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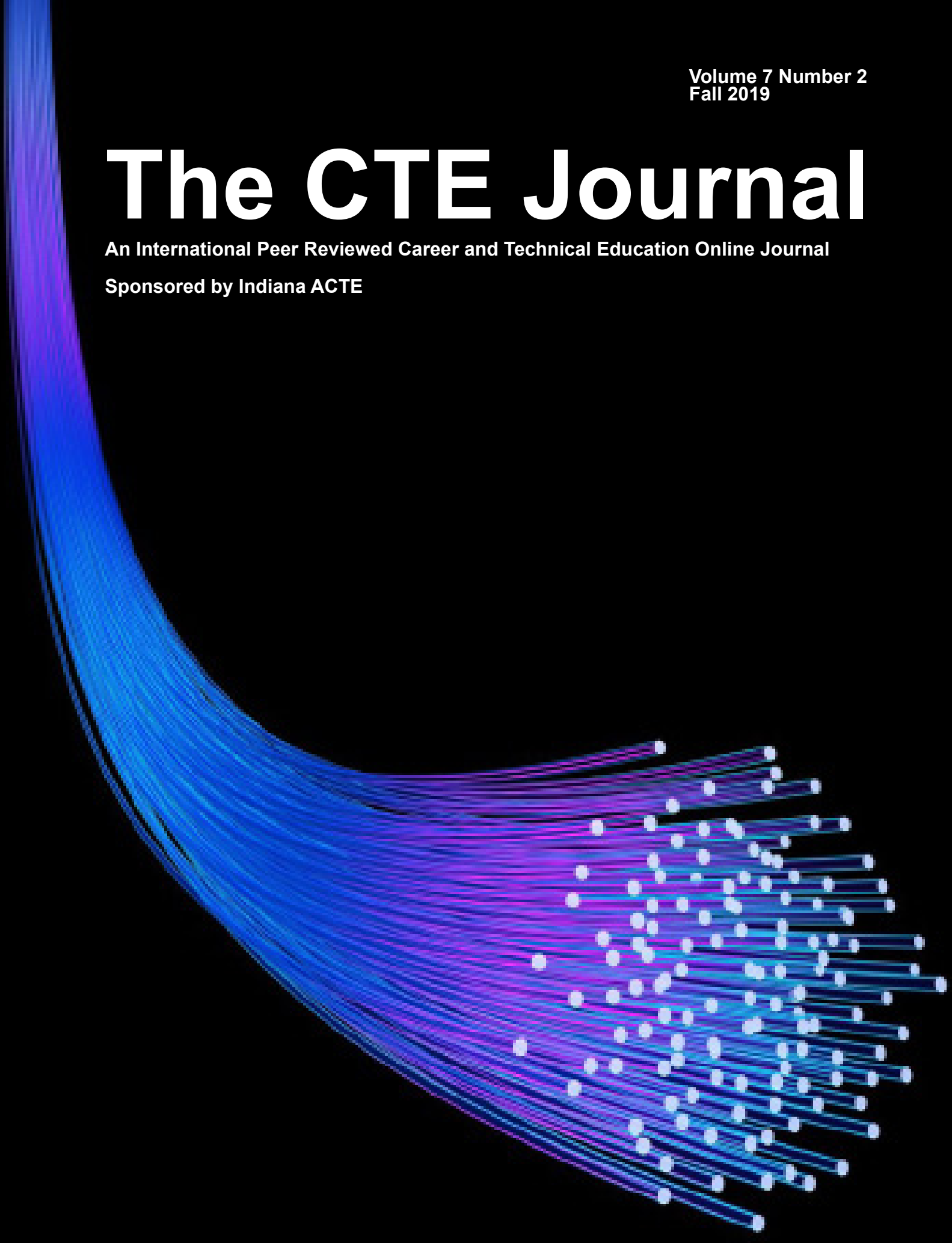

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Learning Analytics and Dashboards for Education Systems

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Abstract
The rapid growth of the usage of learning management systems in the education system is becoming more common nowadays. With easy access to the internet, learners, educators, learning management systems are well connected. Access devices like smartphones, phablets, tablets, wearable devices, smartwatches, all-in-one laptops, etc. are now more affordable than ever. These access devices are promoting online activities. Both learners and educators' online activities generate an enormous amount of data that are traditionally either wasted or dumped into storage devices. Since computing power is continuously evolving and increasing, there are opportunities to process and analyze the data for improving the learning systems. The learning analytics is the process of educational data analysis, data mining, monitoring, assessing, reporting, etc. The result of learning analytics is delivered to the users in a display to a consolidated and arranged display on a single screen so the information can be viewed at a glance called dashboard. This paper introduces blended learning, learning management systems, learning analytics, and learning analytics dashboard that can open a new perspective for educators and education data miners.

Introduction

In the quest of educating learners, various pedagogical methodologies have been researched, designed, and delivered to engage students in learning that is meaningful, relevant, and accessible. Most widely adopted pedagogical method is the combination of the online learning system and in-person classroom learning system called blended/hybrid learning systems. Blended learning (BL) systems incorporate the use of Internet technologies which made the learning environment more realistic, authentic, and engaging. One of the key components of the blended learning system is the educational content delivery using an appropriate learning management system (LMS). LMS is the online environment that allows interaction between educators and learners in virtual space by automating the administration and the management of the courses. The everyday activities in LMS generate massive data which needs to be collected, analyzed, and measured to support the learning process and to optimize the learner's learning ability. The process of extracting useful information from the collected education data emerges as a new area of research field called learning analytics (LA). LA measures, collects, analyzes, and reports learner's data to optimize the learner's learning ability. Reporting of LA is presented to the educators and learners in an application called learning analytics dashboard (LAD) which tracks the learners' activities and visualizes the overall results at a glance.

Blended Learning

The internet and computer technology have become a necessity for everyday activities for all walks of life. Today's education systems have widely adopted and integrated the use of the internet and the computer systems that enables, enhances, and improves the development and delivery of online learning. E-learning, distance learning, remote learning, distributed learning, or web-based

learning are different terminologies of online learning. These many terminologies within this field remain ill-defined (Oliver & Trigwell, 2005). Online learning may be entirely automated, can be accessed at any time, or instructor may be available for interaction online. The interaction between the instructor and learners online at the same time, often called online live course learning. According to the Babson Survey Research Group Report, online learning is defined as one in which at least 80 percent of the course content is delivered online (Allen & Seaman, 2014). In-person classroom learning includes 0 to 29 percent of the content delivered online including both traditional and the web facilitated courses. The blended course learning has between 30 and 80 percent of the course content delivered online. However, there is a number of definitions of these terms (Oblinger & Hawkins, 2005; Dublin, 2003).

Blended learning is an integration of in-person classroom (face2face learning) learning and online learning (Graham, 2013). There are many definitions of blended learning (Oliver & Trigwell, 2005). According to the U.S. Department of Education BL is defined as "a combination of online and in-class instruction with reduced in-class seat time for students" (Lewis & Parsad, 2008). Though it has many definitions, it can be said that it is a technology-assisted and computer-driven learning process to enhance and accelerate the learning process. So, this method requires a computer application called the learning management system.

Learning Management System (LMS)

Learning management system is a core component of blended learning for content delivering, tracking, and managing training activities. LMS usually provide learners with various resources types including graphics, quizzes, forum discussion boards, simulations, rich multimedia contents, etc. Traditionally standalone software systems are used for creating and managing learning materials, delivering statistics and keeping track of the user's personal data. The data exchange between traditional standalone software systems can become cumbersome. This causes 24/7 availability issues and lowers the overall training speed and efficiency. LMS comes and plays a central role of integrating existing standalone software to a centralized system ensuring 24/7 availability over the internet to ensure a simple training process for all participants, providing electronic repositories of learning materials, and offering features for online collaboration. When all training related resources are stored and managed by a single software system, it eases administration as well as it enhances easy access and streamlines training process ("Important LMS features for Blended Learning", 2017). LMS software has been embraced by many institutions. Based on Edutechnica (LMS Data - Spring 2019 Updates, 2019), Blackboard Learn and Instructure Canvas have been widely adopted by more than a thousand universities which are clearly visible in Figure 1.

	Blackboard Learn	D2L Brightspace	Instructure Canvas	Moodle	Sakai	Other
Institutions	1062	381	1050	607	85	257
	30.9%	11.1%	30.6%	17.7%	2.5%	7.5%
Enrollments	6,184,074	2,215,737	6,647,255	2,325,467	622,115	745,388
Average Size	5823	5831	6337	3831	7319	2900

Spring 2019, aggregate 500+ FTE students, www.edutechnica.com

Figure 1: Higher Education LMS Market Share, Spring 2019 (LMS Data - Spring 2019 Updates, 2019)

Popular LMS software platforms are listed below:

a) Blackboard
b) Moodle
c) Canvas
d) Desire2Learn
e) ANGEL
f) Sakai

Learning Analytics

Learning analytics (LA) is a multi-disciplinary field involving machine learning, artificial intelligence, information retrieval, statistics and visualization (Chatti et al, 2012). It deals with the development of methods that harness educational data sets to support the learning process. The early definition of LA by first International Conference on Learning Analytics and Knowledge as "the measurement, collection, analysis, and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs" (Learning Analytics and Knowledge, 2010).

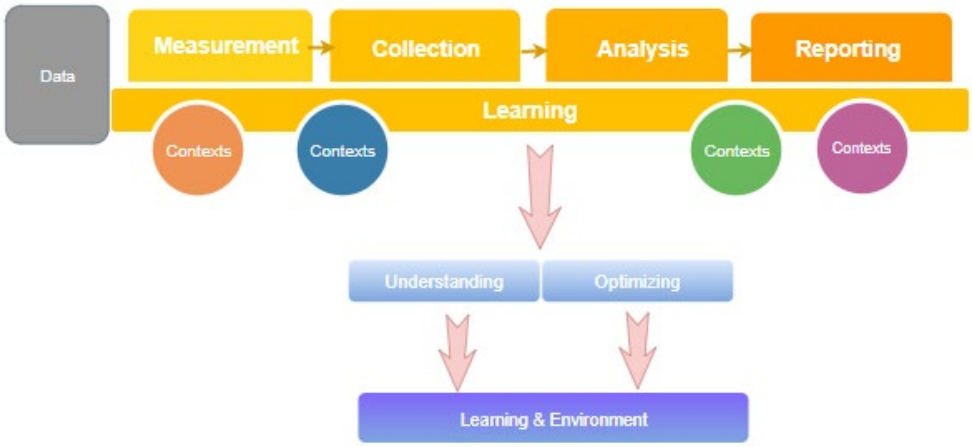

Figure 2: Learning Analytics

LA concepts and methods are drawn from a variety of related research fields including academic analytics, action research, educational data mining, recommender systems, and personalized adaptive learning (Chatti et al, 2012).

There are two primary features of learning analytics (Welsh, n.d.):

a) the leveraging of data management systems to effectively collect learner data in a timely fashion, and
b) the utilization of analytic tools and techniques of other disciplines to interpret the data.

Learning Analytics Process

Learning analytics process has three major steps (Chatti et al, 2012):

a) Data Collection and Preprocessing
b) Analytics and Action
c) Post-Processing

Data collection is the first step in learning analytics. Most often raw data contain unnecessary or irrelevant data for the processing which needs to be filtered, trimmed or normalized to convert into suitable data set or format and to avoid unnecessary computing processing overhead called preprocessing data. Preprocessed data is analyzed to explore the hidden pattern on the data set, to extract the meaningful information. The meaningful information is used for assessment and feedback, adaptation, personalization, recommendation, reflection, monitoring, etc. Post-processing of data is performed for continuous improvement of the LA cycle by refining data set, determining new attributes required for the new iteration, identifying new indicators/metrics, modifying the variables of analysis, or choosing a new analytics method (Chatti et at, 2012).

Benefits of Learning Analytics

By leveraging learning analytics, learners, educators and administrators can improve learning and course outcomes, and develop more engaged and effective teaching and learning techniques. Learning analytics provides feedback to individual learners and faculty but can also surface trends across schools or other scopes of interest, for example within specific programs, subject disciplines, class sizes, or other contexts (A Transformational Methodology to Education, n.d).

The key benefits of learning analytics (Learning Analytics, 2018):

a) institutional administrators to take decisions on matters such as marketing and recruitment or efficiency and effectiveness measures,
b) individual learners to reflect on their own achievements, course contexts, and patterns of behavior in relation to others,
c) educators to get engagement trends and course material effective in the classes they teach,
d) educators and support staff plan supporting interventions with individuals and groups,
e) functional groups such as course teams seeking to improve current courses or develop new curriculum offerings.
f) administrators for offering perspective on activities and outcomes in programs, departments, and curricula they direct
g) school Administrators in offering perspective on trends and impacts supporting decisions of broader oversight and investment
h) instructional designers and support staff to provide perspective on the impact and effectiveness of online course design choices
i) analytics questions, insights, and perspective from each audience help inform and guide the fashioning and offering of integrated analytics to each of these analytics audiences.

Learning Analytics Dashboard (LAD)

Learning management systems produce many educational data sets. These data sets are analyzed using various learning analytics methods. The result of the analysis needs to be presented in a useful way at a glance called a snapshot. These snapshots of the overall progress of the learner's activity and necessary action items are presented in a dashboard view. A dashboard is a visual display of the most important information needed to achieve one or more objectives; consolidated and arranged on a single screen so the information can be monitored at a glance (Few, 2007). It

presents large amounts of data in a way that supports exploration by both teachers and learners (Verbert, Duval, Klerkx, & Govaerts, 2013).

Dashboards are used in many applications. When they are used in education or learning analytics contexts, they are called learning analytic dashboards (LAD). These dashboards can be categorized in many ways based on the context of the application. Volaric & Ljubic (2017) considers the dashboards that can be generally divided into three types:

a) dashboards for teachers only,
b) dashboards for teachers and students, and
c) dashboards for students only.

Joris, Katrien & Erik (2017) categorizes dashboards as:

a) Dashboards that support traditional face-to-face lectures, to enable the teacher to adapt the teaching, or to engage students during lecture sessions.
b) Dashboards that support face-to-face group work and classroom orchestration., for instance by visualizing activities of both individual learners and groups of leaners.
c) Dashboards that support online or blended learning, an early famous example is Course Signals that visualizes predicted learning outcomes as a traffic light, based on grades in the course so far, time on task and past performance.

According to Jacques H., & Shawn G. (2017), a well-designed dashboard, applied with human factors principles, data analytics, and visual analytics, should produce its most noteworthy following advantages:

a) All visualizations need to fit on a single screen
b) Displays the most important indicators to be monitored over time
c) Periodic, on-event, or on-demand updates of data
d) Should be easy to understand, should have less information complexity, and used by anyone with access
e) Reduce the number of alert conditions and instead improve the differentiation of alerts
f) Aggregate and integrate disparate information
g) Include analysis of past performance
h) Ensure visual salience (the ability to focus on the right things for the right reason at the right time)
i) Ensure a match between information and its visual representation (the right kind of graphic for the right kind of data)
j) Direct expression of quantitative measures of performance
k) Ensure coherence and understanding of overall context of activities
l) Should provide customization often like filtering and ‘drill down’ functions which enables users to view the data of most interest to them (e.g., filtering by location, age or gender). The visualizations then update to display only data that meet the characteristics chosen. (Data Dashboard, n.d.):

LAD is an interactive, historical, personalized, and analytical monitoring display that reflects students’ learning patterns, status, performance, and interactions. The outlook of LAD includes visual elements such as charts, graphs, indicators and alert mechanisms (Podgorelec & Kuhar, 2011). Information visualization in LAD tries to influence the users' psychologies and actions to

drive effective teaching and learning. Screenshot of MicroStrategy demo dashboard is shown in the following Figure 3.

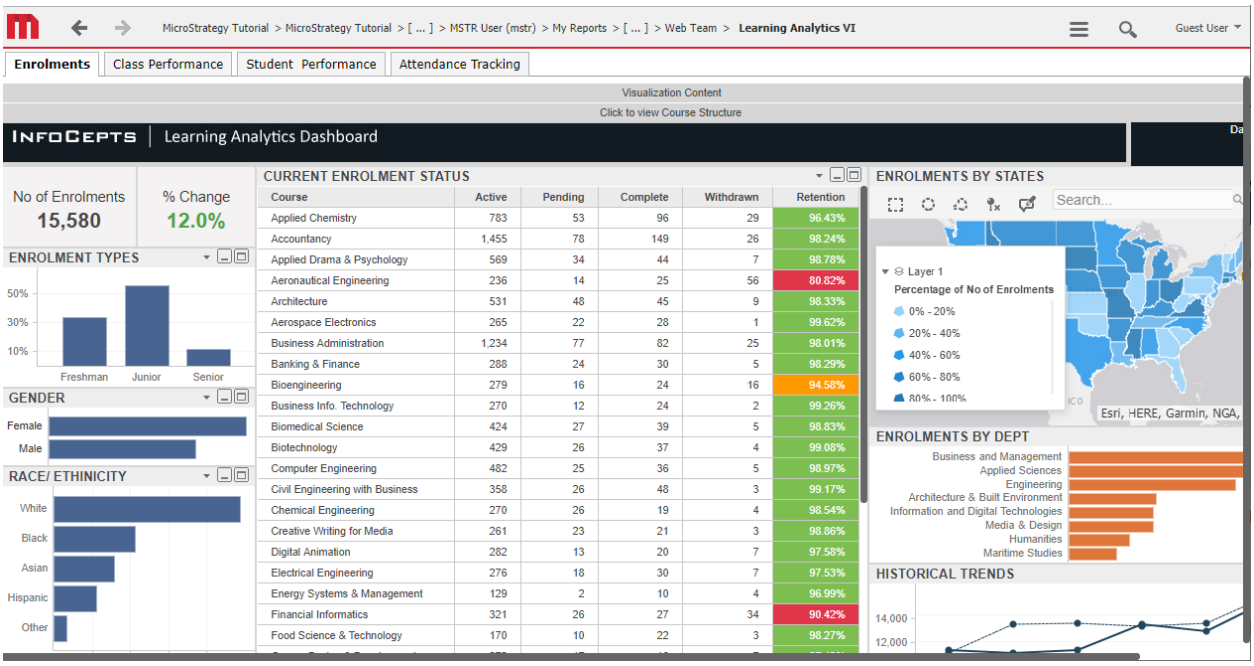

Figure 3: Learning Analytics Dashboard (n.d.) *MicroStrategy* Analytics and Mobility. Retrieved May 12, 2019 from https://www.microstrategy.cn/us/dashboard/learning-analytics-dashboard

Learning Analytics Challenges

There are several challenges that limit the wide adoption and use of leaning analytics. LA challenges are about data tracking, data collection, data analysis, a connection with learning sciences, learning environment optimization, emerging technology, and ethical concerns regarding legal and privacy issues pertaining to the use of student's data.

Some of the major challenges are:

a) focused mainly on technical aspect of LA rather than pedagogical focus
b) focused on the needs of institutions rather than focus on the learners' perspective
c) limited availability of staff and technology dedicated to LA
d) lack of training and educators reluctancy to adopt LA
e) lack of resources availability and budget allocation for LA
f) the analysis of different learning strategies and products in learning analytics research has not received much attention (McNamara et al., 2014)
g) some instances of LA provide summative data which is insufficient to reflect a clear picture of students' academic performance and learning process (Rogers et al., 2016)
h) is often difficult to operationalize and limited in providing an accurate description of all learners (Ellis, 2013)
i) the technical and analytical challenges posed by enormous amounts of unstructured data when using a scalable approach to improve students' learning (Wang, 2016)
j) lack of leadership capabilities to guarantee the implementation of LA in the environment of the institution (Leitner et. al., 2019)

k) gaps between the various stakeholders within institutions with regards to understanding LA causes a barrier for the institutional acceptance of LA (Leitner et. al, 2019)
l) lack of LA Specific Policies and regulations regarding data and ethics, however, few institutions have codes of practice for LA. This lack of clear guidance regarding a practice needs to be addressed (Leitner et. al, 2019).

Future of Learning Analytics Dashboards

The traditional instruction has a paradigm shift due to the proliferation and adoption of learning management systems. The computer-assisted learning is advancing continuously adapting the latest advancements in hardware and software technologies. The capabilities of computers, connectivity to web-delivered content, and rich multimedia content, animated and augmented content, interactive educational video games, simulation, have provided considerable potential for the enhanced learning environment in unlimited course contexts. The rapid growth and popularity of LMS system opened many opportunities in the self-paced customized and immersive learning environment. Learning analytics and dashboard integrated with the university curriculum are available that allows accessing many features like reminders, flashcards, practice quizzes, progress reports, etc. in real time in any device.

Conclusion

In this paper, blended learning, learning management system, learning analytics, and learning analytics dashboard for education where discussed. We started by briefly describing how blended learning leads to learning management systems which have grown tremendously over the past decade and embraced by many higher education institutions. In the latter part of this article, we discussed the benefits of learning management systems, learning analytics, and learning analytics dashboard and their challenges in adopting and updating to new technology for the education system.

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Biological Technician Career Path Exploration

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Introduction

This article focuses on providing factual information regarding a career in biological technology as a biological technician. Prospects interested in such a career may find the information provided as helpful. The following information regarding biological technicians will be presented in this order: responsibilities, how to gain employment, pay and benefits and job outlook.

Responsibilities of Biological Technicians

Biological technicians work in laboratories and assist biologists and/or other scientists to conduct laboratory experiments and examinations. Biological technicians are responsible for gaining detail-oriented skills for conducting experiments, collecting data and analyzing the results of the experiments. They are responsible for the set-up, maintenance and cleanliness of the laboratory instruments and equipment. The instruments and equipment can vary depending on the complexity of the experiment being tested. Technicians gather and prepare different types of biological samples such as bacterial cultures for laboratory analysis (Department of Labor, 2015). Biological technicians can also work with animals and/or other specimens when gathering data (Biological Technician Job Description - Part 1, 2016). After the samples are prepared, biological tests and experiments can be conducted. Once the experiment is conducted, it is the biological technician's responsibility to observe and analyze the results. After the analysis, biological technicians document their findings in raw data form, then later write a report summarizing their findings. These reports include a procedures, observations and results section, so that it makes it easy to read for other technicians and scientists (Department of Labor, 2015).

Most of the time, biological technicians work in teams to conduct experiments. Since biological technicians assist biologists or other scientists, they are supervised and evaluated by the scientists. Biological technicians have the opportunity to work with traditional laboratory equipment as well as advanced equipment. Some of the advanced equipment used by a technician can include advanced robotics and automated equipment. The use of computers is also common with technicians and there is specially developed software to assist technicians with the collecting data, analyzing data, and creating model experimental data (Department of Labor, 2015).

On special occasions, biological technicians may be required to conduct research for their experiments out in the field. When conducting research in the field, technicians are responsible for hiking long distances and gathering data. Ways to collect data in the field can be various samples taken from the environment or from the wildlife, tracking wildlife with GIS (geographic information system) and/or making observations (Department of Labor, 2015).

How to Become a Biological Technician

Completing high school or receiving a GED and achieving a bachelor's degree in biology or a closely related field is necessary to become a biological technician. There are several qualities

needed to be a successful biological technician. Some of these qualities are problem-solving skills, communication skills, analytical skills, and technical skills (Department of Labor, 2015). There are other skills that are needed to be successful such as time management, instructing others, and quality control analysis (Biological Technician Job Description - Part 1, 2016). Several universities provide a program for students to receive a bachelor's degree in general biology. Dependent upon the university, students can receive bachelor's degrees in ecology, microbiology, and physiology. In addition to biology courses, courses in chemistry, mathematics, English, and physics are often required. Taking electives in computer science courses can be useful for the learning of modeling system, simulations of biological processes and how to operate computer dependent laboratory equipment. Internships and classes that offer involvement in a laboratory setting are highly recommended in order to gain experience for future employment in the field (Department of Labor, 2015). Taking other electives that are related to biology can later help specialize on the research and experiments that students wish to conduct.

There are several organizations that allow biological technicians to keep in contact with other professionals in the field and allow technicians to keep knowledgeable with what is happening and developing in the scientific society. Some organizations that help serve biological technicians is the American Society for Biochemistry and Molecular Biology, the American Society for Cell Biology and the American Society for Nutritional Sciences (Biological Technician Overview, 2007). The American Society for Biochemistry and Molecular Biology serves as an organization that allows technicians and other related occupations to become members, make publications, attend conferences and posts possible careers (About Us – ASBMB, 2015). The other organizations listed have a very similar service for biological technicians and other related occupations.

Prior to considering a career as a biological technician, the work environment should be considered. Many positions for biological technicians are held within colleges/universities, the federal government and chemical manufacturers. Most biological technicians work in laboratories and offices to conduct experiments and analyze the results and most work together as a team. Some technicians get a chance to conduct fieldwork so exposure to the weather and wildlife is a risk. Biological technicians also have to follow stringent measures in order to not contaminate the experiment. Depending on the experiment and research being conducted, technicians must exhibit precaution when handling dangerous organisms and/ or toxic substances (Department of Labor, 2015).

Pay and Benefits for Biological Technicians

An annual median wage for biological technicians was observed in May of 2014 to be $41,290. The range of salary per year was from $26,300 to $67,920. In May of 2014, chemical manufacturing was the industry paying biological technicians the most in salary, $47,280. College/universities paid biological technicians an estimated $38,920 to $42,510 in May of 2014. The federal government paid technicians $36,440 in annual salary in May of 2014. One benefit that biological technicians receive is working regular hours (Department of Labor, 2015). For the biological technicians that have the opportunity to conduct fieldwork, they get to experience nature connectivity. Nature connectivity is very beneficial both psychologically and gives comfort in the meaning of life (Howell, Passmore and Buro, 2013).

Job Outlook for Biological Technicians

From 2014 to 2024, employment is projected to increase about 5%, which is about average for all other occupations. As biotechnology develops further, the demand for technicians will increase. The job market for biological technicians is very competitive so experience in a laboratory setting prior to employment is ideal. Employment data projections for biological technicians from 2014 to 2024 were taken and in 2014 there were 79,300 individuals that were employed as biological technicians. By 2024, there is an estimated increase to 83,500 positions. That is a difference of 4,100 or an increase of 5%. This means that in 2024 there will be 4,100 positions available for people who are interested in being employed as a biological technician (Department of Labor, 2015).

Interview with Kristi Confortin at Ball State Univeristy in Muncie, Indiana

Kristi Confortin is a M.S. Candidate and is also the Chair-Elect of the Student Development Working Group for The National Wildlife Society. She conducts her research on the Eastern Small-footed bat summer roosting ecology in the Shawnee National Forest in Sothern Illinois. She is in the Department of Biology at Ball State University in Muncie, Indiana (See Figure 1). Krisit Confortin was interviewed by Dr. Edward J. Lazaros, Angela Gervais and Mary Pat Stemnock on April 19, 2016. In the following section, you can read the questions that Kristi was asked about her career, and you can read her responses:

Figure 1. Kristi Confortin holding radio telemetry equipment.

What kinds of fun technology do biological technicians get to use?

"The technology we use most frequently in our research is telemetry. Telemetry is when you attach a transmitter to any type of species; including small mammals such as bats or birds, fish, and even large animals such a white tailed deer, bear, cheetahs and elk. Telemetry is a very common technique used in the wildlife field" (K. Confortin, personal communication, April 19, 2016).

"When studying bats with telemetry, the transmitters has to be less than five percent of the bat's body weight. Hair is removed from the back between the shoulder blades and then the transmitter is placed on with surgical glue. The bat is track usually between 7-21 days until the transmitter falls off or the signal is lost. The transmitter sits on the bat similar to a backpack (See Figure 2). *The transmitter is comprised of a battery, casing, and wire. The transmitter sends its own frequency to the receiver. We dial the frequency into the receiver* (See Figure 3) *and that's how it picks up the signal. For example, if the transmitter is labeled number 241, that's the number of the frequency you enter. This way, you can have five different bats with transmitters at a time all with different frequencies"* (K. Confortin, personal communication, April 19, 2016).

Figure 2. Eastern small-footed bat with a transmitter attached.

Figure 3. Tracking receiver with frequency gages and cable hook-up for the antenna.

"Along with the receiver, you also need a cable and an antenna (See Figure 1). *Each day we used the telemetry equipment to find the roosting location of the individual bat* (See Figure 4). *The higher the beep from the cable and antenna, the closer the bat is. When you're down to the minimum gain on the receiver, that's how you know you're getting closer to the bat."* (K. Confortin, personal communication, April 19, 2016).

Figure 4. Eastern small-footed bat with transmitter on its back working with the receiver to make sure the frequency is working before the bat is released.

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"The purpose of our research is to learn where this species of bats are roosting during the day. Most bat species roost in trees during the day to sleep and then come out at night and to forage, search for insects. In our study the bats are using rocks as their roost. Its important for land managers to understand what kind of trees or rocks the bats are using. The transmitter helps us find where the bats are and report what kind of roosts the bats are using. A lot of bat populations are declining and some are even becoming threatened or endangered due to white nose syndrome so researching where bats roost is crucial to their survival" (K. Confortin, personal communication, April 19, 2016).

"When collecting data for bat that use trees as roost, we collect what species the tree is and the diameter and breast height (DBH), how tall the tree is, how tall the roost is. We also write down if the tree is dead or alive. Also we collect, how much vegetation is around it, and the amount of canopy cover. There are many factors to take note of" (K. Confortin, personal communication, April 19, 2016).

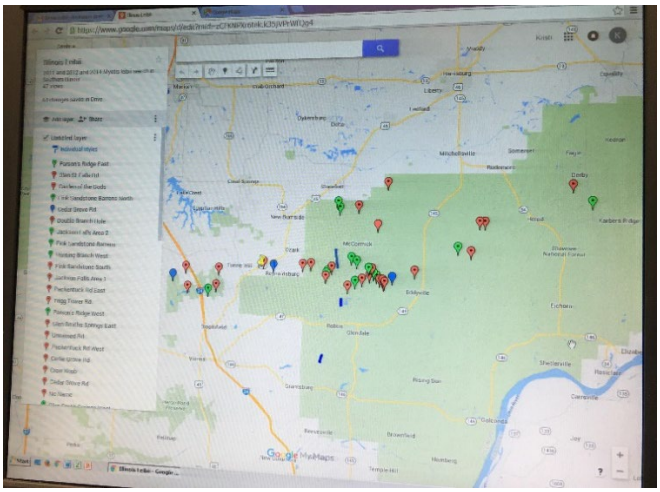
"The bat that I'm researching for my master's thesis roost under rocks on rocky outcrops in the forest. This species is the Eastern small-footed bat (See Figure 5.). *I use telemetry to track the bat's movement across the rocky outcrops. I am hoping to find out why this bat is choosing rocks and learn more about their roosting ecology. Once a bat is tracked to a rock, we then record the length, width, height, percent bare rock under the roost, and its surrounding microhabitat"* (K. Confortin, personal communication, April 19, 2016).

Figure 5. Eastern small-footed bat roosting in a rocky outcrop.

"We use a meter tape and visual cues to determine canopy cover and amount of vegetation around the roost. We record all data onto a data sheet. Then the data collected goes right into excel, and then I use R-Studio, a program for statistics. It allows me to run all of the data and break it down. We also use ARCGIS to map all of the roosts" (K. Confortin, personal communication, April 19, 2016).

"All of the dots on the map represent rocky outcrops. The green area is Shawnee National Forest (southern Illinois) where the research is taking place. Red points mean that bats are not there. Blue means we still have to go look, and green dots mean there is a presence of bats at the location (See Figure 6). *We update this file every year for records for the US Forest Service*" (K. Confortin, personal communication, April 19, 2016).

Figure 6. Map showing the presence or absence of Eastern small-footed bats and locations that still need to be examined for these bats for data.



What's your favorite part about being a technician?

"My favorite aspect of the job is knowing that you're contributing to a bigger picture. In recent years bats have been declining rapidly, new information is helping to conserve their species. The public also has a negative awareness of bats and it's rewarding to teach them about the facts and their ecosystem. Being outside and in nature is also really important to me. It doesn't feel like work at the end of the day. I want to be out there and conducting my research. In 2016, we're still learning about this species so it's interesting and fun" (K. Confortin, personal communication, April 19, 2016).

What would you say has been the most challenging thing a student/recent graduate will encounter when trying to break into this industry?

"The biggest challenge is that students don't get started early enough. A lot of people focus on being book smart, but you need to take advantage of clubs like the Wildlife Society and really get involved. If you aren't going out there and networking, you may struggle because this field is getting more and more competitive. In the summer, go out and take field jobs. Be ready to travel and take opportunities. Anything that can expand your resume is helpful. It's not bad to be

competitive because it's what you have to do. Having a good mentor can also benefit students" (K. Confortin, personal communication, April 19, 2016).

What kind of experiments and research have you been involved in?

"I'm originally from New York and got my undergraduate degree at State University of New York at Cobleskill. I had a great mentor there and I got involved and stayed active. I volunteered while I was there with any student who was doing research. Each summer, I went out and did field jobs. I've worked with bats previously. Where I then discovered my passion with them and knew this was the species I wanted to work with in the future" (K. Confortin, personal communication, April 19, 2016).

"I've also been exposed to bird banding. This is where we set out traps or mists nets and apply bands to birds for identification purposes. This is helpful for songbirds and ducks, as the information goes into a national database. Organizations and people can use the band to identify the bird and track where it travels. Another one of my research experiences was doing telemetry with fawns. We were looking at their movement between rural and urban areas and trying to find if in-town fawns were living longer than fawns in the woods exposed to natural predators" (K. Confortin, personal communication, April 19, 2016).

Conclusion

Entering into a career as a biological technician may be worth considering for those who are interested in working in the biology field after receiving an undergraduate education or during graduate education. With the projected employment growth being average, it is expected that the career is and will continue to be available for the future. With any career choice, it is important to closely evaluate all of the options, such as work environment, and pay and benefits. For those who are potentially interested in this career field, it would be prudent to meet with individuals who are currently employed as biological technicians and also explore field experiences through internships.

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Engaging Students in Learning Public Key Cryptography

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Abstract
One major issue when teaching students about security is the complexity of the mathematics used in encryption. Public Key Cryptography (PKC) is one such concept where students need to use high-level mathematical skills. Through previous interactions in the classroom, the traditional chalk and board approach to teaching PKC was not effective in the retention of the concepts in the long run. To improve the retention level, two pedagogical techniques were developed that involved students working in pairs and accomplishing security tasks. The impact was measured with student feedback forms and with the reference to Blooms taxonomy.

Introduction

Public key cryptography is used for message authentication and key distribution in modern computer communications (Mathivanan, Sharmathi, & Akshaya, 2015). It is truly an advanced encryption technique applied across security domains. Public key cryptography uses algorithms that are made up of mathematical functions rather than employing changing bit patterns and superimposition (Barker, 2016). To comprehend these algorithms, students need high level mathematical computation skills. Studies suggest that most students lack these capabilities (ECPI University, n.d.; Thompson, 2019). There is a need to find alternative pedagogical techniques to make students understand the inner functioning of public key cryptography.

Two cryptographic techniques; RSA public-key encryption algorithm (Ireland, 2019) and Diffie-Hellman algorithm (Rescorla, 1999) were introduced as a part of the computer security course. We used alternative pedagogical techniques for delivering this content. We assessed the impact of the course through blooms taxonomy levels (Armstrong, 2010) and through student's feedback forms.

The paper is organized as follows, we introduce RSA and pedagogical techniques to teach RSA algorithm. We introduce Diffie-Hellman algorithm and the pedagogical techniques that were used to teach Diffie-Hellman algorithm. Blooms taxonomy impact and student feedback is described in this paper.

Public Key Cryptography

Public key cryptography uses two separate keys; public key and private key to encrypt and decrypt data. The public key of the user is distributed to others and the private key is kept with the owner. The users generally exchange keys through public certificate authorities such as Verisign.

For instance, Alice and Bob want to communicate with each other, both Alice and Bob generate public keys and private keys and exchange their public keys. If Alice want to communicate with

Bob, Alice uses Bob's public keys to encrypt data and Bob uses its private key to decrypt data. Alice also can use its own private key to encrypt data, and Bobs uses Alice public key to decrypt the data.

RSA algorithm

RSA was developed in 1977, it uses public key {e, n} to convert plaintext block M into ciphertext block C, and private key {d, n} to convert ciphertext block to plaintext block.

$$C = M^e \bmod n$$
$$M = C^d \bmod n = (M^e)^d \bmod n = M^{ed} \bmod n$$

RSA algorithm involves multiple steps to encrypt and decrypt data.

Step 1. Select two prime numbers p and q
Step 2. Calculate modulus, $n = p * q$
Step 3. Calculate Euler totient, $\emptyset(n) = (p-1) * (q-1)$
Step 4. Select e, such that, $\gcd(\emptyset(n), e) = 1; 1 < e < \emptyset(n)$
Step 5. Calculating d, $de \bmod \varphi(n) = 1$
Step 6. Public key, $KU = \{e, n\}$
Step 7. Private key, $KR = \{d, n\}$
Step 8. Encrypting plaintext M to ciphertext C, $C = M^e \bmod n$
Step 9. To decrypt ciphertext C, $M = C^d \bmod n$

Pedagogical techniques used to teach RSA

As shown in the previous section there are multiple steps and complicated math involved to teach RSA. During our previous sessions, we used the selection of p and q values and used to solve the math, it was challenging making students comprehend all the steps and making them understand the math behind it. To overcome this, we used Excel sheets asks students to select values and perform RSA for themselves and we assisted them on how to calculate GCD (greatest common divisor), modulo, etc.

In the classroom session we asked students to be in two pair groups, both performing encryption and decryption, they were provided with an excel sheet. In the initial step, the students asked to select two prime numbers (p and q) from the list provided, the formulas inside Excel calculates the modulus and Euler totient as show in figure 1. Then they were asked to select a prime integer and enter in cell B15 and change to new integer until cell C15 displays OK. In this step, we explained how GCD is calculated with the selected integer. Once the public key is selected, the system calculates the private key.

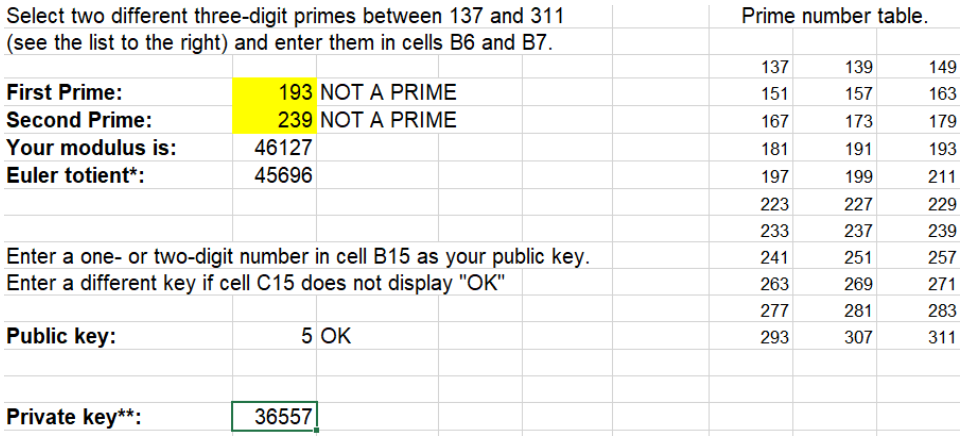

Figure 1

For encrypting plain data, the students need to use their lab partner's public key, they exchange their public keys with each other. In the encrypting Excel sheet, they entered the partner's public key and plaintext to be encrypted as shown in figure 2. The excel sheet generates the ciphertext as shown in figure 2. Then students write their ciphered text on a notepad and exchange with their partners.

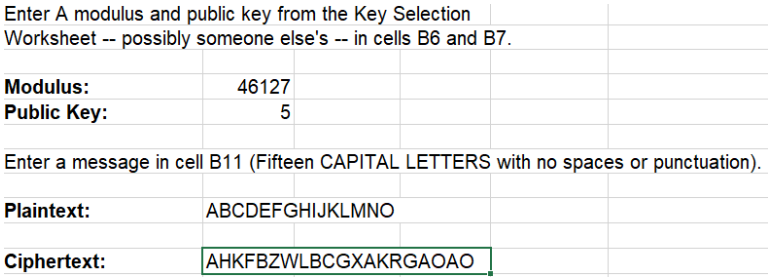

Figure 2

For decrypting, students use their private key and ciphertext exchanged from their partners, they enter the details in the excel sheet as shown in figure 3, once the step is completed plaintext is revealed.

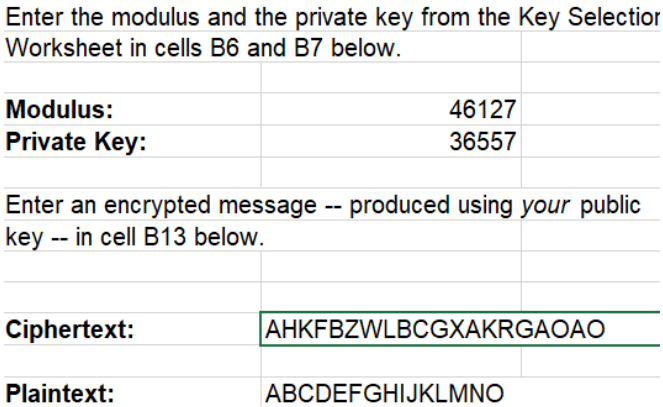

Figure 3

Diffie-Hellman Algorithm

The Diffe-Hellman algorithm is used for exchanging secret keys between two users that can be used for encryption and decryption. The students need prior knowledge of primitive root modulo. The algorithm uses steps shown below for users A and B.

Step 1. A prime number q and an integer α that is a primitive root of q is selected by users A and B
Step 2. User A select random integer X_A, and calculates Y_A, $Y_A = \alpha^{X_A} \bmod q$.
Step 3. User B select random integer X_B, and calculates Y_B, $Y_B = \alpha^{X_B} \bmod q$.
Step 4. User A exchange its Y_A value with user B, User B exchange its Y_B value with user A
Step 5. User A calculates key K, $K = (Y_B)^{X_A} \bmod q$
Step 6. User B calculates key K, $K = (Y_A)^{X_B} \bmod q$

Diffie-Hellman algorithm in-class activity

As discussed earlier, it was challenging for students to comprehend the algorithm and math involved with the traditional instruction techniques. To overcome the issue, we developed a pedagogical technique involving students creating keys for themselves. We provided an online tool where students can perform power mod calculations (Mount Holyoke, 2003) and notes on a small sheet of paper as shown in Table 1. The students are divided into pairs of two, they were provided with prime number q and α values and explained the math how those values were chosen using the primitive root mod. Students are also provided with X values, with all these three integer values and formula involved in step 2 and 3 students calculate Y values using power mod calculator. The students exchange the Y values on the piece of paper to their partners. With the available Y values from their partners, they calculate the key mentioned in step 5 and 6. The complete key calculations are shown in Table 2

Team 1 - Alice	**Team 1 – Bob**
$\alpha = 3$	$\alpha = 3$
q = 7	q = 7
$X_A = 5$	$X_B = 11$
Calculate Y_A =	Calculate Y_B =
Y_B = (from Bob)	Y_A = (from Alice)
Calculate K =	Calculate K =

Table 1

Team 1 - Alice	**Team 1 – Bob**
$\alpha = 3$	$\alpha = 3$

q = 7 $X_A = 5$ Calculate $Y_A = 5$ $Y_B = 5$ (from Bob) Calculate K = 3	q = 7 $X_B = 11$ Calculate $Y_B = 5$ $Y_A = 5$ (from Alice) Calculate K = 3

Table 2

Impact measurement – Blooms Taxonomy

It is crucial to measure the teaching outcomes based on a scale to ensure there is learning in the classroom session. We chose Bloom's Taxonomy, which is a widely used assessment technique used for identifying the outcome. Bloom's Taxonomy measures outcomes such as remembering, understanding, applying, analyzing, evaluating and creating. Remembering being the lowest and creating is the highest level. In traditional teaching techniques used in teaching both the algorithm's attained only two levels: Understanding and remembering. With the proposed pedagogical techniques students were able to apply the concepts; analyze and evaluate the concepts in terms of why and how they chose particular numbers instead of random numbers; and how to calculate using these specific math content. In the end the students were able to create keys, encrypt data and decrypt cipher text using the tools provided in the class.

Student Feedback

At the conclusion of the session, twenty-five students completed a feedback survey. One area of concern was whether students would understand the purpose of the session. All but one student indicated that the learning objectives were clearly conveyed. After using the presented teaching strategies, 100% of the students indicated that they session was effective in understanding the Diffie-Hellman algorithm used in the PKC process. The handouts were helpful to 92% of the students in understanding the cryptographic concepts. The only minor issue indicated in the survey was that three of the students did not recognize the importance of the Diffie-Hellman algorithm and PKC.

Conclusion

Computer science, especially computer security, network security and cybersecurity areas need high mathematical skills. Most of the top universities have special math courses which are mandatory for enrolling in computer science programs. As an alternative, we proposed new pedagogical techniques which are helpful for the students for the retention of the concepts in the classroom sessions. The proposed PKI pedagogical techniques were effective in teaching a complex concept. We also assessed effectiveness of the techniques used in the classroom session with respective to blooms taxonomy levels. Also, student feedback was very encouraging on how they personally involved in the learning process.

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Internet of Things Workshops for High School Students

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Abstract

The Internet of Things (IoT) is an upcoming technology domain used in many environments including smart infrastructures, medicine, manufacturing, logistics, and environmental monitoring. The realization of IoT is being driven by efficient cloud technologies that enable businesses, research institutions and users to manage, aggregate and analyze data resulting in increased efficiencies and predictive analytics.

It is necessary for juniors and senior high school students to grasp the inner working of IoT technologies and methods used to develop smart applications. Students studying computer science or information technology may be exposed to most of the technologies used in building IoT applications individually, it is necessary to show how they are integrated when developing an IoT solution. Through this workshop, we will introduce students to embedded systems used to develop sensing infrastructures with physical sensors. They will also develop backend data management and visualization servers to represent the data collected from the physical environment to the virtual world. The goal of this workshop is to enhance student capabilities to work in a multi-disciplinary environment; provide an opportunity for students to reinforce and apply the theoretical constructs learned in previous coursework, and enhance their retention capabilities.

Internet of Things

The advent of modern web technology has transformed economies and societies. The release of HTML 1.0 followed by HTML 2.0 in the 1990s' were not revolutionary by today's standards. However, simple web pages with text and pictures formed the foundation of advanced web-based processes and applications that are now realized through advanced applications and tools. People have instant communication across the world using "free" applications that only require a simple registration. Online shopping is changing how people purchase goods and services. The world's top three corporations as measured by market cap (White, 2015) are technology companies that include Apple, Google and Microsoft. The Internet of Things (IoT) is expected to be the next technological leap that has a "revolutionary" impact across business and society. IoT was founded on the integration of smart and not so smart sensors using RFID; internet-based technologies that integrate sensors; and devices that are capable of communication and cooperation (Atzori, Iera, & Morabito, 2010). An invisible and embedded communications and data network is being developed and imagined across business and research institutions (Atzori et al., 2010; Gondi, White, Gemmill, & Post, 2016; Gubbi, Buyya, Marusic, & Palaniswami, 2013; Li, Wang, Dai, Wang, & Zhao, 2016; Miorandi, Sicari, De Pellegrini, & Chlamtac, 2012).

IoT end to end systems involve multiple components and are interconnected through multiple systems performing specific tasks to accomplish their objectives in real-time (Karimi &

Atkinson, 2014). The IoT is divided into three different layers: Perception Layer, Communication Layer, and Application Layer (Khan, Khan, Zaheer, & Khan, 2012). The IoT system layers and individual components and protocol stacks associated with the layers are shown in Fig 1. The IoT system architecture involving sensing infrastructures, communication infrastructure, and backbone data processing and application servers is shown in Fig 2.

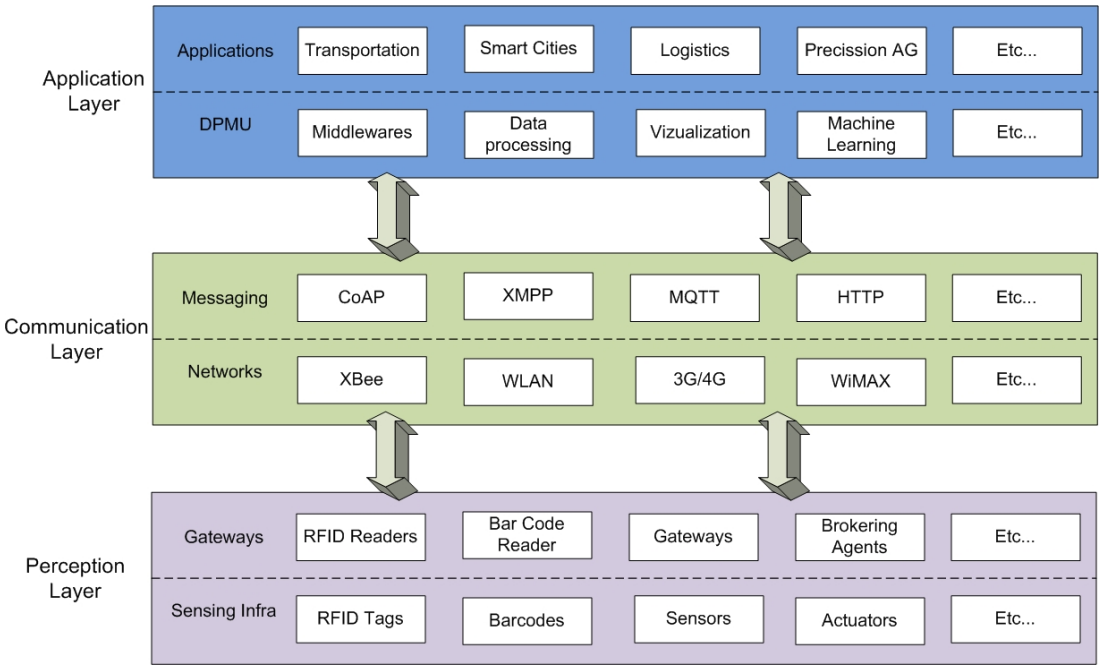

Fig 1. IoT system layers and components

Perception Layer

The perception layer is the foundational sensing layer. This layer utilizes physical sensing devices comprising of sensors, RFID tags, bar codes, and actuators coupled to applications to integrate systems to the communications and application components. The collected sensor data is sent to the back-end systems through gateways that include tag readers, and sensor gateways.

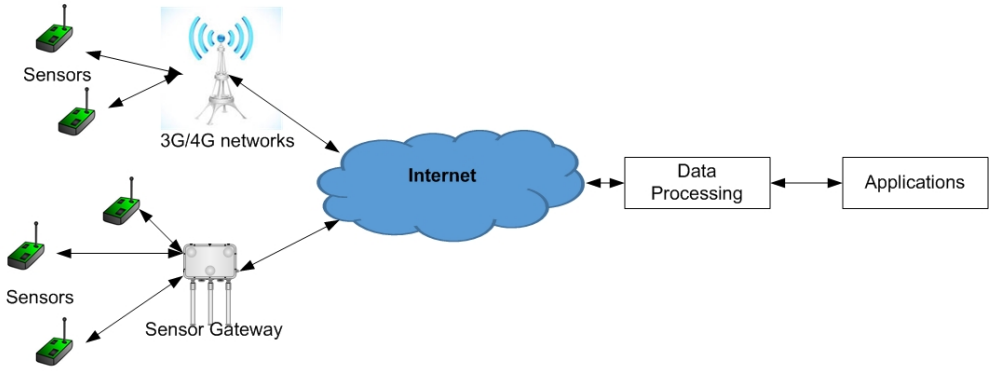

Fig 2. IoT system architecture

Communication Layer
Collected data from the perception layer is sent through ubiquitous networking infrastructures such as XBee, WLAN, Cellular Networks, and WiMAX to the backend systems. IoT uses traditional HTTP messaging protocols as well as custom IoT messaging protocols such as MQTT, CoAP and XMPP to transmit data to back-end data stores and application servers (Al-Fuqaha, Guizani, Mohammadi, Aledhari, & Ayyash, 2015). Custom IoT protocols are widely used for IoT messaging over traditional HTTP based messaging systems due to resource-constrained operational scenario(s).

Application Layer
Data is routed to the application layer and sent to the data processing and management units. These units initially validate data integrity, process the data, and then analyze it in the later steps. The data is represented in the application format, where the application uses these "sets" for the decision making through custom application algorithms. The outcome is represented to the end-users in a human-readable format or in a decision-based format for a M2M (machine to machine) scenarios. The results are stored for historical purposes and can be retrieved based on system and/or user requirements.

Workshop and Content

The intent is to conduct 1-week workshops with high school students. This project will impact two tiers of students, college students, and high school students. The college students will be trained on the content and delivery of the workshops that will be conducted with the high school students.

The objective of the workshops is to have the high school students develop three of the IoT layers described in the previous section. The workshops will be organized in four sections in which they will be learning the concepts, skills, and components used to develop IoT systems.

- Operating System (OS), Networking and Embedded Computing
- IoT Protocols
- Database Management
- Visualization Tools and Data Management

The workshops will be conducted for a duration of 4 hours over a span of 5 days. On the first two days, the students will be familiarized with the hardware, systems components, and protocols. The last three days they will be developing the APIs to integrate physical sensors with embedded platforms. Wireless networks will be used as the communication channel. Using MQTT as an IoT protocol, they will publish the real-time data in RabbitMQ queues. The students will use NoSQL to develop a database for storing and retrieving the data collected and transmitted by their sensor arrays.

OS, Networking and Embedded Computing

In this section, we will provide students with Raspberry Pi kits with microSD memory card. The students will be porting an embedded Linux on to the micro SD card and mount on the embedded platform using instructions provided during the workshop session. Once the

Raspberry Pi's boot with to the Raspbian OS, students will be able to differentiate between ordinary Linux and embedded Linux, asked to execute commands to learn the capability of the Raspberry Pi. They will then learn how to use Python libraries to enable GPIO (general purpose input and output) pins on the Raspberry Pi. This will allow them to send and receive data through these ports to attached physical sensors.

The students will also configure wireless networks on Raspberry Pi to communicate with the backend infrastructure where the published data will be collected from the physical sensors.

IoT Protocols
The objective of the second session will be to enable MQTT libraries on the Raspberry Pi. The students will learn how to configure the system to collect data from the sensors and prepare an MQTT packet to send the data to the backend server.

NoSQL Database
Students will be provided with the MongoDB libraries and scripts for installing and configuring the server on their personal laptops during the third session. Once the system is enabled with the required software and students will learn about the query language used to collect the data coming out of the Raspberry Pi

Visualization Tools and Management
To this point, the students will not have been able to see the output of the system that they have developed. Students will learn how to use time series analysis to visualize the collected data during the final workshop session.

Hardware and Software

To conduct this workshop, specific hardware and software resources will be needed. Students will be provided with:

> Hardware: Raspberry Pi with Micro SD cards, AC to DC power adapter, Mini HDMI to HDMI cable, physical sensors to the students for developing IoT applications.
>
> Software: Raspbian OS, MongoDB, RabbitMQ, MQTT, Python.

For the equipment purchases, and conducting the workshop for 10 students an estimated $1000 is needed, the details are discussed below.

Product	**Unit Price**	**Qty**	**Total**
Raspberry Pi 3 Model B Motherboard	$35.70	10	$357
Power Supply	$7.99	10	$79.90
Samsung EVO 32GB Class 10 Micro SDHC Card with Adapter	$9.99	10	$99.90
Micro USB OTG to USB 2.0 Adapter; SD/Micro SD Card Reader with standard USB Male & Micro USB Male Connector	$7.99	1	$7.99

Sabrent 4-Port USB 2.0 Rotatable Hub [90°/180° Degree Rotatable]	$5.99	4	$23.96
SunFounder 37 Modules Sensor Kit V2.0 for Raspberry Pi 3, 2, Zero & RPi 1 Model B+, A+ 40Pin GPIO Extension Board Jump wires	$98.99	4	$395.96
		Total Cost	$964.71

Learning Outcomes

At the end of the workshop students will be able to:

1. Summarize the concepts involved in developing smart applications using IoT systems and components
2. Design an architecture for smart applications using the IoT 3-layer architecture
3. Develop an IoT enabled Raspberry Pi that will communicate with a physical sensor and collect data in real-time
4. Create software code and scripts to collect and send data from an IoT enabled device to the backend data infrastructure
5. Setup a backend infrastructure to collect data from the deployed physical devices in real-time
6. Develop visualization techniques to extract data from database and represent it with time series analysis
7. Compute the latency between collecting data from physical sensor and the data published in the database

Conclusion

With the provided training and availability of the hardware procured for the workshop, students will be able to develop projects with the assistance from the faculty and college student mentors. This workshop will enhance student employability with additional skills developed through creating smart applications using IoT.

The workshop encourages the use of open-source software, which is essential for computer students for developing their own solutions and contributing to the computing community. The workshop also enhances software tool application capabilities and develops advanced software coding techniques which are necessary for future software developers. Finally, through this workshop, key skills of software design and system architecture design will be developed.

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Engaging Students in Cybersecurity through Co-Curricular Student Organization Participation

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Abstract
Cybersecurity is an upcoming area in the field of information technology. The growth in this area is expected to create an estimated million job openings in the next three years. Cybersecurity is a very complex concept where students need to know the depth and breadth of information technology areas. Recent university graduates are not well equipped to work in this area. This lack of preparation has resulted in many of these recent graduates to opt-out of working in cybersecurity. Industry experts indicate that there is a strong need for students to participate in co-curricular student organizations which align to their interests. Keeping this in mind, faculty need to develop student organizations to equip them with all the necessary tools to excel when they enter into industry. The Computer Technology Student Organization at Ball State University is a co-curricular activity designed to support and extend what is being taught in information technology, information systems, and computer science courses at Ball State University. The current initiatives to focus these activities around cybersecurity will be highlighted.

Keywords: Computer Science Education, Cybersecurity, Student Organization, Retention Rate, Student Engagement, Project Development, Ethics in computing, Certification.

Introduction

The area of information technology is an ever changing and challenging field. Students need to acclimate to these changes and challenges to meet industry standards before they graduate.

Cybersecurity is an area which has huge potential to secure high paying jobs that are unlikely to be impacted by downturns in the economy. According to the Department of Homeland Security (DHS), cybersecurity is termed as "the activity or process, ability or capability, or state whereby information and communications systems and the information contained therein are protected from and/or defended against damage, unauthorized use or modification, or exploitation" (Sinha et al., 2015). In the United States, critical infrastructures such as food, water, electricity, transportation, security, policing, and healthcare are dependent upon cyber infrastructures. These infrastructures are vulnerable to both physical compromises and cyber-attacks by the hackers backed by the terrorist organizations and rogue nations. It is of utmost importance to safeguard these infrastructures; prevent the theft of intellectual property; the disruption of the economy; or threats to democracy. To achieve this, countries and the corporations need an army of cybersecurity experts (Finkle & Randewich, 2012).

There is a high need for cybersecurity professionals in the coming years (Kessler & Ramsay, 2013). In 2019, the DHS estimated that there were half a million vacancies open in public and private space (Department of Homeland Security, 2015; Finkle & Randewich, 2012).

The National Security Agency (NSA), DHS, and other government bodies work with universities and established cybersecurity programs to develop the workforce needed by those agencies (Nakashima, 2013; National Initiative for Cybersecurity Careers and Studies, 2019). The NSA established the National Center of Academic Excellence program which certifies colleges and universities that meet their standards in cybersecurity education (National Security Agency, 2019).

Cybersecurity is one such field in the information technology domain where students need to comprehend various concepts: hardware, software, operating systems, networking, databases, wireless communication, access controls and cryptography (Roussey, 2018). To master cybersecurity, students need to go through rigorous training and have a hands-on experience on implementing cybersecurity across the information technology domain. Students also need to work in groups and have experience of working and leading projects. Cybersecurity education requires more than just technical skills. Students need an understanding of the ethics associated with cybersecurity technologies and practices.

Computer Technology Student Organization (CTSO) is an example of how co-curricular activities can support and enhance the knowledge and skills students are learning in their information technology, information systems, and computer science classes. A framework outlining three levels of cybersecurity activities provided through the student organization. Apart from these activities, the paper will also detail how students are involved in ethics; working in the groups; managing projects; and developing leadership skills.

CTSO Program and Cybersecurity

The Computer Technology Student Organization was formed in 2009 to operate as a co-curricular student group to expand their knowledge of information technology and its role in society. Additionally, CTSO was intended to promote professionalism through leadership, fellowship, scholarship, and a philosophical foundation for future information technology professionals. CTSO was originally developed for students majoring in the undergraduate Computer Technology program. It has since reached out to both information systems and computer science students to participate in its activities.

The growing interest in cybersecurity among students and demand for professionals with such skills has prompted another evolution of CTSO. Adopting a focus area in cybersecurity has mobilized faculty and students to develop a game plan of what can be done outside of class to help prepare students for potential careers in the field. This section will provide an overview of the framework that was developed, detail of some of the activities, and identify the learning outcome of the activities.

In 2018, CTSO identified five focus areas: cybersecurity, robotics, Linux, game development, and community outreach. For cybersecurity, a total of 15 students participated during the first year. A total of 3 faculty with varied backgrounds in the areas of security, networking, database, programming, embedded systems and ethics collaborated to develop the content and lead the activities and labs. CTSO met twice a week to explore cybersecurity. The cybersecurity activities were divided into three different levels: Entry, Medium and Expert.

Year 1 – Entry Level

During the first year the students were introduced to cybersecurity. In the fall semester, faculty presented operating system security and the Kali OS. Kali is a Linux-based operating system which incorporates the tools used for information security assessment and penetration testing. Students started by learning the tools used for information gathering and enumeration of target systems. The theory behind malware and intrusion detection were also presented. Students used the tools in Kali to create and detect malwares and intrusion as a part of the training.

During the spring semester the students learned about software security. Concepts of buffer overflow were simulated in the lab. Concepts of network security were also discussed during this semester. Labs associated with network security (DNS poisoning, DHCP man in the middle attack, ICMP redirect, ARP poisoning, network scanning, DOS attack, packet sniffing and packet spoofing) were conducted during this period.

Year 2 – Medium Level

During the fall semester of the second year the students were introduced to theory and labs associated with access code, authentication, and firewalls. The theory behind the Database Security and the SQL injection techniques were taught during this semester.

In the spring semester, students will learn about wireless security and breaking WPA/WPA2 using brute force attack. Sessions covering the concepts of symmetric encryption and public key cryptography (RSA and Diffie-Hellman) will be discussed.

Year 3 – Expert Level
In the final year during both semesters, the students will be working on simulation projects. Students will also be made aware of computer security laws, the need for ethics within cybersecurity and web security, and implementing it in the lab sessions.

The final project will be a live attack/defend scenario. Students will be divided into red and blue teams. Students on the blue team will build and secure a set of networked resources. Those on the red team will be tasked with attacking those network resources.

Program Outcomes
Content Knowledge on Cybersecurity
The primary goal of this aspect of the student group was to promote content knowledge in the cybersecurity domain. This will be fostered by encouraging independent research, hands-on activities, and guest speakers. Through these activities, students will learn the tools and techniques needed for safeguarding cyber infrastructures.

Certifications
There are many industry certifications the cover different aspects of the cybersecurity domain. Examples of the organizations that sponsor these certifications include the SANS Institute, (ISC)2, CompTIA, Cisco, EC-Council, the Information Assurance Certification Review Board (IACRB), and Offensive Security.

Students will have the opportunity to prepare for the entry level certifications in the cybersecurity domain. Faculty will mentor students as they work through sample questions and activities related to the SANS Institute's Global Information Assurance Certification (GIAC) - Security Essentials certification (SANS Institute, 2019), EC-Council's Certified Ethical Hacker (CEH) certification (EC-Council, 2019), the CompTIA Security+ (CompTIA, 2019a) and PenTest+ (CompTIA, 2019b) certifications. After the successful completion, students can register separately and get certified on their own.

Cybersecurity Competitions
To validate their applied and conceptual understanding, CTSO will participate in student cybersecurity competitions. Similar to the cybersecurity certifications, there are competitions designed for varying skill levels and experience within the realm of cybersecurity. As the collective knowledge and experience of the members is developed, they will be encouraged to participate in competitions of increasing difficulty.

Initially, they will participate in purely online competitions like the competition offered by the National Cyber League (NCL). Students are bracketed into three skill levels based on their success during a mandatory preseason game (National Cyber League, 2019). The registration for the event will be covered by the funds generated from organizational events. All three faculty will serve as faculty mentors for the NCL events.

The plan is for students to participate at in-person competitions and use the skills to attack or safeguard more highly complex computing infrastructures. This will be attempted once the collective knowledge of the members has reached an acceptance level.

Soft Skills

Student organizations grant an opportunity for students to learn more than just technical knowledge. Students learn soft skills and leadership qualities through their interactions with each other and community engagement. Co-curricular activities allow students to develop these qualities through student engagement outside of the classroom.

Students are familiarized with the importance of ethics in computer science, they are actively involved in community development activities, students volunteer by providing technical support for schools in the Muncie school district, organizing food drive events to support those underprivileged. The students also attain project Handling experience and working in the groups as a part of the organization.

Conclusion

Cybersecurity is becoming more relevant in this computer age with trillions of dollars and millions of people's lives at stake. It is very crucial than ever before to develop a credible and knowledgeable workforce to safeguard cyber infrastructures from hackers and rogue nations. We introduced cybersecurity in 2018 for a small part of the student organization and developed labs and content to sustain and develop them, and made aware of the cybersecurity as a career choice. The necessary skills, tools, techniques and concept is introduced and labs that are needed to develop the knowledge of the students are effectively implemented. The students are well prepared to take part of the cybersecurity competitions and certification process. In the Fall 2018 competition, a student team ranked in the top 25% in the nation though they had not been exposed to cybersecurity training prior to that semester. Finally, interpersonal skills were needed were developed through the student collaborations throughout the process.

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Analysis of Subject Matter Topics Presented at AERA's CTE Annual Meetings

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Abstract
The purpose of this study was to identify and categorize subject matter topics presented at the annual American Educational Research Association (AERA) CTE Special Interest Group (SIG) meetings during 2005-2019. A total of 19 subject matter topics were identified that accounted for 237 peer reviewed presentations. The top eight subject matter topics presented during this 15-year period were: assessment, transition to post-secondary education, academic integration, alignment with federal education policy, best practices, professional preparation, instructional strategies, and economic impact of CTE. Emerging subject matter topics included: faculty and staff development, curricula designs, relevance of workforce standards, future CTE content, programs of study, STEM, and integration of technology. It is recommended that additional classifications be considered in future research to include equity/diversity, international CTE (i.e., global subject matter topics), and career exploration and guidance.

Introduction and Theoretical Base

Grouping topics under appropriate categories is considered critical for effective analysis of subject matter topics, regardless of program areas. According to Radhakrishna and Mbaga (1995) "content analysis of conference proceedings provides perhaps the most current source of the state -of the art of research and development activities of a profession" (p.86). Analysis of subject matter topics are more likely to guide our professional organizations to address selected research priorities according to: 1) depth of research conducted in specific subject matter topics, 2) ascertain if the research conducted adds value to the knowledge base, and 3) identify gaps for additional research and practice (Radhakrishna, 1998).

The theoretical base of our study was grounded in work by selected scholars in CTE disciplinary emphasis areas. Also, several scholars have presented and written about subject matter topics in agricultural education and career and technical education at other national conferences in the field (Crunkilton, 1988; Gordon, Shaw, Xing, & Talib-Deen, 2017; Gordon, Xing, & Shaw, 2019; Lambeth, Elliot, & Joerger, 2008; Lambeth, Joerger, & Elliot, 2009; Lambeth, Joerger, & Elliot, 2018; Radhakrishna & Xu, 1997; Reed & LaPorte, 2015). The conceptual framework for this study was based on the National Career and Technical Education Research Agenda (Lambeth et al., 2009) that was developed for the Association for Career and Technical Education Research (ACTER) annual conference meetings. The framework is comprised of five research problem areas (RPAs) with a total of 53 subject matter topics. The five research problem areas are:

1. Knowledge Base for Teaching and Learning
2. Curricula and Program planning
3. Delivery Methods
4. Accountability
5. Program Relevance and Effectiveness

We were unable to locate any published articles that examined subject matter topics of conference presentations of the *annual AERA CTE SIG meetings*. The specific objectives of this study were to:

1. Describe the characteristics of presenters in terms of gender, authorship, and institutional affiliation.
2. Identify and categorize subject matter topics presented at the annual AERA CTE SIG meetings during the last 15 years (2005-2019).
3. Proposed a framework for a national research agenda for AERA CTE SIG annual meetings.

Methods and Procedures

In this study, we employed a deductive quantitative content analysis design. Xing, Shaw, and Gordon (2017) emphasized that "deductive content analysis is often used when there is prior knowledge and researchers intend to test a theory or framework. Researchers organized data based on an existing, though alterable, theory or framework" (p.49). Also, see research reported by Elo and Kyngäs (2008); Riffle, Lacy, Watson, and Fico (2019). In our study we used the ACTER framework that was developed by Lambeth and colleagues (2009). A census was used to examine all peer-reviewed conference presentations that were made at the AERA CTE SIG annual meetings during the fifteen years (2005-2019). According to Riffe et al. (2019) "a census means every unit in a population is included in the content analysis, and often makes the most sense for research that examines a particular event or series of events" (p.74). We excluded all non-peer reviewed presentations from this study. Thus, a total of 237 conference presentations were analyzed to accomplish the objectives of this study.

The following criteria were used to classify the 237 conference presentations into subject matter topics: title of the study, central theme of the study, type of session, and an abstract of the study. We created a subject matter category, namely "other," to include presentations that did not fit into any of the subject matter topics from the framework (Lambeth et al., 2009) used in this study. The researchers obtained conference programs (unit of analysis) of these 15 years from AERA's "online program files" website (sampling frame of the study) during the 2019 calendar year.

A codebook was developed which included the following pieces of information: year of the conference, number of presentations, conference theme, conference location, gender of the first author, authorship of presenters, authors' institutional affiliations, and the

subject matter topics. Gender of the first author was determined by the first name, as well as a Google search if necessary. The authorship of presenters included: 1) single author, 2) two authors, 3) three authors, and 4) more than three authors. Subject matter topics of the 237 presentations at AERA CTE SIG were determined according to the classification made by Lambeth et al. (2009).

Sampling validity (Riffe et al., 2019) of the codebook was established using a panel of experts consisting of two teacher educators and an advanced doctoral student. Inter-coder reliability (Riffe et al., 2019) was achieved by using procedures such as inter-coder comparisons of subject matter categorization and further reviews of consistencies in coding. Data of this study were summarized using frequencies and percentages.

Limitations of the Study

One of the limitations of this study is that the researchers had to administer judgmental and subjective decisions pertaining to the classifications of selected subject matter topics. Content analysis of conference programs may suffer from misjudgments due to unclear titles and descriptions of the study (Christiansen, 1996; Reed & LaPorte, 2015). Despite established procedures for coding consistency, researchers may still lose the focus of study for this particular reason. In addition, coding was completed by faculty and a graduate student from one university located in the Western U.S. This shared culture of the university (college, department, and program area) and the faculty-student relationships may influence faculty and students to think and perceive in a similar manner unconsciously.

Findings and Discussion

As shown in Table 1, a total of 237 presentations were made during the 15 years (2005-2019). The average number of presentations per year was 16 (15.8). The lowest number of presentations occurred in 2008, and highest was in 2018. However, since 2008, the number of presentations has almost doubled from 11 to 21 in 2019. With reference to conference locations, New York City accounted for both the lowest and highest number of presentations per year. It appears that the Great Recession of 2008 (Kenton, 2018), was probably a major factor for the low number of presentations. Conference locations in the Western U.S. and Canada, appeared to be well represented during the last 15 years. Overall, conference locations appear to fit the following criteria: culturally diverse locations, average weather conditions in April, and presence of local post-secondary institutions of higher learning (AERA, 2016).

Table 1

Conferences by Year, Number of Presentations, and Locations (2005-2019)

Year	Number of Presentations	Conference Location
2005	15	Montreal, CAN
2006	14	San Francisco, CA
2007	15	Chicago, IL
2008	11	New York, NY
2009	16	San Diego, CA
2010	15	Denver, CO
2011	14	New Orleans, LA
2012	15	Vancouver, CAN
2013	17	San Francisco, CA
2014	13	Philadelphia, PA
2015	16	Chicago, IL
2016	18	Washington, DC
2017	15	San Antonio, TX
2018	22	New York, NY
2019	21	Toronto, CAN
TOTAL	237	

Presenters' Characteristics

Of the 237 presentations, 128 (54%) were made by male presenters (Table 2). This finding is supported by previous research (Gordon, Shaw, Xing, & Talib-Deen,2017; Gordon, Xing, & Shaw, 2019). The typical AERA CTE SIG presentation consisted of two authors (39%), mostly males, and presenters employed at a land grant institution (Table 3). University of South Florida (a non-land grant institution), accounted for the highest number of presentations (19 or 5.88%). In general, it appears that there is a trend toward multiple authors presenting at AERA CTE SIG annual meetings (Table 4).

Table 2

Total Number of Presentations by Gender of First Author and Year

Gender	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	**Total (%)**
Male	7	7	9	6	11	9	8	10	8	5	6	10	**8**	**12**	**12**	**128 (54)**
Female	8	7	6	5	5	6	6	5	9	8	10	8	**7**	**10**	**9**	**109 (46)**
Total	**15**	**14**	**15**	**11**	**16**	**15**	**14**	**15**	**17**	**13**	**16**	**18**	**15**	**22**	**21**	**237 (100)**

Table 3

Total Number of Presentations by Institution and Year

Institution	Year																
	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	**Total**	
Univ. S. Florida	-	-	-	-	-	-	3	-	2	3	3	3	1	2	2	19	5.88%
Univ. Georgia	1	1	-	1	2	-	-	-	-	-	1	3	3	-	1	13	4.02%
Univ. Louisville		1	1	-	-	1	2	3	2	1	2	-	-	-	-	13	4.02%
Univ. Illinois	3	3	-	1	-	-	1	-	-	-	1	-	-	-	-	9	2.79%
Univ. Missouri	-	-	1	-	-	-	-	1	3	1	-	1	-	1	-	8	2.48%
Nat. Center CTE	1	4	3	-	-	-	-	-	-	-	-	-	-	-	-	8	2.48%
Purdue Univ.	-	-	1	2	2	1	-	1	-	-	-	-	1	-	-	8	2.48%
NC State	-	-	-	-	1	1	-	1	-	1	-	2	-	-	1	7	2.17%
Ohio State	-	3	1	-	2	-	-	-	-	-	-	-	-	1	-	7	2.17%
Iowa State	-	-	1	2	1	-	-	2	-	-	-	-	-	-	-	6	1.86%
Univ. Minnesota	-	5	-	-	-	-	-	1	-	-	-	-	-	-	-	6	1.86%
Penn State	2	1	-	-	-	-	-	-	-	1	-	1	-	-	1	6	1.86%
Wageningen Neth.	-	1	1	-	1	-	-	1	-	1	-	-	-	1	-	6	1.86%
Iowa DOE	-	-	1	1	2	-	-	-	-	-	-	-	-	-	1	5	1.55%
W. Michigan	-	1	2	-	-	1	-	-	-	-	-	-	-	1	-	5	1.55%
Virginia Tech	-	-	-	-	-	-	-	1	-	1	1	1	1	-	-	5	1.55%
Columbia Univ.	-	-	-	2	-	-	-	-	-	-	-	-	-	-	2	4	1.24%
Cornell	-	-	1	-	-	2	1	-	-	-	-	-	-	-	-	4	1.24%
Georgia State	-	1	1	1	1	-	-	-	-	-	-	-	-	-	-	4	1.24%
Oklahoma State	1	-	-	-	-	3	-	-	-	-	-	-	-	-	-	4	1.24%
RTI International	-	-	-	-	1	-	-	1	-	-	-	1	-	-	1	4	1.24%
UCSB	-	-	-	-	-	-	-	-	-	-	-	1	1	1	1	4	1.24%
UNLV	1	1	-	-	-	-	-	-	-	-	-	1	-	-	1	4	1.24%
*Other	10	2	8	6	11	9	8	8	22	7	13	11	13	23	13	164	50.77%
Total	19	24	22	16	24	18	15	20	29	16	21	25	20	30	24	323	

*Note. Institutions accounting for less than one percent or three conference presentations during the 15 - year analysis.

Table 4

Total Number of Presentations by Position of Authorship and Year

Author	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	**Total (%)**
Single	6	3	3	2	6	3	4	4	4	5	4	3	2	6	5	**60 (25)**
Two	7	6	5	6	5	5	3	7	7	4	5	7	7	9	9	**92 (39)**
Three	1	2	6	2	1	6	3	3	2	4	3	5	4	4	5	**51 (22)**
> Three	1	3	1	1	4	1	4	1	4	0	4	3	2	3	2	**34 (14)**
Total	**15**	**14**	**15**	**11**	**16**	**15**	**14**	**15**	**17**	**13**	**16**	**18**	**15**	**22**	**21**	**237 (100)**

Subject Matter Topics

The 237 presentations were categorized into the relevant subject matter topics (Table 5). The **top 8 subject matter topics** presented during this 15 year were *assessment* [10.97%] (RPA4—Accountability), *transition to post-secondary education* [7.59%] (RPA3—

Delivery Methods), *academic integration* [7.17%] (RPA2—Curricula and Program), *alignment with federal education policy* [6.33%] (RPA5—Program Relevance and Effectiveness), *best practices* [5.91%] (RPA3—Delivery Methods), *professional preparation* [5.91%] (RPA1—Knowledge Base for Teaching and Learning), *instructional strategies* [5.49%] (RPA1—Knowledge Base for Teaching and Learning), and *economic impact of CTE* [5.06%] (RPA4—Accountability]. The **least researched subject matter topics** were impact of CTE courses on student achievement, alternatively certified teachers, policy development, and quality of teachers. **Emerging topics** included faculty and staff development, curricula designs, relevance of workforce standards, future CTE content, programs of study, STEM, and integration of technology. Overall, the top category was ***"other"*** (40 presentations, 16.88%), a variety of topics unrelated to the subject matter topics as classified by Lambeth et al.'s framework (2009). The top three subject matter topics in the "other category" were equity/diversity (15 presentations), international CTE (i.e., global subject matter topics) (9 presentations), and career exploration and guidance (8 presentations). Thus, subject matter topics labeled as "other" appeared to be dominant among AERA CTE SIG presenters during 2005-2019.

Table 5

Subject Matter Topics Presented at AERA by Year (2005-2019)

Subject Matter	Year																
	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	**Total**	**%**
Assessment	3	1	2	1	2	1	-	4	2	1	2	2	2	3	-	26	10.97%
Transition to Postsecondary	1	2	1	2	1		1	-	3	-	1	1	1	3	1	18	7.59%
Acad. Integration	1	1		1	3	4	1	1	-	-	-	2	1	2	-	17	7.17%
Alignment Fed. Policy	-	-	2	-	3	-	3	1	-	-	-	1	1	1	3	15	6.33%
Best Practices	2	-	-	1	-	2	-	-	-	-	1	1	1	2	4	14	5.91%
Prof. Prep.	2	3	-	-	1	-	-	2	2	-	1	1	2	-	-	14	5.91%
Instructional Strategies	2	3	-	1	2	1	1	-	1	-	-	-	-	1	1	13	5.49%
Econ. Impact	1	-	1	2	1	1	-	1	-	-	1	-	1	-	3	12	5.06%
Faculty & Staff Development	-	1	-	-	-	2	1	3	-	2	-	-	-	1	-	10	4.22%
Curricula Design	-	1	1	-	1	-	2	-	1	-	1	-	-	1	2	10	4.22%
Relevance Wrkf. Stand.	-	1	3	-	-	2	1	-	-	-	-	1	1	-	1	10	4.22%
Fut. CTE Content	-	-	3	1	-	-	-	-	1	1	1	-	-	2	-	9	3.80%
Prog. Of Study	-	-	-	1	-	-	2	1	2	-	1	-	-	-	-	7	2.95%
STEM	-	-	-	-	-	-	2	-	-	-	2	3	-	-	-	7	2.95%
Integ. of Tech.	1	-	2	-	-	1	-	-	-	-	-	-	-	1	-	5	2.11%
Impact of CTE courses	-	-	-	-	-	-	-	-	1	2	-	-	1	-	-	4	1.69%
Alt. Cred/Cert.	-	-	-	-	-	-	-	-	-	-	-	1	-	1	1	3	1.27%
Policy Dev.	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	2	0.84%
Quality of Teach.	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	0.42%
*Others	1	1			2	1		2	5	6	5	4	4	4	5	40	16.88%
Total	15	14	15	11	16	15	14	15	17	13	16	18	15	22	21	237	

*Note. Adult learners, Career exploration & guidance, CTE high school course taking & dropout, Equity/Diversity, Extension, International,
Juvenile Justice programs, Retention of non-traditional students, Special needs.

Framework to Establish a National Research Agenda for AERA CTE SIG

The findings of this study suggest that AERA CTE SIG presenters researched a variety of subject matter topics during this 15- year period. However, there is no specific research agenda for our AERA CTE SIG. In general, the data from this study suggest that subject matter topics were more likely to align adequately with the five RPAs (Lambeth et al., 2009). Based on our findings, we recommend additional classifications be considered in future research to include the following subject matter topics: *equity/diversity*, *international CTE*, and *career exploration and guidance*. Findings from a content analysis of 37 annual conferences held by the International Technology and Engineering Educators Association, revealed that more attention is needed in all areas associated with diversity. The study's findings also noted that diversity accounted for only 124 topics between 1978 and 2014 (Reed & LaPorte, 2015). In addition, several scholars have argued that professional development for CTE instructors and professionals should place more emphasis on equity/diversity. This is very beneficial for preparing a high-quality competitive workforce (Advance CTE, 2018; Bezard & Shaw, 2017; Imperatore, 2019). With reference to international CTE, selected scholars have addressed the importance of benchmarking of CTE, widening of the skills gap among young people, and creating a global pipeline for dual enrollment options (Fitzgerald & Singmaster, 2017; Higgins, 2015; McCage, 2017). As of 2019, over 10% of AERA members were from more than 90 countries (AERA, 2019). Research indicates the need for an increased emphasis on career exploration and guidance to help students make more intentional choices, especially during the middle grades (McFadden & Curry, 2018; Meeder, 2016; Stone & Lewis, 2012). Figure 1 illustrates the proposed framework for establishing a research agenda for AERA CTE SIG. Our goal is to have a national summit to identify and discuss critical issues of the profession at the national, regional, and international levels.

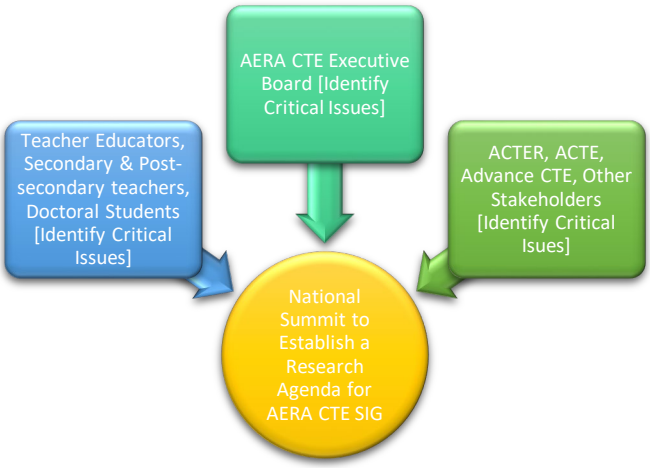

Figure 1. Conceptual Framework to Establish a Research Agenda for AERA Career and Technical Education Special Interest Group

Conclusion

This content analysis was designed to identify and categorize subject matter topics from 15 annual conferences of the AERA CTE SIG, spanning 2005-2019. Nineteen subject matter topics were identified, and using a deductive approach, presentations were tagged if they aligned with Lambeth et al.'s framework. The number of presentations ranged from 15 in 2005 to 22 in 2018, which accounted for a modest percentage increase of 46.6%. It appears that top subject matter topics in this study may be highly ranked because they were necessary and important. Data from this study suggest that there is a trend toward multiple authorship presentations at AERA CTE annual meetings, which is considered as a strength. This study highlights the need for AERA CTE SIG executive committee to work closely with the conference planning committee and selected sponsors to examine priorities in the field. Because over 15% of the presentations were classified as "other," we suggest that additional classifications be considered in future research.

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UDL: A Primer for Community College CTE Instruction

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Abstract
Community college career and technical education (CTE) programs serve students from all walks of life. Students learn in their own ways, and it is the difference between each student's learning style and mental and physical ability that poses challenge for CTE instructors. When Universal Design for Learning (UDL) guidelines are used to design curricula, all learning styles are accommodated because multiple means of engagement, representation, action, and expression have been provided. In the making of a case for UDL in CTE programs, learning styles, pedagogy, andragogy, Bloom's Revised taxonomy, Dave's taxonomy, Conscious Competence, UDL, and blended instruction are explored. UDL is introduced as the ideal model for CTE curriculum design, which is demonstrated in a sample CTE assignment and rubric.

Introduction

Career and technical education (CTE) programs play a vital role in the preparation of people for rewarding careers in technical industries. CTE programs are tasked with the simultaneous training of students with diverse demographic and psychographic attributes, and they come with a wide range of personal experience that influences their inherent learning ability. While the application of child learning theory may be appropriate for K-12 CTE programs, and adult learning theory may be appropriate for adult CTE programs, Universal Design for Learning (UDL) accommodates all learners (CAST, 2019) and is therefore most appropriate for the diverse population of community college CTE programs.

Notwithstanding a variety of learning styles, the age of students and their life experiences are key components to the challenge of CTE instruction (Gawronski, Kuk, & Lombardi, 2016). In 2011, the average CTE student was 26 years old. Four in ten students were older than 25 and six in ten were younger than 25 (NCES, 2011). Most learning theories fall under the category of child learning, or pedagogy. Researchers have theorized that pedagogy is best employed when students are younger than 24. One learning theory, andragogy, is suited for students older than 24. However, this 24-year point of demarcation is highly subjective and dependent on life experience and maturity (Noor, Harun, & Aris, 2012). In reality, community college classrooms are filled with students ranging from immature to mature, and inexperienced to very experienced. At an average age of 26, neither pedagogy nor andragogy is 100% appropriate for CTE programs.

A blend of child and adult learning theory is most effective for the *almost-adult* learner, who is not entirely responsive to pedagogical and andragogic methods (Panacci, 2017). Universal Design Theory (UDL) is a learning theory that goes beyond pedagogy, andragogy, or other blended instruction modalities. UDL serves the child learner, the almost-adult learner, and the adult learner through multiple forms of engagement, representation, action, and expression. UDL also serves students with disabilities who struggle to receive, act upon, or express information (CAST, 2019). UDL is ideal for CTE instruction because UDL serves all learners, and CTE kinesthetic activities provide opportunity for multiple forms of engagement, representation, action, and expression.

Literature Review

Peer reviewed articles, research reports, and government data were used to present facts and formulate arguments. UDL concepts were drawn from UDL guidelines (2019), which are published by CAST, a nonprofit education research and development organization. Other research highlights include Usman (2015), Loeng (2018), and TEAL (2011), who effectively define pedagogy and andragogy. Hill, Fadel, & Bialik (2018) reinforce the importance of previous experience in learning processes via their Conscious Competency theory. Other research was chosen for the purpose of reinforcing specific ideas and concepts.

Methodology

A research-based descriptive methodology was used to document instructional methods that are applicable to CTE instruction. UDL principles were applied to a lab and lecture wiring-schematic learning module, and then the attributes of five learning module assignments were mapped to the Knowles Cognitive domain, Dave's Psychomotor domain, and UDL principles.

Background

Every student learns differently (CAST, 2019) and the diversity of community college students is challenging for the CTE instructor. New CTE instructors might be experts in their respective discipline, but rarely begin their instructional careers after being trained in the art and science of instruction (Kerna, 2012); trial by fire is common, which leads to poor student engagement, retention, persistence, and success (Touchstone, 2015).

Considering the diversity of today's higher education student, and the millennial generation's preference for experiences (Talreja, Wahi, Ghosh, Marwah, Verma, 2018), there is debate among educators as to whether instructors should be equally qualified in their discipline and in the art and science of instruction (Hartsoe & Barclay, 2017). In the context of CTE, instructors are faced with the need for professional development on two fronts: (a) maintaining skill and knowledge in rapidly changing industries, and (b) learning and maintaining the art and science of instruction.

For many CTE instructors, it is difficult to maintain competency in both disciplines. Consequently, they concentrate on what they feel has the higher priority—competency in

their craft. Proponents of instructional training for CTE instructors point to a decline in the completion of post-secondary, sub-baccalaureate occupational credentials from 2011 to 2015. Conversely, the award of sub-baccalaureate credentials and bachelor's degrees increased during the same time period (NCES, 2011-2015). If CTE courses were designed to naturally engage students, instructors could concentrate on instruction of their craft, which could reverse the current credential-completion trend.

In UDL, learners essentially choose their preferred learning style in each assignment and are naturally engaged as they make choices. Combined with the use of a learning management system (LMS), UDL has the potential to mitigate the need for CTE instructors to be expertly qualified in the art and science of instruction. Therefore, CTE instructors can train for what they do best: teaching of their craft. In its purest form, UDL removes consideration for pedagogic and andragogic learning theory, focusing instead on the learner, and the result has been increased engagement and student success (NEA, 2008). UDL is a viable option for CTE programs, especially when employed with an LMS where curriculum can be consistently organized.

Learning Styles

Learning styles are habits or strategies that people inherently employ when they are actively learning. One research group identified 71 learning-style theories (Pearson, 2016), some being more popular than others. David Kolb introduced a four-part learning theory in 1984, which includes four learning styles (Tan & Laswad, 2015):

- Accommodating—the accommodating learner is a hands-on, intuitive student who does and feels through practical experimentation.
- Assimilating—an assimilating learner, who thinks and watches with minimal emotion, prefers a concise, logical approach.
- Diverging—this student is a sensitive feeler and watcher who thrives on contemplating different perspectives.
- Converging—this student is a problem-solving, jump-in doer and thinker, who prefers technicality.

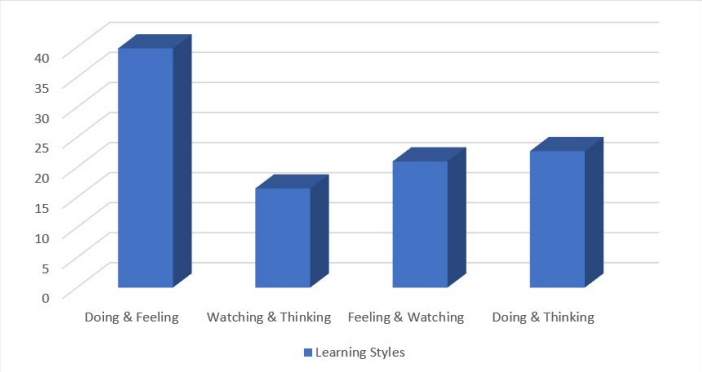

Figure 1. Kolb learning styles for automotive technology students (Threeton, & Walter, 2009)

It is logical to assume that CTE students are hands-on accommodating learners, but this is not always the case. Figure 1 demonstrates a 2009 study of 176 automotive technology students (Threeton, & Walter, 2009), where 39.8% of students were accommodating learners, 16.5% were assimilating learners, 21% were diverging learners, and 22.7% were converging learners. In total, 60.2% of 176 students were not hands-on, accommodating learners. CTE students are not always hands-on, accommodating learners.

Child Learning

Pedagogy is a widely used term among educators that has evolved in meaning over time. Pedagogy is derived from the Greek words *paid* meaning "child" and *agogos* meaning "leader of" (Usman, 2015, p. 58). Paraphrased in a modern context, pedagogy means "the art and science of teaching children" (TEAL, 2011, p. 1). However, the term is also used as a synonym for instructional design and practice.

The word pedagogy is frequently used by college faculty and administrators, which can be confusing because community college students are not thought of as children. According to Noor, Harun, & Aris (Noor, Harun, & Aris, 2012), 24-year-old college students may still be responsive to pedagogic learning theories depending on their life experience, or some 24-year old students are more mature than others. And according to the National Center for Education Statistics, about six in 10 American CTE students in 2011-12 were younger than 25 (NCES, 2011). The application of pedagogy in CTE programs is therefore appropriate, but this leaves nearly four in ten community college students who are older than 24, and less likely to respond effectively to pedagogy.

Many specific pedagogic methodologies have been theorized, but child learning theory is based on the leading of unknowing children. Having not yet fully matured, children are unknowing and prefer to be led. In pedagogy, the learner is dependent on the instructor. The instructor is responsible for what is taught and how it is learned. Child learners have limited life experience, making the instructor's experience most influential. Pedagogic coursework is sequenced and subject matter systematically introduced. Child learners are motivated to succeed by external pressures, for example, by grades, competition, and consequence of failure. Moreover, instructors tend to teach the way in which they were taught, and they have frequently been taught with pedagogical methods (Threeton, & Walter, 2009).

Adult Learning

Andragogy, or adult learning theory, is derived from the Greek words "*aner* (genitive *andros*), [which] means 'man,' while *agein* means 'to lead'" (Loeng, 2018, p. 1). When paraphrased in a modern context, andragogy means "the art and science of helping adults learn" (TEAL, 2011, p. 1). In 1980, Malcom Knowles brought awareness to andragogy while identifying differences between pedagogy and andragogy. Knowles identified five assumptions for adult learners (TEAL, 2011):

- With increasing maturity, adults move from dependency to independent self-directedness.
- By drawing on an inventory of life experiences, adults aid their learning.
- New social or life roles invigorate adults to learn.
- Adults want to immediately apply what they have learned by solving problems.
- Motivation is generated internally, not externally.

Validity of Knowles's assumptions can be found in the success of distance-learning programs, where older adults enjoy greater retention and success than young adults (Dibiase & Kidwai, 2010). Another example is self-evaluation surveys that create self-awareness as to what the adult learner does not know; this in-turn creates motivation for the learner to fill their knowledge gap and engage (Conaway & Zorn-Arnold, 2016).

Adult learners bring life experience that may not be directly relevant to subject matter. Nonetheless, the adult learner may use life experience to connect or synthesize learning material (Conaway & Zorn-Arnold, 2016). Adult students serve as diverse resources for other students, and confident adult learners will eagerly step in as ad hoc instructors. Change for adult learners invigorates the desire to learn, and their need to know is germane to the way in which knowing will affect their lives. Adult learners want to perform and solve problems, and what they want to learn are those things that move forward their quality of life and ambitions (Zorn-Arnold & Conaway, 2016). Subject matter is irrelevant if it is not directly beneficial to the adult learner. They are intrinsically motivated by improvement of self-esteem, quality of life, self-confidence, recognition of performance, and self-actualization (Conaway & Zorn-Arnold, 2015).

The age of an adult learner should not be confused with the legal adult age of 18, or even 21. Generally speaking, by the time a student reaches the age of 24, enough life experience has accumulated to achieve maturity resulting in sense of self (Noor, Harun, & Aris, 2012). Consequently, a CTE instructor teaching mature adults will better serve students by acting in the capacity of a guide or facilitator. The facilitating instructor allows students to explore achievement of learning outcomes on their own terms, but with guidance and within boundaries set by the facilitator (Crowder, & McCaskey, 2015).

According to the National Center for Education Statistics (NCES, 2011), nearly four in ten American CTE students in 2011-12 were 25 or older. The application of andragogy is therefore appropriate in the CTE classroom, but this leaves about six in ten community college students who are younger than 25, and less likely to engage via andragogic learning theory. This creates an obstacle for the CTE instructor, who must decide whether one of the pedagogy learning theories or andragogy is best applied in the classroom. It is from this dilemma that blended learning theories are born (Worthen, 2016).

Bloom's Revised Cognitive Taxonomy

A committee of educators created Bloom's taxonomy in 1956 for the purpose of classifying learning objectives. The committee devised three learning domains for the objectives:

- Affective (emotional or attitude)
- Cognitive (mental or knowledge)
- Psychomotor (physical or skills)

The cognitive domain is widely used by educators and includes six learning objectives that were revised in the late 1990s. Figure 2 demonstrates the hierarchical order of Bloom's revised cognitive domain, which can be used to effectively plan curricula by starting with memorization and building to creation (Burwash & Snover, 2016). CTE instruction requires curriculum in the cognitive and psychomotor domains, but the Bloom's taxonomy committee did not progressively develop the psychomotor domain, citing lack of expertise and leaving the domain for future development.

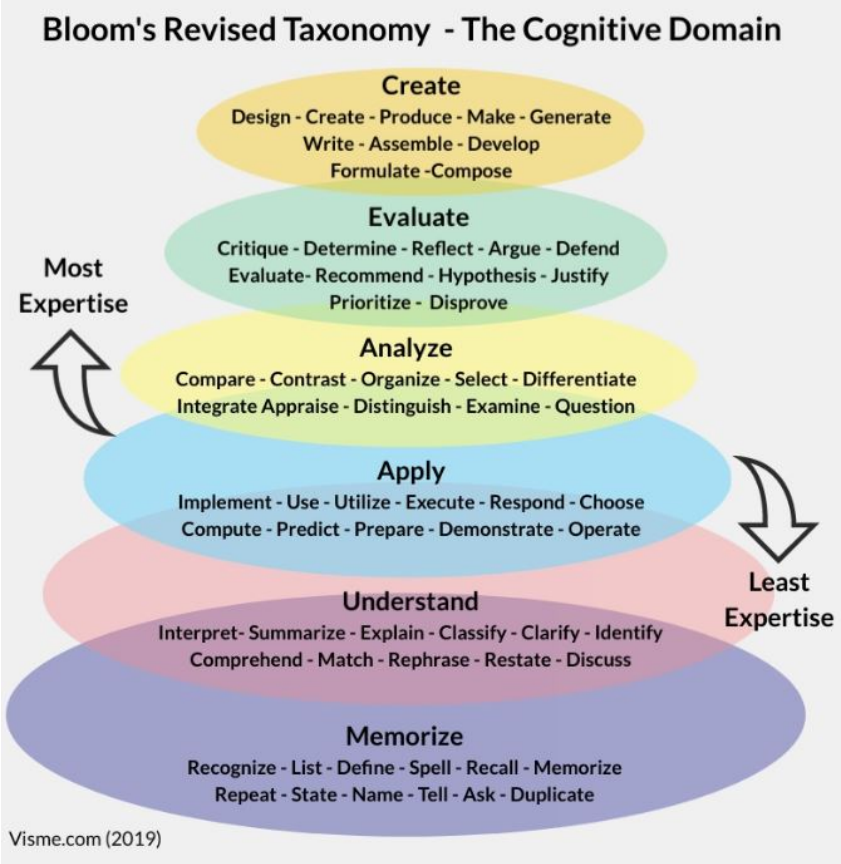

Figure 2. Bloom's Revised Taxonomy (Burwash & Snover, 2016)

Dave's Psychomotor Taxonomy

Dave's psychomotor taxonomy (Dave's) was introduced in 1975 and is one of several psychomotor taxonomy theories. Dave's can be readily applied in the development of CTE curriculum and is commonly used in the design of corporate training. Figure 3 demonstrates the hierarchical order of Dave's, where confidence is built as a pyramid of skills are assembled (Hill, Fadel, & Bialik, 2018).

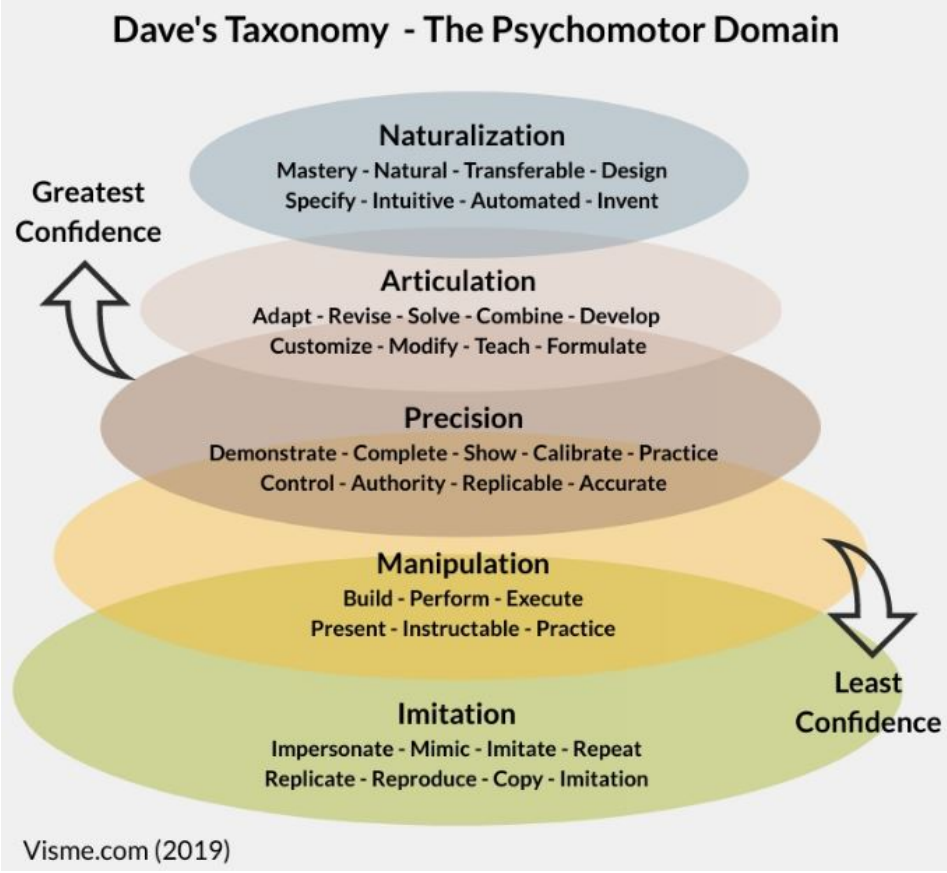

Figure 3. Dave Psychomotor Taxonomy (Hill, Fadel, & Bialik, 2018) & (Dalto, 2014)

While psychomotor taxonomies like Dave's portray hierarchical learning functions as flowing in a linear fashion, the Center for Curriculum Design (CCR) argues that psychomotor learning is not linear in the way it is portrayed by Dave's. Psychomotor learning occurs in parallel tracks depending on the learner's competence in different segments of psychomotor tasks.

In CCR's psychomotor Conscious Competence Model (Figure 4), learners begin an unfamiliar task in a state of *unconscious incompetence*, where the learner cannot yet conceptualize the goal, and feedback cannot be received because the goal is not yet conceptualized. In the second stage, the learner moves to *conscious incompetence* as the goal is understood and the learner becomes aware of their own incompetence; feedback is

now received and processed. As learners practice, they become *consciously competent*, the third stage. In the fourth stage, the learner achieves *unconscious competence* through trial and error, and the psychomotor task becomes natural to the learner. This allows the learner to use unconscious competence to assist in the learning of another task segment (Hill, Fadel, & Bialik, 2018). In other words, experience builds competency, and competency lays the foundation for additional learning.

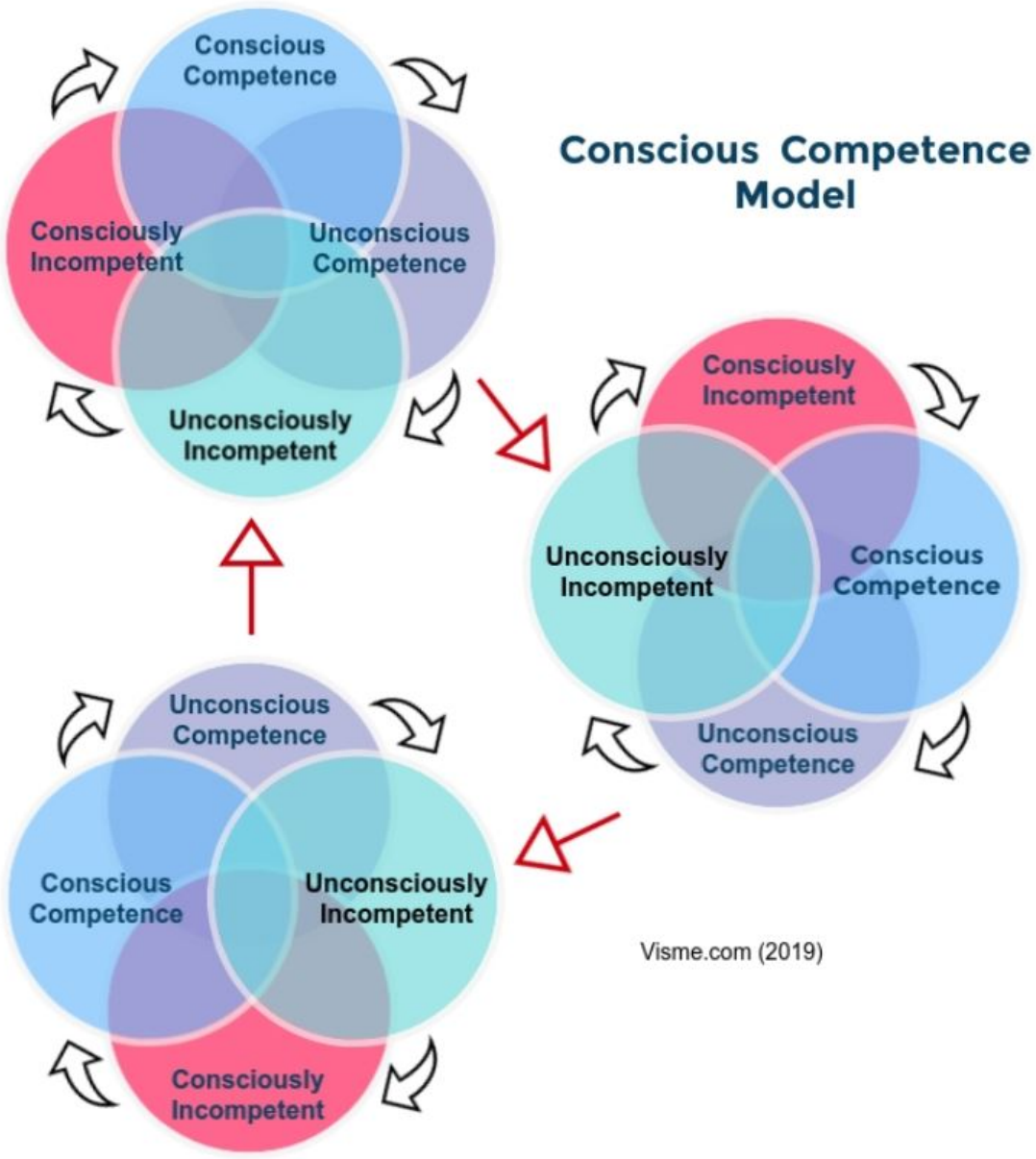

Figure 4. Conscious Competence model (Hill, Fadel, & Bialik, 2018)

Consider John, who was unconsciously incompetent in his first month as a tow truck operator, because each vehicle's spare tire was uniquely mounted and working alongside a roadway is dangerous. In the weeks that followed, John changed dozens of tires on hazardous roads and freeways. With each day of work, John found conscious incompetence as he discovered similarities between vehicles, learned which safety gear worked best, and devised ways to work faster and safer. In John's third month of work, he discovered conscious competence when he noticed that his days were less stressful. Thereafter, when John was challenged with new tasks, he quickly accelerated from unconscious incompetence to unconscious competence. He also felt safe when he worked.

Universal Design for Learning (UDL)

UDL is a framework for accommodating all learners when designing curriculum. UDL is learner-centric, providing guidance as to how all learners can be engaged to learn, how to represent so all learners have opportunity to learn, and how learners might best act or express themselves when they are being assessed. At its core, UDL is about providing choice through multiple means of engagement, representation, action, and expression. In doing so, all learners have opportunity, irrespective of their age, experience, personal learning style, cognitive ability, or disabilities (CAST, 2019). According to the National Center for Education Statistics, almost two in ten students enrolled in post-secondary institutions were disabled[1] in 2015-16 (NCES, 2019); accommodation for disabled students is important. Considering its universal capability, UDL is a logical and necessary design tool for CTE programs.

UDL Engagement

Engagement of students is the first battle to be won by an instructor. The way in-which curriculum affects a learner will define whether the learner will be motivated to learn, and learners respond markedly different to various teaching strategies (Lancaster, Lundberg, 2019). Learners are uniquely influenced by a variety of sources like background, experiences, and culture. Some learners prefer strict routine while others are engaged by novelty and spontaneity. There are learners who prefer to work with peers while others who like to work alone. Moreover, information is inaccessible to a learner when it is not attended to, or doesn't cognitively engage the learner (CAST, 2019).

For improved engagement, UDL Engagement Guidelines prescribe inclusion of multiple means of interest, sustained effort, persistence, and self-regulation. Examples include the provision of choice in learning objective pathways, reinforcement of content relevance to real-world scenarios, and clear direction in how a learner can succeed. Other UDL recommendations include reinforcement of the current goal, variance in demands and

[1] "Students with disabilities are those who reported that they had one or more of the following conditions: blindness or visual impairment that cannot be corrected by wearing glasses; hearing impairment (e.g., deaf or hard of hearing); orthopedic or mobility impairment; speech or language impairment; learning, mental, emotional, or psychiatric condition (e.g., serious learning disability, depression, ADD, or ADHD); or other health impairment or problem" (NCES, 2019, p.1).

resources for optimized challenge, encouragement of community and collaboration, and provision of consistent feedback leading toward mastery (CAST, 2019a).

UDL Representation

People perceive and comprehend information in different ways. Consequently, there are dozens of learning style theories (Pearson, 2016). Some learners grasp information most efficiently through printed text, while others are more responsive to visual or auditory representation. Other challenges to curriculum representation include cultural and language differences, sensory disabilities such as blindness or deafness, and learning disabilities like dyslexia. Most important, when multiple representation methods are used, learning and transfer of information occurs because the learner has made a connection between and within concepts.

There is no single "means of representation that will be optimal for all learners" (CAST, 2019b, p. 1). Rather than be dependent on a single sensory input like sight, hearing, movement, or touch, UDL Representation Guidelines prescribe more than one means of representation in the curriculum. For example, an instructor lectures for no more than 20 minutes, then a lecture video [with transcript] of the same content is provided. Supplemental text with similar information from a different perspective is also provided. A web-based game can reinforce terms requiring memorization or key concepts.

Less obvious forms of representation include perception, language, symbols, and comprehension. For instance, when purchasing digital simulation software for use in a learning laboratory, a CTE instructor evaluates whether the software is capable of sound, speed, language, and text adjustments. The software should include features such as transcripts for languages that reflect learner demographics, images with text descriptions, and embedded symbol glossaries. A text-to-speech feature could open new doors for a learner with dyslexia.

Comprehension is an obvious priority for instructors, but learners who have not been exposed to a given CTE industry prior to enrollment will struggle to put information in context (Noor, Harun, & Aris, 2012). Access to background knowledge via web links can help a naïve learner establish context for subject matter. Highlighting of patterns, relationships, and big ideas drive comprehension through subject matter importance. Comprehension is achieved one component at a time, so a logical and sequential release of information is important. Last, the instructor should provide mechanisms for transfer of information, like checklists, reminder emails, and templates (CAST, 2019b).

UDL Action and Expression

Learners approach, navigate, and express themselves in different ways. When a learner has a language barrier, movement impairment, or organizational or strategic disability, their approach to learning will be very different. Some learners may best express themselves in written form, while others excel in verbal expression or demonstration. When learners act or express themselves, the learner will employ unique strategies,

organization, and practice. Therefore, availability of multiple options for action and expression drives the optimization of action and expression (CAST, 2019c).

Textbooks, even software, provide for limited navigation and interaction. Software developed for technical industries can be limited in navigational function. For those learners who have physical disabilities, operation of software via a keyboard or joystick, could prove challenging. The option of navigation via keyboard or a joystick can open doors for the disabled. Ideally, software will operate by voice activation, an expanded keyboard, or even a single switch (CAST, 2019c). For the instructor who must choose among software and hardware designed by industry, choices in navigation can be limited. Nonetheless, choice in navigation should be one of the questions asked when selecting software for the CTE laboratory.

For the purpose of assessment, a medium of expression does not exist that is equally suited for all learners or communication types. However, a learner with dyslexia may struggle to write an assignment but excel in the recording of a video. Conversely, learners with limited social skills may excel in a writing assignment but struggle to produce a short video with a smartphone. In CTE, recording of a video while performing a task, and then reciting information from memory, can effectively demonstrate subject matter competence (CAST, 2019c). Fluidity of information in a video can indicate whether a student has reached a state of naturalization (Hill, Fadel, & Bialik, 2018). In other words, the activity is second nature to the student. Also, web tools used for expression serve as excellent resources for the filling of gaps in spelling, writing, and creative skills.

Blended Instruction, UDL, and CTE

Considering the diversity of students in community college CTE programs, the adoption of either a pedagogic or andragogic instructional method may lead to undesirable student engagement, persistence, retention and success (Panacci, 2017). In blended instruction, the CTE instructor attempts to incorporate the best features of pedagogy and andragogy. When blended instruction is executed correctly, engagement of different learning styles and early connectivity is achieved (Crowder, C., & McCaskey, 2015). However, blended instruction can be difficult to competently execute (Jokinen & Mikkonen, 2013). Since the CTE lab and lecture environment provides generous opportunity for multiple means of engagement, representation, action, and expression, UDL is uniquely suited as a replacement for blended instruction.

Table 1
Sample Wiring Schematic Learning Module

Assignment	Engagement	Representation	Action Expression	Taxonomy
1. Build a load and switch electrical circuit.	Hands-on assembly; choice of circuitry type.	Instructor led lab demo; video lecture/transcript;	Assemble circuit; hand-drawn circuit diagram, or with web tool.	Dave's Imitation; Bloom's Memorize
2. How does electricity work?	Web terms game; knowledge survey.	Lecture; video lecture/transcript; text reading	Retention & comprehension quiz or video.	Bloom's Understand; Dave's Manipulation
3. Define a sequence of operation.	Choice of lab equipment; group study.	Lecture, video lecture w/ transcript	Online presentation, manuscript, or outline w/ recorded audio commentary	Bloom's Apply-Analyze; Dave's Manipulation
4. Diagram, build, & demonstrate the sequence.	Independent or group study.	Equipment lab models.	In-person demonstration or video presentation w/ transcript	Bloom's Create; Dave's Articulation
5. Demonstrate circuit dysfunction.	Independent lab study.	Lecture, video lecture w/ transcript	In person or group demonstration w/ recorded audio commentary	Bloom's Create & Evaluate; Dave's Naturalization

Table 1 demonstrates utilization of UDL in a CTE learning module that includes three kinesthetic laboratory assignments and two cognitive assignments. Moreover, the relationship between each assignment and Bloom's taxonomy, Dave's taxonomy, and UDL is demonstrated. The assignments incorporate engagement choice outline by UDL, for example, challenge, web games, knowledge surveys, and group and independent study. Choice for UDL representation includes lecture, video lecture, transcripts, and reading. UDL action and expression submissions are enhanced through the choice of text, hand drawn, web drawn, video-with-transcript, web, and group presentations.

Table 2
Sample Lecture-Lab Assessment Rubric

Dave's & Bloom's Taxonomy Alignment	Exceeds Trade Standard	Meets Trade Standard	Fails to Meet Trade Standard	Unacceptable Submission
Imitation & Understanding	10	7	4	1
Manipulation & Application	10	7	4	1
Precision & Analyzation	10	7	4	1
Articulation & Evaluation	10	7	4	1
Naturalization & Creation	10	7	4	1

Rubrics are an effective, learner-centric tool for objective assessment of knowledge and skills. Students find rubrics to be effective in the guidance of their learning processes (Leader, & Clinton, 2018). Table 2 demonstrates an assessment rubric for the cognitive and psychomotor assignments found in Table 1. The rubric ties Bloom's and Dave's taxonomies to trade standards previously represented to students. When considering this process from learning module to rubric, the application demonstrates how the use of UDL guidelines in CTE instructional design can result in multiple forms of engagement, representation, action, and expression.

Conclusion

CTE instructors are tasked with preparing diverse student populations for careers requiring formidable cognitive and psychomotor skills. Students come from no less than three generations, have unique mental and physical capabilities, and are likely equipped with a limited catalog of life experience. Fortunately, CTE instruction provides for a variety of instructional opportunity including lecture, demonstration, ad hock laboratory instruction, hands-on practice, and experimentation in the lab. The unique instructional experience found in CTE represents opportunity for development of new ways to engage students, represent information, incite student action, and cultivate student expression. UDL provides the framework for realization of CTE instruction that goes beyond the norms of pedagogy, andragogy, and blended instructional methodology. When UDL oriented curriculum has been integrated into learning management systems capable of audio, video, and other digital experiences, the stage has been set for exceptional CTE instruction that can effectively reach all community college learners. Achievement of UDL in CTE programs will require investment of time, resources, and concerted effort by faculty and administrators, but UDL holds the potential to raise the bar for CTE and is worthy of aspiration by community colleges.

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Why Apprenticeship Programs Matter to 21st Century Postsecondary Education

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Abstract
The United States job market will soon face a deficit of middle-skilled workers upon the retirement of the baby boomer generation. Measures to address this issue must be presently implemented and meet these demands by preparing workers in the middle-skilled professions gap. Further, current Career and Technical Education programs must expand to include training in emerging industries. This present research explores the expansion of apprenticeship programs in the United States and posits how they may support the successful transitions of students and workers into postsecondary education and business and industry. A new apprenticeship model is proposed.

Introduction

Over past decades, the need to better prepare high school students for further education or work in today's high-tech and knowledge-based economy has been well documented (Aasheim, Li, & Williams, 2009; Carnevale, Smith, & Strohl, 2013). This lingering issue has fueled a national push for emphasizing college and career readiness in high schools to help students experience successful transitions and better preparation into postsecondary education and the workforce (Loera, Nakamoto, Oh, & Rueda, 2013). However, in a school-centered education system with limited connection to work experiences, this push is often misconstrued as a need for a 4-year degree (Gordon, 2014). However, nearly one-third of students do not continue to postsecondary institutions, and many of the students that do enter into postsecondary institutions are said to still be under-equipped for careers upon graduation (Parton, 2017).

What experiences are students having leading up to college or their entrance into the workforce? High schools with Career and Technical Education (CTE) programs are doing their part in supporting student achievement, occupational exploration, technical skills attainment, and workplace readiness. However, with work-based learning as a key component of the Association of Career and Technical Education (ACTE) Framework (ACTE, 2017), how are policy makers, stakeholders, postsecondary institutions, and educators looking at extending those critical learning opportunities to better support future workers?

High-quality apprenticeships help prepare students for potential careers, often providing a pathway to postsecondary education and training, while offering paid, real-world experiences. These programs give students hands-on learning experiences promoting

engagement, retention, and transferability of skills (OECD, 2017). Apprenticeships help improve skills and competencies that meet the need of industry and the employer. In these programs, apprentices receive on-the-job training and education in their career focus, opportunities for career advancement, while also receiving industry issued, nationally recognized credentials and articulation agreements between training programs and 2 and 4-year colleges (OECD, 2017). This can create opportunities for college credit and postsecondary education certificates and degrees. Further this may aide students in avoiding student loans for academic and training completion.

Purpose of Study

Apprenticeship programs are largely underutilized in the Unites States compared to other countries such as Germany and Switzerland **(**Hoffman et al., 2015). There has been an increased focus on CTE programs and workplace readiness. Even with grant funding being allocated to develop and strengthen apprenticeships, and further emphasis on the expansion of pathways, many postsecondary institutions, employers, and students may not be aware of the positive outcomes of apprenticeship programs. The purpose of this paper is to describe and discuss apprenticeship programs, pathways for program expansion, and rebranding to increase positive public perceptions.

Theoretical Frameworks

Situated Cognitive Theory (SCT), Cognitive Apprenticeship Model (CAM), and Social Cognitive Career Theory served as the theoretical frameworks that guided this research. The proposed Career Development Through Apprenticeships Model (Figure 1), in the present research is a gestalt model constructed from the synergistic components of these three theories and highlight the core constructs and goals of high-quality apprenticeships. Apprenticeships support the idea of learners being situated in the contexts in which they will be working, the development of students through carefully articulated steps, and posit that students will gain career related efficacies through experiences (Brown, Collins, & Duguid, 1989; Lent et al., 2005; Pappas, 2015; Vygotsky, 1978).

The Situated Cognition Theory (SCT), outlined by Brown, Collins, and Duguid (1989), is centered on the idea that knowing is "inseparable" from actually doing and highlights the importance of learning within context. SCT is based upon principles related to the fields of anthropology, sociology, and cognitive sciences. Its main argument is that all knowledge that a learner acquires is somehow situated within activities that are socially-, physically- or culturally-based (Brown et al., 1989). SCT supports that knowledge cannot be acquired if the learner is not in the context the skill is being taught and eventually utilized in.

The Cognitive Apprenticeship Model (CAM), developed by Collins, Brown, and Newman (1989), closely relates to SCT, indicates that context learning and immersion in a field is important for learning. In CAM, the student is expected to develop, with guidance from the expert in the field of interest. Also, in CAM, the student and expert work through *Modeling*: Where the expert demonstrates the skills and efficacies;

Coaching: Where the apprenticeship then demonstrates the skills and efficacies and the expert provides meaningful feedback for improvement; *Scaffolding*: Applying the skills and efficacies through tasks and building upon knowledge; *Articulation*: The expert has the apprentices apply skills to other projects, while still providing feedback; *Reflection:* Having the apprentice think about practices during demonstrations, and after, also reflecting on the feedback given by the expert; *Exploration:* When the apprentice is encouraged to perform new strategies, problem-solve, and critically analyze on their own (Pappas, 2015), (see Figure 1). This workforce training strategy is based on Bandura's Social Cognitive Theory (1986). This approach to skill development and acquisition moves from classroom training to actual workplace practices. During this development process, Bandura suggests the in-vivo practice, or Situated Cognition, where the learning takes place in the real-life environment (Bandura, 1986; Collins et al., 1989).

Both SCT and CAM frameworks are based on salient features from the social cognitive theory, where the learners are best engaged in immersion of rhetoric, activities, and links theory to doing. Students are able to apply knowledge and content in a relevant and practical environment, enhancing skills and efficacies. Learning extends beyond the cognitive processes to include real life environments to apply and test knowledge (Merriam et al., 2007). These frameworks highlight when external activities become an internalized function, the learner moves through higher intellectual levels because the structure and organization of the cognition is changed (Luria, 1982; Vygotsky, 1978).

The application of Social Cognitive Career Theory (SCCT) to apprenticeship programs provides a unique lens regarding intentions of career development. SCCT, Social Cognitive Theory (1986), explains how academic and career interests develop, how educational career choices are made, and how career success is obtained. Three constructs that are central to SCCT are *self-efficacy, outcome expectations, and goals* (Lent et al., 2005). These three variables are important for the development of learner engagement in the apprenticeship pathways, as well as overall success in regards to retention and career aspirations in career development (Lent & Brown, 2019).

Self-efficacy, or an individual's personal beliefs about his or her own capabilities, are immutable. It can increase or decrease depending on the confidence levels in particular fields. If a person has a set of industry preferred skills and experiences in a particular working environment, SCCT predicts that the person will generate interest, perform better, and be inclined to pursue that career pathway (Lent & Brown, 2019).

Outcome expectations are the beliefs about performing specific behaviors and related consequences. According to SCCT, people are more likely to engage in activities if the activities lead to positive outcomes. Positive outcomes can be: social mobility, tangible rewards, and better working environments. When students or employees have negative outcome expectations, they are less likely to actively engage in the career pathway (Lent & Brown, 2019).

Personal goals according to SCCT are the intentions to engage in specific activities. Goal setting helps engage a person in the guidance and organization of their behaviors. SCCT posits personal goals are important to both self-efficacy and outcome expectations. The success or failure of goals directly effect, by altering or confirming, self-efficacy and outcome expectations.

The SCCT supports career development activities by reinforcing continued engagement, skill development, and the interaction of career development processes. These processes include interest, choice, and performance (Lent & Brown, 2019). Self-efficacy has been researched as an important determinant of many workforce fields. Observing positive, or successful, models tend to increase self-efficacy, and negative, or failed, tend to decrease self-efficacy. SCCT is concerned with proximal contextual variables for facilitative support and influence (Lent et al., 2005). Based on this model of developing interest through activity exposure and performance, one could potentially gain interest in career and technical fields through apprenticeships that yield positive experiences (see Figure 1). SCCT's framework indicates that a person's learning experiences will affect their self-efficacy and outcome expectations, so when those prove to be negative their interests will diminish further positive actions (Lent & Brown, 2019).

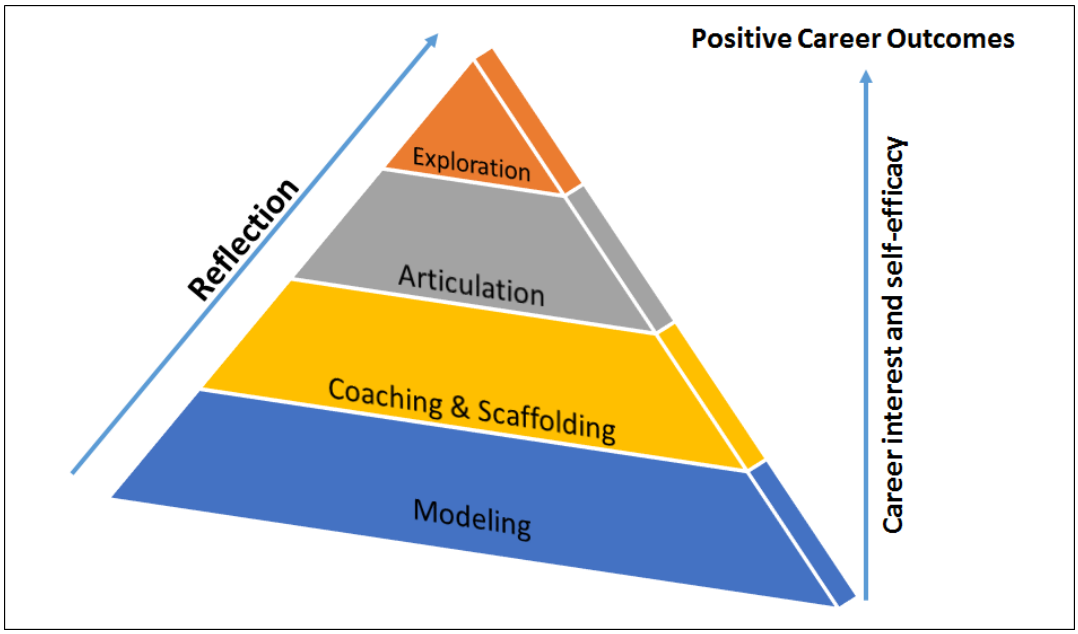

Figure 1. Career Development through Apprenticeships Model

The Career Development through Apprenticeship Model was developed using the CAM and SCCT. The models were used to describe the cognitive development of an apprentice (i.e. modeling, coaching, scaffolding, articulation, exploration), reflection of practice, and the positive career outcomes attributed to successful completion of the cognitive domains. In this model, reflection is an ongoing process throughout the apprenticeship that can produce positive career outcomes by increasing career interest, as well as career

and self-efficacies. As the learner moves through each stage, it is proposed that the apprentice will gain career interest and self-efficacy, as well as more positive career outcomes (Lent et al., 2005).

Apprenticeships in the 21st Century

The 21st century demands a new approach to apprenticeships as a call for the vacancies of an array of middle-skilled occupations. There are trends of retirements that will be happening with the baby-boomer generation that will lead massive amounts of openings in the middle-skills labor market. Fifty-three percent of American labor market fall within "middle-skill job" category (OECD, 2017). However, data suggest that there is a 10% deficit of workers to fill those positions (National Skills Coalition, 2017). With globalization, changing industries and an evolving job market, the middle-skills gap will continue to widen unless institutions can create and implement apprenticeship programs to prepare students for stepping into the workforce and becoming more qualified workers (Center for American Progress, 2017).

Workforce professionals are challenged with developing new and cutting-edge training programs that meet the needs of employers, labor market demands, and a more diversified landscape of students. Apprenticeships can connect classroom learning and theory to real-world workplace efficacies, career development, goals, and outcomes (Lent et al., 2005; Merriam et al., 2007; Parton, 2017). According to the U.S. Department of Labor, apprenticeships are defined as: paid, on-the-job learning under the supervision of skilled employees; it is related to classroom-based instruction; has ongoing assessments against skills standards; culminates in a portable, industry-recognized credential (Department of Labor, 2018).

Apprenticeships can offer training, workforce experience, and career readiness that employers are looking for while offering employees breaks from large student debt and providing certificates to indicate effective and customized industry training. Apprenticeships support a talent pool by delivering industry standard training, the employees are engaged and tend to stay longer within career paths. Employers are partnered with the institutions to craft curriculum that supports student learning and acquisition of knowledge, meets the needs of the industry, and familiarizes students with workplace interpersonal skills and company culture.

Apprenticeship programs have the opportunity to provide a more skilled workforce, provide livable wages, and readily gain employment and workforce experiences. Twenty-seven percent of workers with credentials less than an associates' degree earn more than the average worker with a bachelor's degree (Austin, Mellow, Rosin, & Seltzer, 2012). These programs pay students to work and go to school and offer pay incentives by increasing wages with each credential attained. Having students work in fields of interest, while simultaneously completing credentials, can increase motivation and engagement. Students are looked at as employees, not just students. Although the idea of students as paid employees participating in experiential learning processes is developing in the

United States, this view has already produced gains in European education models (Hoffman et al., 2015).

Youth Apprenticeship Programs

Youth apprenticeships are largely underutilized in the United States. Though they are developing gradually, little has been written and there still remains no legal definition. Youth apprenticeships, or apprenticeships that occur during high school, have the same criteria except that the partnerships transpire between the high schools, postsecondary institutions, and employers (Parton, 2017). These programs are designed for students to successfully transition into a registered or other high-quality apprenticeship program. Re-evaluating and promoting the need for youth apprenticeships in high school can begin training for high demand trades at an earlier age. This can aide students' transition into the workforce earlier, or develop 21st century skills that will be needed as the student enters into postsecondary institutions.

Youth apprenticeships are not federally vetted; however, the US Department of Labor have profiled a series of high-quality standards including: approved training and curriculum; strategies for long-term success; Access to appropriate support services; promotes greater use of Registered Apprenticeship to increase future opportunities, meaningful hands-on training that does not displace paid employees, and facilitated entry and/or articulation (Department of Labor, 2018). Youth apprenticeships are not regulated by the government, therefore it is important to align high-quality standards for program and student success.

Though an answer to education and industry need, apprenticeship programs should be selective in participants involved. Recommendations for programs acceptance can comprise interviews, pre-apprenticeship or internship experiences with the employer. Students should fulfill all prerequisites, a minimum GPA requirement, have no attendance issues, and should be able to pass a drug test. Employing students that have demonstrated a commitment to occupational learning will help strengthen apprenticeship programs. Students selected must go through required safety and legal training to ensure they are prepared for the workforce, as well as the employer and the secondary institution. Parents of underage workers must agree to terms and conditions and apply all federal laws pertaining to time restrictions, payment, and other legalities (Council of State Governments, 2017; Parton, 2017).

Pre-apprenticeship Programs

A pre-apprenticeship program is a program that helps prepare students for the apprenticeship program in a particular trade or field. These programs equip students with training and experience to be further prepared for the apprenticeship program and the working environment. These programs focus on hands-on experiential opportunities to gain prerequisites, understanding of daily tasks, and professional strategies so they are the most viable apprenticeship program candidate.

Registered Apprenticeships

A registered apprenticeship program (RAP) is an apprenticeship program proven by the Department of Labor or State Agency Program, as a proven and validated model. The validated model includes paid work, work-based learning, mentorship, educational and instructional components, and industry-recognized credentials (Department of Labor, 2018). According to the Department of Labor, 94% of apprentices continue to work after completing their apprenticeship program. As of 2018, there were 585,000 registered apprentices in the United States, indicating a 56% growth since 2013. There are 23,400 registered apprenticeship programs (Department of Labor, 2018). During the 2018 Fiscal year, construction was the largest industry for apprentices.

Extended Apprenticeship Pathways

Labor market research found that apprenticeships can be expanded from twenty-seven programs to seventy-four commonly used occupations for apprenticeship programs (Fuller & Sigelman, 2017). Two specific categories are identified as being pathways for expansion: expander role and booster role occupations. Expander roles do not require a bachelor's degree while booster roles often times request a bachelor's degree by employers but are not necessary. The expansion of these roles is not to eliminate higher education from the pipeline but to streamline training in a more effective, and systematic way. Apprenticeship expansion across more occupations can give different trades a way to gain the experience, skills, and paid compensation as well as increase the labor market by 3.2 million job opportunities (Fuller & Sigelman, 2017).

Expanding apprenticeship programs can be a way to mitigate degree inflation, or up-credentialing, in the labor job market. Degree inflation is a term that describes employers requiring a bachelor's degree when one is not needed for those specific job requirements. Middle-skilled jobs, defined as occupations needing more than a high school degree but less than a Bachelor's degree, are being filled by workers that have 4-year degrees because employers ask for that credential although bachelor degrees are not necessary in many of these sub-baccalaureate occupations (Fuller & Sigelman, 2017).

Apprenticeship opportunities are predominant in career pathways within areas such as construction and the skilled trades, despite promising efforts underway to bring it to white-collar fields such as pathways in information technology, financial services (Parton, 2017). If students are given the opportunity to experience apprenticeship programs across career pathways, they can utilize this model in a variety of occupations that could streamline their path to the workforce. Offering apprenticeship programs in high school in career fields can increase career efficacies, positive career outcomes, and increase motivation in a chosen pathway (Lent et al., 2005). According to SCCT and CAM, students experiencing the modalities of learning and the engagement in positive career experiences, are more likely to stay in their chosen occupations (Brown et al., 1986; Brown et al., 1989).

Public perceptions of apprenticeship programs and career and technical education continue to persist as a terminal career path for blue collar occupations with limited upward mobility. However, there are European countries such as the United Kingdom, Germany, and Switzerland that are creating pathways to not only develop the highly-skilled workforce that is being called for but also create extended pathways to white-collar position in the profession (Hoffman et al., 2015). Creating these pathways and changing the public perception, may further change social stigmas attached to career and technical education by recruiting students for training, on the job the job paid experiences, and a way for potential candidates to pave pursuit to upward mobility. Extended apprenticeship pathways can increase student achievement, job marketability, retention, and provide a bottom up approach to training and promotion.

Importance of Postsecondary Alignment

In order to support the expansion of apprenticeships, there will need to be a strong partnership with postsecondary institutions. As apprenticeship programs are being used to promote workplace readiness and job training, there is not a smooth and continuous link for apprentices to complete their 2- or 4- year degree. Program benefits such as completion of program certificates, American Council on Education approved credits, which they are able to use for a 2- or 4-year degree, are not articulating as seamlessly as they could be. When postsecondary institutions include registered apprenticeships as a part of their attainment goals, it signals that apprenticeship programs are valid pathways into careers (Leventoff, 2018). According to Leventoff (2018), only twenty-one states reported the inclusion registered apprenticeship certificates within their postsecondary attainment goals.

The Importance of Business and Industry Partnerships

Business and Industry (B & I) partnerships are critical in the success of all apprenticeship programs, as well as provides correlations of the levels of opportunities that students can achieve in career development. Business and Industry is a key factor in whether or not apprenticeships can be developed within the partnership. If schools or institutions do not have the support and resources of the stakeholders, operators, companies, or sectors, apprenticeship programs will not have the on-the-job training component that the workforce is demanding from our young adults.

In effective apprenticeship models, B & I partnerships are main components in the training system. Partners give insight and expertise in the development of content, the access to real-world working environments, industry standards and benchmarks in regards to assessments and evaluations, and the mentorship and training parallel to academics (Howze, 2019).

Rebranding Apprenticeship Programs and changing the Paradigm

The transformation of apprenticeship programs as a key component to a streamlined workforce pipeline is critical when moving forward and bridging the skills gap with more

qualified workers. Apprenticeship programs are often regarded as a disconnected pathway from higher education and primarily for career placement. If a student is not "college bound" they may come across an apprenticeship program. However, by making apprenticeship programs a high priority in Career and Technical Education recruitment and a main objective of career guidance, students may identify a pathway for individual success. Administrators and educators should highlight the tremendous opportunity in apprenticeships to market the programs as practical ways to get high wages, technical, and workplace skills that can create opportunities for extensions into 2-4-year college, career advancement and socio-economic mobility.

Currently, the diversity of our students, industry changes, and our nation's call for more hands-on, relevant training brings highlight to a once criticized parallel track approach to education. John Dewey once criticized the dual pathway system stating separating vocational and academic education will only further an academic divide (Dewey, 1939). The separation system would lead to the division of socio-economic classes and social predestination (Gordon, 2014). Just as recent as the early 21st century, vocational education and apprenticeship programs were attached to a negative stigma. However, within the recent decade CTE has been in the midst of an important transition period of redevelopment. With this, important components of the CTE high quality standards have risen to the top of expected student outcomes. Work-based learning is an essential part of CTE. Work-based learning involves hands-on experiences that give students opportunities to gain practical and workplace efficacies that supplement academic attainment. Thus, apprenticeships should be structured into curriculum and developed as a structured extension to further education and working experience.

The US Department of Labor (DOL) has reported 100 million dollars in grant funding in creating new apprenticeship opportunities across sectors and industries (Department of Labor, 2018). According to the DOL, the grants use funds authorized by the American Competitiveness and Workforce Improvement Act which has been amended to expand the Industry-Recognized Apprenticeship Program. These industry sectors include focusing on Information and Communication Technology, including cybersecurity, and artificial intelligence, healthcare occupations, advanced manufacturing, and financial services. There is a call for apprenticeships for those sectors that do not have a significant track (Department of Labor, 2018).

There now exists a government impetus to recruit, train, and retain more women in apprenticeship programs in fields such as cybersecurity and advanced manufacturing (Department of Labor, 2018). Grants will be awarded to organizations that develop pre-apprenticeship or nontraditional skills training, ongoing orientation for workers and employers on creating a safe working environment for women, and/or developing and setting networks for advanced support for women retention (Department of Labor, 2018).

There are a few states that are implementing pre-apprenticeship programs to support the workforce initiative for advanced training and workforce development. Colorado is one

state that is implementing a pre-apprenticeship program for high school students. Modeled after VET, Colorado is working to fill employment in informational technologies, engineering, and biomedical sciences by working with major industry partners. With reports of less turnover and a decrease in training costs for those that participated in apprenticeships, Colorado along with states like California, Minnesota, Wisconsin, and South Carolina are creating opportunities to explore this underutilized education model (Council of State Governments, 2017). This initiative aims to create a modern, effective, and more streamlined training paradigm for high school students to either enter the workforce or into a postsecondary institution with occupational experiences (Council of State Governments, 2017).

Conclusion and Implications for Policy and Practice

It is essential that business and industry professionals embrace the apprenticeship education model as an effort to work collectively to streamline student achievement, technical skill attainment, and workplace readiness. Industry professionals should work in tandem with education partners to identify skills, training plans, and paid on-the-job training (Hoffman et al., 2015). CTE teacher educators should increase collaboration with business and industry in establishing cohesive and salient liability contracts for all parties. Rigid contractual documents for the employer, institution, student, and parent is imperative for standard safety issues and liabilities. All parties should agree before engaging in apprenticeship partnerships.

Having a coordinator or a team of coordinators work in conjunction with key partners to help create apprenticeship programs is instrumental in a success apprenticeship program. This should be a dedicated, full-time position that is filled by someone that can devote time, communication skills, resources, and engagement in partnerships to successful apprenticeships. This partnership can ensure a more seamless succession that connects the apprentice from classroom, to training, and then into the workforce.

Directing state funds to promote the expansion of current apprenticeship programs, as well as develop apprenticeship programs into new industry sectors can assist in creating a more skilled and prepared 21st century pipeline of workers. State funds can support the growth of youth apprenticeships and pre-apprenticeships into secondary schools. These state investments may provide an incentive for more employer participation and engagement. Apprenticeships are usually financed through the employers; therefore, having state investment can multiply dividends.

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Announcer Career Path Exploration

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Introduction

This article provides factual information for those interested in a career as an announcer. The given information about the job specifications, such as duties and benefits, may prove beneficial in helping those who are interested decide if this career is right for them. The following information about the announcer career will be presented in this order: responsibilities, how to become one, pay and benefits, job outlook, and an interview with someone currently working in this field.

Responsibilities of Announcers

According to the U.S. Department of Labor (2019), announcers' main responsibility is to verbally present material, including news, music, the time, the weather, commercials, and sports, as well as give commentary and conduct interviews. Those in the profession are expected to read scripts, choose some of the program's content, make announcements throughout the entertainment as a way to guide the audience, and appear at events for promotional purposes (U.S. Department of Labor, 2019). The two types of announcers are television and radio announcers and public address system announcers (U.S. Department of Labor, 2019).

Television and radio announcers present the news or music, must have knowledge of current events, and may need to conduct some research to properly comment on specific topics, as stated by the U.S. Department of Labor (2019). They are additionally expected to read scripts, make appointments for guests to appear on their show, work to create content alongside producers, and use studio equipment (U.S. Department of Labor, 2019). Many announcers work with advertising, which includes persuading advertisers to purchase advertising time, recording advertisements, and broadcasting commercials, public service announcements, and schedules for the program (U.S. Department of Labor, 2019). Those in the occupation tend to do promotional activities, such as appear at events and use social media to maintain a connection with the audience and promote the program (U.S. Department of Labor, 2019). According to the U.S. Department of Labor (2019), the types of television and radio announcers include disco jockeys (DJs), podcasters, and talk show hosts.

The U.S. Department of Labor (2019) states that public address system announcers entertain or provide information to audiences to enhance their experience. They may be required to write their own scripts or improvise, but the other responsibilities of public address system announcers vary depending on the specific position (U.S. Department of

Labor, 2019). For instance, sports team announcers read the starting lineups and advertisements and announce as players enter or exit while train announcers read details about train schedules, serving a more informative purpose (U.S. Department of Labor, 2019). According to the U.S. Department of Labor (2019), public address system announcers also include emcees, who host events by informing the audience of upcoming speakers or performers, and party DJs, who present music and give commentary at an event.

Television and radio announcers tend to record in soundproof studios (U.S. Department of Labor, 2019). Many of those in the announcing profession work full-time, while some work part-time, as found by the U.S. Department of Labor (2019). Some announcers work for the early morning or late-night programs, but many of these programs are recorded during the day (U.S. Department of Labor, 2019).

How to Become an Announcer

As stated by the U.S. Department of Labor (2019), some job positions for announcers may only require a high school diploma or equivalent, but many positions tend to require a bachelor's degree, often in the areas of broadcasting, journalism, or communications. Broadcasting classes can help students work on their vocal ability and quality and give them experience working with equipment and software used in studios (U.S. Department of Labor, 2019). Sports attorney and *Forbes* contributor Jason Belzer (2016) says that those interested in becoming a sports announcer may consider a degree that offers a concentration in sports media, which helps provide students with more specific training and networking opportunities. According to the U.S. Department of Labor (2019), announcers will often need on-the-job training for a brief period. For instance, public address system announcers will need to understand the equipment and event for which they work while those with only a high school diploma or equivalent who work as television and radio announcers will need training to use the equipment properly (U.S. Department of Labor, 2019). Those interested can gain additional experience through taking college classes, working for a television or radio station on their college campus, or obtaining an internship, and employers often expect potential employees to have some previous experience (U.S. Department of Labor, 2019). According to Chicago announcer James Van Osdol (2005, p. 11-12), internships provide students with the opportunity to connect with professionals and make themselves visible in the field, and many students are able to transition from an internship to a paid position at the same broadcasting company.

According to the U.S. Department of Labor (2019), announcers tend to begin their career at a small-market station where they can learn to develop their on-air personality. To advance their career, many move to a large-market station. The U.S. Department of Labor (2019) explains that large-market stations will look at announcers' past work because they want to hire someone with an attractive and engaging on-air personality. Large-market stations additionally look for someone who has experience with social

media, selling commercial time, and making appearances for promotional purposes (U.S. Department of Labor, 2019).

Communication skills – interpersonal, speaking, and writing – are important because of announcers' need to work with interview guests or clients, speak effectively, and often write their own scripts (U.S. Department of Labor, 2019). Announcers' voices are an important aspect of their career, and Glenn Halbrooks (2018), who worked in news broadcasting for 30 years, advises those beginning in the field to record and listen to their own voice, try impromptu speaking, and make adjustments to their scripts to practice speaking in a natural way. According to Van Osdol (2005, p. 13), reading material, from the newspaper to novels to brochures, can help announcers gain different perspectives and communicate more effectively. They additionally need to develop computer skills to use editing software and other equipment, research skills to properly report about events, and persistence to work at small-market stations with the hopes of advancement (U.S. Department of Labor, 2019).

Pay and Benefits

According to the U.S. Department of Labor (2019), the median annual wage for public address announcers in May 2018 was $27,720. An annual salary of less than $18,250 was received by the lowest 10 percent, as opposed to more than $63,760 which was earned by the highest 10 percent (U.S. Department of Labor, 2019). For public address system announcers, the top industries in May 2018 were performing arts, spectator sports, and related industries with a median annual wage of $33,700 (U.S. Department of Labor, 2019).

As stated by the U.S. Department of Labor (2019), the median annual wage in May 2018 for television and radio announcers was $33,220. An annual salary of less than $19,120 was earned by the lowest 10 percent while more than $94,450 was earned by the highest 10 percent (U.S. Department of Labor, 2019). The top industry for television and radio announcers in May 2018 was television broadcasting with a median annual wage of $47,020 (U.S. Department of Labor, 2019).

According to professional writer Frank Howard (2018), those who are television or radio announcers have many benefits including interviewing interesting guests, performing a variety of tasks on the job, and traveling to cover certain events which may all provide additional satisfaction. Additionally, Van Osdol (2005, p. 13) says announcers are able to find positions at companies related to their own passions, such as music or sports, and they are able to immerse themselves in their passion.

Job Outlook

For announcers in general, employment is expected to decrease by 9 percent from 2016 to 2026 according to the U.S. Department of Labor (2019). For public address system announcers, employment is expected to increase by 2 percent, which is below average compared to other occupations, while employment for television and radio announcers in

expected to decline 12 percent from 2016 to 2026 (U.S. Department of Labor, 2019). The U.S. Department of Labor (2019) states the projected decline may be a result from the consolidation of many broadcasting companies which means broadcasting companies have less job positions to offer. Syndicated programming is used when a broadcasting company prerecords a segment and has the rights to sell the segment to other local broadcasting companies, which means they do not have to hire as many announcers (Halbrooks, 2019; U.S. Department of Labor, 2019). The popularity of satellite and online radio stations has provided competition for over-the-air radio stations (U.S. Department of Labor, 2019).

Some announcer job positons are expected to remain in demand. For instance, announcers for podcasts or Internet radio may be in demand (U.S. Department of Labor, 2019). Additionally, there is a large number of national news stations, so the audience may want an increase in local news stations (U.S. Department of Labor, 2019). Public address system announcers will remain in demand because of the information or entertainment they provide according to the U.S. Department of Labor (2019).

Interview with Joel Godett, director of Broadcasting and Athletics Communication at Ball State University in Muncie, Indiana

1. What type of activities do you do on a typical working day?

If I'm working at a Ball State University football game or basketball game,

As we approach football seasons and I'm getting ready for a football broadcast, I listen to the previous week's game while multi-tasking and doing other things. I listen to myself in an announcer capacity and determine if there are details that I want to focus on during the next game. This is a constant self-reflection to improve as an announcer. I will also start research prior to the next game. I familiarize myself with players, trends on the team, and I start laying out spot charts (These are what I have in front of me for each broadcast with all information that I might need). Spot charts are prepared in advance with a great deal of research via multiple sources including Internet sites, coaches, and coach teleconferences with other teams.

When it comes to preparation for a television broadcast there's a whole different set of preparations. I'll trade emails with my producer and analyst and talk about what we think is important and how we want to tell the story of our upcoming game. We'll set up a conference call with opposing players and coaches and then, of course, I get to travel to the various locations of games. So it's a whirlwind.

2. What kinds of fun technology do announcers get to use?

Announcers get to use a Zoom voice recorder. This is used when interviewing coaches and players. This helps with gathering notes that could then be referenced on the air

when broadcasting. This information could also be used during a pregame or half-time show. Announcers also use broadcast headsets during broadcasts. These are very expensive headsets because they produce quality sound to provide the best experience for viewers and listeners.

Announcers may use a Zoom voice recorder (pictured) to gather direct quotes from coaches and players that can be referenced later.

Joel Godett sits in his office, showing the Zoom voice recorder mentioned above.

Godett is shown wearing a broadcast headset, which is designed to provide the highest quality listening experience to those listening to announcements and programs.

3. What is your favorite part about being an announcer?

My favorite part of being an announcer is getting to attend athletic games and experience the energy of the environment. Being part of the performance aspect of the production is rewarding. I am able to be part of the performance to entertain viewers and listeners, and while it's not scripted at all it is definitely still a performance in some respects. There is a depth to how you use your voice and the vocabulary selected and how you paint a picture for viewers and listeners. Every word choice matters! That challenge, much like walking out on stage, is part of the fun.

4. What are the main challenges you have in your typical work?

One challenge that I have is multitasking because I serve as an announcer and a sound engineer for all radio broadcasts. Prior to games when working as a sound engineer, I must connect to the radio station and make sure all equipment is functioning properly. I also have to monitor the connection to the radio station during the game. I troubleshoot broadcasting issues before and during games and, believe me, they come up all the time. This is typical of smaller radio stations and at certain levels of college athletics and particularly at the minor league baseball level.

5. What is your advice for someone interested in pursuing this career?

My advice is to want to really pursue this career because it is hard. Climbing the ladder in this industry is not easy, and you have to have a lot of work ethic and perseverance. You will need to be ready to move out of state and often miss family events due to athletic commitments. You have to have a genuine sense of curiosity. This is important because you can't be fake. You have to want to know the answers to questions that you ask to players, coaches, fans, etc. You have to be genuinely interested in those answers and be genuinely curious and want to get to know people. That curiosity shows in the way you'll be able to better tell athlete's stories.

Conclusions

Announcers verbally deliver material to either inform or entertain the public, depending on the specific position. Therefore, this career is best for those who have strong skills in verbal communication because much of their success relies on their ability to effectively communicate and engage with the audience. Despite the overall decline in announcer employment, announcers can receive fulfillment from working with their passions. Those who are interested in this career may want to consider finding an internship and practicing their vocal skills.

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Construction Project Engineer - Career Exploration

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Abstract:
The construction industry is one of the most diverse job markets because of the variety of specialties involved. With such a wide range of skills and expertise needed for the same project, it is essential that students within the construction management field are not only prepared before entering the workforce but are also aware of the expectations and the work environment of the various options they have. This paper provides an overview of the skills and qualifications necessary to become a successful project engineer in the construction industry. Interviews, with three current project engineers, provide professional insight from career experts depicting what it takes to be a successful project engineer.

Introduction:

Within just one construction project there are a variety of tasks that must be addressed. This includes the many different positions within the construction industry that are involved in the completion and success of a project. Because the construction industry has seen rapid growth in the number of projects, the number of jobs has also increased (Luo et.al., 2017). The more complicated a project, the more professionals are needed and the more specific their job requirements will be. The complexity of a project also influences who is involved. Specifically, a project engineer is a key part of a construction project from start to finish because of their involvement in almost every aspect of the construction process. Since there are so many parts that go into a construction project, having one person involved in everything from the first meeting with the client to the end result is crucial to the continuity of the project.

Responsibilities of Project Engineers:

Project engineers have numerous responsibilities throughout the entirety of a project. From start to finish they plan, design, develop and manage the construction project. They work alongside superintendents who oversee the project from planning to completion. The project engineer is responsible for the small daily tasks such as specifications, scheduling and running materials while communicating with other members of the team and the client. Project engineers have a wide range of responsibilities since they work both on and off site during the project.

The main focus of a construction project engineer is to understand the needs of the project and find a way to execute those needs. Organization and attention to details are important in order to set up a proper timeline for the project. Once on the site, their job consists of ensuring safety for workers and resolving problems before they happen. They

build relationships with the contractors, project manager, and owners to update everyone throughout the process (Novotny, 2018). The project engineer is a management position, but engineering knowledge is also required because project engineers must know the technical elements of a project. The ability to update construction documents and develop specifications are key responsibilities of a construction project engineer. The project engineer of a construction project is the "go-to" person who makes sure everything runs smoothly and ensures the lines of communication are smooth between everyone else involved in the project.

The project engineer's responsibilities on a construction project are vast. Some of the day-to-day tasks that can be assigned to project engineers in construction companies include:

- Procuring of materials required for self-performing site teams.
- Communing with sub-contractors and suppliers about addressing emerging issues on site.
- Following up with company's superintendents or subcontractors' project managers on schedules and look-ahead plans.
- Writing and documenting request for information (RFIs) that are sent to architects, engineers or owner representatives.
- Assisting in managing transmittal processes where the contractors require approvals on shop drawings, materials and methods that are to be used on site.
- Take-off material and estimating of changes orders.
- Assisting the project manager in handling project documentations including logs and reports.

Becoming a Project Engineer:
When deciding to become a project engineer in the construction field, a bachelor's degree in a construction or engineering program is preferred. An engineering degree provides the ability to interpret and comprehend technical elements required on the project (Novotny, 2018). Management experience is also a very important component in properly managing the rest of the team involved with the project. Many project engineers in the construction field have a professional engineer's license that shows clients how reliable they are (Novotny, 2018).

Pay and Job Outlook for a Project Engineer:
According to payscale.com, the average base salary for a project engineer was $61,358 as of March 2019. The more experienced project engineer (10-20 years) averaged $72,378 while the top ten percent made over $106,000. There is an exceptional pay difference by location, but an entry-level position as a project engineer can average $58,000 a year. This proves that through experience and growth, this career path provides the possibility for advancement, and with the construction industry growing, one can forecast higher pay for more knowledgeable candidates.

Interviews with Project Engineers

Ball State University offers a baccalaureate degree in Construction Management and provides a minor in Construction Management for those majoring in others field but interested in gaining more construction/project management knowledge. The Construction Management program is accredited by the American Council for Construction Education (ACCE). In the past five years, the program has had 100% job placement in the construction management industry, including those who are placed as project engineers.

The program aims to prepare professionals who:

- Utilizing critical thinking and decision making to solve problems
- Possessing entry level technical knowledge and skills of construction science and management
- Applying effective leadership, team building and communication skills to the overall construction process
- Managing the construction project successfully from start to finish
- Integrating and apply knowledge to produce safe, efficient, economic, and sustainable solutions
- Exhibiting honesty, integrity and high ethical standards
- Demonstrating the ability to work effectively with diverse populations
- Analyzing needs and provide necessary training and/or feedback to improve desired outcomes
- Committing to continued professional growth and have the initiative to grow in their positions and assume leadership roles within their chosen profession

During the spring of 2018, three graduates of Ball State University's Construction Management program were interviewed, capturing specific insights to the field. Two of the interviewees have been working at the same company for two years while one has three years of experience. All three project engineers received their current job offers from the annual campus career fair.

When asked what a typical workday as a project engineer entails, all three project engineers explained their daily tasks change depending on what phase they are in with the current project. One of them explained in each phase, "there is lots of communication with the sub-contractors to figure out issues and to relay information". All three shared that they spend more time on-site than in the office. This of course depends on the time of year. "In the busy months (March to November), [he] spends about 60 percent of his time on site versus 40 percent in the office."

All three interviewees discussed that dealing with unexpected challenges was a common challenge. They all revealed every project is different, and one of the three specifically mentioned "turn-around time is a challenge because the sub-contractors expect an answer

right away which coincides with what another project engineer said about having to make sure everyone involved like owners or general contractors are happy."

A consensus for the most enjoyable and rewarding part of their project engineer job was "when the final project comes together." One of the three specifically mentioned, "[he] likes to navigate through the challenges that come every day and [how he] learns something new every day."

Interpersonal skills become critical when working in this field. Communication was the number one skill discussed by the interviewees. One project engineer explained that, "the ability to have tough conservations with contractors is important", and another said "the ability to deal with different personalities is important since there are so many people involved in a project."

The three interviewees were past students enrolled in a bachelor's degree. They revealed that during the four years of their construction management degree, specific classes: scheduling, materials, specs, and electrical management helped them excel in their job. One project engineer suggested that an internship be considered at varying times of the year, not only in the summer. The second engineer emphasized the importance of job shadowing and on-site experience as well as focusing on certification classes like LEED. His advice to students was "to participate in any extracurricular activities in construction to better prepare for the field". When asked what skills were recommend for a current student to focus on before entering the industry. One of the three project engineers stated, "It is important to understand how to read drawings and get a full grasp on the details." Another suggested, "…learning the specs and drawings quickly… and not to be afraid to ask questions". The third project engineer stated, "it is important for students to build good relationships with their professors and mentors because those are the building blocks for their network. The relationships are potential job opportunities when the students graduate."

All the project engineers interviewed had plans for their future that involved future growth in the construction management field. One of the three desired to eventually have more of a superintendent role so he could be more involved in field work. The second project engineer plans to "move up the ranks" in his current company and become an executive. The third, plans to own his own construction business by first becoming superintendent followed by becoming an estimator to gain all experience he can.

Conclusion:

Project engineers are essential to any smooth-running project in the construction industry. Since they are a critical part of the construction process, dependent on throughout the entirety of a construction project, they are required to have a wide range of skills, knowledge and experience. The attention to detail with the technical elements and the communication between contractors are vital skills they must obtain to be successful.

Though this is a challenging profession filled with a different set of tasks each day, it is a rewarding way to start and advance a career in the construction industry.

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