

# Cyber Infrastructure: Training and Mentoring

A way to engage students in their technology future

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## ABSTRACT

The Cyber Infrastructure: Training and Mentoring (CI:TraM) program is designed to engage with local-area high school students and undergraduates in Las Cruces, New Mexico to teach them technology skills, as well as provide career mentoring. We have seen a variety of results, mostly aligned with the amount of effort and involvement the student demonstrates. As part of the program, students leave behind the “do for me” mindset of high school and early college and enter the “how do I” mindset of successful adults.

CI:TraM is an individualized program designed to give students the freedom to explore career options in-depth, as well as expose students to the technology needed in their desired career choice. Students engage with professionals in possible disciplines to decide their career paths and determine how to reach those goals both academically and financially. Students learn core technology skills, such as Excel, and discipline-specific ones, such as Matlab and Auto-CAD.

The CI:TraM program has helped engaged students to solidify their career paths and feel more confident both professionally and as persons on college campuses. Although longitudinal data is forthcoming, students have identified their believed benefits of the program and its impact on their lives.

## CCS CONCEPTS

• **Social and professional topics** → *Computing literacy; K-12 education; Computing occupations.*

## KEYWORDS

workforce development, K-12 education

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## 1 INTRODUCTION

Mentoring has been widely recognized as one of the key factors contributing to skills development, psychosocial or socioemotional support, and career advancement and success [3]. The *Cyber Infrastructure: Training and Mentoring* (CI:TraM) program is a “Technical Intern” program at NMSU inside the Information and Communication Technologies (ICT) department that targets high school seniors and undergraduates. The program is designed to increase individual employ-ability through career mentoring and increasing a student’s technical skills aligned with their individual career pathway. The mentoring in the CI:TraM program teaches the interns how to use the technical requirements in real job postings to create an individual technology learning plan that involves selecting short-cycle self-guided Tech Training Modules (or Build-your-own modules) to better align their resumes with workplace requirements.

Higher education institutions aim to equip new generations of students with skills and expertise relevant to workforce participation for decades to come, but their offerings sometimes mis-align with commercial needs and new techniques forged at the frontiers of research [1]. The CI:TraM program works to mentor the career-relevant soft skill of ownership by having each Technical Intern take individual control of their own learning, and the program teaches how to acquire and align technical skills to their own career interests. Additional career relevant skills include how to gain and demonstrate work-related communication skills, create a well designed resume and electronic-portfolio (e-Portfolio) to highlight technical and other skills, and actively build a professional network through doing career-advice interviews with professionals in their potential field(s) of interest.

The ability to create a professional network is particularly valuable to STEM students who often have good technical skills, but sometimes do not understand the value of these networks or, possibly, lack the communication skills and confidence to make the connections with people in their field of interest. These connections can lead to acquisition of more field-specific mentors and experience. To optimize field-specific internships [2], both the industry mentor and the academic internship coordinator ensure that the experience offers professional-level experiences while allowing students to make mistakes in the course of the learning experience. CI:TraM ultimately moves the Technical Interns towards obtaining field-specific internships or job shadowing experiences achieved through the students’ own efforts. The development of career-related skills throughout the CI:TraM program advances each intern towards greater career success even in the cases where career goals may shift.

## 2 CI:TRAM PROGRAM DETAILS

CI:TraM is designed to engage local-area high school students to teach them technology skills aligned with career mentoring. The program was piloted with six students from January 2016 to Spring 2017 that were specifically interested in information technology (IT) career pathways. National Science Foundation funding in Summer 2017 allowed the program to expand to serve a variety of STEM disciplines and grew the program from serving a handful of students to serving 30+ students per year. Sixty-one students have participated in the program to date, with interests ranging from strongly centered in STEM to those who are dedicated to the fine arts.

The community consists of a mix of socioeconomic backgrounds due to the presence of a university in an agricultural community, and includes a high percentage of minority groups and with many students being the first to consider attending college. Many of the students cannot afford to ineffectually manage their college experience. The CI:TraM program focuses on STEM students and functions first to explore their future career options. However, those interested in the fine arts not only benefit from their experience, one became an ambassador. This proposed Language and Linguistics student took it upon herself to promote the CI:TraM program and its usefulness to all fields as each is touched by technology.

The CI:TraM program provides a student a core set of technical skills, discipline-specific technical skills aligned with their career of interest, and career mentoring (Table 1). The core technical modules were chosen based on knowledge gaps observed by faculty and other community members and are designed to be completed by the CI:TraM students within several hours. These include how to use collaborative software, Microsoft Excel, and financial accountability. Predetermined career-specific technical skills include cybersecurity, Linux/Unix, and SQL and grew to include, among others, AutoCAD and MatLab as students explored the technology they would need in their careers. In some cases prior training documents were leveraged for the creation of the modules, but often they were new topics taking anywhere from a couple of hours to a couple of weeks to complete by the module creators, depending on the topic and desired depth. As an aspect to career mentoring, the students are expected to interview working professionals, in academia and/or industry both locally and afar, in their designated areas of interest. The program managers discuss how to design emails asking for interviews, how the students should conduct themselves during an interview, and guide them in designing questions. These interviews hone a student's interest area, develop their professional network, and offer opportunities for internships and additional people to interview. Both technology and career modules have the ability to be multi-platform, allowing the students to present both in person (live presentations) and via Canvas (documents and pictures).

## 3 EDUCATOR ENGAGEMENT

Without educator engagement to bring students to the program or retain them through stimulating interactions, the CI:TraM program cannot succeed. We depend heavily on the student-professional interaction for the success of the program and our students.

### 3.1 University faculty engagement

It is sometimes difficult to translate enjoyment for a subject into a career, especially when one is a high school student. As on most university campuses, NMSU faculty are happy to engage with students and provide advice regarding careers, knowledge, and social networking. These interactions allow the students to understand what "a day in the life" of someone is like. We also encourage the students to talk with faculty at other universities if they plan to attend elsewhere, as well as professionals working in the community and industry. These interactions with faculty and community members expose the students to a variety of career choices for any single discipline and sub-discipline.

At the end of each of these interviews, the students ask for advice on additional professionals to speak to, as well as internship opportunities, if a good personality and professional match are found. This not only has the potential to create a more in-depth experience for the students through an internship, but also exposes the students to the life-skill of accepting rejection gracefully. It can be difficult for some, both in the vulnerable act of asking and being declined. How to recover and continue the interaction past the initial interview are also discussed. As the students learn, "it's not who you know, but who knows you, that matters". Continuing the relationship past the initial interview builds future prospects and current ones.

### 3.2 University student engagement

The technical modules that the students use to gain technical skills are envisioned by faculty members, but often created by graduate or undergraduate students. These NMSU students are thus exposed to how to create a module using the NMSU learning management system (LMS), Canvas, and they have to critically think about how to convey information to the high school students. Of the self training technical modules, most were designed by students; a rough 50/50 split of undergraduate to graduate module creators was seen. The quality of these modules were slightly better when created by graduate students, on average, but the undergraduates were either involved in research in a lab or already active members of active outreach groups aimed at younger audiences (ex. Young Women in Computing [YWIC]).

The CI:TraM students are required to take several core modules, including computational thinking, Microsoft Excel, and collaborative software, among others, but are then free to explore a variety of modules or to create their own. This create-your-own type of module is designed to allow self-exploration of a software/technology that a professional has suggested is important to the high school student's desired career choice. As the program was not designed for pre-law students, for example, such students are encouraged to take advantage of this type of module experience. Creating these modules then also allows the next group of high school students to benefit from the experiences of those in cohorts before them and allows the high school students the pride of leaving a lasting impact on and improvement to the CI:TraM program. The "Build Your Own Tech Module" which we added during the Fall 2018 cohort would be a good start, we could improve on the ones that prior students picked for themselves.

### 3.3 High school engagement

For over a decade, the Las Cruces Public School system has had the Academic Career Experience (ACE) program that allows students to experience job sites. It places students on job sites each morning or afternoon for either a semester or all year for a total of 120 or 240 hours of experience, respectively. The program initially focused on trade and medical professionals, but has evolved to encompass other fields. Their partnership with CI:TraM has increased the number of STEM students that consider the ACE program. We have developed a rapport with the leaders of the program and they see the value in the skills, both interpersonal and technical, that the program offers students. The ACE leaders are learning which students gain the most out of participating in CI:TraM.

Some of the skills that the CI:TraM program hones are touched upon by the ACE program as well. Each student has created a resume and mock interview by the end of the ACE program. The CI:TraM students work one-on-one with a CI:TraM program manager and hone public speaking skills every week at the group meeting. This practice, while dreaded by some students, is beneficial in increasing their comfort with answering questions, speaking in front of a group, and engaging with an audience.

## 4 STUDENT ENGAGEMENT

Student engagement is vital for the program and the individual to succeed. The students are intended to work independently as each is pursuing avenues leading to their specific career of choice. If they choose to take full advantage of the CI:TraM program, they will exit it with a better understanding of what they want to do, how they plan to pay for it, what they need to study in school and the certifications they may need, and technical skills related to each of these areas. However, we cannot force students to conduct interviews or participate in the technical modules. The CI:TraM program and ACE do not assign grades. The motivation for these students is a good letter of reference.

The level of engagement is truly dependent on the student and not their intended area of interest. The CI:TraM program has had engineers who chose not to engage and Fine Arts prospective majors who did; prospective NMSU students who chose not to interview persons in their area and students intending to venture out of state that spoke to professionals both on their prospective campuses, as well as NMSU.

### 4.1 Student recruitment

Because student engagement is critical, student recruitment is as well. Student recruitment happens throughout the semester using various methods. ACE has been active for several years; originally focusing on the medical profession, due to established ACE-teacher connections, and trade professions for those who desired to work after high school instead of attending college. The CI:TraM program managers meet with ACE and local computer science and STEM teachers to discuss the program and encourage them to suggest that students join ACE and CI:TraM specifically.

*Student 1: You learn new things, about what you want to do. Gives you more of an insight, rather than just picturing what you want to doing going to college for it.*



**Figure 1: CI:TraM interns working the Tech Day booth**  
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*Student 2: It is one thing to think about what you want to do but then you actually start experiencing and talking to people and see what it takes, I think it's a totally different thing.*

*Student 1: Because you think you want to do something and then you do something and you're like, "oh I like this better." – Two Fall 2017 CI:TraM Students*

Due to these historical reasons, there is a concern by STEM students that ACE is not as beneficial to them as taking a dual credit course at NMSU or the local community colleges, so having a teacher encourage them has a substantial impact in recruiting the type of students that would thrive in CI:TraM. ACE holds events throughout the year as well, where the program managers and former CI:TraM students speak about the program and, if applicable, their experiences to potential students. At these events, flyers are distributed and interested parties are referred to the CI:TraM webpage for more information.

The CI:TraM program appeals to college students as well. With the program in its second year of funding, we have reached out to the campus students during "Tech Day" (Figure 1); an event organized by ICT to educate the campus about the technology and technological research on campus. The current CI:TraM students hosted a booth and had over 20 people who wanted to receive more information. A junior computer science major joined the program in January 2019, before "Tech Day", and two more joined so far at the time this paper was written. One of those joining was a student with a MS in Industrial Engineering that is now working on an MS in MIS, and the other was a MIS undergrad. Both immediately saw the efficacy of the program for their STEM career path. As NMSU undergraduates, these student gain no class credit for participation in CI:TraM and yet they attend the weekly group meetings and engage in interviews and tech modules because they see the value in what they are learning.

### 4.2 Student characteristics

Las Cruces is the seat of the Doña Ana County in southern New Mexico, and, as a border community, Doña Ana County is socially and economically disadvantaged (25.7% of population in poverty). Our population is 67% Hispanic [4], and many of these individuals are first- or second-generation Americans and the first in their families to graduate from college. They often lack role models and mentors that are successful STEM (or other) professionals, and they and their family often do not see the social mobility a STEM

degree can provide. To date, the CI:TraM program has supported 41 minority-students and 26 females. The overlap between these characteristics was 16 students.

In the 1.5 years that the CI:TraM program has been active, we have encountered a diverse group of students. Some have parents that work at NMSU, some are emancipating themselves from their parents, some are surrogate parents to their siblings, and some are young parents themselves. Independent from their home situations, those students who put effort into the program, experience success in it. The CI:TraM program gives them a safe space to explore, make mistakes, and learn how to correct them. The students, through their interviews and hands-on technological experiences, are sometimes made more passionate about their career choice and sometimes realize that exploring other options is of greater merit. The CI:TraM program encourages the students to “own” their futures, and those that do benefit the most from the experience.

During one of the pilot years, two students participated; one female junior with a mother who works on campus and one Hispanic, male senior. The female student returned the following semester and encouraged her friends to join as well; one of these friends was a Language and Linguistics student who became our first “Ambassador”, and another who had firm plans to study virology and became a computer science major after because of CI:TraM. The male student wanted to work in IT, specifically web page design, but didn’t think that designing web pages paid enough to be a career. He was encouraged to explore further and discover what education path would best suit him. Since his time in the program, he earned his AS in computer technology and will be transferring from the local community college to NMSU to pursue a BS in Engineering Technology with the goal of being a networking professional. Both of these students continue to remain in touch with the CI:TraM program mentors.

### 4.3 Student activities

The students are registered as unpaid interns at NMSU, allowing them the same benefits as regular students with respect to access to software, the LMS, and computer labs. The modules in Canvas are both technology- and career-based. The technology modules are divided into core, science, engineering, and cyber-infrastructure support. The career-based modules require interns to work on a professional resume, at least twelve “career advice” interviews per semester, research professional job postings for their field of interest, matching their field of interests to certifications and education required, a detailed plan about how to obtain these including how to pay for it, FASFA, and degree plans.

*You have some other things taught to you that the school won’t ever teach you. Certain things about interviews and stuff like that, a classroom will never teach you. – A Fall 2018 CI:TraM Student*

Those students that are with the program for 2 semesters are encouraged to find job-shadowing opportunities for their second semester. For these students, they sometimes shadow several people or they may delve deeper and work specifically with one person. Most of the students that desire job shadowing or professional mentoring are able to find it. They advocate for themselves during each interview and if they are interested in a particularly difficult-to-find



**Figure 2: Spaghetti Challenge with the 2018–2019 cohort**  
©NMSU

career option in town, the CI:TraM mentors work with the students to find a suitable, although potentially not ideal, placement. The students continue to learn about their desired career path, despite not being placed with exactly that profession.

*I’m enjoying my job shadowing. It’s in the field I like and I’m not just shadowing one person. I’m doing it at the computer center, so there’s several group[s] there. I’m interviewing three different groups with however many people in it. I’ve shadowed like six people so far. One day I’ll go shadow one person, and I’ll just sit back there, and they’ll explain what they’re doing to me. I’m enjoying it a lot. – A Fall 2018 CI:TraM Student*

Even those who are program interns for one semester are encouraged to ask about possible internship and shadowing opportunities if they feel they have a strong interest in a topic or connection with the person. The students are still required to complete core modules, but they are expected to learn technology specific to their field while shadowing and are therefore excused from the non-core tech modules.

Roughly every other Friday, the students engage in a team-building exercise. These are scheduled at a time when most students are available and therefore allows students in the morning and afternoon or full year versus single semester to meet and bond. Activities range from exploring the virtual reality lab on campus, playing in a volleyball tournament, touch football, participating in the “Spaghetti Challenge” (Figure 2), and Pictionary, among others. These interactions encourage friendships and translate into a more cohesive and supportive group, making the times when students spoke in front of their cohort less awkward as well. In addition to camaraderie, these activities also encourage the students to maintain a work-life balance now and into the future.

## 5 OUTCOMES

A total of 61 interns have participated in the CI:TraM program, as outlined below:

- 2016–17 Pre-grant Pilot Program = 6 Interns
- 2017–18 Cohort = 22 Interns (1st year of NSF grant)
- 2018–19 Cohort = 33 Interns (2nd year of NSF grant)

Long-term impact of the CI:TraM mentorship program is not yet available due to the program being less than 2 years old; however, an external evaluator will collect longitudinal data from the 2017–18

cohort during Summer 2019. The data will document the progression of interns towards a previously stated and/or current career goal. However, the external reviewer has already published interim reports based on focus groups conducted with interns towards the end of their CI:TraM experience. The program mentors are not involved in these independent focus groups. Intern feedback in the report indicated that they were gaining valuable career and technical skills reflected in the following benefit categories:

- (1) Scaffold learning of professional skills - They found this scaffold approach particularly helpful for accomplishing "Career Advice" interviews and gaining professional networks.
- (2) Mentoring - Interns describe relationships with CI:TraM leadership as both personal and professional - *this is the definition of strong mentoring.*
- (3) Easing the transition to college - Interns describe being treated like adults with both freedoms and expectations.
- (4) Building new support communities - Interns find they are learning how to build new friendships and work groups with students coming from different high schools.
- (5) Understanding the intersections of computing with other disciplines - Interns are gaining a better understanding of the connections between computing and other fields.

Informal pre/post interviews of interns conducted by program mentors, as well as task deliverables, show a dramatic increase in professional communication abilities, as well as an increase in technical literacy. Between the pre- and post-surveys for the first cohort (Fall 2017–Spring 2018), the greatest growth was in the awareness of statistical and mathematical software, programming, and web-design from never having heard of a tool to a moderate awareness of it. Before the program began, half of the students stated they had networking experience, and after it, 90% indicated experience. This cohort had guided modules that focused on exposure to each of these technical areas/tools. As expected, those who fully participated in the program self-assigned a higher degree of familiarity with any particular technical experience. The second cohort has not finished their year with the program yet and therefore no conclusions can be drawn, yet.

It has been noted by the CI:TraM program managers, as well as the external evaluator and the students, that those with an interest in IT and/or programming (computer science) have a different experience than those who are not, despite a possible interest in STEM. The CI:TraM program mentors tailor to each student's interests, however those with an interest that is more technical sometimes have an easier time working through the tech modules. This is where the create-your-own type of modules become invaluable to the students and incoming students. Although this is an option for CI:TraM students, we have not had many who have chosen this route. This is likely due to the wide array of tech training modules available now. When the program began Fall 2017, the entire cohort of students worked on each technical assignment at the same time. This limited a student's ability to determine what technical skills would be most beneficial to them. For the second year, Fall 2018, the students were asked to complete core modules that taught widely beneficial skills such as financial literacy and Microsoft Excel, and they were then free to choose the non-core modules based on their personal interests. This resulted from a restructuring of

the program that we hoped would benefit the students that were not IT or programming inclined. The evaluation to be performed on this second cohort of students is set to begin at the end of May. Longitudinal tracking by the independent evaluator will provide insight into the long term impact of the CI:TraM program based on the responses of the first cohort Summer 2019.

*I think it's an extremely helpful program overall, because it gives you technical experience as well as career experience, but it's focused on you individually. I think it's one of the most unique internship programs that I've heard about when it comes to career readiness, because it approaches it with that dual track method. I really like how it works and I like the individual plans where they help you focus on what you wanna do specifically, even if they don't know anything about what you're trying to do. – A Fall 2017 CI:TraM Student*

## 6 FUTURE PLANS

As CI:TraM continues to mature, the program managers are looking at how to expand the program into something that non-local students can also participate in. To date, the program has been limited to local public high school students due to the strong relationship with the ACE program which allows the students time during their regular school days. To adapt to one that non-local students can engage in, a summer and mostly online program are being explored as a way to engage with more students across the area and the state. This will also allow non-public school students to attend, as we have also had interest from local private schools. In addition to distance education, reviewing the modules for Quality Matters standards as well as their ability for independent completion is needed to allow students in different disciplines to pursue individualized self-paced modules independently.

To assist with the sustainability of the program, CI:TraM will be run by one or two undergraduate students in Fall 2019 with the current program managers acting as mentors, but stepping back as program leads. This will not only allow the student(s) to grow into a leadership position, but will also increase CI:TraM intern engagement. This phenomenon was evident by the increased involvement of the students when a Business Master's undergraduate student assisted with the program during Fall 2018 and Spring 2019. This undergraduate won the confidence of the students and the rapport built helped improve engagement and intern success. Although former CI:TraM program interns would be ideal in the program manager positions due to their familiarity with the program, the position will be filled by someone who will also benefit by adding this position to their resume and could be a business or communications major.

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**Table 1: Description of offered modules.**

| Module                                 | Type             | Description                                                                                                                                                                                                                          |
|----------------------------------------|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| My Resume                              | Core-Career      | This module is revisited several times throughout the year and results in a polished resume                                                                                                                                          |
| My Mini-Bio                            | Core-Career      | Students essentially develop an "elevator speech". They practice giving these speeches so it becomes second nature.                                                                                                                  |
| Career Advice Interview Journal        | Core-Career      | Describes the interviews each student holds. They describe what they learned and additional interview or job-shadowing leads.                                                                                                        |
| Real Job Postings                      | Core-Career      | Students look at real job postings in their area of interest to determine qualification requirements (skills and education), salary, and whether the job is available in the location they desire to reside.                         |
| My Credential Plan                     | Core-Career      | Students create a plan to achieve the credentials for their desired career, including education needs and how to pay for them.                                                                                                       |
| My e-Portfolio                         | Core-Career      | Students create a webpage they can use to show their skills in a more visual way than a standard resume.                                                                                                                             |
| Final Job Interview                    | Core-Career      | Students are required to find a job posting in their area of interest that they can apply to now and do a mock interview for it. This combines all of the skills learned in the Career-centered modules.                             |
| Evaluate Tech Services for NMSU        | Core-Tech        | To familiarize students with resources on campus, they are asked to explore and review the computer labs and NMSU IT resource web pages.                                                                                             |
| Smart Web Searching                    | Core-Tech        | Students learn where to go for primary research articles and how to think critically about their sources and the data they are presented with.                                                                                       |
| Collaboration Software                 | Core-Tech        | Students explore the various applications that can be used to support collaboration, including conferencing software (Ex: Zoom), document sharing (ex: Dropbox and GoogleDrive), and scheduling software (ex: Doodle), among others. |
| MS Excel                               | Core-Tech        | This module covers both basic and more advanced Excel skills, including formulas, graphing, cell-referencing, etc.                                                                                                                   |
| Financial Literacy                     | Core-Tech        | Students learn about how interest works, develop a realistic personal budget, various financial service products, and the positive and negative effects of credit use their impact on credit histories.                              |
| Computational Thinking                 | Core-Tech        | The modules asks students to demonstrate the ability to abstract, decompose, and recognize patterns in data, develop algorithms, and design and justify a solution(s) to assess a problem.                                           |
| Intro to Raspberry Pi                  | CI-Support-Tech  | Students learn how to use a Raspberry Pi, gain knowledge on Python, and create code to address a chosen project.                                                                                                                     |
| Python Client/Server Application       | CI-Support-Tech  | This module expands Python knowledge and covered networking and socket programming. Students create a Python socket client script and learn how to communicate with a socket server.                                                 |
| Cyber Security                         | CI-Support-Tech  | This module covers virtual machines and hardware, malware, encryption/decryption, password security, and the importance of cyber security.                                                                                           |
| Intro to SQL                           | CI-Support-Tech  | The students learn about relational databases and how to use MySQL to interface with and organize databases                                                                                                                          |
| Intro to Web Design: HTML + JavaScript | CI-Support-Tech  | This module introduces students to HTML, CSS, JavaScript, lists and tables, conditionals and functions, and much more.                                                                                                               |
| Linux/Unix Fundamentals                | Science-Tech     | Students develop a basic knowledge of the command line, how to move around, create files and directories, move these items, text editors, and more.                                                                                  |
| App Inventor                           | Science-Tech     | This module takes advantage of App Inventor to teach user interface components and then covers basic programming elements, event handling, and how to use components of the system.                                                  |
| Symmetries in Nature                   | Science-Tech     | Students dive into how nature is math and how it can be represented by such. They learn about how symmetries in materials influence those materials.                                                                                 |
| Intro to Alexa                         | Science-Tech     | Students learn how to interact with an Alexa and how to code it to perform other functions.                                                                                                                                          |
| Intro to OSG                           | Science-Tech     | Open Science Grid (OSG) is a distributed computing platform. Students learn how to create an account and submit jobs as well as what types of jobs are appropriate to be run on this type of system.                                 |
| Intro to Matlab                        | Engineering-Tech | Students learn about a powerful coding/statistical program and use it to perform computations and create modules.                                                                                                                    |
| Intro to AutoCAD                       | Engineering-Tech | Students learn about the workspace, user interface, and tools to organize and create objects on layers.                                                                                                                              |
| Intro to ArcGIS                        | Engineering-Tech | This module explores how to use ArcGIS, including how to add data to a map, analyzing relationships between data, and digitizing map features.                                                                                       |