PERIPHERAL TECHNOLOGIES TO GEOGRAPHIC INFORMATION SCIENCE (GIS)

Ashtan Rodgers

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PERIPHERAL TECHNOLOGIES TO GEOGRAPHIC INFORMATION SCIENCE (GIS)

by

Ashtan Rodgers

A Thesis
Submitted in Partial Fulfillment of the
Requirements for the Degree of
Master of Science

Major: Interdisciplinary Studies, Earth Science

The University of Memphis
May 2022
DEDICATION

To my loves, my wonderful husband, Jimmy and my amazing son, Miles. You two have made many sacrifices for me to complete this degree and I cannot thank you enough for allowing me the time and support to chase my dreams. I love you each dearly.
ACKNOWLEDGMENTS

I owe a debt of gratitude to Dr. Esra Ozdenerol and my graduate committee. I have been told I can be unpleasant when I am stressed but they helped me through the process regardless. They should also be acknowledged as visionaries for helping me bring this project to life. It is not a typical thesis, but a project I think was worth the time and effort.

I would be remiss not to take this opportunity of my greatest academic achievement thus far to acknowledge those who have assisted in me in getting here. Beyond my loving family to whom this work is dedicated, I must acknowledge the United States Navy for a chance to see the world, a decade of training, and countless opportunities. Each of my alma maters, American Military University, Murray State University and now University of Memphis. Lastly, my employer, Memphis-Shelby County Airport Authority and the wonderful people I have met there. Not the least of which, Khalid Siddiqi who has taken the time to introduce me to FME and made me a better analyst for it.
ABSTRACT

This thesis is a feasibility study that addresses the need for cross-training from GIS perspective into fields of planning, architecture, engineering, the earth sciences and beyond to create a more seamless transition for students into the work force. This study utilizes Python, AutoCAD, and Feature Manipulation Engine (FME) to develop a semester long course at the undergraduate level or an interdisciplinary cross-training workshop series. A survey is conducted to identify the knowledge and skills needed and then cross-referencing to a list with an inventory of current student and GIS employees’ proficiencies to reveal gaps. There is a great amount of unfamiliarity with these products, although most respondents estimated a time saving with proficiency. 93% of survey respondents stated that they would be more likely to hire someone with one or more of these skills on a resume.

The outcome of this thesis is not only the development of a 15-week long cross-training course with assignments, quizzes, and projects, but also the evaluation of the use of these software products in both academic and industry settings.
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CHAPTER 1 INTRODUCTION

Problem

The career field is often far varied from the short list of courses offered at any university. Students can be unprepared for the job market simply because they haven’t had enough exposure to cross-training for the ever-increasing number of niches within a single career title. Many universities unofficially and perhaps inadvertently provide tracts for students to follow within a department, because that is what is important to the topic of interest of the region. For example, at Murray State University (MSU) the Earth Sciences Department Geographic Information Science (GIS) courses focus on agricultural uses for GIS though drones, image processing, and Normalized Difference Vegetation Index (NDVI), MSU has a large agriculture program and is likewise surrounded by farmland. The University of Memphis (UofM) focuses on water resources because the Memphis Aquifer is the main source of potable water in the region. While this allows some students to specialize in a topic, others may feel their education opportunities have been limited to the forte of the region they choose to attend university. GIS is still a relatively new industry, and no single program can cover every topic in GIS. However, a cross-training course can provide a wider breadth of knowledge beneficial to students and young professionals just beginning a GIS career.

Statement of Research Objectives

This thesis project aims to create a useable solution to this problem by developing a course for college students in GIS and GIS-adjacent fields with cross-disciplinary knowledge of software products to help them understand how they fit into the job market amongst these adjoining fields. This could be accomplished by teaching three software products which are commonly seen and used by professionals in GIS, although often not considered GIS-centric or
sometimes unknown to students until beginning the search for a job. Aspiring professionals often have little or no experience with these GIS-adjacent programs until after starting their careers; a course of this type could flatten the learning curve and help new graduates find jobs. The purpose of this project, the research and subsequent course, is not to create experts, but to teach students what technologies are out there, broadening their horizons, filling resumes, teaching them where to find resources, and introducing these students to career fields with a GIS degree that may have been previously unknown.

**Key Objectives**

- Identify the most useful and underserved software elements for GIS professionals and students; both in quantity of use and time-saving abilities
- Determine which software programs will provide the best value to students and early career professionals
- Gain an understanding of the efficacy of this type of cross-specialty training and create the ability for near-seamless translation of work between adjacent professions
- Develop a course based on the research of professional organizations that determine the necessary skills in early career professionals to feed their cycle of growth and technology adaption.
- Cast a wide net of training for those unspecialized students preparing them for the cross disciplinary field of opportunities available to them through internships and jobs after graduation.
Thesis Structure

This study focuses on the benefits of Autodesk’s AutoCAD, Safe Software’s Feature Manipulation Engine (FME), and Open-Source computer language Python, referred to together in this project as Peripheral Technologies to GIS. These products were chosen based on the two surveys conducted of GIS professionals. First, Urban and Regional Information Systems Association “(URISA) 2019 GIS MANAGEMENT SURVEY: SUMMARY OF RESULTS” and second the 2020 “Survey of GIS Professionals” conducted by GIS Lounge. (Croswell, 2020) (Dempsey, 2020) Products were also choose based on the understanding that ESRI software and most GIS programs are developed for Python to be the primary scripting language. There has been discussion for additional suggested software which will be addressed in Chapter 2.

A survey was also conducted under the scope of this project to gather quantitative data on the current use of these products in the industry and academia and gather thoughts on the usefulness of this training. Questions were focused to garner information about current knowledge levels and how best to administer the training. Survey was created in Qualtrics and administered anonymously online.

Definition of GIS Professional

Subjects of this study were not asked to indicate if they had received the GISP certification. In this report the author uses the term GIS professional, with a lowercase “p”. This is to indicate individuals who have chosen a career in GIS but is not intended to refer to only those who have become certified GIS Professionals via the GIS Certification Institute (GISCI) program which requires a lengthy education and work history portfolio and written test. (GIS Certification Institute, 2021) The GIS Professional program is becoming a highly sought-after
accreditation in the field of GIS but is not yet an indicator of any measurable metrics of success in the GIS field. Both GISP and GIS professionals were allotted the opportunity to engage in the survey.

CHAPTER 2 LITERATURE REVIEW

GIS is a Diverse Field

The GIS field has many sectors, some GIS work in software development, forestry, archaeology, transportation, or even on topics of space exploration. With each niche comes a different set of skill requirements and knowledge gaps. GIS is still an emerging technology for many established markets such as real estate and agriculture, but over the last decade has become invaluable to retailers, utilities, and all levels of government from local to federal. With such a variety of people, backgrounds, education, and sectors of work, it is easy to understand the goal of diversifying education as a gift to students.

Existing Studies

Surveys of GIS professionals were incorporated from two sources to provide insight into the status of the GIS industry and organizational composition. Participants from around the world provided feedback about the structure of management and staffing. (URISA, 2017) In addition, respondents are asked about their data standards and the software programs they use. The responses of the following surveys were used to identify software programs of interest for this course.
Urban and Regional Information Systems Association (URISA) Survey

A standing information source in the GIS profession is URISA, “a multi-disciplinary geospatial organization that provides professional education and training, a vibrant and connected community, advocacy for geospatial challenges and issues, and essential resources.” (URISA, 2017)

The URISA study below indicates many software programs used but focuses on primarily mapping based software. It is not a complete chart as some software programs are mentioned in text that are not in the bar graph. For instance, 20% of the surveyed URISA professionals (572 complete responses) reported using AutoCAD regularly. (Croswell, 2020) These are the professionals with access to the program and does not account for those who use CAD .dwg files and other forms of CAD data regularly.

![Software programs used](image)

*Figure 1: Software programs indicated as used by survey respondents URISA GIS Management Survey 2020, Figure C11: GIS Software Use (Croswell, 2020)*
GIS Lounge Survey

GIS Lounge is an online medium of GIS related articles and forum for professionals in GIS to problem solve. (Dempsey, 2020) The GIS Lounge survey of GIS professionals had 1,129 online participants and indicates there are at least 22 over-arching fields in which GIS plays a role. Similarly, GIS Lounge found that education of GIS professionals has a strong curve at bachelor’s and master’s level degree with 88% of participants falling into these two categories. Certificates, a non-degree option, offered by some colleges and universities which often require about four undergraduate level courses, was indicated as received by 52%. (Dempsey, 2020) Almost 5.5% of GIS Lounge respondents reported using AutoCAD, Table 1.
Table 1: GIS Lounge’s Survey of GIS Professionals, The commonly used tools. (Dempsey, 2020)

<table>
<thead>
<tr>
<th>Software</th>
<th># of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>ArcGIS (includes the suite of all Esri products)</td>
<td>1009</td>
</tr>
<tr>
<td>AutoCAD</td>
<td>61</td>
</tr>
<tr>
<td>ENVI</td>
<td>55</td>
</tr>
<tr>
<td>ERDAS</td>
<td>88</td>
</tr>
<tr>
<td>FME</td>
<td>45</td>
</tr>
<tr>
<td>Geomedia</td>
<td>11</td>
</tr>
<tr>
<td>GeoServer</td>
<td>23</td>
</tr>
<tr>
<td>Global Mapper</td>
<td>62</td>
</tr>
<tr>
<td>Google Earth or Google Maps</td>
<td>40</td>
</tr>
<tr>
<td>Google Earth Engine</td>
<td>8</td>
</tr>
<tr>
<td>GRASS</td>
<td>18</td>
</tr>
<tr>
<td>IDRISI</td>
<td>12</td>
</tr>
<tr>
<td>ILWIS</td>
<td>12</td>
</tr>
<tr>
<td>MapInfo</td>
<td>60</td>
</tr>
<tr>
<td>Microstation</td>
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</tr>
<tr>
<td>PostGIS</td>
<td>139</td>
</tr>
<tr>
<td>PostgreSQL</td>
<td>15</td>
</tr>
<tr>
<td>QGIS</td>
<td>546</td>
</tr>
<tr>
<td>R</td>
<td>36</td>
</tr>
<tr>
<td>SAGA GIS</td>
<td>16</td>
</tr>
</tbody>
</table>
Other Programs Considered

The Peripheral Technology products were chosen above other programs in these surveys and community suggestions because of their broad applicability. The proposed course needs to be advantageous to a wide group of professionals to fill the classroom and justify the cost. Other topics could be integrated by either reducing the number of weeks on each topic which may not provide enough time on a subject to have a lasting benefit, or by including other easily accessible programs. Options that have been mentioned for other programs or topics: CityWorks, PropWorks, Drone2Map, R/R Bridge, Oracle, SQL, ArcGIS Extensions and applications, and Agile Project Management. Each of these have merit to a GIS professional, but many have limited use across lines for planners, engineers, architects, and others in earth science.

Through working with GIS professionals, FME has been highly recommended, and many believe there will be time saved by their use. There are days in which I do not open ArcMap in lieu of FME. Activities like schema editing and complex spatial joins are easier in in the visual workbench Graphical User Interface (GUI). Again, FME is still a relatively new program gaining popularity across data science professions.

CHAPTER 3 RESEARCH METHODS

Existing Courses

By searching The UofM course catalog with the search term “Computer Aided Design”, the author found 430 courses relating to CAD. Of the results, 171 were in fields that would appear to require AutoDesk’s AutoCAD program (mostly a variety of Engineering classes) of interest in this study, contrasted with a computer aided design program for art or music. Six Earth Science classes also appeared in the search as having Computer Aided Design in their
description but no specified use of AutoDesk’s AutoCAD program in their descriptions.

(University of Memphis, 2020) University of Memphis has no license for FME, therefore there
are no courses teaching the program. Python is taught in 2 Computer Science courses at
University of Memphis. (University of Memphis, 2020)

Course Development

After spending many months reviewing courses and material for this project, a list of key
points emerged for new GIS professionals. These items guided the development of the lectures
for each module, from which the quizzes were created. Most data for the lectures were
referenced to a few websites which provided visuals or teaching points.

The workbooks came from varied locations. Learn Python in One Day and Learn it Well,
for Module 2, was in a series of workbooks which I purchased prior to this project to teach
myself coding. (Chan, 2017) I enjoyed working through the book and as coding is not my
strongest suit, I decided if I can work through the book, it would be a great resource for other
beginners who are apprehensive about learning coding as well.

The FME workbook is published by Safe Software the developer of the FME program
and is full of hands-on examples of use. (FME Training, 2019) Many models in the book are
focused on true-to-life examples of spatial relationships and tabular data which relate heavily to
this project’s central theme of GIS.
CHAPTER 4 TEACHING MODULES

Course Structure

The course is developed with a 15-week semester in mind and awaiting publishing on CANVAS a Learning Management System (LMS) which is used at the University of Memphis for courses currently being taught both online and in-person (Overview: Canvas, 2022). CANVAS provides the teacher with a manageable course layout by partitioning the course into sections of purpose under individual tabs. Sections include “Syllabus”, “Announcements”, “Grades”, “Quizzes”, “Assignments”, and “Modules” (Figure 2). *Peripheral Technologies to GIS* broken into four key learning Modules: “Computer Basics Refresher”, “Python”, “AutoCAD”, and “FME”, with a fifth module for “Final Project”. Module refers to a section of related learning material in 1- or 4-week increments. Provided documents for the course are Syllabus, a PowerPoint lecture for each module, a quiz for each module, 11 assignments, one extra credit assignment, and a final project.
Module 1 Computer Basics Refresher

Module 1 is the shortest module at only one-week long. The goal of this week is to provide a level foundation for all students where some may otherwise have a limited computer science background. While there is plenty of material on computer science related to GIS and peripheral technologies. However, the key concept for this portion of the course is to understand what to expect as far as computing power for your device, how and what upgrades may be necessary for software to perform at the greatest capacity, to have enough knowledge to clearly explain needs to IT personnel, and to understand how data is stored. Data storage is a very
important concept. How a program stores data, describes its behavior in its native program and what factors differ when used in other programs. Understanding data storage behavior is key to working with data in several formats. This module requires no book or software beyond the ability to view the course in Canvas.

Figure 3: An introduction to shapefile extensions, From Module 1 Computer Basics Lecture.

Figure 3 is a sample of the lecture for Module 1. This slide speaks to the parts of an ESRI shapefile by describing each portions’ functions and clearly marking the required extensions.
Module 2 Python

Figure 4: View of Python IDLE with a simple code.

Module 2 is the first four-week course on Python, a scripting language (Figure 5 indicates the difference between a scripting language and a programming language) used in a stand-alone (Integrated Development Environment/Integrated Development Learning Environment) IDE/IDLE program (Figure 4) and within ArcMap and ArcGIS Pro in specialty tools to perform analysis. Four weeks is not long enough to learn any language and computing languages are no exception. This course focuses on the very basics of syntax, understanding variables, parameters,
operators, and where to find example codes. If students gain only one item of knowledge from this module it should be that existing code is readily available, especially for GIS uses. Having the resources to find that existing code and manipulate it to one’s own variables is the essence of coding.

For visual learners there is the Abstract Syntax Tree, which is a visual representation of code broken down into tree elements to help the coder understand where each function lies in the code and the effect each variable has on the outcome.

Python IDE/IDLE is an open-source software freely available for download at www.python.org. (Python Software Foundation, 2022) In addition to the free software, it is my recommendation to use the book Learn Python in One Day and Learn it Well one of a series of coding topic books by Jamie Chan. (Chan, 2017) This book, like other books of the series are

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**Programming vs scripting**

<table>
<thead>
<tr>
<th>Programming Language</th>
<th>Scripting Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>C++ is the programming (system) language for ArcGIS, meaning this is the language used to develop the program</td>
<td>ArcGIS allows scripting with Python among others (VBScript, JavaScript, Jscript, and Perl)</td>
</tr>
<tr>
<td>Programming is the from scratch drafting of a program, all of the software objects and elements are written here.</td>
<td>Scripting is usually a language closer to human-readable</td>
</tr>
<tr>
<td>Programming often requires a compiler (converts high level syntax into binary)</td>
<td>Used to complete smaller individual tasks within a functioning software, like automation</td>
</tr>
</tbody>
</table>

*Figure 5: Sample page from Module 2 Python Lecture, programming language vs scripting language.*
easily affordable and can provide students with a gateway to learning other increasingly important languages like Java, SQL, or C#.

*Module 3 AutoCAD*

The third module is another 4-week section on AutoCAD. AutoCAD is one of a few Computer Aided Drafting and Design (CADD or CAD) software programs but the most common seen by GIS professionals, as indicated by both the URISA and GIS Lounge surveys. CAD data can be imported directly into ArcGIS, both Desktop and Pro, or converted between file types by exporting the file as a shapefile in AutoCAD (and vice versa for ArcGIS). Figure 6 shows how a CAD .dwg file can be viewed in ArcGIS. Although, in theory data exports into different formats can be done innumerable times, each conversion adds a chance of minor changes which degrades the reliability of the data over time. It is best to work with data in its native format or to use a specialty 3rd-party translator to minimize loss of information.
Figure 6: Sample page from Module 3 AutoCAD lecture, breakdown of CAD file parts as viewed in ArcGIS Catalog.
Drafting and design software are used by engineers to create a model of a real-world element, that element is to scale, but not always georeferenced to its true location on Earth. Georeferencing is a common action when working with CAD data (Figure 7). Understanding feature topology, how data elements are stored in a layer, is also vital to working effectively with CAD data. This is an example of how data storage determines its behavior; one example of these differences is in CAD polygons and polylines can be stored on the same layer, which can not be done in ArcGIS.

AutoCAD requires a license, but University of Memphis already purchased for the Herff College of Engineering. I have not recommended a book for this section therefore this module has no cost to the school or student.
The final 4-week module is on Safe Software’s Feature Manipulation Engine (FME). This brilliant tool is a data integration program for reading and translating data to other formats, (Figure 8).

FME is based on a visual coding GUI akin to that of Model Builder within ArcGIS, however, FME reads and writes over 450 file types and has over 450 transformers. (Safe Software, 2021) Workbench is the FME term for their GUI and is built using the three elements: readers or input files, transformers like that of ArcGIS Toolbox, and writers output files, as seen in Figure 9.

FME’s multistep processing makes data exploration and editing easy without the cumbersome need to create an output file after every transaction. More advanced topics for FME
are APIs which can pull data directly from ArcGIS Online and automation, which creates triggers for the program to run specific workbenches, like the one in Figure 9.

Figure 9: Screenshot of a FME Workbench program.

A great benefit of FME is the support from the developers. Safe Software has published a number of workbooks and sample data free to use on their website. One I recommend for this course: FME Desktop Basic Training 2019. (FME Training, 2019)

The limitation to using FME in a course of this kind is the cost of licensing. The University of Memphis does not currently have a license; therefore, a purchase would be required. Educational licenses are available for a school of UofM’s size $10,000 buys unlimited “seats”. Benefits highly outweigh cost as the program can be used in several colleges on campus, increasing the number of students benefitting from the program’s purchase. Additionally, the return on investment is heightened when the consideration of use for the University staff and
community resources such as Center for Applied Earth Science and Engineering Research (CAESER).

CHAPTER 5 SURVEY

Development of Survey

The survey was created in Qualtrics, through the University of Memphis agreement, and was structured to mimic the earlier referenced URISA survey tone and wording. Questions were written to find quantitative data to answer questions about the respondent’s education and work history. Questions regarding the current knowledge of these software products and the usefulness of a course of this type followed. The survey and material handouts were reviewed by the University of Memphis Institutional Review Board and found to be outside the definition of human subject’s research; protocol number PRO-FY2022-378.

The survey was posted on LinkedIn, sent out via email to the Earth Science departments at The University of Memphis and Murray State University, a few large consulting companies, and Memphis Shelby County Airport Authority Development Department. The survey was also sent to the staff and membership of the two Memphis-area institutions, CAESER which includes students and staff from University of Memphis and Memphis Area Geographic Information Council (MAGIC) a non-profit organization of GIS professionals centered on local geography and GIS topics. (MAGIC, 2022)

Survey results

The survey resulted in 61 responses forming a majority of GIS respondents at 48%. Engineers and architects combined accounted for 23% (they will be evaluated together for the remainder of this study). Thirdly, the “Other” subcategory, “Earth Science” (15%). There were
also respondents who claimed planning and computer science as their primary profession.

Question 4, age, resulted in a near-perfect bell curve from the choices: 18-25, 26-35, 36-45, 46-55, 55 and over; standard deviation 1.17. For 59%, time working in job field was 10 years or more. Question 1, on highest level of education, a majority (93%) of respondents possessed a bachelor’s degree or higher, 54% were bachelor’s degree. Some respondents did not answer every question so there will not be a complete count of 61 responses in each question.

Figure 10: Total breakout for primary job function, Question 5.
In addition to the question of job title, Question 5 asked how GIS is related to your primary job function: “GIS work IS NOT my primary job, I seldom encounter it”, “GIS work IS NOT my primary job, but I encounter it often”, or “GIS is my primary job function” (Figure 10). Engineers and architects indicated at 71% they encounter GIS often, planners indicated at 100% their job function is primarily GIS. Only 97% of GIS professionals indicated that GIS is their primary job function, see Figure 11. Of the Others, 81% indicated GIS is primary function or they encounter it often. Seven respondents were teachers and 11 were students.
Figure 12: Question 7 indication of current knowledge level for each suggested project, broken out by job title.

Figure 12 depicts totals for Question 7 on familiarity of programs before reviewing the accompanying materials. Most respondents from all job types were unfamiliar with FME. Surprisingly, GIS professionals appear in every category except expert for each program. As expected, the engineers and architects were on the more knowledgeable end of the spectrum for CAD but low on most others, less one engineer who is proficient in Python.
Figure 13: Question 17, the number of hours currently saved per week or expected to be saved per week based on materials provided with survey.

Hours saved is a heavily weighted aspect of this project where the goal is to make efficient well-rounded professionals. Architects appear to be very specialized within CAD but split on the usefulness of these new technologies indicating either zero hours saved or 10+ hours saved, Figure 13. A more in depth look at each job follows.
Table 2: Question 16, when in a career would a student most benefit from this training.

<table>
<thead>
<tr>
<th>Field</th>
<th>Choice Count</th>
</tr>
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<tbody>
<tr>
<td>#1  As early as possible</td>
<td>46.67%</td>
</tr>
<tr>
<td>#2  As part of Undergraduate work</td>
<td>30.00%</td>
</tr>
<tr>
<td>#3  As part of Graduate work</td>
<td>3.33%</td>
</tr>
<tr>
<td>#4  0-5 years experience in the job</td>
<td>16.67%</td>
</tr>
<tr>
<td>#5  5+ years experience in the job</td>
<td>3.33%</td>
</tr>
<tr>
<td>#6  I would not recommend these skills</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

Table 2 shows 77% of respondents believed that these technologies should be explored early in a career where 17% felt they should be learned after beginning to work. There was no opposition to learning these skills.

Question 15 was a simple question of hiring, “If you are/were a hiring authority, would the addition of these skills influence hiring of a candidate?”, choices: “Yes, I would be MORE likely to hire someone with these skills.”, “Yes, I would be LESS likely to hire someone with these skills.”, “No, the skills would not influence hiring”. 93% were more likely to hire, the other 7% or only two responses claimed no impact on hiring. Figure 14 is a depiction of these metrics indicating that the two “no impact” answers were from GIS professionals. Again, the implication is made that this course is a benefit to several professions.
Figure 14: Question 15, expected effects of this training on hiring. Where blue is no effect on hiring, and red is more likely to hire.

Below is a look at the metrics from the perspective of each job field.

GIS (29 respondents)

As mentioned in Figure 14, 88% of GIS professionals are more likely to hire a candidate with these skills. Interestingly, only 97% indicated GIS as their primary job function. Table 3 shows the highly varied background in which GIS professionals work being at least somewhat familiar with each product at 97%, 59%, and 90% respectively. The least known product is FME which every GIS respondent indicated at least 1-3 hours of time saved with this program.
Table 3: GIS professionals’ current familiarity with the listed products.

<table>
<thead>
<tr>
<th>#</th>
<th>Field</th>
<th>Unfamiliar</th>
<th>Somewhat familiar</th>
<th>Knowledgeable</th>
<th>Proficient</th>
<th>Expert</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AutoDesk (AutoCAD, Map3D, etc.)</td>
<td>3.45%</td>
<td>48.28%</td>
<td>14</td>
<td>31.03%</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>Feature Manipulation Engine (FME)</td>
<td>41.36%</td>
<td>48.28%</td>
<td>14</td>
<td>3.45%</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Computer languages such as Python</td>
<td>10.34%</td>
<td>41.38%</td>
<td>12</td>
<td>20.69%</td>
<td>6</td>
</tr>
</tbody>
</table>

Figure 15: Question 17, GIS professionals’ estimates for time saving per week for each program.
Engineers and Architects (14 respondents)

Engineers and architects indicated 71% encounter GIS often and they were 100% more likely to hire (Q15) someone with these skills. None of this group was unfamiliar with AutoCAD; although there was 77% unfamiliar with FME and 85% unfamiliar with Python (Table 4). Four respondents believed there would be a time saved in using FME, however, three did not. Five believed there would be a time saving for Python although most thought it would be only 1-3 hours a week (Figure 16)

Table 4: Engineering and Architecture professionals’ current familiarity with the listed products.

<table>
<thead>
<tr>
<th>#</th>
<th>Field</th>
<th>Unfamiliar</th>
<th>Somewhat familiar</th>
<th>Knowledgeable</th>
<th>Proficient</th>
<th>Expert</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AutoDesk (AutoCAD, Map3D, etc)</td>
<td>0.00% 0</td>
<td>7.14% 1</td>
<td>57.14% 6</td>
<td>21.43% 3</td>
<td>14.29% 2</td>
</tr>
<tr>
<td>2</td>
<td>Feature Manipulation Engine (FME)</td>
<td>76.92% 10</td>
<td>23.08% 3</td>
<td>0.00% 0</td>
<td>0.00% 0</td>
<td>0.00% 0</td>
</tr>
<tr>
<td>3</td>
<td>Computer languages such as Python</td>
<td>84.62% 11</td>
<td>7.69% 1</td>
<td>0.00% 0</td>
<td>7.69% 1</td>
<td>0.00% 0</td>
</tr>
</tbody>
</table>
Figure 16: Question 17, Engineering and Architect professionals’ estimates for time saving per week for each program.

*Planning (2)*

The planner metrics are incomplete, neither of the planners who took the survey completed all questions. Of the answered questions 100% claim GIS is primary job function, and 100% more likely to hire a candidate with these skills. One answered these skills should be taught as part of undergraduate work. This sample size is too small to draw conclusions; however, as in Table 5, only 50% were somewhat familiar with FME, but the planners remained knowledgeable of the other products.
Table 5: Planning professionals’ current familiarity with the listed products.

<table>
<thead>
<tr>
<th>#</th>
<th>Field</th>
<th>Unfamiliar</th>
<th>Somewhat familiar</th>
<th>Knowledgeable</th>
<th>Proficient</th>
<th>Expert</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AutoDesk (AutoCAD, Map3D, etc)</td>
<td>0.00%</td>
<td>0.00%</td>
<td>100.00%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>2</td>
<td>Feature Manipulation Engine (FME)</td>
<td>50.00%</td>
<td>50.00%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>3</td>
<td>Computer languages such as Python</td>
<td>0.00%</td>
<td>0.00%</td>
<td>50.00%</td>
<td>50.00%</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

Others (15 respondents)

Others included Earth Science, survey mapping, environmental studies, and archaeology, etc. 100% were more likely to hire someone with these skills, 81% encounter GIS often or GIS is their primary job responsibility. In Table 6, 87% were unfamiliar with FME, 31% unfamiliar with Python, and 56% unfamiliar with AutoDesk.

Table 6: Other professionals’ current familiarity with the listed products.

<table>
<thead>
<tr>
<th>#</th>
<th>Field</th>
<th>Unfamiliar</th>
<th>Somewhat familiar</th>
<th>Knowledgeable</th>
<th>Proficient</th>
<th>Expert</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AutoDesk (AutoCAD, Map3D, etc)</td>
<td>56.25%</td>
<td>18.75%</td>
<td>18.75%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>2</td>
<td>Feature Manipulation Engine (FME)</td>
<td>87.50%</td>
<td>12.50%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>3</td>
<td>Computer languages such as Python</td>
<td>31.25%</td>
<td>43.75%</td>
<td>12.50%</td>
<td>6.25%</td>
<td>6.25%</td>
</tr>
</tbody>
</table>
Figure 17: Question 17, Other professionals’ estimates for time saving per week for each program.

Figure 17 shows a perfect bell curve for hours saved per week for all products as indicated by the “Others” group. Standard deviation for this group is 1.26.

Teachers (7 respondents)

Of the seven who indicated they were a teacher (can be of any job field), all held a PhD; 57% were GIS and 43% were “Other”. 100% were more likely to hire someone with these skills and indicated these skills had most value to learn as soon as possible or part of undergraduate course work. For the education platform, they were split 50/50 on in person and online offerings. 43% were unfamiliar with FME, while most (43-57%) were at least “somewhat familiar” with
each product (Table 7). 1-9 hours of time saved per week for each product, less one response which indicates zero hours of use for AutoDesk (Figure 18).

**Table 7: Teaching professionals’ current familiarity with the listed products.**

<table>
<thead>
<tr>
<th>#</th>
<th>Field</th>
<th>Unfamiliar</th>
<th>Somewhat familiar</th>
<th>Knowledgeable</th>
<th>Proficient</th>
<th>Expert</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AutoDesk (AutoCAD, Map3D, etc)</td>
<td>0.00%</td>
<td>57.1%</td>
<td>28.5%</td>
<td>14.29%</td>
<td>0.00%</td>
</tr>
<tr>
<td>2</td>
<td>Feature Manipulation Engine (FME)</td>
<td>42.86%</td>
<td>42.86%</td>
<td>14.29%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>3</td>
<td>Computer languages such as Python</td>
<td>14.29%</td>
<td>42.86%</td>
<td>28.57%</td>
<td>14.29%</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

**Figure 18: Question 17, Teaching professionals’ estimates for time saving per week for each program.**
CHAPTER 6 DISCUSSION

Survey Concerns

Beyond the addition of more responses there are a few ways in which the survey could have been more accurate. Some of the respondents were not provided the full set of reference materials when taking the survey, which could have affected their answers. There were 11 student respondents. Planners did not have a good representation with only two responses and those did not complete the whole survey.

Some of the survey questions would have been more beneficial if formatted differently. For example, Question 21– “How would this course be most effectively taught?”, this question should have allowed the respondent to choose multiple options to properly gauge the interest in the in-person or online environment and additionally in a professional workshop. A workshop-style course would be more easily accessed to professionals already working and responses from a similar survey given to workshop attendees would provide more exact information. The short 11 slide presentation provided with the survey is not as accurate as that of one who had hands on experience with the programs.

Additional Software

As mentioned, there was a question of which software programs would be most beneficial, from the previous list: CityWorks, PropWorks, Drone2Map, R/R Bridge, Oracle, SQL, ArcGIS Extensions and applications, and Agile Project Management. One solution to this problem would be to test them in a series of workshops and review the student surveys for metrics, or simply to rotate through different sections based on the needs of the students. I wouldn’t recommend shortening the modules below 4-weeks.
Cost of FME Licensing

Another hindrance to this course is the cost associated with software procurement. Computer science basics and Python are open source, there is no cost for the use of these two programs. The University currently has a license for AutoCAD for the Engineering and Architecture departments. The one program which would incur a cost, is FME for which 83% of respondents expected a return in time saved each week. The cost of an educational license from Safe Software is structured on the size of the school, for University of Memphis the cost would be $10,000 per annum for an unlimited number of Desktop and Server users. Minding the broad range of careers for respondents and the number of hours a week saved, it proves relevant. There is also the benefit to the University for onsite use for GIS, CAD, Building Information Modeling, or asset management.

Continuing Education Credits (GISP and PE)

As a last point, this course has potential to become certified to serve as continuing education credits for both Professional Engineers (PE) and GIS Professional (certified GISP). As a workshop or workshop series this could gain interest as seen by the results of the survey. The steps to getting a course certified are outside the scope of this study.

CHAPTER 7 CONCLUSIONS

Relevance

This course has relevance as a cross-training tool for many educated professionals. These technologies were well-received by the community; many thought the course could provide value to the workforce and indicated they would be more likely to hire someone with these skills. The technological circle uses the opinion of professionals to determine what is needed in
academia then teaches the next generation who cyclically identify new technologies. Technology is constantly evolving. I am not aware of another university which is currently teaching FME to their students. A course of this kind allows University of Memphis an excellent opportunity to continue to provide their students with the best education and to be on the leading edge of technology.

Future Implications

The swift adoption of GIS into the large assortment of industries coupled with the number of tangential industries which are commonly encountered produces several cross-training opportunities. As an information technology, GIS evolves at a rapid rate with near constant updates to existing technology and a rising number of new peripheral technologies. Peripheral Technologies to GIS has staying power as a teaching tool. As new technologies are produced; they can be filtered into the program replacing those that are at the end of their lifecycle and no longer seeing the time saving returns. In perpetuity, this course can meet the needs of the evolving workplace.
REFERENCES


Chan, Jamie. Learn Python in One Day and Learn It Well: Python for Beginners with Hands-on Project. the Only Book You Need to Start Coding in Python Immediately. 2nd ed. Coppell, TX: s.n., 2021.


Peripheral Technologies to Geospatial Information Technology

Please complete this short two-part survey.

Complete the first block of questions before the presentation, and the second block of questions following the presentation.

Point of Contact: [Student] Ashton Rodgers, rdgers10@memphis.edu,
[Advisor] Esra Ozdenero, eozdenero@memphis.edu

THE UNIVERSITY OF MEMPHIS
Appendix B- Survey Questions

Pre-Training Portion of Survey

Please complete this portion of the survey before the presentation to help us understand your experiences and expectations for the training.

Highest level of education obtained?
High School
Certificate
Associate
Bachelor
Master
PhD

Age
18-25
26-35
36-45
46-55
56 or over

What is your primary profession (or course of study for current students)?
Geographic Information Systems (GIS)
Architecture
Engineering
Construction
Planning
Computer Science

How long have you been working in your field?
1-5 years
6-10 years
10+ years
Have not begun to work

How is GIS related to your primary job function?
GIS work is NOT my primary job, I seldom encounter it.
GIS work IS NOT my primary job, but I encounter it often.
GIS work IS my primary job function.

Are you a student or a teacher?
Student
Teacher
No

Please indicate how familiar you are with the following products.

<table>
<thead>
<tr>
<th>Product</th>
<th>Unfamiliar</th>
<th>Somewhat familiar</th>
<th>Knowledgeable</th>
<th>Proficient</th>
<th>Expert</th>
</tr>
</thead>
<tbody>
<tr>
<td>AutoDesk (AutoCAD, Map3D, etc)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feature Manipulation Engine (FME)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer languages such as Python</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What are your expectations for this training program?

Questions continued on following page. Please view presentation before completing the following portion.

Post-Training Portion of Survey

Please complete this portion of the survey to help us understand your experience and recommendations for the training.

Was this course relevant to your work?
Yes
No
Unsure

Tell us about the quality of course materials.

<table>
<thead>
<tr>
<th></th>
<th>Poor</th>
<th>Unremarkable</th>
<th>Great</th>
</tr>
</thead>
<tbody>
<tr>
<td>AutoCAD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feature Manipulation Engine (FME)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Python</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If you are/were a hiring authority, would the addition of these skills on a resume influence hiring of a candidate?
Yes, I would be MORE likely to hire someone with these skills.
Yes, I would be LESS likely to hire someone with these skills.
No, these skills would not influence hiring.

When during a career do you think learning these skills is most valuable?
As early as possible
As part of Undergraduate work
As part of Graduate work
0-5 years experience in the job
5+ years experience in the job
I would not recommend these skills

What number of person-hours do think proficiency in these programs would save on a weekly basis?

<table>
<thead>
<tr>
<th>Program</th>
<th>None</th>
<th>1-3 hours</th>
<th>4-6 hours</th>
<th>7-9 hours</th>
<th>10+ hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>AutoCAD</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Feature Manipulation Engine (FME)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Python</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

What topics or exercises would you like to see in the AutoCAD portion of this training?


What topics or exercises would you like to see in the Feature Manipulation Engine (FME) portion of this training?


What topics or exercises would you like to see in the Python portion of this training?


How would this course be most effectively taught?

- In person
- Online
- At student's own pace
- As a short professional workshop

https://memphis.co1.qualtrics.com/I/editSectionBlocks/AjaxGetSurveyRedirect?ContextSurveyId=SV_2gWcaLU8TPTI6Lo&ContextLibraryId=U... 4/5
Is there anything else you would like for us to know or consider?

End Survey. Thank you for your input.
Appendix C: supporting data for survey

Peripheral Technologies to Geographic Information Science

Masters Thesis Proposal
Ashtan Rodgers, CM

Survey Links

- Begin the survey by scanning the QR code or selecting the link, you will be directed to Qualtrics.
- Begin the first page of questions in the survey now.
- After this presentation, use the blue arrow at the bottom of the screen to access and complete the second page of questions.

https://memphis.co1.qualtrics.com/jfe/form/SV_2qWxaU4I61PT1Lo
Course Premise

- Develop a course to encompass important programs that are often encountered by GIS professionals.
- Provide varied training to help students find their interests and minimize learning curves in the workforce.
- Create a single course for professionals returning to school to get maximum exposure to material in the short time they will be in school.

Basis of Project and Research

- Reviewed several surveys taken of the GIS workforce about programs used and proficiency.
- Took notice of reoccurring technologies and software that were largely impactful to workflows.
Programs Chosen

Computer Science Refresher
Python
AutoCAD
FME (Feature Manipulation Engine)

Course Overview

University of Memphis is moving from eCourseware to Canvas, the course is being developed on Canvas as ESC16555 M50.
Module 1: Computer Science

Concepts:

→ Computer components
→ hardware requirements for software
→ data storage

Module 2: Python

Concepts:

→ understanding variables and basic operators
→ visual coding (abstract syntax trees)
→ learning to manipulate code to suit your needs
Module 3: AutoCAD

Concepts:

→ Scale/Georeferencing

→ Layer naming conventions and storage (standards)

→ feature topography (open polygons)

Module 4: FME

Concepts:

→ Basic file translation

→ multistep processing, only one output

→ API to AGOL

→ automation
References


Appendix D: Qualtrics Results Export

Q1 - Highest level of education obtained?

<table>
<thead>
<tr>
<th>Field</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Variance</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest level of education obtained?</td>
<td>1</td>
<td>6</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>61</td>
</tr>
</tbody>
</table>

Field

<table>
<thead>
<tr>
<th>Field</th>
<th>Choice Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>High School</td>
<td>1</td>
</tr>
<tr>
<td>Certificate</td>
<td>0</td>
</tr>
<tr>
<td>Associate</td>
<td>3</td>
</tr>
<tr>
<td>Bachelor</td>
<td>33</td>
</tr>
<tr>
<td>Master</td>
<td>17</td>
</tr>
<tr>
<td>PhD</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>61</td>
</tr>
</tbody>
</table>
Q4 - Age

<table>
<thead>
<tr>
<th>Field</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Variance</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>61</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Field</th>
<th>Choice Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-25</td>
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</tr>
<tr>
<td>26-35</td>
<td>14</td>
</tr>
<tr>
<td>36-45</td>
<td>10</td>
</tr>
<tr>
<td>46-55</td>
<td>14</td>
</tr>
<tr>
<td>56 or over</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>61</td>
</tr>
</tbody>
</table>
Q2 - What is your primary profession (or course of study for current students)?

<table>
<thead>
<tr>
<th>Field</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Variance</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is your primary profession (or course of study for current students)? - Selected Choice</td>
<td>1</td>
<td>7</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>61</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Field</th>
<th>Choice Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geographic Information Systems (GIS)</td>
<td>20</td>
</tr>
<tr>
<td>Architecture</td>
<td>4</td>
</tr>
<tr>
<td>Engineering</td>
<td>10</td>
</tr>
<tr>
<td>Construction</td>
<td>0</td>
</tr>
<tr>
<td>Planning</td>
<td>2</td>
</tr>
<tr>
<td>Computer Science</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>15</td>
</tr>
<tr>
<td>Total</td>
<td>61</td>
</tr>
</tbody>
</table>

Other - Text

Public Safety IT/GIS
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Archaeology</td>
<td></td>
</tr>
<tr>
<td>Geology</td>
<td></td>
</tr>
<tr>
<td>Survey Mapping</td>
<td></td>
</tr>
<tr>
<td>Consulting</td>
<td></td>
</tr>
</tbody>
</table>
Q3 - How long have you been working in your field?

<table>
<thead>
<tr>
<th>Experience</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Variance</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5 years</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>61</td>
</tr>
<tr>
<td>6-10 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10+ years</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have not begun to work</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Experience</th>
<th>Choice Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5 years</td>
<td>11</td>
</tr>
<tr>
<td>6-10 years</td>
<td>9</td>
</tr>
<tr>
<td>10+ years</td>
<td>36</td>
</tr>
<tr>
<td>Have not begun to work</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>61</td>
</tr>
</tbody>
</table>
Q5 - How is GIS related to your primary job function?

![Bar Chart]

<table>
<thead>
<tr>
<th>Field</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Variance</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>How is GIS related to your primary job function?</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>61</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Field</th>
<th>Choice Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>GIS work IS NOT my primary job, I seldom encounter it.</td>
<td>7</td>
</tr>
<tr>
<td>GIS work IS NOT my primary job, but I encounter it often.</td>
<td>22</td>
</tr>
<tr>
<td>GIS work IS my primary job function.</td>
<td>32</td>
</tr>
<tr>
<td>Total</td>
<td>61</td>
</tr>
</tbody>
</table>
Q6 - Are you a student or a teacher?

- Student: 11
- Teacher: 7
- No: 42

Total: 61
Q7 - Please indicate how familiar you are with the following products.

![Bar chart showing familiarity levels for different products]

<table>
<thead>
<tr>
<th>Field</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Variance</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>AutoDesk (AutoCAD, Map3D, etc)</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>61</td>
</tr>
<tr>
<td>Feature Manipulation Engine (FME)</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>60</td>
</tr>
<tr>
<td>Computer languages such as Python</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>60</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Field</th>
<th>Unfamiliar</th>
<th>Somewhat familiar</th>
<th>Knowledgeable</th>
<th>Proficient</th>
<th>Expert</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>AutoDesk (AutoCAD, Map3D, etc)</td>
<td>10</td>
<td>18</td>
<td>22</td>
<td>8</td>
<td>3</td>
<td>61</td>
</tr>
<tr>
<td>Feature Manipulation Engine (FME)</td>
<td>37</td>
<td>20</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>60</td>
</tr>
<tr>
<td>Computer languages such as Python</td>
<td>19</td>
<td>20</td>
<td>9</td>
<td>11</td>
<td>1</td>
<td>60</td>
</tr>
</tbody>
</table>
Q8 - What are your expectations for this training program?

- I have none
- Learning more about other GIS products
- None
- Get a better understanding of GIS applications and how it would integrate into my work.
- NA
Q13 - Was this course relevant to your work?

<table>
<thead>
<tr>
<th>Field</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Variance</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Was this course relevant to your work?</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>29</td>
</tr>
</tbody>
</table>

Field | Choice Count
--- | ---
Yes | 14
No | 4
Unsure | 11
Total | 29
Q14 - Tell us about the quality of course materials.

<table>
<thead>
<tr>
<th>Field</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Variance</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>AutoCAD</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>Feature Manipulation Engine (FME)</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td>Python</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>25</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Field</th>
<th>Poor</th>
<th>Unremarkable</th>
<th>Great</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>AutoCAD</td>
<td>1</td>
<td>12</td>
<td>12</td>
<td>25</td>
</tr>
<tr>
<td>Feature Manipulation Engine (FME)</td>
<td>2</td>
<td>13</td>
<td>9</td>
<td>24</td>
</tr>
<tr>
<td>Python</td>
<td>3</td>
<td>12</td>
<td>10</td>
<td>25</td>
</tr>
</tbody>
</table>
Q15 - If you are/were a hiring authority, would the addition of these skills on a resume influence hiring of a candidate?

<table>
<thead>
<tr>
<th>Field</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Variance</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>If you are/were a hiring authority, would the addition of these skills on a resume influence hiring of a candidate?</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>28</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Field</th>
<th>Choice Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes, I would be MORE likely to hire someone with these skills.</td>
<td>26</td>
</tr>
<tr>
<td>Yes, I would be LESS likely to hire someone with these skills.</td>
<td>0</td>
</tr>
<tr>
<td>No, these skills would not influence hiring.</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>28</td>
</tr>
</tbody>
</table>
Q16 - When during a career do you think learning these skills is most valuable?

As early as possible
As part of Undergraduate work
As part of Graduate work
0-5 years experience in the job
5+ years experience in the job
I would not recommend these skills

<table>
<thead>
<tr>
<th>Field</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Variance</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>When during a career do you think learning these skills is most valuable?</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Field</th>
<th>Choice Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>As early as possible</td>
<td>14</td>
</tr>
<tr>
<td>As part of Undergraduate work</td>
<td>9</td>
</tr>
<tr>
<td>As part of Graduate work</td>
<td>1</td>
</tr>
<tr>
<td>0-5 years experience in the job</td>
<td>5</td>
</tr>
<tr>
<td>5+ years experience in the job</td>
<td>1</td>
</tr>
<tr>
<td>I would not recommend these skills</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
</tr>
</tbody>
</table>
Q17 - What number of person-hours do think proficiency in these programs would save on a weekly basis?

<table>
<thead>
<tr>
<th>Field</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Variance</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>AutoCAD</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>28</td>
</tr>
<tr>
<td>Feature Manipulation Engine (FME)</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>27</td>
</tr>
<tr>
<td>Python</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>27</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Field</th>
<th>None</th>
<th>1-3 hours</th>
<th>4-6 hours</th>
<th>7-9 hours</th>
<th>10+ hours</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>AutoCAD</td>
<td>4</td>
<td>9</td>
<td>10</td>
<td>0</td>
<td>5</td>
<td>28</td>
</tr>
<tr>
<td>Feature Manipulation Engine (FME)</td>
<td>4</td>
<td>11</td>
<td>7</td>
<td>2</td>
<td>3</td>
<td>27</td>
</tr>
<tr>
<td>Python</td>
<td>3</td>
<td>6</td>
<td>10</td>
<td>5</td>
<td>3</td>
<td>27</td>
</tr>
</tbody>
</table>
Q18 - What topics or exercises would you like to see in the AutoCAD portion of this training?

<table>
<thead>
<tr>
<th>What topics or exercises would you like to see in the AutoCAD portion of this training?</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
</tr>
<tr>
<td>AutoCAD basics on how to navigate the software</td>
</tr>
<tr>
<td>I think basic functions are most important if learning in college or sooner.</td>
</tr>
<tr>
<td>Editing &amp; creating</td>
</tr>
<tr>
<td>I don't know</td>
</tr>
</tbody>
</table>
Q19 - What topics or exercises would you like to see in the Feature Manipulation Engine (FME) portion of this training?

<table>
<thead>
<tr>
<th>What topics or exercises would you like to see in the Feature Manipulation Engine (FME) portion of this training?</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
</tr>
<tr>
<td>Example of uses in real life settings</td>
</tr>
<tr>
<td>I do not know what this is</td>
</tr>
<tr>
<td>I don't know</td>
</tr>
<tr>
<td>N/A</td>
</tr>
</tbody>
</table>
Q20 - What topics or exercises would you like to see in the Python portion of this training?

<table>
<thead>
<tr>
<th>Options</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td></td>
</tr>
<tr>
<td>If you're new, basic exercises from start to finish would be helpful.</td>
<td></td>
</tr>
<tr>
<td>Basic</td>
<td></td>
</tr>
<tr>
<td>I don't know</td>
<td></td>
</tr>
<tr>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>
Q21 - How would this course be most effectively taught?

Field | Min | Max | Mean | Standard Deviation | Variance | Responses |
--- | --- | --- | --- | --- | --- | --- |
How would this course be most effectively taught? | 1 | 4 | 2 | 1 | 1 | 27 |

Field | Choice Count |
--- | --- |
In person | 10 |
Online | 7 |
At student's own pace | 5 |
As a short professional workshop | 5 |
Total | 27 |
Q22 - Is there anything else you would like for us to know or consider?

<table>
<thead>
<tr>
<th>Is there anything else you would like for us to know or consider?</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
</tr>
<tr>
<td>Would not let me choose multiple options on the question above but I'm a fan of a mix of classroom/online learning and longer labs/workshops.</td>
</tr>
<tr>
<td>I am learning autocad &amp; python for the first time in my entry level GIS tech job</td>
</tr>
<tr>
<td>no</td>
</tr>
<tr>
<td>Are these software available on campus?</td>
</tr>
</tbody>
</table>
GIS PERIPHERAL TECHNOLOGIES

SECTION 1
INFORMATION TECHNOLOGY REFRESHER AND INTRODUCTION

UNDERSTANDING REAL GIS JOB ENVIRONMENT

- Environmental Protection
- Land Survey and Parcels
- Agriculture
- City and Regional Planning
- Health and Safety
- Government Intelligence
- Architecture and Engineering
- Geotechnical

- Academics
- Utilities
- Aerospace
- Asset Management
- Business Analytics
- Energy
BASIC COMPUTER PARTS

Parts of Computer

Monitor
Mouse
Printer
Speaker
Power Supply
GPU
Hard Disk

https://quicklearncomputer.com/parts-of-computer/
COMPUTER REQUIREMENTS FOR GIS

- Not every laptop is going to run this kind of data and analysis “heavy” program.
- Depends on architecture- Pro vs. ArcMap vs Server (on/off prim) vs FOSSGIS.
- QGIS not specific but suggestions can be found https://gis.stackexchange.com/questions/25177/which-hardware-configuration-is-necessary-for-qgis

HARD DRIVE

- HDD (Hard drive disk)- mechanical component with a spinning magnetic disk, read/write arm. This form of hard drive is old and most newly produced computing machines will use SSD. Highly susceptible to corruption.
- SSD- Solid State Drive, made of flash-memory chips dedicated to long term storage. SSDs are much smaller, light-weight and reliable.
RANDOM ACCESS MEMORY (RAM)

- Short term memory (vs. the hard drive where data is permanently and safely stored when the computer is shut down)
- The processor will be slowed if you do not have enough RAM for the requests you are making (think streaming in HD, 10 Chrome tabs, and running a heavy analytics tool)

MONITOR DISPLAY

- How clearly something can be displayed; for most industries, the standard is Full HD 1080p resolution
- Resolution is measured in pixels (picture elements) to quantify the clarity of an image or video
  
  MORE pixels = HIGHER resolution = BETTER image quality
- Visual resolution depends on the resolution of the content, a higher resolution monitor does not make content higher resolution
- Refresh rates- measured in frames per second (fps), reliant on the processing ability of the CPU and GPU.
GRAPHICS PROCESSING UNIT (GPU)

• Specialized processor to increase the speed and efficiency of image rendering (also called “dedicated graphics card”)

• Two types:
  • Discrete - card and slot style, can easily be removed and added for upgrades, best for resource-intensive computing like image processing
  • Integrated - often included with system at purchase, located on the motherboard

• Helps to take processing load of high resolution, quick refresh off the CPU

CENTRAL PROCESSING UNIT (CPU)

• CPU central processing unit
• Primary memory
• Often found on the motherboard,
• storage

• Again, not the case/tower, which is just a plastic or metal housing unit with no computing power
ARCGIS REQUIREMENTS

Hardware requirements

<table>
<thead>
<tr>
<th>Supported and recommended</th>
<th>ArcMap 10.8x</th>
<th>ArcGIS Pro 2.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAM</td>
<td>Minimum: 4 GB</td>
<td>Minimum: 8 GB</td>
</tr>
<tr>
<td>Hard drive</td>
<td>None required</td>
<td>None required</td>
</tr>
<tr>
<td>Operating system</td>
<td>Windows 7 or later</td>
<td>Windows 10 or later</td>
</tr>
<tr>
<td>Intel Core i7 or higher</td>
<td>Optional</td>
<td>Optional</td>
</tr>
<tr>
<td>NVIDIA GeForce GTX 1060 or higher</td>
<td>Optional</td>
<td>Optional</td>
</tr>
</tbody>
</table>

SERVER AND CLOUD

- Server and Cloud computing removes the strain of computations from your local computer.
- Server computing is a hardware system build for large data computing, much more powerful that even a very well-built desktop.
- Cloud computing removes the storage of the data from your local (on-premises) system, into a large server off location.
- These types of computing are often done by renting space or usage amounts from a large company providing this service. (Amazon AWS, ESRI Server, etc.)
WHAT IS SOFTWARE

- Software or software programs are packaged executable codes which are designed to perform some function
- Examples: Microsoft Word Processor, Adobe Acrobat, Photoshop

SOFTWARE

- The most important software on a computer is the operating system. IOS v Windows v Android
- It is important to know your operating system as it can pose some limitation to other software compatibility.
- This is why some applications are released to one platform before another or exclusively
WHAT IS A DATABASE SYSTEM

- Data - bits and bytes and binary
- Database - collection of information structured and organized similarly to be stored together electronically
- Database System - Database Management System (DBMS), data, and applications which access stored data or commands.
- Application - end user GUI or translation program (software program, website, GIS system, mobile app)

COMMON FILE TYPES

- Keyword for this course is "behavior".
- GIS professionals need to understand how the data is stored and how it behaves when being used so you understand how/why something is going wrong.
- Behavior effects how data is translated and manipulated within a program
ESRI FILE TYPES

- .shp—The main file that stores the feature geometry; **required**
- .shx—The index file that stores the index of the feature geometry; **required**
- .dbf—The dBASE table that stores the attribute information of features; **required**. There is a one-to-one relationship between geometry and attributes, which is based on record number. Attribute records in the dBASE file must be in the same order as records in the main file.
- .prj—The file that stores the coordinate system information; used by ArcGIS. Used in addition to .prj files are .wld3 files for CAD and BIM data.
- .xml—Metadata for ArcGIS—stores information about the shapefile.


FIELD DATA TYPES

- String—text
- Integer—(short or long) whole number
- Float—single precision fractional numeric value
- Double—double precision fractional numeric value
- Character—single letter, number, or symbol
SCARY PART... COMPUTER LANGUAGES

- High-level languages (low-level being hex and binary)
- Like most written languages they have rules called syntax
- To run any code language, you must use the correct language base and rules
- Most have cheat sheets or libraries to reference, so you don’t have to memorize every code option
- Visual learners will like our Abstract Syntax tree

You don’t have to become fluent, but you need to understand the structure for basic tasks.

SENTENCE TREES

ABSTRACT SYNTAX TREE

- Nodes and leaf nodes
- Covered in Module 2, just a brief intro

An abstract syntax tree for the following code for the Euclidean algorithm:

```
while b ≠ 0
  if a >= b
    a = a - b
  else
    b = b - a
return a
```

Module 1 Assignment

Job Variability

Take a few moments and search job boards for 3 GIS related jobs and make a list of the software requirements and suggestions. The goal is to understand the variety of skills used in GIS field.

Use job boards such as LinkedIn, Indeed, and USAjobs to compile the list. Please include the job title, link to the posting, and identify the software programs listed. You may submit your answers in a Word or Excel document.

Points 50

Submitting a file upload
File Types doc, xlsx, and txt

Due For Available from Until
- Everyone - -

+ Rubric
Module 1 Quiz

Quiz Instructions

Question 1
Computer primary memory resides in the CPU, secondary memory is in RAM or external location.
- True
- False

Question 2
What purpose does RAM serve for computing memory?
- Short-term memory
- Long-term memory
- Not a memory function

Question 3
Graphics resolution is measured in pixels.
- True
- False

Question 4
Which of these is a software program?
- Monitor
- Word processor
- Keyboard
- Mouse pad
Question 5

Select all answers which are examples of hardware:

- RAM cards
- motherboard
- email
- GPU

Question 6

The case, or tower, is where information is processed and saved.

- True
- False

Question 7

Pixels are a unit of measure for how clearly an image can be displayed.

- True
- False

Question 8

HDD and SSD are two forms of hard drive.

- True
- False
Peripheral Technologies

Section 2
Python

Program Basics

• What is programming- a way to tell the computer what you want it to do

• What is meant by programming “language”- programming language is like any other language; it is a set of rules that provide context for controlled and comprehensible interaction be it in string or graphical form (Model Builder)
Computing language

- High level programming vs low level programming
  - High level is understandable to humans
- There are many high-level programming languages
  - Python
  - C++, C, C#
  - JAVA or JavaScript
  - BASIC
  - R
  - PHP
- Machine language is hex or binary

Types of programming

- Python is considered an Object-Oriented Programming language
- Means the code is structures around the data elements or objects, and given direction from there (lexically this is like the subject of a sentence)
- Another form of programming language is Functional Programming, which focuses on the application of the command and plugs in data where needed
Libraries and Functions

- Each code language has a library which contains predefined actions for the code.
- A library can also be imported to allow the use of the new tools.
  - ArcPy is an example, which when imported brings the ArcGIS Toolbox functions into the notebook to use as plug-and-play
- These coded words or phrases are called reserved words but often act as functions, and can not be used as variables, and must be carefully used even in a string format to prevent errors in your script
- Some examples of reserved word functions for Python:
  - `print()`
  - `import`
  - `def`
  - “Try” and “except”, or “if” and “else”

Programming vs scripting

Programming Language

- C++ is the programming (system) language for ArcGIS, meaning this is the language used to develop the program
- Programming is the from scratch drafting of a program, all of the software objects and elements are written here.
- Programming often requires a compiler (converts high level syntax into binary)

Scripting Language

- ArcGIS allows scripting with Python among others (VBScript, JavaScript, Jscript, and Perl)
- Scripting is usually a language closer to human-readable
- Used to complete smaller individual tasks within a functioning software, like automation
Model Builder (visual programming)

- Model Builder is often referred to as “visual programming” because you are formatting a string of commands which are programmed into graphical elements
- It requires minimal knowledge of coding to input variables and parameters to create workflows

[Diagram of Model Builder]


Python Notebooks

- Integrated into ArcGIS Pro and easily called by selecting “New Notebook”, in the “Insert” tab
- Calling a Notebook will open a new tab in the “Map View” window
- Notebooks are not live, in the sense that they do not run every line of code as it is entered. It allows you to input all the lines you wish and choose when to run the entire program by selecting the “Run” option

[Diagram of Python Notebook]

Parts of code

- Color coding: (pg 12) key elements will be color coded to differentiate themselves from other aspects of code. The color coding can be different in each program.

- For example, this code clip if from Python IDLE
  - Red - comment
  - Purple - command
  - Green - object (data element)

```python
# Name: Clip_Example2.py
# Description: Clip major roads that fall within the study area.
# Import system modules
import arcpy

# Set workspace
arcpy.env.workspace = "C:/data"

# Set local variables
in_features = "major_roads.shp"
clip_features = "study_quad.shp"
out_feature_class = "C:/output/study_area.shp"

# Execute Clip
arcpy.Clip_analysis(in_features, clip_features, out_feature_class)
```

Lexical analysis

- Object-oriented coding is very similar to spoken or written language
- Code Object = Subject of a sentence
- Functions = Verbs/Actions
  - Some functions are like phrases themselves
    - `print()` - often a check, “Do you understand the instructions so far?”
    - `for loop` - “Please repeat.”
    - `input` = “Teach me about...”
- Comments = facial expressions or inflection, to provide context
**syntax**

- Rules for how the language operates: indents, punctuation, special characters, abbreviations
-Parsed into tokens, which are like sentence elements

---

**Toolbox example (assn)**

- Geo processing tool (from Python for ArcGIS pg9)
- Inputs: variables, parameters
Abstract Syntax Tree

- ASTs can be created within a code which can be useful when troubleshooting, or debugging, a code
- We are going to create a simpler version of an AST by hand
- The left is code requesting and AST for a file, then a short version of the AST
- https://pybit.es/articles/ast-intro/

Abstract Syntax Tree

- This code is a full AST
Abstract Syntax Tree Diagram

• The diagram is a simpler way of looking at the same code

Let's rework the output into a diagram with the following conventions:
  • One rectangle for each node, marking in bold the related node type.
  • Node attributes decorating rectangles are reported in blue.
  • Other node attributes are associated with their type.
  • Nodes are connected based on their attributes.

https://pybit.es/articles/ast-intro/

Abstract Syntax Tree (assn)

• You can run AST self contained but we are going to do a little by hand to help us understand how the code operates.

• Let’s check a tool from ArcGIS and develop an AST module
Learn Python in a Day (assn)

• Chapters 3 and 4, if you are not using a lab computer you may need to use Chapter 2 to download and set up the free IDLE software.

• Download and use the IDLE, a software which allows you to test script without making changes to the system

• Scripts which are not directly input into the IDE/IDLE are drafted and saved in a word processing document with the file type .py (the book describes the specifics in Chapter 2)
Module 2 Assignment 1

Python Programming Structure

Identify the callout areas of the code in the attached file. Python Merge Tool Analysis Assignment stud-2.pdf.

Points: 100
Submitting a file upload

<table>
<thead>
<tr>
<th>Due</th>
<th>For</th>
<th>Available from</th>
<th>Until</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Everyone</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

+ Rubric
Python Merge Tool Analysis Assignment
Fill in this document labeling the parts of the code as learned in the lecture.

# Name: Merge.py
# Description: Use Merge to move features from two streets
# feature classes into a single dataset with field mappings

# import system modules
import arcpy

# Set environment settings
arcpy.env.workspace = "C:/data"

# Street feature classes to be merged
oldStreets = "majors.shp"
newStreets = "Habitat_Analysis.gdb/futrds"
addSourceInfo = "ADD_SOURCE_INFO"

# Create FieldMappings object to manage merge output fields
fieldMappings = arcpy.FieldMappings()

# Add all fields from both oldStreets and newStreets
fieldMappings.addFieldTable(oldStreets)
fieldMappings.addFieldTable(newStreets)

# Add input fields "STREET_NAME" & "NM" into new output field
fldMap_streetName = arcpy.FieldMap()
fldMap_streetName.addInputField(oldStreets, "STREET_NAME")
fldMap_streetName.addInputField(newStreets, "NM")

# Set name of new output field "Street_Name"
streetName = fldMap_streetName.outputField
streetName.name = "Street_Name"
fieldMappings.addOutputField(streetName)

# Add output field to field mappings object
fieldMappings.addFieldMap(fldMap_streetName)

# Add input fields "CLASS" & "IFC" into new output field
fldMap_streetClass = arcpy.FieldMap()
fldMap_streetClass.addInputField(oldStreets, "CLASS")
fldMap_streetClass.addInputField(newStreets, "IFC")

# Set name of output field "Street_Class"
streetClass = fldMap_streetClass.outputField
streetClass.name = "Street_class"
fieldMappings.outputField = streetClass
# Add output field to field mappings object
fieldMappings.addFieldMap(fldMap_streetClass)

# Remove all output fields from the field mappings, except fields
# "Street_Class", "Street_Name", & "Distance"
for field in fieldMappings.fields:
    if field.name not in ["Street_Class", "Street_Name", "Distance"]:
        fieldMappings.removeFieldMap(fieldMappings.findFieldMapIndex(field.name))

# Since both oldStreets and newStreets have field "Distance", no field mapping # is required

# Use Merge tool to move features into single dataset
uptodateStreets = "C:/output/Output.gdb/allroads"
arcpy.Merge_management([oldStreets, newStreets], uptodateStreets, fieldMappings, addSourceInfo)
Module 2 Assignment 2

Learn Python in a Day

Complete Chapters 3 and 4 from Learn Python in a Day book. If you are not using a lab computer you may have to run through Chapter 2 to download and install IDLE.

Submit a Word document with screenshots of your code and the results in IDLE.

Points 100

Submitting a file upload

Due For Available from Until
- Everyone - -

Module 2 Assignment 3

ArcGIS Toolbox Example

Choose a tool from ArcGIS toolbox and copy the Python code into a word document. As we did in the class example, Python Clip Tool, use highlighting or color coding to identify the parts of the code, including variables, parameters.

Points 100

Submitting a file upload

Due For Available from Until
- Everyone - -
Module 2 Extra Credit Assignment

Extra Credit "Cheat Sheet"

This assignment does not count toward the final grade.

Develop a cheat sheet of Python code, syntax, and operators.

A point for every 10 items, up to 10 points.

Points: 10
Submitting: a file upload

Due: -
For: Everyone
Available from: -
Until: -

+ Rubric
Module 2 Quiz

Module 2 Python

This is a preview of the published version of the quiz

Started: May 13 at 11:04 am

Quiz Instructions

1. Question 1
   What type of programming/scripting language is Python?
   - [ ] Procedural Programming Language
   - [ ] Functional Programming Language
   - [ ] Logical Programming Language
   - [ ] Object-Oriented Programming (OOP) Language

2. Question 2
   Is Python a what kind of language?
   - [ ] Machine Language
   - [ ] Assembly Language
   - [ ] Low Level Language
   - [ ] High Level Language

3. Question 3
   The terms scripting and programming are synonymous.
   - [ ] True
   - [ ] False
Question 4

What is the lowest form of computing language: consists of binary?

- English Language
- Foreign Language
- Machine Language
- Object-Oriented Programming Language

Question 5

Python is the programming language of ArcGIS.

- True
- False

Question 6

What is the program which opens a testing environment for your script?

- Jupyter
- Integrated Development and Learning Environment (IDE)
- NotePad
- One Drive

Question 7

What is the file type used to save a Python script?

- .script
- .python
- .py
- .aml
Question 8
1 pts

What is the symbol used to allow the author to make a comment inside a script?

- #
- @
- $
- +

Question 9
1 pts

Which of the following is not a part of Python code:

- variable
- class
- operator
- C

Question 10
1 pts

What will be the outcome of the following script?

```python
>>> print(nothing)
```

- nothing
- space
- new line
- 'nothing'

Quiz saved at 11:05pm  Submit Quiz
PERIPHERAL TECHNOLOGIES

Section 3
AutoCAD

WHAT IS CAD

• Computer-Aided Drafting and Design (CADD sometimes simplified to just CAD) is a system of hardware and software used by design professionals to design and document real-world objects.

• CAD programs are used in industries such as architecture, engineering, and construction (AEC), but also to engineer physical items such as airplanes, dentures, and ceiling fans.

• The programs create scale drawing of real-world feature like parcels, building footprints, and floorplans
CAD SOFTWARE

- AutoDesk is one software company which produces the most common CAD programs. AutoCAD
  - Files types are often native DWG or exported DXF
  - AutoDesk creates a number of CAD programs: AutoCAD, Map3D, Infraworks
  - We will be focusing on AutoCAD

- The second most popular program is Bentley Microstation
  - File type DNG; (or .DNG.PAR for specialty parcel data)

CAD DATA ORGANIZATION

- CAD data is developed and stored differently than GIS data

- A CAD drawing can contain all data on a single layer even mixing feature types
  - polylines, polygons, points but also attributes and symbology

- These files can be translated into feature classes similar to GDB schemas through specialty tools
BEHAVIOR DIFFERENCES IN DATA

CAD
• Usually not spatially referenced
  begins at (0,0,0)
• Free to mix geometry types in a
  single layer
• Perfectly calculated arcs between
  2 nodes
• Uses naming conventions with color
  and line type to classify data

GIS
• Generally tied to a location on
  Earth’s surface
• One geometry type per layer (point,
  line, polygon)
• Number nodes and line segments to
  create an arc-like feature
• Uses tabular data in the form of
  attributes to classify data

TERMINOLOGY

<table>
<thead>
<tr>
<th>AutoCAD</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attribute</td>
<td>A user-defined data element that may be linked to or embedded in another</td>
</tr>
<tr>
<td></td>
<td>CAD object. Often embedded in block or cell definitions to store field</td>
</tr>
<tr>
<td></td>
<td>values.</td>
</tr>
<tr>
<td>Block reference</td>
<td>A user-defined collection of graphic elements and data treated as a single</td>
</tr>
<tr>
<td></td>
<td>element or object, often used to symbolize point features.</td>
</tr>
<tr>
<td>Entity</td>
<td>A generic term used to describe a fundamental component object, usually</td>
</tr>
<tr>
<td></td>
<td>with graphic representation, such as a point, a line, or text.</td>
</tr>
<tr>
<td>Layer</td>
<td>A collection of entities or elements of varied types and styles managed</td>
</tr>
<tr>
<td></td>
<td>and visualized as a named stratum. It usually includes properties such as</td>
</tr>
<tr>
<td></td>
<td>visibility and color and other visual characteristics.</td>
</tr>
</tbody>
</table>

**TERMINOLOGY**

<table>
<thead>
<tr>
<th>AutoCAD</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Properties</td>
<td>Data values that control specific visual characteristics of an entity or element such as visibility, color, and line style.</td>
</tr>
<tr>
<td>Style</td>
<td>A named collection of properties used to classify and define specific geometric and textual elements such as a line style or text style.</td>
</tr>
<tr>
<td>Template file</td>
<td>A drawing file used to store standard styles and common settings intended for reuse in other drawing files. Used by the ArcGIS geoprocessing tool <code>Export To CAD</code> as an optional input parameter.</td>
</tr>
<tr>
<td>XREF</td>
<td>An external drawing file attached to the current drawing file and often used for assembly or overlay purposes. (Think of a read-only layer file in ArcGIS, usually a raster)</td>
</tr>
</tbody>
</table>


---

**ANNOTATION VS TABULAR DATA**

- Page layouts and blocks
DATA INTEGRATION

- Data can be transferred between .dwg and .shp an endless number of times but there is a chance of minor changes to the data which decrease the accuracy over time.

- It is best to work with data in its original format or use a third-party translator like ArcGIS Data Transformation Tool or FME which we will learn in our next section, which are specifically designed to work with data in multiple forms.

CAD INTO GIS

- Like GIS files CAD files come in parts, but the parts are different.
- From catalog you may drag and drop the entire dataset or any individual feature class.
- Unreferenced files will not have .wld or .prj file types.
CAD INTO GIS

Key CAD File Parts
- Annotation - text which can be transferred into attribute data
- Multipatch - entities used for 3D representation
- Point - node or sometimes blocks
- Polyline - lines, polylines, arcs
- Polygon - closed polylines, specialty shapes

EXPLORING CAD DATA (ASSN)

- Check the assignments tab in CANVAS for this assignment
CAD INTO GIS

- CAD data can be directly read without conversion by these ArcGIS program at all license levels
  - ArcCatalog
  - ArcMap
  - ArcGIS Pro
  - ArcScene
  - ArcGlobe

GEOREFERENCING CAD DATA (ASSN)

- Check the assignments tab in CANVAS for this assignment
GEOREFERENCING

- Spatially adjusting a CAD drawing with or without changing the original source data.
- This is usually done as a manual process.
  - Activate the Geoprocessing Toolbar in ArcMap/Pro, then use the displacement links, control points or rotate, shift, and scale the image into place
  - Saving georeferenced work will create a .wld file
- CAD data **CAN BE** created in a referenced x, y coordinate system, it’s uncommon to receive them

BIM VS CAD

- The term Building Information Modeling (BIM) is often used in conjunction or synonymously to CAD, however they serve similar yet distinct functions
- A CAD file is meant to draw that project as it will be when built, sometimes changes will be input as updates occur
- BIM is built on CAD data but is meant to be a living document to help manage a project or building from concept to final days
- Although CAD had 3D options, often floor plans in CAD will remain in 2D where BIM allows fly through and advances specialized data visualization
- Created in a product like REVIT which is also created by AutoDesk
TRANSFORMING CAD DATA (ASSN)

- Check the assignments tab in CANVAS for this assignment
Module 3 Assignment 1

Exploring CAD data in ArcGIS

Follow the instruction in the included document with the data below. Answer the questions and provide your results.

Points 100
Submitting a file upload

Due For Available from Until
- Everyone - -
Exploring CAD data

One of the reoccurring themes of this course is studying data and software behavior. Let’s take a look at CAD data components and learn how CAD data acts in ArcGIS. We are going to look at some parcel data received in CAD form.

Again, unlike a shapefile, drawing files (.dwg) come in multiple parts which are organized by geometry type.

- Annotation- text which can be transferred into attribute data
- Multipatch- entities used for 3D representation
- Point- node or sometimes blocks
- Polyline- lines, polylines, arcs
- Polygon- closed polylines, specialty shapes

When adding CAD data to a GIS map you may choose an individual geometry type to add or select the .dwg and drag into the map area, this will bring all of the associated geometry types in at once. This dwg file is not georeferenced and as such will not come into Pro in the proper location.

Right click the polyline layer and choose “Zoom to Layer”. Open the attribute tables for each layer.

Q1- Which layers have no features in them?
Q2- How many features are in the layer's with data?

There are a few fields which are often in the attribute table for CAD files.

Entity- describes the geometry type
Layer- name of the data layer
Color- describes a specific numeric color in CAD
LineType- describes the features of the line continuous, dashed, dotted
LineWt- is similar to GIS line width point

Often the way to identify different types of data are using the Color, LineType, and LineWt. In a file that has more information you might see something like this. Each line is colored differently based on the type of data, all within the polyline group.

Q3- View the layer properties, in the Source tab what is listed as the spatial reference for this file?
Module 3 Assignment 2

Georeferencing CAD data

Follow the instruction in the included document with the data below. Answer the questions and provide your results.

Due: Everyone
Available from: -
Until: -
Points: 100
Submitting: a file upload

Rudic
Georeferencing CAD data

How to georeference a CAD file. When georeferencing CAD data which are part of the same dwg file, it is important to know that when you create a reference file for one of the feature classes the others will be referenced as well.

Right-click the Map in Table of Contents and open the Properties pop-up. Check the Coordinate Systems tab to find the coordinate system.

Q1: What is the coordinate system of the map?

In the Table of Contents, when you select a CAD feature class a new tab will appear on the ribbon pane, grouped under CAD Layer and tab Manage. The second button in this tab is Georeference, select this option.
Selecting Georeference opens a new tab on the left-hand side named Georeference.

Here you have options to move the layer into the correct position by moving the data by hand or using control point to find matching locations in the new data layer and the base layer.

Move to the bookmark “Memphis International Airport”, using the Map tab and “Bookmarks” in the Navigate pane. This will move the map to the correct location, I have preset for this assignment. Now in the Georeference tab select “Move to Display”; this action brings the unreferenced data on the screen, but still not in the correct location.

When using control points, select Add Control Points. Start with selecting a known area on the unreferenced data layer. Select a couple of known points, then apply by selecting the “Apply” button in the Adjust section of the Georeference tab.

You may need to move and scale the data into the final location.

**Note:** it is very important to know that this type of georeferencing is good for data overlay for quick inspections but is not the most accurate way to reference data.

Now we need to save the new location of the file and create a .prj or .wil file.
Select save on the Georeference tab and save in the same folder as your data to create a permanent reference for this CAD file.

Q2 - provide a screenshot of the new spatial reference for one of the CAD features.

Q3 - Provide a screenshot of the georeferenced map.
Module 3 Assignment 3

Transforming CAD Data

Follow the instruction in the included document with the data below. Answer the questions and provide your results.

Transforming CAD data.docx

Points 100
Submitting a file upload

Due For Available from Until
- Everyone - -

Rubric
Transforming CAD data

For this exercise you are the GIS at a firm and have received a CAD file with buildings that are going to be built. You want to incorporate it into your GIS model of existing buildings, so we are going to transform the CAD data into GIS data. Luckily, this time we have new imagery that shows the new buildings.

Open an map in ArcGIS Pro, and inspect the GIS data.

Q1: How many building are there in the ExistingBuilding.shp?

Next, import the NewlyBuiltBuildings.dwg.

Q2: How many features are in the CAD file?

Notice that there is no option in Geoprocessing for CAD to Feature Class. We will explore this more in our next Module on FME.
Next in the Geoprocessing Pane, search for the CAD to Geodatabase. Open your .dwg file and select this map's geodatabase location. Name the dataset. The spatial reference will automatically set to that of the environment in the geodatabase.

We will use this data in our final project.

Q3: Include a screenshot of your map and Table of Contents.
Module 3 Quiz

Module 3 CAD

Quiz Instructions

Question 1
What does CADD mean?
- Computer Aided Design and Drafting
- Civil Architecture Design Device
- CAD/Regional Drafting
- Computing Aided Development

Question 2
Which of these is not a CADD file type?
- .dwg
- .gif
- .xml
- .sld

Question 3
What is the start location of unreferenced CADD files?
- (0,0,0)
- an arbitrary geometric origin (0,0,0)
- your current location
- sea-level
Question 4  1 pts

AutoCAD annotations are the same as attributes in ArcGIS.

- True
- False

Question 5  1 pts

Which of the following are not a CADD system?

- Civil3D
- Microstation
- AutoCAD
- ArcGIS Inventor

Question 6  1 pts

ArcGIS software will not run CAD files.

- True
- False

Question 7  1 pts

CAD layers can be a mix of geometry types (polyline, polygon) and other data on a single layer.

- True
- False
<table>
<thead>
<tr>
<th>Question 8</th>
<th>1 pts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Once data is in a GIS system it can not be exported to CAD.</td>
<td></td>
</tr>
<tr>
<td>○ True</td>
<td></td>
</tr>
<tr>
<td>○ False</td>
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</table>

<table>
<thead>
<tr>
<th>Question 9</th>
<th>1 pts</th>
</tr>
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<tbody>
<tr>
<td>To create permanent georeferencing you must create a .shp file.</td>
<td></td>
</tr>
<tr>
<td>○ True</td>
<td></td>
</tr>
<tr>
<td>○ False</td>
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<table>
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<tr>
<th>Question 10</th>
<th>1 pts</th>
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</thead>
<tbody>
<tr>
<td>REVIT is a form of CADD data.</td>
<td></td>
</tr>
<tr>
<td>○ True</td>
<td></td>
</tr>
<tr>
<td>○ False</td>
<td></td>
</tr>
</tbody>
</table>

No new data to save. Last checked at 11:08pm [Submit Quiz]
FME

Section 3
Peripheral Technologies

What is FME

Feature Manipulation Engine (FME) created, maintained, and sold by Safe Software®, known for its exceptional flexibility to work in ETL (extract, transform, load)

The purpose of FME is to remove data silos and minimize the time it takes to share data into different formats.

FME claims that the #1 data translation workflow for their users is translating CAD between GIS data.

SAFE SOFTWARE®
Use

Workspace to visually model connections to data and configure the best output for your needs.

Supports 450+ file types

Over 450 transformer tools, not including custom transformers created by users.

Quick Video

- [https://www.youtube.com/watch?v=S8tMsrRlIAA](https://www.youtube.com/watch?v=S8tMsrRlIAA)
**Purpose**

“The world’s most valuable resource is no longer oil, but data.” The Economist, 2017

Data vs Information

“Data is raw and unprocessed, often over-gathered. Information is processed data which provides insight and correlates to action items.”

Created to help the forestry industry to translate maps with minimal loss of information

Mission statement is “To help you maximize the value of data.”

---

**Industry Applications**

**Industry Solutions**

- Agriculture
- Construction
- Education and the Military
- Emergency Services
- Energy
- Federal Government
- Healthcare and Health Technology
- Local Government
- Natural Resources
- Water

**Data Type Solutions**

- AI
- Big Data
- BI
- Business Intelligence
- Cloud
- Cybersecurity
- Internet of Things
- Mobile
- Social Media
- Scientific Research
- Transportation
- Utilities
FME Platform

- Data Integration: Convert and transform data so you can access it easily from a single source.
- Data Transformation: Alter the structure, content, and characteristics of data to make it more useful for your needs.
- Data Validation: Verify the quality of data to make better, more informed business decisions.
- Data Conversion: Configure data for use in specific applications by converting the data format or model.
- Application Integration: Create connections between various applications to allow for direct access to data.
- Spatial Data: Integrate data with spatial data to gain new knowledge about location intelligence.

https://www.safe.com/fme/
Model builder differences

- FME looks and feels like ESRI’s Model Builder
- Different terminology
- Model Builder uses ArcGIS tools to transform data with all of the same limitations.
  - Only tools in Toolbox on ones you have written
  - Tied to license level
  - Must create an output file each time
  - No data inspector
- Model Builder is a data transformer, NOT a data translator
- However, FME is not an analytical tool
Componets of a workbench

Key Transformers


Tester

Attribute manager

JSONExtractor

Spatial relator—similar to spatial join in ArcMap

Coordinate extractor
Notes

ArcGIS Data Interoperability tool developed by FME and has some of the transformative abilities of the desktop program.
Module 4 Assignment 1

FME Basic Training
Exercise 1

FME Desktop Basic Training Course workbook Exercise 1: Opening and Running a Workspace (pg 16-34)

Submit a Word document with screenshots of your completed workspace and results.

Workbook and data is found here: https://wwwSAFE.com/training/recorded/fme-desktop-2019-basic-training/

Points 100

Submitting a file upload

Due For Available from Until
- Everyone - -

Rubric
Module 4 Assignment 2

FME Basic Training Exercise 3

Submit a Word document with screenshots of your completed workspace and results.

Workbook and data is found here: https://www.safe.com/training/recorded/fme-desktop-2019-basic-training/

Points 100

Submitting a file upload

Due: Everyone
Available from: -
Until: -

+ Rubric
Module 4 Assignment 3

FME Basic Training
Exercise 4

FME Desktop Basic Training Course workbook Exercise 4: The FME Data Inspector (pg 60-69)
Submit a Word document with screenshots of your completed workspace and results.
Workbook and data is found here: https://www.safe.com/training/recording/fme-desktop-2019-basic-training/

Points 100
Submitting a file upload

Due For Available from Until
- Everyone - -
Module 4 Assignment 4

FME Basic Training
Exercise 2.2

FME Desktop Basic Training Course workbook Exercise 2: Grounds Maintenance Project: Structural Transformation (pp 97-106)
Submit a Word document with screenshots of your completed workspace and results.

Workbook and data is found here: [https://www.safe.com/training/recorded/fme-desktop-2019-basic-training/](https://www.safe.com/training/recorded/fme-desktop-2019-basic-training/)

Points 100

Submitting a file upload

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<th>Until</th>
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<tbody>
<tr>
<td>-</td>
<td>Everyone</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

+ Rubric

Related Items

**SpeedGrader™**
Module 4 Quiz

Module 4 FME

Started: May 13 at 11:09pm

Quiz Instructions

Question 1  1 pts

What does FME stand for?

- File Model Engineer
- Feature Model Builder External
- Feature Manipulation Engine
- File Manager Excel

Question 2  1 pts

Which of the following is not a major component of FME workbench?

- Python IDE
- Canvas
- Navigator
- Visual Preview

Question 3  1 pts

Which of the following best describes Data Translation?

- A complicated scripting tool
- Conversion of data from one format to another
- Google Translate
- A tool to quality check ASCII data
Question 4
1 pts

What is the limitation of FME Data Inspector?

- It takes a long time to run
- It's just an extra software
- Does not allow application of translators
- Does not open in full resolution

Question 5
1 pts

Which of the following is a workbench file type?

- .dot
- .jnl
- .jsw
- .jsw

Question 6
1 pts

What workbench cache function allows you to group elements, such as readers and transformers, together into categorized units which can be run separately?

- bookmark
- translation log
- feature caching
- workspace

Question 7
1 pts

The user must run the entire workspace each time?

- True
- False
<table>
<thead>
<tr>
<th>Question 8</th>
<th>1 pts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Missing parameters are indicated by what symbol?</td>
<td></td>
</tr>
<tr>
<td>□ yellow exclamation point</td>
<td></td>
</tr>
<tr>
<td>□ upside-down exclamation point</td>
<td></td>
</tr>
<tr>
<td>□ FME Limit</td>
<td></td>
</tr>
<tr>
<td>□ red +c wheel</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 9</th>
<th>1 pts</th>
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<tbody>
<tr>
<td>FME can only be used for GIS and CAD data types?</td>
<td></td>
</tr>
<tr>
<td>□ True</td>
<td></td>
</tr>
<tr>
<td>□ False</td>
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<table>
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<tr>
<th>Question 10</th>
<th>1 pts</th>
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<tbody>
<tr>
<td>What are the 3 types of workflow tools which can be added into a workbench canvas?</td>
<td></td>
</tr>
<tr>
<td>□ Reader</td>
<td></td>
</tr>
<tr>
<td>□ Toolbox</td>
<td></td>
</tr>
<tr>
<td>□ Transformer</td>
<td></td>
</tr>
<tr>
<td>□ Writer</td>
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APPENDIX I: Final Project

For this project you will process some data files using all three of our newly learned skills. You may choose your own project or have data provided.

<table>
<thead>
<tr>
<th>Due</th>
<th>For</th>
<th>Available from</th>
<th>Until</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Everyone</td>
<td>-</td>
<td>-</td>
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</tbody>
</table>

- Rubric

Points: 100
Submitting: a file upload