat 32° 41' 21.50"N and Long 114° 29' 58.39" W; by Lat 32° 41' 6.74"N and Long 114° 30' 14.40" W; by Lat 32° 41' 6.79"N and Long 114° 30' 2.14" W

South-east campus

Lat 32° 41' 9.89"N and Long 114° 29' 37.24" W; by Lat 32° 41' 12.70"N and Long 114° 29' 29.52" W; by Lat 32° 41' 6.34"N and Long 114° 29' 37.42" W; by Lat 32° 41' 6.39"N and Long 114° 29' 29.27" W

These areas are indicated by the red outlines in the photographs below.



(Image source: GoogleEarth)

Launch Recovery

The Phantom 4 is a VTOL aircraft. Launch and recovery will be done on level surfaces such as grass fields, asphalt, or any other surface that does not have any loose debris. During takeoff and landing personnel will be at a minimum distance of 50ft from the aircraft.

Both takeoff and landing of the Phantom is done autonomously. During takeoff the operator commands a higher altitude to the aircraft until liftoff is achieved. At which point the Phantom can continue to climb to the desired operating altitude. Landing the Phantom is done by the operator commanding a lower altitude until the aircraft is in contact with the ground. It is at this point where the Phantom detects that it is not descending further and powers off the rotor.

Lost Communication

The UAS operators will have redundant communications with the ATC authority, which include the use of a 2 -way base station radio and cellular phones. In the event of a loss of communications with the ATC authority, the aircraft will be commanded to the lost link flightplan, which is a RTB and landing.

The UAS Pilot and Observers will be collocated and on 2-way radio or cellular phone communication at all times. In the event of a loss of communications between the Observer and Pilot, the aircraft will be commanded to the lost link flightplan, which is a RTB and landing.

Contingency Plan

Determine alternate landing site.

Communicate with ATC

Plan for parking and control station location.

Minimize risk to other aircraft

Think through flight termination, a deliberate process of controlled flight to the ground.

Think through lost link procedure.

Think through flyaway procedure.

Lost Link Mission

During the pre-flight process, the operator sets up a lost link waypoint and a communications timeout. After passing the timeout limit the Vapor will automatically fly to the lost link (home) waypoint and hover for 30 seconds until communication is reestablished. If communications are not reestablished in 30 seconds of reaching home waypoint, the UA will automatically commence landing at home waypoint. This lost link waypoint may be set up as any standard flight plan available to the operator (standard flight plan, hover, video flight plan, or landing plan). The communications timeout

specifies how much time for the autopilot to wait before turning to the lost link waypoint. The aircraft will maintain its last commanded flight plan for 60 seconds which is the manufacturer recommendation for timeout. At the end of 60 seconds with no communication re-established, the aircraft will RTB (Return to Base). All Launch and recovery activity will be in the requested COA airspace. After a time out of 1 minute located at the RTB lost link location, the Aircraft will initiate an auto land at the lost link waypoint. The lost link waypoint will be the coordinates of the location where the aircraft is launched.

LOST (Link) COMMUNICATIONS

A. Radio Settings - Verify

B. Antenna – Verify/Switch

C. RF Attenuation/Line Of Sight – Verify

D. Back-up Station - Switch

IF (Link) COMMUNICATIONS NOT RE-ESTABLISHED

1. Last Known Position – Record

2. ATC – Notify

3. Time to Base – Estimate

REPEAT AS NECESSARY

E. Land – As Required

Loss of link between control station and UAS preventing control

- Performs a pre-set procedure, from manufacturer
- Procedure ensures predictable
- Auto-lands
- Terminates flight when power depleted

Causes of a lost link

- Frequency Interference
- Poor GPS Signal
- Inflight Fire
- Control Link Interruption

Flyaway

Starts as a lost link, prevents control, and as a result the UAS is not operating in a predictable manner.

It must be reported to the ATC. And later to the FAA.

Thermal runaway of a lithium battery

Don't purchase counterfeit batteries. Put in a protective pouch. Don't allow spare batteries to come into contact with metal. Take steps to prevent crushing or puncture. Create a routine maintenance schedule.

It must be reported to the ATC. And later to the FAA

No Certificate

This letter is in connection with Arizona Western College application for the Certificate of Authorization (Case #####-###-##-###). The unmanned aerial system (UAS) aircraft is

a public aircraft which is flown, owned, and operated by the Geospatial Sciences Department, Arizona Western College, Yuma, AZ 85365. This is to certify that the aircraft, that we will use for our application, is airworthy with safety features embedded on the aircraft hardware and software as described on our application package. Additionally, the aircraft is airworthy when used in accordance with the manufacturer's recommendations. Added to this safety features, the aircraft will only be used in a low altitude and less than 1,500 feet distance from the launch/recovery location with a maximum flight time of 30 minutes. The Pilot In Command (PIC) will make a thorough inspection of the aircraft and flight control systems prior to each flight to insure that all aircraft structures are capable of performing the required mission and that all controls are operating properly. Operations shall be conducted only during daylight hours in visual meteorological conditions, flight trajectories shall always keep the aircraft within line-of-sight of both the pilot and observer.

Other Certified Training

Holders of:

FAA Medical Certification

FAA Part 107

TSO

No TSO authorization material or equipment is utilized.

Appendix H - UAS Policy (Proposed)

Document contains nineteen pages pending college review. Draft proposal available on request.

Appendix I - UAS forms (Proposed)

Arizona Western College Unmanned Aircraft Systems (UAS) Project Application Form		UAS Project Application Number No. _____ (Internal Purposes Only)																									
<p>Instructions: Answer each of the following questions. Incomplete applications will not be considered for approval. Once the application is complete please submit the application to the Vice President of Learning Services at: linda.elliott-netson@azwestern.edu.</p> <p>Submission type: <input type="checkbox"/> New Project <input type="checkbox"/> Project Amendment Today's Date: _____</p> <p style="text-align: center;">SECTION A: Administrative Information</p> <p>A1. Applicant Name: _____</p> <p>A2. Department: _____</p> <p>A3. Phone Number: _____ A4. Email Address: _____</p> <p>A5. Title of Project: _____</p> <p>A6. Status of Funding: <input type="checkbox"/> Pending <input type="checkbox"/> Established <input type="checkbox"/> Unfunded</p> <p>A7. <u>If funded</u>, funding Source/Sponsor: _____</p> <p>A8. Complete the table below for each member of the flight personnel crew (See Page 3 of the College UAS Policy Manual). Note:</p> <ul style="list-style-type: none"> • Pilot-in-Command: A UAS may only be operated by a pilot, known as the Pilot-in-Command ("PIC"). The PIC must, (1) hold a pilot certificate, (2) hold a FAA airman medical certificate or valid U.S. driver's license, and (3) must maintain an understanding of regulations applicable to the airspace where the UAS will be operated. • Visual Observer: A visual observer (VO) is a person who assists the operator to see and avoid other air traffic or objects. At a minimum, VOs must (1) have sufficient knowledge of the airspace to permit them to adequately assess risks, (2) have knowledge of basic VFR weather minimums, (3) maintain a thorough understanding of all operational aspects of the UAS, and (4) be familiar with the requirements of the COA and the College UAS Policy Manual. • Other Personnel: Any other personnel include any personnel that will be used for the safe conduct of flight operations. 		<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 25%;">Full Name</th> <th style="width: 15%;">Crew Member (see above)</th> <th style="width: 40%;">Description of Training/Qualifications</th> <th style="width: 20%;">Dates of any applicable trainings</th> </tr> </thead> <tbody> <tr><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td></tr> </tbody> </table> <p style="text-align: center;">SECTION B: Project Summary</p> <p>B1. Provide a brief description of the nature and goals of the work to be undertaken and need for unmanned aircraft system:</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>B2. Identify the unmanned aircraft type(s) and model(s):</p> <p><input type="checkbox"/> DJI Phantom 1</p> <p><input type="checkbox"/> DJI Phantom 2 Vision+</p> <p><input type="checkbox"/> 3D Robotics X8,</p> <p><input type="checkbox"/> 3D Robotics X8+</p> <p><input type="checkbox"/> 3D Robotics Iris+</p>		Full Name	Crew Member (see above)	Description of Training/Qualifications	Dates of any applicable trainings																				
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<p>B3. Describe the control that will be used to make sure the UAS is operated safely:</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>B4. Describe the communications systems for each UAS:</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>B5. Anticipated start date: _____ Anticipated end date: _____</p> <p>NOTE: Approval for any UAS may not exceed one year, but may be renewed.</p> <p>B6. Describe the geographical area where the UAS will be used: (Consider attaching a map print out)</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>B7. Describe the plan for communication between the Operator and Visual Observer(s):</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>B8. Identify all congested areas within the proposed geographical area of UAS use:</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>B9. Identify any threatened or endangered species which may be disturbed or harmed by the proposed operation:</p> <p>_____</p> <p>_____</p> <p>_____</p>		<p>B10. Identify any areas subject to a Temporary Flight Restriction (TFR) issued by the FAA:</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>B11. Identify any airports within the proposed area of operation (or indicate that you have attached a map with this information):</p> <p>_____</p> <p>_____</p> <p>_____</p> <p style="text-align: center;">SECTION C: Certification of UAS Applicant</p> <p>I certify I will operate the UAS, or monitor the operations of the UAS in accordance with all applicable laws, the College's Certificate of Authorization, and the College UAS Policy Manual. I agree that I will immediately report any accident or damage related to operation of the UAS to the Vice President of Learning Services.</p> <p>Signature: _____ Date: _____</p>																									

<div style="text-align: center;"> Arizona Western College Unmanned aircraft systems (UAS) Post Flight Summary Reporting Form </div> <p style="text-align: right; font-size: small;">UAS Project Application Number No: _____ (Internal Purposes Only)</p> <p>Instructions: Answer each of the following questions. Once the form is complete, please submit the form to the Vice President of Learning Services at: linda.elliott-nelson@azwestern.edu. Note: the form must be completed and submitted within five (5) business days following the operation of the UAS.</p> <p>Today's Date: _____</p> <p style="text-align: center;">SECTION A: Administrative Information</p> <p>A1. Name: _____</p> <p>A2. Department: _____</p> <p>A3. Phone Number: _____ A4. Email Address: _____</p> <p>A5. Title of Project: _____</p> <p style="text-align: center;">SECTION B: Project Summary</p> <p>B1. Identify the UAS type(s) and model(s) that were used:</p> <p> <input type="checkbox"/> DJI Phantom 1 <input type="checkbox"/> DJI Phantom 2 Vision+ <input type="checkbox"/> 3D Robotics X8, <input type="checkbox"/> 3D Robotics X8+ <input type="checkbox"/> 3D Robotics Iris+ </p> <p>B2. List the operating locations (include city name and latitude/longitude):</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>B3. List the number of flights (per location per UAS):</p> <p>_____</p>	<p>B4. List the total number of UAS operational hours:</p> <p>_____</p> <p>_____</p> <p>_____</p> <p>B5. Was there any take-off and landing damage during the operation of the UAS(s)? If the answer to this question is yes, please attach a copy of the applicable maintenance log.</p> <p style="text-align: center;"><input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>B6. Were there any lost link events during the flight? If the answer to this question is yes, please attach a copy of the applicable data discrepancy log.</p> <p style="text-align: center;"><input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p>B7. Were there any equipment malfunctions during the operation of the UAS(s)? Equipment malfunctions include malfunctions related to onboard flight control systems, navigations systems, power failure during flight, fuel system failure, electrical system failure, and control station failure. If the answer to this question is yes, please attach a copy of the applicable maintenance log.</p> <p style="text-align: center;"><input type="checkbox"/> Yes <input type="checkbox"/> No</p> <p style="text-align: center;">SECTION C: Certification of UAS Applicant</p> <p>I hereby certify that the above statements are true and correct to the best of my knowledge.</p> <p>Signature: _____ Date: _____</p>
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<p style="text-align: center;">ARIZONA WESTERN COLLEGE UAS Flight Operations Procedures Checklist</p> <table style="width: 100%;"> <tr> <th style="text-align: left; width: 80%;"><u>Pre-Flight Checklist</u></th> <th style="text-align: center; width: 20%;"><u>Completed</u></th> </tr> <tr> <td colspan="2">1. Equipment Check</td> </tr> <tr> <td>a. UAS is free of visible defects.</td> <td style="text-align: center;"><input type="checkbox"/></td> </tr> <tr> <td>b. All propellers in good condition are free of cracks, holes, dings, or other defects.</td> <td style="text-align: center;"><input type="checkbox"/></td> </tr> <tr> <td>c. All propellers are firmly mounted and installed correctly.</td> <td style="text-align: center;"><input type="checkbox"/></td> </tr> <tr> <td>d. All screws are tightened securely.</td> <td style="text-align: center;"><input type="checkbox"/></td> </tr> <tr> <td>e. 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6. Initiate Launch sequence.	<input type="checkbox"/>																																																																		
<u>Landing Checklist</u>	<u>Completed</u>																																																																		
1. UAS geographically positioned for landing.	<input type="checkbox"/>																																																																		
2. Complete landing Sequence	<input type="checkbox"/>																																																																		
<u>Shut Down Checklist</u>	<u>Completed</u>																																																																		
1. Unplug and remove battery from UAS.	<input type="checkbox"/>																																																																		
2. Fold all antennas on UAS.	<input type="checkbox"/>																																																																		
3. Complete Post Flight documentation.	<input type="checkbox"/>																																																																		

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