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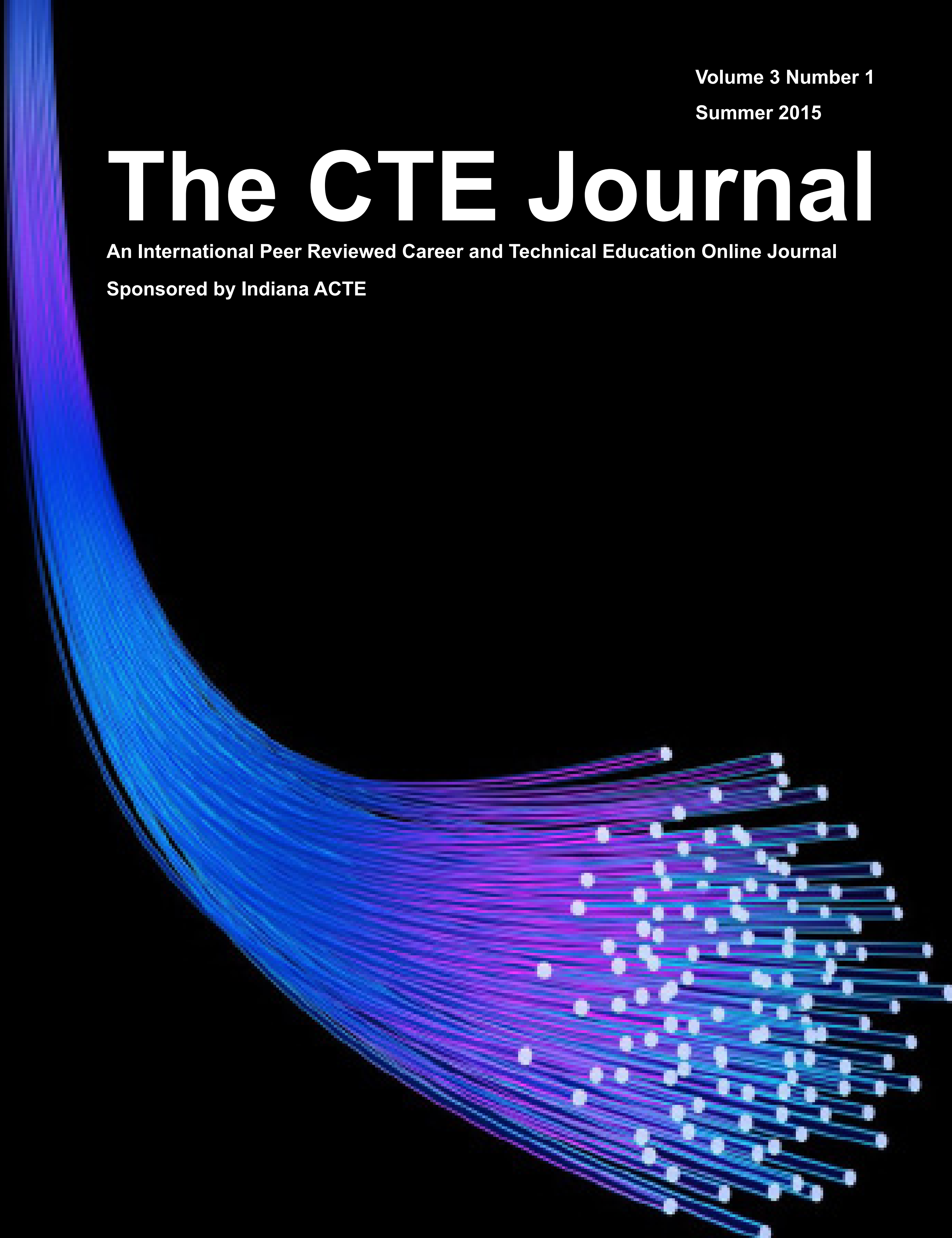

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Reflection on One's Own Teaching Style and Learning Strategy Can Affect the CTE Classroom

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Abstract
Whether we are aware of it or not, many of our current teaching practices are not the most effective. Often times, teachers are not considering the audience within their classrooms when they establish their teaching practices; and because of this, students might find it difficult to comprehend or retain the information being presented. This work explores the concepts of becoming aware and reflecting on one's learning strategy and implementing that knowledge into one's teaching style. Specifically, this study focused on teachers in Career and Technology Education (CTE) classrooms; however, the issue is not limited to CTE content areas alone. Understanding the impact this work could have on student success may be applied to other disciplines as well.

Introduction

Career and technical education (CTE) is part of the United States secondary education system and has existed as a federally funded program, in various forms, since the passage of the Smith-Hughes Act of 1917. CTE has evolved over time from the more general vocational education courses of wood, metal, and auto shop to include topics such as criminal justice, education, and medical sciences (Gentry, Peters, & Mann, 2007).

The primary goal of teachers within CTE is to prepare students for postsecondary careers upon graduation from high school. Gray (2004) stated that,

> for students who (a) are at risk of dropping out of high school, (b) seek employment directly after high school, or (c) want to go to college at the one- or two-year level to prepare them for preprofessional technical careers, CTE is arguably the most important curriculum in the American high school. Together, these three groups make up a majority of all high school students. (p. 5)

Each CTE teacher is unique in many ways. Students with varying academic interests and abilities enroll in their classes with different learning preferences. Additionally, CTE teachers may enter the classroom with little or no professional educational background (Fritsch, 2013). While the authority for licensing teachers lies within each state, many school districts have been forced to explore alternative methods for teaching certifications. The Bureau of Labor Statistics (2014) indicated some states and school districts have recruited individuals directly from business and industry to help address CTE teacher shortages. While many of these individuals have extensive work experience in a related occupational field, they are likely to have only a high school diploma, associate degree, or a bachelor's degree in a non-teaching academic discipline. They have rarely been given any training on teaching methods or classroom assessment. However, as Knowles (1970), Muijs and Reynolds (2011), and Stronge (2007) noted that the teacher is the most important variable in the classroom for student achievement; secondary CTE teachers must find a way to overcome educational shortcomings and address the unique learning preferences of their students.

One way to make a difference in the success of their students is for teachers to identify their own teaching style, and then implement classroom practices related to that style while creating an environment conducive to the different learning styles of their students. “Knowledge of teaching style can make a difference in how teachers organize their classroom, how they deal with learners, and how well their students do in the learning content” (Conti, 1989, p. 3).

The desirability of identifying a teacher’s learning preference directly relates to “a teachers’ own experience of learning as learners and to their experience as teachers in schools teaching others” (Lawrence, 1997, p. 160). Additionally, by making teachers aware of how they learn “two things can be established, (a) that learning is a process, and (b) people learn in different ways” (Lawrence, 1997, p. 160). Considerable research supports the view that when students' learning preferences match their instructor's teaching styles, student motivation and achievement usually improve (Miller 2001; Stitt-Gohdes 2001). However; according to David Kolb, educational theorist, "it is more effective to design curriculum so that there is some way for learners of every learning style to engage with the topic, so that every type of learner has an initial way to connect with the material, and then begin to stretch his or her learning capability in other learning modes" (Delahoussaye 2002, p. 31). Zhang, Sternberg, and Fan (2013) recommended that teachers should teach for a diverse and balanced use of learning styles to ensure all students can benefit from the teaching, irrespective of their learning style. Therefore, the purpose of this study is to explore the concepts of teaching styles and learning strategies and to encourage CTE educators to reflect on their own teaching style and learning strategy and implement that knowledge into their classroom.

Literature Review

Most human behavior is learned; therefore, it is important to investigate the principles of learning to understand why humans behave the way they do. Moreover, there is a close relationship between the principles of learning and educational practices. In many circumstances, principles that have been uncovered while studying the learning process in the laboratory have been eventually utilized in the classroom. The current trend in American education toward individualized instruction can be considered a spin-off from research on the learning process. Educators may reasonably conclude that as knowledge of the learning process increases, educational practices should become more efficient and effective (Hergenhahn & Olson, 2005).

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Teaching Impact

Teaching

Teachers have complicated and difficult jobs. “They have to consider many sources of knowledge and explanation, take into account their specific classroom situations and students, and determine when and how various ideas can inform their practice” (Darling-Hammond, Rosso, Austin, Orcutt, & Martin, 2003, p. 20). However, documents such as the Nation at Risk (1983) have argued that teachers have been doing an unsatisfactory job in educating the children of this country, and the No Child Left Behind (2006) legislation further emphasized the same sentiment by mandating all teachers be highly qualified and held accountable. This leads to the question, is there a lack of quality among teachers in the profession?

Contemporary educational reform movements such as this have challenged educational professionals to raise the level of academic rigor thus preparing students with the knowledge, abilities, and skills necessary for post-secondary education and successful entry into the competitive global workforce (Cannon, Tenuto, & Kitchel, 2013). Based on this data, federal and state legislators who have little to no background in education are writing and implementing policies regarding what teachers must do and competencies they must attain. The negative attacks continue because teachers, as a group, are not able to clearly state their beliefs about teaching. Educators need to clearly express their position on the following types of questions: What is their view on the nature of the learner? What is the purpose of the curriculum? What is their role as a teacher? What is their mission in education? Until teachers “are able to clearly articulate their position on these types of questions,” they “will remain open to attack” (Conti, 2015, p. 75).
To counteract this attack upon teaching and to regain control of their own profession, educators must have the freedom to identify their own teaching style and reflect on their beliefs about what constitutes good teaching, personal preferences, their abilities, and the norms of their particular discipline (Pine, 2009). Conti (2015) stated, “Such an assessment will pinpoint their specific classroom practices and relate them to what is known about teaching and learning” (p. 19). This reflection can lead to the implementation of classroom practices that are related to that teaching style while creating an environment conducive to the different learning styles of their students. “Knowledge of teaching style can make a difference in how teachers organize their classroom, how they deal with learners, and how well their students do in the learning content” (Conti, 1989, p. 3).

Teaching Style

There are many ways to conceptualize teaching style. However, much of the research suggests that there are two primary, fundamental teaching styles: (a) learner-centered, and (b) teacher-centered (Conti, 1985, 1989; Ahmed, 2013). Lasry, Charles, Whittaker, Dedic, and Rosenfield (2013) and Tomlinson (2015) suggested the effective use of technology-enhanced environments and addressing the needs of diverse student populations requires the adoption of learner-centered active learning approaches. However, adopting a new pedagogy seems difficult for some teachers. The teacher-centered approach assumes the learners are passive and that they become active by reacting to stimuli in the environment. The learner-centered style of teaching refers to a "method of instruction in which the authority for curriculum formatting is jointly shared by the learner and the practitioner" (Conti, 1985, p. 7).

The main purpose of teacher-centered style is to transmit knowledge. It is characterized by using a traditional skilled teaching technique to convey a selection of knowledge to learners (Jarvis, 2010). Lecturing is the primary means of controlling the learning environment, although other means can also be used to maintain control of the learning environment. Historically, instructors were seen as the main source of knowledge and authority (Marra, 2005; Wenglinsky, 2000). Outcomes are evaluated by the learner's ability to reproduce a selected portion of material and are reinforced by the instructor's approval through good grades.

In the classroom, learner-centered education focuses upon the individual learner rather than on a body of information. Piaget's theory stressed the constructive nature of learning referring to the idea that all students attempt to interpret their work based on their skills, knowledge, and developmental levels (Darling-Hammond & Bransford, 2012). Subject matter is presented in a manner conducive to student's needs and to help students develop a critical awareness of their feelings and values. Freire (1970), Knowles (1970), and McCombs (2001) argued that curriculum should be learner-centered, that learning episodes should benefit from learner's experience, and that the teacher should serve as a facilitator rather than a lecturer of facts. This learner-centered, student-active instruction – often called constructivism – affords students opportunities to explore ideas and construct knowledge based on their own observations and experiences (Smerdon, Burkam, & Lee, 1999; Ahmed, 2013).

Pedagogical Framework for Career and Technical Education Instruction

Since the Smith Hughes Act of 1917, the implicit learning theory underlying the curriculum and pedagogy of Career and Technical Education (CTE) has been behaviorism as practiced in the classroom and laboratory (Dobbins, 1999). Many scholars in the CTE profession have advocated changes that implicitly relied on cognitive principles (Doolittle & Camp, 1999). This cognitive approach revolves around the idea of constructivism and the learner-centered approach to teaching. "What sets CTE apart from other academic area is its focus on the application of knowledge and the creation of in-depth understanding to solve problems" (Drage, 2009, p. 34). The pedagogy shift has required teachers to reflect on their own teaching style and the learning style of their students (Doolittle & Camp, 1999).

Teachers often feel that a teacher-centered teaching style is the most expeditious method for covering a large volume of material without considering student's learning style preferences (DiMartino, Clarke, & Wolk, 2003). However, Stitt-Gohdes (2001) stated "for students to reach higher standards and learn more effectively, learning situations that are best for students need to be developed and encouraged" (p. 1).

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Teaching styles and profiles are likely to be quite different among teachers in a given school due to numerous variables. Students also vary, by age, aptitude, degree of socialization, cognitive styles, preferred methods of learning, etc. Thus, it is important that all teachers be aware of these differences, and it is critical that they understand there are various learning strategies for both teachers and students.

Learning Strategy

The term learning style only began to appear in the learning literature in the 1970s. One of the reasons for the emergence of the term is that learning style has a practical application, particularly in education and training. There is general acceptance that the manner in which individuals choose to or are inclined to approach a learning situation has an impact on performance and achievement of learning outcomes (Canfield, 1992).

While knowledge of learning styles can help instructors better understand learners and "have important implications for program planning, teaching, and learning" (Smith, 1993, p. 24), they are not something that an instructor can teach to a learner because they are inherent within the learner. This has led educators to the concept of learning strategies (Conti, 2009). "They differ from learning style in that they are techniques rather than stable traits and they are selected for a specific task" (Fellenz & Conti, 1989, p. 7). Therefore, "knowing the kinds of learning experiences that students most value may help instructors develop alternative course structures that provide a better fit between their instructional goals and the learning style preferences of their students" (Canfield, 1992, p. 1). The implementation of different learning strategies requires a shift in the paradigm for learning as well by increasing the student accountability significantly (Frame, et al., 2015).

Inclusion in Career and Technical Education

Career and Technical Education classes have always been popular among special needs students because of the nature of CTE content, essentially its focus on functional life and vocational skills. Cross, Cantwell and Summers (1993) stated, "the broadly based; holistic human ecology approach to home economics provides opportunities for educators to contribute to eliminating discrimination based on disability" (p. 33). Indeed, the special education area of career education interfaces well with the concepts, content, and curriculum of CTE (Clark & Kolestoe, 1995).

The very definition of inclusion clarifies teaching as the delivery of services to students with special needs in regular classroom settings. In an inclusion classroom, many levels of academic ability are represented. For a teacher to best serve his/her students, a teacher must recognize their method of delivery and the learning preferences of the students. Students with special needs are just that, needs that require accommodations to the learning environment (Gal, Schreur, & Engel-Yeger, 2010; Gold, 1980). For this population to succeed, teachers need to be cognizant of their method of deliver and the various learning capacities of their students in order for mastery of the material to occur (Mahadevan, Grenwelge, & Peterson, 2014). However, most CTE teachers have no

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understanding or training regarding how to manage a regular classroom that includes students with special needs.
Identifying issues with teaching styles and learning strategies could be added to teaching preparation programs to allow current and pre-service teachers to reflect and modify their teaching practice. Inclusion of students with exceptional learning capacity and teachers lacking basic pedagogical knowledge are factors that will create barriers to successful classroom practices.

Conducive Learning Environment: The Need to Study Learning
Most human behavior is learned; therefore, it is important to investigate the principles of learning to understand why humans behave the way they do. Moreover, there is a close relationship between the principles of learning and educational practices. In many circumstances, principles that have been uncovered while studying the learning process in the laboratory have been eventually utilized in the classroom. The current trend in American education toward individualized instruction can be considered a spin-off from research on the learning process. Educators may reasonably conclude that as knowledge of the learning process increases, educational practices should become more efficient and effective (Hergenhahn & Olson, 2005).

Learning How to Learn
Learning-how-to-learn is a difficult concept to define with precision (Smith, 1976). Robert M. Smith developed a theory of training founded on the idea that it is “as important to teach adults how to learn as it is to specify particular domains for learning (Brookfield, 1991, p. 64). Initially Smith defined learning-how-to-learn as “a matter of the adult’s having the knowledge and skill essential to function effectively in the various learning situations in which he finds himself” (p. 5). Later Smith (1982) defined learning-how-to-learn as “possessing, or acquiring, the knowledge and skill to learn effectively in whatever learning situation one encounters” (p. 19). Critical to this process is the development of each learners’ awareness and capacity for effective self-monitoring through instrumented learning and active reflection (Smith, 1991).

Instrumented Learning
While researchers generally prefer to observe behavior directly, practical and ethical consideration sometimes necessitate self-reports by individuals (Leary, 2011). Self-reports are individuals’ “reports of how they behave” (p. 80). More specifically, “self-reports may provide affective, behavioral, or cognitive information about individuals” (p. 52). People self-reporting on themselves using an instrument is an essential way of gathering “information no one else knows” about people (Baldwin, 2000, p. 3); it may be the only source of information (Kurtzman, 2000). Therefore, self-reported information or data is needed to investigate important issues not otherwise available with other measures (Critchfeild, Tucker, & Vuchinich, 1998; Podsakoff, MacKenzie, Lee, & Podsakoff, 2003).

A learning instrument is a set of “tactical instructions that enable the learner to learn without a teacher” (Mouton & Blake, 1984, p. 60). In other words, learning instruments provide adult learners with metacognitive references for reflecting upon their experiences. Thus, the instrumented learning process is analogous to the learning process of reflective practice.

Reflective Practice

Professional learning is often a result of reflecting on practice (Cervreo, 1988). Reflecting on practice involves individuals thoughtfully considering their own experiences when applying knowledge to practice (Loucks-Horsley, Stiles, Mundy, Love, & Hewson, 2009; Pedro, 2006; Schon, 1987). Schon (1983) believed that reflective practice must be a definite part of continuing education. Continuing education programs should be a place where "practitioners learn to reflect on their own tacit theories of the phenomena of practice, in the presence of representative of those disciplines" (Schon, 1987, p. 321) related to their own practice situations (Cervreo, 1988, p. 44). For educators to know and then reflect upon their learning strategy and teaching style can prepare them to more effectively apply these learning principles (Conti & Kolody, 2004); this in turn can lead to more reflection. In Broyles, Epler, and Waknine's (2011) study, participants were able to identify and reflect on their negative teaching attributes and were able to improve for the second round of teaching experiences by modifying lesson plans.

Research has shown that the teacher is the main reason for a student's success (Fox, 2009; Knowles, 1970). It is important for them to understand and reflect on their own teaching style and learning strategy for students to be academically successful. Parents, education leaders, government, and the American public are calling for every teacher to be accountable for each student.

Conclusion

Research indicates that most students do not learn well when an instructor uses a passive teaching method and is the principle disadvantage of the teacher-centered approach. Critical thinking, an essential skill for CTE students, does not develop well in this passive learning environment. Changes need to be made so that CTE teachers adopt a more learner-centered approach to teaching. Individuals who are committed to the teacher-centered teaching style should review the concepts of self-identifying learning preferences, teaching style, and learning strategies. These principles need to be communicated to CTE teachers, university professors, and trainers who prepare CTE teachers. University professors and other educators should provide instruction and guidance on the importance of becoming aware and reflecting on one's learning strategy and teaching style. This would include instruction on how to create a learner-centered classroom through instructional strategies and curriculum activities. CTE teachers need to incorporate instrumented learning into their professional development. Knowledge of one's learning strategy preference creates an awareness of how one learns best and the importance of incorporating differing instructional strategies to accommodate all learning preferences of students.

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Redesign of Indiana Workplace Specialist I Teacher Training: Lessons Learned

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Abstract
The purpose of this manuscript is to provide information about the processes used and lessons learned by those who researched, developed, and completed a redesign of the Indiana Workplace Specialist I teacher training program. In July of 2013, the State of Indiana committed $10 million dollars to the Science, Technology, Engineering and Mathematics Teacher Recruitment Fund. Indiana University Purdue University Indianapolis, Ball State University, Indiana State University, the Indiana Association of Career and Technical Education Districts (IACTED) and the Indiana Department of Education created a partnership and consortia to completely redesign the Workplace Specialist I (WSI) teacher training program for all new Career and Technical Education (CTE) teachers in Indiana and deliver it asynchronously online. The consortia were awarded nearly $300K to complete all elements of the revision. This manuscript details the design of the program, the research based unit development, and the lessons learned by all partners in the consortia.

Introduction

Teacher preparation in career and technical education (CTE) has a long and illustrious history that has often blazed new trails in alternative teacher certification. Traditionally, K-12 teachers are prepared by attending a four year university and attaining a Bachelor's degree. Completion of this degree along with a clinical experience in schools — commonly referred to as "student teaching" — is the traditional way that most universities prepare teachers (Wilson, S.M., Floden, R.E., and Ferrini-Mundy, J., 2002).

Historically, CTE teachers have not followed traditional pathways to teacher certification and licensure like other K-12 disciplines (Zirkle, Martin, and McCaslin, 2007). Practical, on the job, work experience in the occupation to be taught has long been a prime consideration in the certification/licensure of CTE teachers, primarily due to a stipulation in the Smith-Hughes Act of 1917 that only personnel with practical work experience be permitted to teach in federally reimbursed programs (Miller, 1982). Trade & Industrial (T & I) fields such as automotive technology, construction technology, advanced manufacturing, and health occupations programs such as nursing, pharmacy technicians and emergency medical technicians rely heavily on occupational experience. According to Lynch (1997), about twenty-percent of CTE faculty comprise the T & I content areas. The required years of work experience vary by state and often are combined with education levels. In the last twenty years, university-based CTE teacher preparation programs have diminished significantly. Studies by Bruening (2001) and Gray and Walter (2001) found that colleges and universities are closing traditional CTE teacher training programs at an alarming rate. These studies are now over 15 years old and the number of colleges and universities that offer undergraduate or graduate degree programs in any discipline area of CTE have decreased even further since 2001. Colleges and universities may offer traditional or alternative CTE teacher certification pathways, but all 50 states now offer an alternative pathway similar to the Indiana Workplace Specialist requirements outlined above (Zirkle, et. al., 2007).

Alternative pathways to teacher certification for CTE instructors are enticing to faculty new to the profession, as they do not have to spend four years in a traditional university teacher preparation program. In many cases, the state requires all first year CTE teachers to complete coursework that is focused on pedagogical issues including curriculum development, instructional strategies, formative and summative assessment, students with special needs, and standards-based reforms and accountability. Profiles of teachers who take alternative routes to certification have been completed at the national level (U.S. Dept. of Education, 2009). Findings indicate that nearly half of those entering teaching through alternative routes would not have done so if an alternative to traditional teacher education programs had not been available. Clearly, alternative routes to teacher certification are attractive to many demographics and this trend continues nationally, as seen in states that have completed research on alternative teacher certification (Feistritzer, 2008; Chin and Young, 2006).

The Indiana CTE Teacher Training Model

A consortium consisting of Ball State University, Indiana State University, Purdue University, the Indiana Association of Career and Technical Education Districts (IACTED) and the Indiana Department of Education (IDOE) has been administering the Workplace Specialist I (WSI) teacher training program for over 20 years. The purpose of the project is to deliver teacher training services for qualified, occupationally competent individuals that allow them to meet requirements of the WSI certificate. Since early 2000, the entire Indiana WSI teacher training program has been delivered asynchronously online.

Rules for the Indiana WSI Certificate were adopted in 2006 and on January 1, 2009 the Workplace Specialist teaching certificate replaced the Occupational Specialist teaching certificate. These rules specify the conditions of first year employment and advancement to the Workplace Specialist II. Among the requirements are (1) a 45 clock-hour teacher training program conducted during the first year (commonly known as the WSI teacher training program), (2) a mentor program, (3) a professional development plan, and (4) basic skills testing (Indiana Department of Education, 2011).

In January of 2013 the aforementioned consortia submitted a grant application to the Indiana Education Roundtable to completely revise, design, reengineer and implement an online teacher training program for all new Indiana Career and Technical Education (CTE) teachers. As per the stipulations of the grant, IACTED served as the lead non-profit grantee and the remainder of the organizations listed above served as partners in the consortia.

Since 1988 the Indiana Department of Education (IDOE) has contracted with the aforementioned consortium in the amount of $74,999 to provide annual services for providing teacher training to all first year WS I faculty in Indiana. Usually there are 75 to 100 WSI faculty trained annually. While this amount was adequate for maintaining the current program, it did not allow for research, revisions, updates, and redesign to include the latest curricular development, pedagogies, technology and assessments for the online WSI teacher training program.

Research-Based Design, Development, and Delivery of the New Indiana WSI Teacher Training Program

While it is very difficult to predict specific long term outcomes and return on investment, what is known is that enrollment by students in Indiana CTE courses has increased by 96% since 2005. According to the Indiana Department of Workforce Development (2012) and the Indiana Department of Education (2012), there were 96,034 students enrolled in at least one CTE course in 2005 and by 2012, there were 188,017 students enrolled in at least one CTE course. Clearly, there is an upward trend in CTE enrollment and clearly, Indiana will need more CTE faculty to teach CTE students. The creation of a high quality first year experience for WS I faculty is imperative to recruit, retain and reward the best and brightest who choose to make CTE a career.

Research is clear that effective teachers are critical to student success in the classroom (Aaronson et al. 2003; Chetty et al. 2011), yet little is known about the best strategies to identify, attract, train, and support such teachers. The need for effective teachers is especially acute in schools serving low-income students who already face numerous disadvantages (Monk 2007; Jacob 2007). These schools face particular difficulty attracting qualified teachers to teach secondary STEM classes (Ingersoll and Perda 2009; Ingersoll and May 2012). While Indiana has been successful in the creation of a network of CTE centers serving Indiana schools, it is important to understand that CTE courses are also offered by WSI faculty at the Indiana Department of Corrections and Ivy Tech Community College. WSI faculty serve underrepresented minorities and underserved geographic areas throughout Indiana.

A recent report by Presley and Coble (2012) for the National Science Foundation developed critical questions that all teacher training programs should ask. They wanted to identify the most critical components or indicators of quality programs. Amongst the four themes that emerged from interviews and focus groups, two were most relevant to this proposal and are introduced below. Each highlights key elements of teacher preparation embraced by this project in an effort to meet the needs of underserved schools:

Theme # 2: Clinical Preparation

- *Consensus Statement: Learning to teach should primarily be a clinical practice thoroughly grounded in the realities of schools and classrooms.*

- *Well-sequenced and well-supervised clinical experiences should provide teacher candidates with realistic experiences upon which to base their decisions to pursue teaching and, for those that do, to prepare them well for the realities and the possibilities of teaching.*

- *Teacher candidates should be engaged in and experience the art and craft of teaching early and often.*

- *Recognized master teachers and teachers-in-residence should play a key role in the clinical preparation of teachers.*

- *Clinical experiences should be in a range of grades in schools that closely mirror where teacher candidates' ultimate placements will likely be.*

- *There should be strong support for program completers through their critical induction period into teaching.*

Theme #3: Knowing and Teaching Disciplinary Content

- *Consensus Statement: Teachers need to both know the discipline they are teaching and have the pedagogical skills to teach it, requiring deep collaboration between education and disciplinary departments.*

- *There is no one best program design. But all programs must be rigorous and accommodate students at different points in their education, their lives, and their financial circumstances.*

- *Pedagogical content knowledge needs a more prominent place in program design and should be blended into the instruction of content courses.*

- *Out-of-classroom experiences help teacher candidates gain an understanding of the nature of the discipline beyond what they can acquire in classes.*

- *Education and disciplinary faculty, along with master teachers and teachers-in-residence, need to create strong partnerships.*

- *No matter the discipline of training, teachers need to be able to make cross-disciplinary connections in their teaching.*

Utilizing the above themes, this project ensured that the WS I teacher training program was research-based, redesigned and updated using input from all consortium members, previous mentors, previous program participants, and recent CTE research. The Indiana STEM Teacher Recruitment Program (Section 246. IC 20-27-14) was a perfect opportunity to reengineer the training program and make Indiana a national leader in alternative certification for first year CTE faculty. This manuscript focuses on the research-based revision, processes used and lessons learned during those processes.

The Redesign and Reengineering Processes

After formulating the research-based framework for teacher preparation (Presley and Coble, 2012), members of the consortia began the strategic planning process by researching the latest findings on CTE teacher training. After examining what other states were doing in terms of CTE teacher training, researching best practice from the National Research Center for Career and Technical Education, and meeting with representatives from the Southern Regional Education Board (SREB) to discuss their research-based CTE teacher preparation model, the consortia decided to get additional feedback from specific Indiana stakeholders. After an initial content analysis was performed by the STEM Education Research Institute (SERI) at IUPUI, it was decided that the current Indiana model should be compared with the SREB CTE Teacher Preparation Project to help determine gaps.

Working with IDOE and IACTED to develop surveys for former WSI program participants (CTE teachers and mentors) and Indiana CTE Directors proved to be an excellent strategy. A survey designed to determine content priorities for the new WSI teacher training project was disseminated by the STEM Education Research Institute (www.seri.iu.edu) and results were analyzed and presented at the Indiana Association of Career and Technical Education conference during the Fall of 2014. Additionally, during the Spring and Fall of 2014, the consortia presented at numerous quarterly meetings of IACTED that were attended by IDOE members. These presentations served as data gathering, information presenting and question and answer sessions that proved very helpful in the strategic planning process.

The survey results guided the consortia as they developed the Unit topics for the reengineering training. The topics listed below were developed as a result of the research and survey results:

- *Unit 1: Orientation and Personal Page*
- *Unit 2: Classroom Management and Procedures*
- *Unit 3 and 4: Special Education, Diverse Learners and Cultural Competence*
- *Unit 5: State and National Career Pathways*
- *Unit 6: Standards Based Objectives*
- *Unit 7: Assessment*
- *Unit 8 and 9: Instructional Planning*
- *Unit 10: Instructional Planning Follow Up and Reflection*
- *Unit 11: Integrating Academics*
- *Unit 12: Instructional Materials and Resources*
- *Unit 13: Advisory Committee's and CTE Student Organizations*
- *Unit 14: Professional Development Plan*
- *Unit 15: Wrap-Up*

After making the research-based instructional unit topics public and gaining support from various stakeholders, the consortia developed a preliminary Unit number, title, survey question and faculty champion matrix. Faculty and graduate assistants at Ball State University were responsible for development, design and completion of Units 1, 2, 6 and 14; faculty and graduate assistants at Indiana State University were responsible for Units 5, 11, 12 and 15 and faculty and graduate assistants at IUPUI were responsible for the remainder of the Units. The consortia developed a Unit format that included the following:

1. Video Introduction: (Voice Over) Go through each step of the Unit – less than 5:00 minutes
2. Standard Based Objective (SBO)
3. Readings
A) Required
B) Suggested/optional with a little intro for each.
4. Best Practice Videos:
A) CTE Director B) CTE Teacher C) Community Member and/or D) CTE Student

5. Written Assignment:
A) Include all assignment information here.
B) Make sure that specific headers for the assignment are included with a brief description below the header for exactly what the students are to include.
C) Include a sample of the written assignment as an example.

6. Group Discussion:

A)Provide no more than 2-3 focus questions germane to the topic of the Unit and then have a link to the Group Discussion Board.

7. Checklist:

A) Prepare a checklist for the student to use to be sure they have included all aspects of the assignment. A template for the checklist will be provided for students to utilize.

8. Perform a "usability test" to determine if each Unit is functional, intuitive and user friendly. Use graduate or undergraduate students to go through the entire Unit and make comments.

Work on the 8 steps necessary to create a Unit began in earnest in the late Fall of 2014. Each consortia member used a similar process when developing Units that included completion of research on the topic, development of standards based objectives, research and development of required and suggested readings, development of a written assignment, development of an online group discussion and development of an assignment checklist. The consortia consulted online instructional designers at Ball State University and IUPUI and it was decided that the structural framework for the instructional unit should be developed first. Then, best practice videos were developed and finally a video introduction was prepared. After a rough-draft of each element of the Units was completed, a "usability" test was performed using graduate and undergraduate students.

There were a number of face to face and asynchronous meetings during the development period between all consortia partners, but especially between representatives from IUPUI, ISU and BSU. As this was a complex project that involved no fewer than 10 members to develop Units, it was important that benchmarks be set and progress be measured and aligned. Ultimately, a single project manager from Ball State University was appointed to ensure quality and productivity as other partners completed work. As of this writing, the project will be ready for the 2015-16 WSI teacher training that begins in August of 2015.

The evaluation of the entire project will be completed by SERI and focuses on the goals and outcomes of this proposal and the indicators of program success as specified in the request for proposals. Specific research questions (Table 1.) were designed accordingly. The evaluation was and will be both formative and summative. During the 2014-15 academic year the WSI program continued with current practice and students completed the existing survey, developed by the consortium, and provided to all WSI students. As new materials were designed and produced for the 2015-16 academic year, they were pilot tested through this evaluation providing formative data to the program staff. Below are the guiding research questions, outcomes, data source and data collection methods that will be used for evaluation purposes.

Table 1.Program Evaluation Design.

Research Questions	Outcomes	Data Source	Methods
Q1: Do WS I participants feel more connected to the curricular materials, their peers, and instructors through the use of the revised curriculum when compared to past cohorts?	Increased learning and retention in the program.	Teachers	Program evaluation surveys
Q2: Are the new WS I modules enhancing participant learning of the given content of the modules including pedagogy for CTE, development of course materials, classroom management, creation of evaluation materials, and integration of academic skills in their CTE classroom?	Enhanced learning and increased instructional and classroom skill mastery.	Teachers	Pre- and Post-test
Q3: Does the new WS I program facilitate career retention?	Increased retention in program, increased retention in teaching, & number of years of planned teaching in Indiana schools	Teachers	Survey, licensure information
Q4: Does the new WS I program facilitate participant recruitment?	Increased number of individuals participating in the WS I program	Participants	Enrollment information
Q5: Are WS I teachers who have gone through this program prepared for their teaching experience?	Higher teacher ratings and increased student learning opportunities	Teachers & Students	Principal and mentor observations/evaluations, see also Q3
Q6: Do students of new WS I have increased learning outcomes and opportunities?	Increased or continued industry certification options, dual credit opportunities, and STEM courses offered.	Students	Survey

Evaluators worked with program staff to provide the necessary data for both the development of the modules and their outcomes as well as for reporting purposes. Regular communication between program staff and the evaluators happened during both program development and implementation to provide ongoing feedback of the program implementation and its early and ongoing impacts.

Lessons Learned

Large, complex projects involving multiple institutions and multiple stakeholders can be challenging. This project was no exception. Instructional designers often use some version of the ADDIE Model (Analysis, Design, Develop, Implement, Evaluate) according to research (Gagne, 2013; Dick, 2012; Morrison, Ross, Kemp and Kalman, 2010) and this project was no exception. However, in an effort to make sure that the

Indiana WSI teacher training program met the needs of adult learners in an online setting, some challenges arose. The consortia learned that with today's technology being available to all students and faculty regardless of time and place, there was a need to think of this project differently. We wanted, and the literature supports (Nair, 2014), that active, experiential and collaborative learning is something important to adult learners, and that whenever possible, learning in context was vital to each Unit developed. In an attempt to ensure that all learning was flexible, customized and iterative for novice CTE faculty, the consortia learned some valuable lessons about the process used to create a high quality, online, adult learner focused program.

Time is of the Essence:
The major challenge for this particular project, as is often the case, was time. The original timeline for this project is below:

Nov. 2013 through August 2014: Begin strategic planning process with all members of the consortium and their representatives to develop a plan to research, redesign and reengineer the WS I Teacher Training Program. Begin redesign of all instructional units. Begin development of mentor program revisions. A blank HTML based website with a functioning navigation structure will be developed. Portals will be added to the WS I website for IRS-W9, Mentor Teacher Conference Records, Teacher Observation forms, and Mentor Observation forms. Mentor details will be added to the new WS I website, such as pay structure, expectations, guide/training, registration process, and withdrawal process. Formative and summative project evaluation will be developed with an outside vendor, and those evaluation tools will be used to create a longitudinal tracking system for WS I and II faculty in Indiana and CTE student achievement impact.

Sept. 2014 through January 2015: Visit CTE centers throughout Indiana to get video of various best practices to support instructional redesign. Complete editing of all web-based, multi-media, reusable learning objects and create high quality products for all elements of the WS I teacher training program. Work with graduate assistant(s) and consultants to develop the learning website. Policies and procedures relating to mentorship will be added to the WS I website. Beta test all instructional units and develop them based on a single template for ease of use and consistency.

Feb. 2015 through Aug. 2015: Finalize development of WS I teacher training modules. Work with graduate assistant(s) to prepare "go live" for July, 2015. From May 5, 2015-May 10, 2015, the completed WS I website will be beta tested for functionality and ease of use. The website will be revised based on the feedback during the test. Project evaluation is completed.

Unfortunately, the grant was not fully executed until November of 2013. Nearly five months of valuable time was lost as consortia members did not have the funding or the certainty to begin stakeholder development and input. By the time all sub-awards from IACTED to the 3 universities were signed and fully executed it was January of 2014. While some technical and strategic planning was completed during the time period from

November of 2013 to January of 2014, this project was nearly 8 months behind when work started in earnest.

Luckily, the consortia had been delivering the existing WSI training program for many years and all consortia members had developed personal and professional relationships over that time frame. Not only is time of the essence, but trust and relationship building is important for large scale reengineering of instructional units to be redesigned. With complex projects such as this one, it is important to know those you are working with and to trust that they will get their portions of the job completed to specification. Fortunately, that was the case for the consortia. Being nearly 8 months behind schedule from day 1 of this project was certainly a challenge, and certainly the benchmarks, calendar and timeline had to be altered, but due to the fact that the consortia members had worked together for many years, this element of the project was not ever seen as an insurmountable issue. It was a challenge, but never an obstacle that was unable to be overcome.

Stakeholders and Research Matter:
This element of the project was absolutely crucial to success. It was imperative that the consortia reach out to numerous stakeholders to ensure that they could provide input and feedback from the very beginning of the process. Certainly the WSI program is important to the CTE teachers it serves and their input was imperative, but it is also very important to CTE leadership in Indiana. CTE Directors and principals want the highest quality faculty available and the WSI program must supply those faculty, for all CTE schools, especially those located in high needs school districts. The universities that provide the actual training are also very conscious of teacher training, and as CTE teacher training has traditionally blazed the trail for alternative certification, universities are being watched carefully as they reengineer teacher preparation programs all over the country. Finally, the Indiana Department of Education, Indiana Commission for Higher Education and the Department of Workforce Development also have high expectations for teacher training, and in the politically charged state of Indiana, any program revision would be foolish to not be open, honest and transparent with all of the aforementioned entities.

The single most important thing paramount to the success of this project was the formation of the consortia prior to making application for the grant. The consortia represented all stakeholders and most importantly, the process used by the consortia was open and transparent. No process or product was developed in secret or with a hidden agenda. All stakeholders agreed that it was time to reengineer the WSI teacher preparation program, but none had more stake or ownership than another. The value of the consortia was that it allowed the process to unfold without creating “winners and losers.” While the history of the existing WSI program was respected and the best parts of that program were embraced, it was clear to all stakeholders that the old program needed a structural overhaul that must include research-based best practice, the highest quality instructional technology and buy-in from all stakeholders.

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The research-based elements really mattered to all stakeholders and recent research from the National Research Center for Career and Technical Education (NRCCTE), and meeting with representatives from the Southern Regional Education Board (SREB) played a key role in the revision of the instructional Units. As a matter of fact, nearly 7 months were spent researching best practice, meeting with representatives from NRCCTE and SREB to gather data. One consortia member from IACTED was sent to an SREB conference to learn more about how other states were using the CTE Teacher Preparation program in their states. While this process was in full swing, the university members of the consortia were working with the STEM Education Research Institute (SERI) at IUPUI to create a stakeholder survey that led to a matrix comparing existing Indiana WSI curriculum to SREB developed curriculum. As soon as data were discovered and content analyses were complete, reports were provided to all stakeholders at IACTED meetings and via email. Final products were clearly research-based and embraced best practice in CTE at all levels.

Finally, after significant stakeholder input, survey results and numerous dissemination on the part of all consortia stakeholders, there was agreement on which CTE topics to cover, how to create Units and how to deliver Units for a reengineering WSI program. Certainly, there were disagreements during the months long process, but rarely were those disagreements so intense that consortia members could not continue work. Because of the open and transparent process, and the ability for all stakeholders to have meaningful input, it was clear that compromise could be reached as a result of the trust that had been built early in the process.

High Quality Evaluation is Critical:
Another important element of the success of this program was that we developed a relationship with the STEM Education Research Institute at Indiana University Purdue University Indianapolis (IUPUI). The request for proposals for the grant required an external evaluation, and the consortia decided that it would be a good thing to find the external evaluator prior to submitting the proposal. As one consortia member was a faculty member at IUPUI it was logical to work with SERI.

After discussing the goals of the project with the consortia members, it was decided that SERI would develop both formative and summative evaluations. The existing WSI program was still in existence during the 2013-14 and 2014-15 academic year. SERI was asked to develop evaluation materials to compare the results of WSI participants from 2014-15 to 2015-16. Realizing that the grant ended in 2015, the materials that SERI develops for the comparison will be provided to the consortia. If the consortia has funding for SERI to do the comparisons, then that is what will happen. If not, then the consortia can perform the comparative analyses. SERI also worked with the consortia to perform a content analysis on existing CTE research-based best practice for teacher preparation. This formative assessment helped set the stage for instructional design and development of the Units. The early relationship between SERI and the consortia helped build trust and set the stage for high quality program assessment and evaluation.

A total of six research questions were developed with the blessing of the consortia, and outcomes, data sources and data collection methods and analysis were discussed openly with consortia members. Regular communication between SERI leadership and staff and consortia members occurred during program development and implementation and ongoing feedback was provided in both directions as the Units were designed, developed and reengineered.

The fact that early adoption of high quality program assessment and evaluation was a part of the culture of the consortia was very important to building trust with stakeholders. All good projects should begin with the end in mind. Too often assessment and evaluation are afterthoughts when making application for funding to complete large-scale, complex, change-oriented projects. That was clearly not the case in the reengineering of the WSI teacher preparation program, and it seemed to be an asset to the entire consortia and all stakeholders throughout the grant process.

A Single Project Manager is Crucial:

The single most important lesson learned from this complex project was that at some point, consensus-based decision making must stop and a single project manager must take over the project. The consortia made application for the grant as a team, reached out to various stakeholders as a team and attempted to make decisions on the reengineering of the WSI teacher preparation program as a team. This process worked for the "big picture" items that needed stakeholder input and buy-in. This process was less effective during the development of the Units and the build of the online course management site.

After some back and forth between the university consortia members who were developing the Units, and the instructional designers who were responsible for the look and feel of the revised WSI website, it became clear that a single project manager should take over the project and have executive decision-making power. This was an easy decision for the consortia to make, as the website was going to be hosted by a single university member of the consortia. That university had resources and a very good instructional design team, so it was natural that this university consortia member would take responsibility for managing all aspects of the project. This happened towards the end of the project when it became clear that time was of the essence. The transition from a consensus-based decision making process to a single project manager with decision-making power was seamless and natural due mainly to the trust that had been developed within the consortia.

Conclusion

The WSI teacher preparation project is now on target and will be unveiled in August of 2015 for the 2015-16 group of CTE faculty. A rough draft will be revealed to consortia members and other stakeholders at the annual IACTED meeting in June of 2015. This will allow for one additional round of feedback, and one additional round of editing before the go live date in August of 2015.

The lessons learned throughout this process include the fact that time is essential to create a high quality product. Certainly, there must be a period of stakeholder input and research to create trust that the project has no hidden agendas and that the process is open, honest and transparent. This consensus-based decision-making process takes time, which is often at a premium when working on a complex reengineering of an online training program that includes many partners. However, when decisions are based on the latest and highest quality research in the field, the time it takes to move the project forward is worthwhile. Finally, it is important to begin with the end in mind, and develop a high quality project assessment and evaluation for any complex project. Both formative and summative assessment should be a part of the evaluation process and the fact that the consortia worked with the assessment team from the very beginning of the project made things seamless throughout.

It is crucial for large scale projects with multiple partners to realize when it is time to move from a group-based, consensus-based, decision-making model, to the appointment of a single project manager which ultimate decision-making power. Had this not happened in this case, it would negatively impacted the project time to completion, the trust and partnership mentality built within the consortia and project assessment and evaluation process.

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Enhancing Learning Experiences in Data Networking Education

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Abstract

Instructors of data networking face the challenge of providing students with lab experiences to apply their learning. This often is accomplished through the use of actual hardware lab environments, remote lab environments, and simulated lab environments. The high cost and access limitations of hardware and remote lab environments can serve as obstacles to achieving student learning outcomes. These limitations can be overcome through the use of simulation software such as Packet Tracer. There are concerns that simulation software does not provide the “presence” or realism offered by physical and remote labs. This article will address several of these concerns and offer strategies for creating more realistic user experiences for students using the Packet Tracer network simulation software.

Introduction

Data networking provides the foundation upon which all other information technologies are built. Students learning these technologies need strong theoretical and applied understanding of how networking infrastructures are designed, built, and maintained. Instructors have long provided the theoretical framework for data communications through lecture and case study. The difficulty is in providing the resources required by students to learn the applied aspects of data networking. Hands-on lab activities are recognized as an essential component in fulfilling this aspect of their education(Comer, 2003; Guo, Xiang, & Wang, 2007; Hua, 2013; Lahoud & Krichen, 2010; Stohr-Hunt, 1996). Students need to be able to design, install, configure, and troubleshoot a networking environment (Zhang, Liang, & Ma, 2012). These applied experiences also reinforce the theoretical framework provided in the classroom (Sarkar, 2006; Zhang et al., 2012).

Providing network lab experiences

To provide this experiential learning, there are three options that an institution can adopt (Adams, 2004; Brown & Lahoud, 2005; Hua, 2013; Lahoud & Tang, 2006). The first option is to provide a physical lab where students can build and configure their network topologies. The next option is to utilize a remote lab solution in which students connect to network equipment over the Internet. The final option is to utilize simulation software that provides a virtual environment that allows students to design and configure network topologies without physical equipment.

Physical Labs
The challenge has been providing students with the lab environment in which students can apply concepts and theories. Such a lab would require an assortment of equipment such as routers, switches, network cables, and computers. Students are able to manually connect the equipment based on a given network topology. The cost for providing a physical lab can be quite prohibitive (Hua, 2013; Lawson & Stackpole, 2006; Wong, Wolf, Gorinsky, & Turner, 2007). The financial burden is increased when student access is considered. One of the factors that affect student engagement is the accessibility of lab equipment (Ma & Nickerson, 2006). A lab environment with insufficient equipment can create situations in which students are competing with each other for access to the equipment needed to complete their lab assignments (Hua, 2013).

Remote Labs
Remote labs allow students to connect to hardware devices without the requirement of physical proximity (Lindsay & Good, 2005). The Cisco Networking Academy offers the NetLab Academy Edition in support of its networking curriculum (Cisco Networking Academy, 2007). Like a physical lab, NetLab requires a set of network hardware as well as NetLab control equipment to allow students to access those resources from anywhere over the Internet. The advantage of such a remote lab offering is that it provides students with lab experiences that have nearly the same authenticity as sitting in front of the actual equipment in a physical lab. This remote access to physical equipment allows instructors to create academically meaningful activities (Kuh, 2001) that engage students by providing them with the configuration capabilities at a distance (Border, 2007; Rigby & Dark, 2006).

NetLab is not without costs or limitations. As with physical labs, there is a significant financial cost for the initial deployment of a NetLab system. The system requires the network hardware associated with the physical lab as well as a NetLab Academy Edition device and annual maintenance plan. In addition to the financial costs, there is a significant limitation with remote labs. Accessibility continues to be an issue as it is with physical labs. Only one student or team of students can access the hardware at a given point in time. This necessitates a scheduling system for which instructors grant access to preconfigured topologies for set time blocks.

Simulation Software
The simulation software available for data networking typically provides a virtual sandbox in which students can create and configure network topologies (Lahoud & Krichen, 2010). Simulation software overcomes the problems of availability associated with physical and remote labs. Students are able to install the software on their own computers allowing them to work on labs at any time. Boson NetSim, GNS3, and Packet Tracer are examples of network simulation applications. Boson NetSim offers a feature rich simulator available for students to purchase that aligns with the Cisco CCNA certification. Packet Tracer is offered at no charge to students enrolled in the Cisco Networking Academy. These simulators do not offer the full feature set found in the operating systems of Cisco network hardware. They are limited to the configurations

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enabled by the programmers of the simulators. GNS3 differs in that it is an open source simulator that allows students to load actual Cisco operating systems into the virtual devices. This gives them access to the full range of commands available on actual hardware. The problem is getting the Cisco operating system files. Typically this requires one to download the operating system from physical hardware and then upload it into the virtual device in GNS3.

An exploratory study by Lahoud and Krichen (2010) found that in most situations, students preferred simulation software over physical and remote lab experiences. While it was found that physical labs were desirable among students, accessibility issues made simulation software the more preferred source for lab experiences. These findings suggest that students would like the authentic experience of working on actual hardware but are frustrated by gaining access to those limited resources.

If this holds true, the key to engaging students while using simulation software is to create “real” experiences (Sauter, Uttal, Rapp, Downing, & Jona, 2013). Studies have defined this realism or “presence” as the degree to which the user experience with the simulation software matches the experience working on physical hardware (Witmer & Singer, 1998). As the user experience of simulation software replicates what the student would experience on actual hardware, students are more likely to perceive it as an educationally authentic experience (Lahoud & Krichen, 2010; Lindsay & Good, 2005; Ma & Nickerson, 2006).

Creating Realism in a Simulated Environment

The Cisco Networking Academy is one of the most broadly adopted networking education curricula available. There are hundreds of thousands of students enrolled in over 9000 academies located in over 170 countries (Cisco Networking Academy, 2014). Packet Tracer is a network simulation application available to all instructors and students participating in the Cisco Networking Academy.

Configuring Realism

Despite the robustness of its capabilities as an educational tool for data networking, there are default configurations that detract from the realism of the user experience. Presented below are a series of modifications to the Packet Tracer environment that will provide students with a user experience that more closely aligns with what they will experience on actual hardware.

Activity Wizard Password

An instructor choosing to use a Cisco Networking Academy lab as a graded assignment or quiz should do so with trepidation. Embedded in the labs provided by the Cisco Networking Academy is the answer key for the lab activity. This answer key includes a list of assessment items that are used by Packet Tracer’s assessment features. Access to the answer key is password protected. The problem is that a simple Internet search will reveal a thriving community of individuals finding ways to bypass this password security.

An instructor should change the default password on Academy labs before assigning them to students for a grade.

Changing Activity Wizard Password

1. Open the Packet Tracer lab.
2. Select the Activity Wizard in the Extensions menu.
3. Enter the default password.
4. Select Password within the Activity Wizard (See Figure 1).
5. Enter and confirm a new password for the lab.
6. Select Save and then Exit.
7. Re-open the Packet Tracer lab
8. Verify that the new password is required to enter the Activity Wizard by repeating steps 2 and 3.

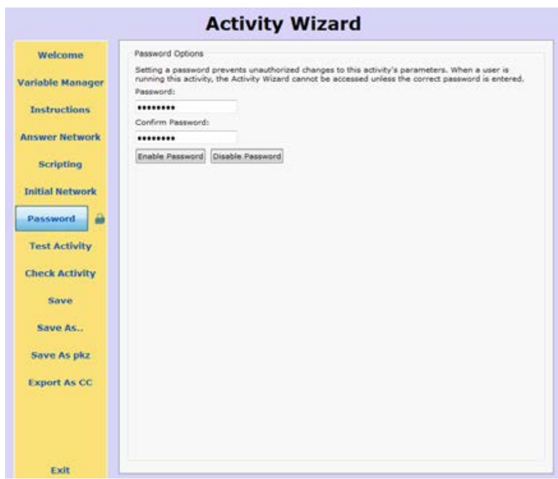

Figure 1

This modified copy of the Cisco Networking Academy lab is what should be assigned to the students. This procedure can also be used to secure the Activity Wizard on instructor created labs within Packet Tracer. Passwords are disabled by default when an instructor creates a custom lab. The Enable Password option would need to be selected after entering and confirming a password as seen in Figure 1.

Self-Assessment

Feedback is a key requirement in the early stages of network education. Packet Tracer incorporates self-assessment features that allow students to monitor their progress as they work through the labs. These features include individual assessment items and an overall completion percentage. These self- assessment features when combined with detailed instructions provide a supportive learning environment for novice networking education students. As the students develop their networking skills, this level of feedback can be counter-productive. These features can foster a dependence on feedback mechanisms that will not be present as students transition to physical hardware. Instructors need to know how to change Packet Tracer configurations to scale back these self-assessment features as students develop in their networking skills.

Completion Percentage
One of the self-assessment features on the PT Activity window is the completion percentage. The percentage found in the bottom, right corner of the window indicates the amount of configurations that are successfully completed (See Figure 2). This provides students with feedback on their overall progress during a formative, skill-acquisition lab.

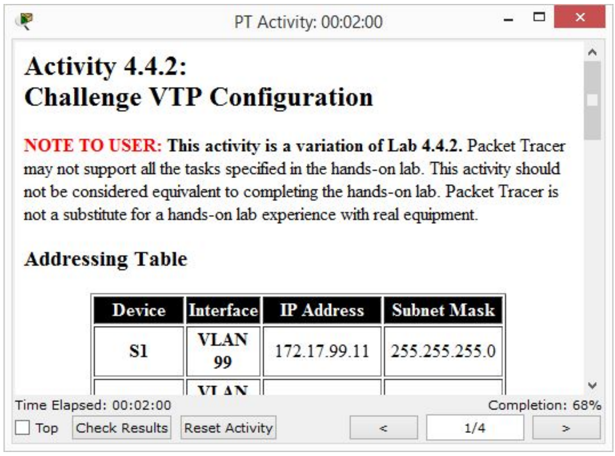

Figure 2

The presence of the completion percentage becomes counter-productive once an instructor chooses to assign a lab to assess skill comprehension and retention. The completion percentage feature does a line item monitoring of the configurations on the devices in the network topology. The completion percentage increases each time a configuration item has been entered correctly. The fallacy is that a completion percentage of 100% does not indicate an accurate configuration. Packet Tracer does not monitor extra lines of configuration that are unneeded or incorrect. A student with a completion percentage of 100% may find that the lab does not work properly because extra configurations have been added that counter-act the intent of the correct configurations. A student may choose to go beyond the stated instructions and independently add a misconfigured firewall that does not allow network traffic to flow through the topology as expected. The completion percentage will show 100% if the monitored configuration items are correct even though the intended outcome of the lab has not been accomplished properly.

The following set of procedures will remove the completion percentage from the PT Activity window for a given lab.

Disabling Dynamic Feedback

1. Inside the Activity Wizard, click on Answer Network (See Figure 3).
2. Click on the Settings tab.
3. Select No Dynamic Feedback to disable the completion percentage feedback. Selecting Show Item Count Percentage will re-enable the completion percentage feedback.

4. Click Save.
5. Click Exit.

Figure 3

Assessment Items
Selecting the Check Results button on the instructions window will allow students to view the list of configuration items being assessed and whether they have correctly configured those items (See Figure 4). A red X next to an assessment item indicates that it has either not been configured yet or that it has been configured incorrectly.

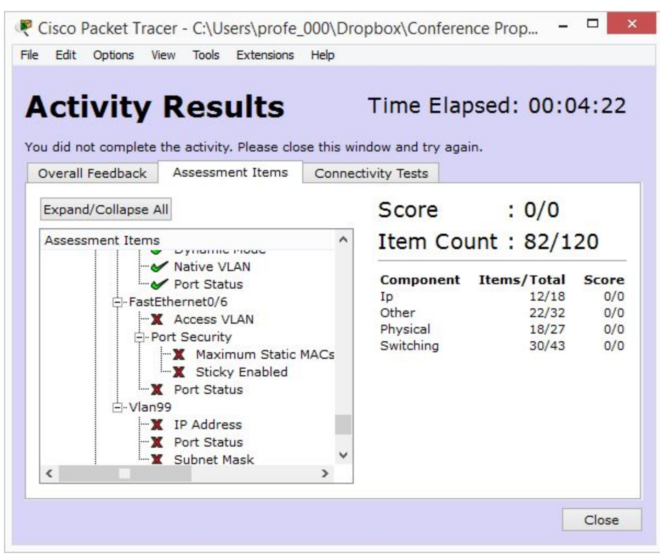

Figure 4

If the lab is being used as an in-class exercise for skill acquisition, self-assessment is beneficial. It becomes a liability once an instructor decides to use a lab to assess retention or comprehension. Students should not be able to view these assessment items as they are working on a lab for these purposes. Students need to become more self-reliant as they develop in their networking skills. Disabling assessment items allows an instructor to assess whether students can transfer the skills developed during the acquisition stage to a more realistic networking environment.

Disabling Assessment Items

1. Select Initial Network within the Activity Wizard.
2. Expand the folder directory to Locking/Interface/Activity (See Figure 5).
3. Place a check mark in the box next to View Assessment Items.
4. Click Save.

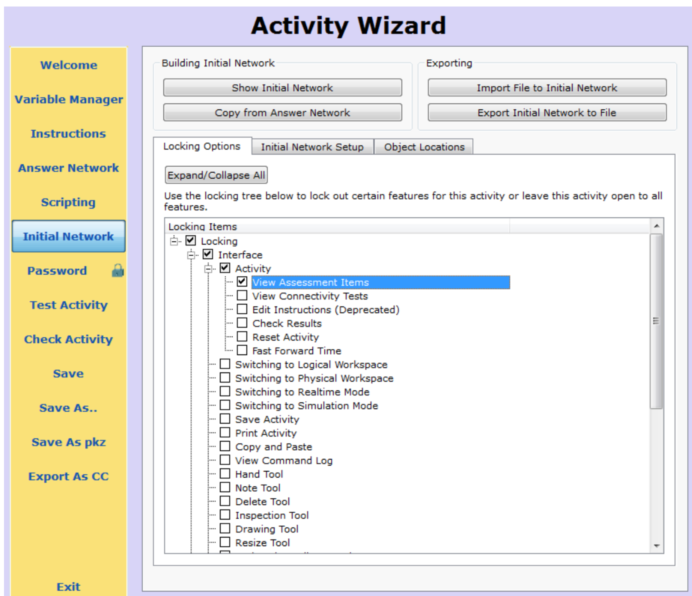

Figure 5

Config Tab

The Config tab in Packet Tracer presents students with a graphical configuration interface that is unique to the software. The purpose of the Config tab is to provide the user with a quick method of entering basic configurations. The problem is that the Config tab bears no resemblance to the interfaces students will use when configuring Cisco networking devices. Students using this interface do not have to learn the syntax needed to configure Cisco routers and switches. Instructors can enhance the realism of the simulation software by disabling the Config tab. This will require students to use the command line interface that is present on actual physical hardware.

Disabling the Config Tab

1. Inside the Activity Wizard, click on Initial Network.
2. Expand the folder directory to Locking/ Topology/Global (See Figure 6).
3. Place a check mark in the box next to Use Config Tab.
4. Click Save

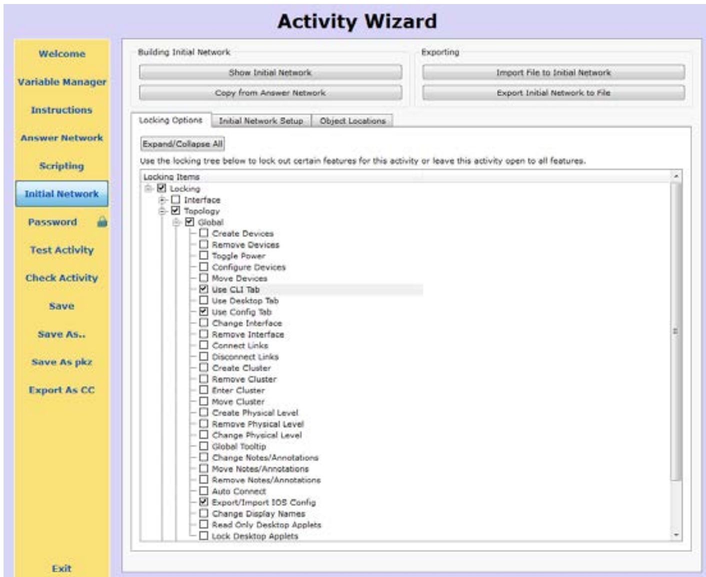

Figure 6

Requiring Console Port connectivity

The initial configuration of network devices is typically accomplished through the device's Console port. A student in a hardware lab environment would accomplish this by connecting a console or rollover cable from a computer to the Console port on the network device. The student would then use a terminal emulation program, such as Putty, to configure the device.

Within the Packet Tracer logical topology, students can configure the devices in the CLI tab after selecting the device. The user interface in the CLI tab is the same as what the student would experience using a terminal emulation program. The problem is that this does not reflect what a student would have to do with actual hardware. An instructor can require students to manually connect a computer to the console port by disabling the CLI tab. Students will then have to establish a console connection between the RS232 port on a computer and the console port of the network device within the topology. At that point, the student would open the computer and use the Terminal program in the Desktop tab (See Figure 7).

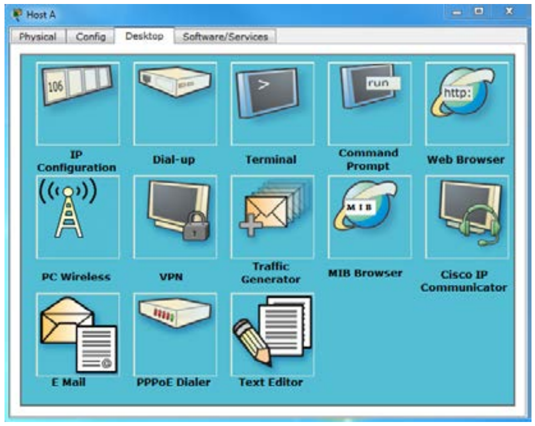

Figure 7

Disabling the CLI Tab

1. Inside the Activity Wizard, click on Initial Network.
2. Expand the folder directory to Locking/ Topology/Global (See Figure 6).
3. Place a check mark in the box next to Use CLI Tab.
4. Click Save

Maintaining Academic Honesty

A student's work is stored in an electronic file when working with the Packet Tracer application. In a physical lab, an instructor is able to actively monitor student participation in the lab. This is not the case when using Packet Tracer. By default, there is nothing to uniquely identify the work to a particular student. This creates the opportunity for a student who has completed the lab to share the file with other students. If the student who initially completed the lab did it correctly, there may be no way for the instructor to identify whether the student work is original or a copy of someone else's file. This only becomes apparent when the source file was not configured properly and the identical error manifests in multiple student submissions.

One method of forcing student participation is through the use of profile locking. Profile locking requires students to embed their name into the file. The author of the file becomes readily apparent with profile locking. The question then becomes, "Why not just change the user name in the file?" When profile locking is engaged, any change to the user name results in all the configurations to be returned to the default original settings.

Enabling Profile Locking

1. Inside the Activity Wizard click on Answer Network
2. Click on the Settings tab.
3. Place a check mark in the box for User Profile Locking (See Figure 3).
4. Click Save.

Students will have to create a user profile for their assignment once profile locking has been enabled. If they do not create a profile, the profile for the lab will default to "Guest". Instructors should require that students create a user profile for each Packet Tracer lab.

This should be done before the student does any configurations as the process will return the lab to its initial state.

Creating a User Profile in Packet Tracer

1. Click on Options on the Menu Bar
2. Select User Profile from the list of options.
3. Enter your name in the Name field and click OK (See Figure 8).

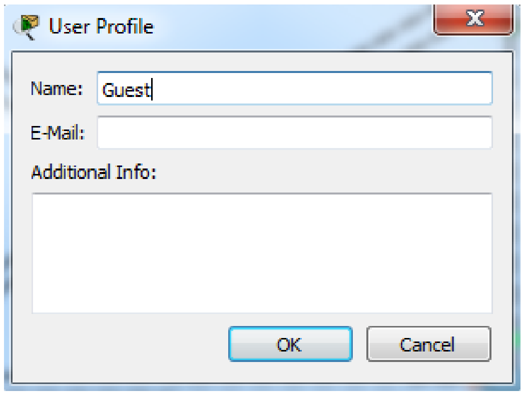

Figure 8

Another potential problem is sharing of configuration files. This is an issue for both physical labs and simulation software. One of the features of Cisco networking devices is the ability to export the configuration file. In an actual production environment, it is critical that a network administrator restore network connectivity as quickly as possible. Having an exported configuration file allows the network administrator to restore the network device quickly.

In an educational environment, this ability provides an opportunity for academic dishonesty. User Profiles will prevent students from making copies of a lab and submitting it as their own work. It will not, however, prevent a student from exporting the configuration files from a completed lab. Nor will it prevent that student from importing that configuration file into the Packet Tracer file using their own user profile. This can be prevented by disabling the ability to export or import configuration files within the Packet Tracer lab.

Disabling Import and Export of Configuration Files

1. Inside the Activity Wizard click on Initial Network.
2. Expand the folder directory for Locking/ Topology/Global (See Figure 6).
3. Place a check mark in the box for “Export/Import IOS Config”.
4. Click Save

Conclusion

Instructors of data networking courses have several options for providing students with hands-on learning experiences. They can provide their students with physical labs, remote labs, and labs through simulation software. Each option has its own set of strengths and weaknesses. The most significant obstacle to offering students access to physical and remote labs is cost. This is where simulation software provides a low to no cost alternative. It also provides unrestricted and portable access to the lab experiences.

Packet Tracer is a freely distributed network simulation application offered through the Cisco Networking Academy. It is what students use to complete the lab assignments available through the Cisco Networking Academy. Instructors may also use the program to create their own topologies and lab scenarios.

There are, however, aspects of the Packet Tracer interface that do not align with what students will experience on actual networking hardware. Several strategies were presented to help an instructor to improve the realism of the user experience. Studies have found that students are more engaged as the lab experience more closely reflects what they will experience on actual hardware.

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Biomedical Engineering Career Exploration

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Introduction

In the past, biomedical engineering has been about using technological devices to solve medical and biological problems. The field has evolved in recent years to bridge the gap in between biology and engineering, allowing for solutions that are a combination of technology and biology working together, rather than just technological replacements and stand-ins for biological systems (Katona, 2007, p. 89). This article details information about the field of biomedical engineering, how to become a biomedical engineer, and what the pay and job outlook for biomedical engineers are. This article provides information about a lesser known engineering field that combines the sciences with engineering techniques.

Responsibilities of biomedical engineers

Biomedical engineers take problems in medicine or in biology and use their knowledge of engineering processes and of life sciences to come up with a solution to those problems. They often do this to enhance the effectiveness or quality of medicine and patient care. The solutions to these problems can come in a variety of forms. Biomedical engineers can design technology or instruments to make procedures more effective or faster, or they can make artificial organs to give to patients that need a transplant. Those that work in this field can develop new drugs and treatment for diseases. They can also design software so that doctors have an easier time diagnosing a patient and coming up with a treatment plan (U.S. Department of Labor, 2014).

In addition to designing the solutions to medical problems, biomedical engineers make sure that their solutions are safe for use. This can involve conducting research and clinical trials on proposed solutions, to make sure that they are performing at the level that is required without adverse side effects. They can oversee the installation, maintenance, and use of biomedical equipment to make sure that it is being used in a safe and effective manner (U.S. Department of Labor, 2014).

Biomedical engineers often collaborate with members of other disciplines. They often supervise technicians that are working in the lab with them. Biomedical engineers can work with clinicians and doctors to teach them how to use biomedical equipment. Often biomedical engineers will work on interdisciplinary projects, such as working with a chemist to design and synthesize new drugs, as shown in Image 1, or computer scientists to design new software. Other related career professionals that they will often collaborate with are biochemists, electrical and mechanical engineers, and surgeons (U.S. Department of Labor, 2014).

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Image 1

A scientist works on synthesizing a drug in a biomedical laboratory. Taken by Linda Bartlett for the National Cancer Institute.

Subfields of biomedical engineering

There are a number of fields and specializations that fall under the category of biomedical engineering. Some key ones are bioinstrumentation, biomechanics, cellular, tissue, and genetic engineering (U.S. Department of Labor). Bioinstrumentation is the science of making instruments for biological devices, and to integrate biology with technology in medical devices and implants (NC State University, 2014). Biomechanics is the study of human movement, and of muscle strength and control (Ball Sate University, 2015). Cell and tissue engineering are related fields that use cells and biological materials to grow new tissue to help treat diseases or to grow new organs (Johns Hopkins University, 2015). Genetic engineering means manipulating and transferring the genetic materials of organisms to control the expression of genes (University of Nebraska, 2006). A genetic engineer is shown working in Image 2.

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Image 2

A genetic engineer works to prepare samples of DNA for processing in a PCR machine. Taken by Daniel Stone for the National Cancer Institute.

Becoming a biomedical engineer

To gain entry in the career field of biomedical engineering, a bachelor's degree from an accredited university is required. The degree can either be in biomedical engineering, or it can be in another form of engineering combined with a graduate degree in biomedical engineering or with on-the-job training. During degree study, students should become familiar with biology and the principles of engineering design. Students should take laboratory classes and lecture classes. They should take courses in biomaterials, fluid mechanics, computer programing, and other biological sciences. Undergraduate biomedical engineering programs are accredited by ABET (U.S. Department of Labor).

Specializations such as genetic engineering often require a masters degree or a Ph.D. To advance in the field and lead a research team, biomedical engineers need to have a graduate degree. If the biomedical engineer is planning on specializing in a specific field in medicine, it is common for the engineer to go to medical school or dental school to study in that field (U.S. Department of Labor, 2014).

Pay and benefits of a genetic engineer

The U.S. Department of Labor (2014) reports that in 2012 the median wage for biomedical engineers was $86,960. The lowest 10 percent of biomedical engineers earned less than $52,600, and the highest 10 percent of biomedical engineers earned more than $139,450. The wages paid to biomedical engineers vary according to the industry they are working in. If they work in scientific research or in development, the median salary is $94,150. If they work in manufacturing medical goods and equipment the median salary is $88,850. If the biomedical engineer works in the pharmaceutical industry, their median salary is $87,340, and the median salary is $69,910 if the biomedical engineer works in local, state, or private hospitals. Finally, the biomedical engineer's median salary is $63,440 if they work at a university or college. The biomedical engineer is expected to work on a normal schedule full time, though they may be expected to work longer to meet a deadline. They receive normal benefits such as health care and a pension (U.S. Department of Labor, 2014).

Job outlook for biomedical engineers

The job outlook for biomedical engineers is expected to increase. According to the U.S. Department of Labor (2014) the jobs for biomedical engineers are expected to increase by 27% from 2012 to 2022. This equates to approximately 5,200 new jobs. Biomedical engineering is in such high demand because those in the field engage in a wide variety in activities and produce many different goods. Those goods will be in high demand because the baby boomer generation will need more biomedical devices and services, including procedures to replace hips and joints. In addition, biomedical engineers and researchers will be more in demand as public knowledge of biomedical solutions to problems continues to increase. In addition, many of the current biomedical engineers are aging and will be retiring in the near future, which will create job vacancies that will need to be filled (U.S. Department of Labor, 2014).

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Addressing the Challenges of Teaching Big Data in Technical Education

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Abstract
There is a growing demand for professionals with knowledge of big data and data science. This knowledge can range from data storage, systems infrastructure, to data analytics. The problem in technical education is two-fold: big data is a relatively recent phenomenon, and the infrastructure required for big data is prohibitively expensive. The purpose of this paper is to present strategies that will assist educators in teaching big data on a little classroom budget.

Introduction
Big data is everywhere. From the choices found at login to Amazon (i.e., Amazon's recommendations) to the coupons received in the mail. Big data and the concomitant data analytics provide useful information to any organization. The issue addressed in this paper is teaching technology students big data concepts (e.g., storage, retrieval, and analytics) on a little classroom budget. Servers and storage are expensive and big data requires massive storage, retrieval, and CPU cycles. The networks that transport big data are high speed and expensive as well. The analytics software required to process massive amounts of data can be expensive and complex. All of these issues create a complex scenario with regard to teaching big data on a little classroom budget.

This paper begins by providing definitions specific to big data and data sciences. This will set the context for the subsequent sections and the discussions therein. Following that, the importance of big data education is discussed. The next section explores specific challenges faced by educators when attempting to teach big data concepts and practices. This is followed by a presentation of tools that can be utilized by educators when teaching big data. Finally, three classroom exercises are presented that will engage students in learning about big data.

Definitions
As it is a recent phenomenon, big data's definition is a moving target. The size and scope of what constitutes big data can vary. In the general sense, the size of big data is an N where traditional Relational Database Management Systems (RDBMS) cannot scale to process the enormity of the data. In today's sense, this can be measured in petabytes of information. However, as that number is a variable and data management software undergoes continual updating and improving, it could be much larger tomorrow. According to Hashem, Yaqoob, Anuar, Mokhtar, Gani and Khan (2015), big data is more than size but it is encompasses the integration of techniques and technologies to uncover hidden values in complex, massive, and heterogeneous data sets.

Laney (2001), provides a more holistic and three dimensional definition for the growth and challenges associated with big data. His definition addresses not only the size but the scope of big data: The Three Vs (Volume, Velocity, and Variety). Volume refers to sheer size (quantity) of the data. Volume is perhaps the most important characteristic of the definition as the term big data itself implies volume and is relative to size. See Figure 1 for a graphical representation of Laney's work.

Velocity refers to the speed at which big data is generated and processed. An example of this is the streams of data generated in multi-modal sensing environments. Large sensor arrays generating massive streams of low-level data can potentially overwhelm networks and data management systems. As these sensor streams converge to their destination, the sheer velocity of the data presents interesting challenges.

Finally, variety refers to the heterogeneous nature of big data. The data could be structured in the typical RDBMS sense or quite unstructured such as combinations of video, text, and various file formats streaming into a big data system. Managing, cataloging, indexing, and providing retrievals and analytics on top of a variety of data pose unique challenges to system designers.

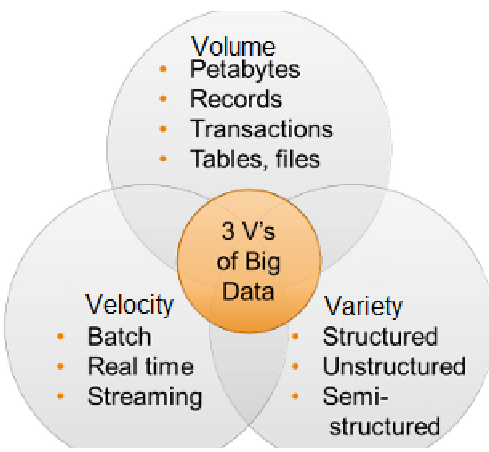

Figure 1. The three V's of big data. This figure illustrates the three elements that define big data.

Another facet of big data requiring definition is data analytics. Data analytics includes the technologies that make sense of big data and provide meaning from it. While business intelligence models and analyzes current and past periods, data science is more forwarding looking and produces predictive models (EMC, 2015). In the aggregate, data analytics encompasses the tools, technologies, and techniques that transform big data into useful, actionable information. Data analytics often makes use of sophisticated software for data mining, process mining, statistical analysis, predictive analytics, predictive modeling, business process modeling, data lineage, complex event processing and prescriptive analytics. Algorithms to perform this level of knowledge creation and management are complex and quite sophisticated. The software expense reflects this level of sophistication.

The concepts above and their concomitant definitions are normally derived from the Information Systems (IS) domain. Conversely, the systems and networking required to host, transmit, and process big data are found in the Information Technology (IT) domain and will be discussed further in this paper.

Importance of Learning Big Data

The U.S. White House has announced several Big Data partnerships in what the government refers to as Data to Knowledge to Action partnerships. John Holdren (2013), White House Office of Science and Technology Policy Director, calls Big Data a "big deal" (para. 4). From a government perspective, big data is important to not only the business of running the U.S., but it is also important to the economic future and well-being of the country.

According to the USA Today (2013), the sexiest job of the 21st century is a data analyst. The newspaper quantifies the starting salary in the $125,000 per year range. Additionally, USA Today finds the demand for such skills far exceeding the supply: roughly 20 percent of the demand is met. From an employment perspective, high salaries and a plentiful employment market makes big data analytics an enticing area.

The future for the data science job market appears healthy. The McKinsey Global Institute (2011) report is projecting that by 2018, "the United States alone could face a shortage of 140,000 to 190,000 people with deep analytical skills as well as 1.5 million managers and analysts with the know-how to use the analysis of big data to make effective decisions" (para. 8).

Pedagogical Issues Educators Encounter with Big Data

While learning about big data is important and the career outlook for big data employment is optimistic, educators face challenges in teaching data science. First there is the lack of technology infrastructure to teach the subject. Secondly, since the concept of big data is a relatively recent phenomenon, the instructor's knowledge of data sciences and available tools might be lacking. In order to address these issues, there are a number of tools and partnerships available to educators and academic institutions. Many of these tools are free, open-source, or web-based tools.

Consider the expense and complexity of the eBay.com 40 petabyte (PB) data warehouse; the company has two of these in separate clusters. Furthermore, eBay has an additional Teradata 7.5PB data warehouse (Tay, 2013). For educators to attempt to duplicate the smaller 7.5PB warehouse would require thousands of dollars in hardware expenses for storage arrays, networking, and clustered computational systems. The software (operating systems, database and data analytics) will add thousands of dollars more to the cost. Finally, there is the question of populating the database with information. The analytics software must process data and these data have to originate from somewhere and be meaningful.

The IT infrastructure required to manage big data can be quite complex and expensive. Considering the velocity aspect of big data, the networking infrastructure must be fast and the corollary to fast is expensive. The volume and variety aspects require massive storage, retrieval, and CPU cycle architectures. Again, this can be an expensive proposition; prohibitively so for educators and the educational environment. As an alternative to engineering the IT infrastructure, educators can turn to cloud-based computing which would provide massive computational capabilities without the need to maintain expensive hardware and software (Hashem, Yaqoob, Anuar, Mokhtar, Gani, & Khan, 2015). However, cloud computing and storage is often expensive even for educators with academic pricing.

Big data requires not only complex hardware and software but also new techniques for computational analysis. MapReduce is one such framework for processing and generating large data sets (Dean & Ghemawat, 2004). The MapReduce framework is designed to work on a distributed system (commodity PCs) and it parallelizes (i.e., adapts for concurrency) and distributes the computations and data across the system. The framework analyzes geographical and network costs and processes data locally to the storage while also providing fault tolerance from node crashes. The Map function processes data in parallel across assigned nodes then reports results to the Reduce function that merges those results. The Apache Hadoop system has an implementation of MapReduce that is free and open source. Hadoop is available at: http://hadoop.apache.org/ with a number of release versions available.

Even if the aforementioned technology challenges in hardware and software are overcome, educators must be trained in big data science. As big data analytics are complex and new, many instructors may not have the requisite knowledge which draws from a variety of domains. A strong quantitative background and knowledge of statistics is necessary. There is often a great deal of IS and IT infrastructure knowledge and troubleshooting that comes with big data education. Furthermore, it requires a good deal of effort, expense, and training to become proficient in just one aspect of big data.

While there are a number of challenges for big data educators, there are a number of tools, many of which are free, available to educators. These tools are discussed in the next section.

Tools for Educators

There are a number of free tools available for educators and data scientists. Tools such as R (The R Project for Statistical Computing: http://www.r-project.org/
Goo) is open source and can be downloaded free of charge. While there will not be terabytes of data for students to practice analytics, the R software is relatively straightforward to download and setup. It supports Windows, Mac, and Linux. Furthermore, R is extensively utilized in the data analytics community (Tippmann, 2015)

so this can provide the fundamentals for students. There is a distinct learning curve for R as it is a programming language. R is a command line, interpreted language and as with any command line programming language, practice and effort must be invested.

To assist with learning and using R, another free tool, RStudio, is available. RStudio is an open source, graphical user interface (GUI) integrated development environment (IDE). RStudio is available at: http://www.rstudio.com/ and fully integrates with R. The R package (version 2.11.1 or higher) must be installed first before loading RStudio.

Installing these tools in a Windows workstation environment requires certain operating system permissions that may not be granted to instructors or students (Davison, 2015). Institutional technical support policies often prevent instructors from installing software. Many classroom environments reset the laboratory computer systems' state (e.g. Deep Freeze system restore) to a base level installation. An effective compromise is to install the software in a virtual machine environment where the instructors and students have administrator privileges on the virtual machine and the technical support personnel retain administrator control of the hosting machine. This creates a fully functional testbed for students including machine setups and operation (Gonzales, Romney, Bane, & Jeneau, 2013). Virtual machine environments are common place in online educational environments as well (Chao, Hung, & Chen, 2012)

As discussed earlier, mining big data can be problematic from a logistical sense. Most educators do not have large data sets from which to mine, but there are free and web-based tools to mine Google and Twitter data.

Free and web-based data analysis tools are provided by Google with their Correlate (http://www.google.com/trends/correlate) and Trends (http://www.google.com/trends/) tools. Correlate was originally designed to analyze flu-related searches (https://www.google.org/flutrends/) compared to flu activity (Ginsberg, Mohebbi, Patel, Brammer, Smolinski & Brilliant, 2009). The tool was expanded to allow users to correlate search activity (Vanderkam, Schonberger, Rowley, & Kumar, 2013). Additionally, users may upload their own data for analysis. Google Trends allows users to analyze search terms and search activity as well as filter results based on locations and date ranges. Google Correlate can create heat maps based on US State maps (comparing search activity by state) as well as provide line and scatter plot diagrams. Both tools allow users to download their data as a CSV file, if they have a Google account.

A free web-based tool to analyze Twitter content (http://maps.iscience.deusto.es/) is provided by iScience Maps (Reips & Garaizar, 2011). Twitter activity can be analyzed from a worldwide or local search. The search can be fine-tuned with time periods and radius of search area. The count (number of hits) that the search term is found in the parameterized Twitter activity is provided along with the ability to download the data in a CSV file.

Twitter provides an Application Programming Interface (API) for programmers and scientists to sample their data. The sample set is a random sample of 1 to 10 percent of total content. While programmers are free to design their own customized Twitter Activity data miner, the iScience Maps team provides a web interface to mine the Twitter activity for users with no programming knowledge.

Classroom Activities

The following three classroom activities are designed to engage students in big data concepts and practices. While there is no *a priori* knowledge of big data concepts assumed; basic computer, mathematics, and Windows proficiency is required. These activities are meant to build upon each other. The first is an exercise designed to assist students in beginning to quantify data size (volume). The second is an activity that will examine the speed at which big data can be transmitted (velocity). The third exercise is a data analytics exercise examining Google queries (variety) and the difference between causation and correlation.

Learning Objectives

1. Students will demonstrate knowledge of quantification of data.
2. Students will mathematically analyze and calculate transmission speed of big data.
3. Students will synthesize and evaluate Google queries in terms of frequency, distribution, correlation, causation, and geography.

Required Materials

1. Computer with Web Browser
2. Internet Connectivity
3. Calculator

Procedures

1. Quantification of Big Data
    a. The instructor begins the discussion on "How big is big data?" and shares information regarding large, commercial data warehouses such as eBay, Google, Twitter, and Amazon. Big data classification issues such as volume, velocity and variety are discussed.
    b. The following figure (Figure 2) can be used to explain byte quantification prefixes and sizes.

PREFIXES USED TO NAME MULTIPLES OF ONE THOUSAND

Prefix & Abbreviation		Decimal	Binary	Actual Decimal Value	
Byte	-	10^0	10^0	One Byte	1
Kilobyte	KB	10^3	10^{10}	Thousand	1,024
Megabyte	MB	10^6	10^{20}	Million	1,048,576
Gigabyte	GB	10^9	10^{30}	Billion	1,073,741,824
Terabyte	TB	10^{12}	10^{40}	Trillion	1,099,511,627,776
Petabyte	PB	10^{15}	10^{50}	Quadrillion	1,125,899,906,842,624
Exabyte	EB	10^{18}	10^{60}	Quintillion	1,152,921,504,606,846,976
Zettabyte	ZB	10^{21}	10^{70}	Sextillion	1,180,591,620,717,411,303,424
Yottabyte	YB	10^{24}	10^{80}	Septillion	1,208,925,819,614,629,174,706,176

Figure 2. The quantification of data. This figure illustrates large numbers and their representation.

2. Transmission of big data
   a. The instructor explains basic computer networking concepts such as bandwidth, propagation delay, transmission delay, and link speed. Discuss how the speed of light (*c*) and geographic distance impacts data transmission rates.
   b. Students can calculate the transmission delay of 1 byte of data versions the transmission delay of 1PB of data over various link speeds, using the following formula:
   T = L/R, where T = time (seconds), R = link bandwidth (bits per second), L=packet length (bits).
   c. Consider the impact of *c* (propagation delay) on big data. Discuss how propagation delay exceeds transmission delay in implementations such as the Mars Rovers.

3. Analyzing Google Queries
   a. The instructor will guide the discussion to analysis of big data, statistics, and analytics. The instructor will discuss with the students the difference between causation and correlation.
   b. Students will use Google Correlate to find search patterns that correspond to real-world trends. Using the following tool: http://www.google.com/trends/correlate students will enter in a search term and find the closest correlated search terms. Students will then critically analyze the results for both correlation and causation.
   c. Using the results from (b) above, students will further explore the frequencies of their search terms by geography. Google supports analysis of search terms by country and further geographical analysis by U.S. states.

Conclusion

In this paper, the proliferation of big data was discussed. Big data was defined from the perspectives of size (volume), the speed at which it is generated (velocity), and the various forms that it can manifest (variety). The employment gap in the U.S. coupled with the high salary for data scientists should encourage interest in learning about this field. However, educators face a number of issues when teaching big data, notably the lack of tools or training (as big data is a relatively new concept) and the lack of infrastructure. There are a number of tools available to address these issues including free tools such as Google, iScience Maps, and R. Finally, three classroom exercises were offered to assist instructors in teaching big data on a little classroom budget.

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Chemical Engineers: Creating New Technologies and Materials

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Introduction

This paper gives information about a lesser known career for career and technical education students. Chemical engineering is a career path that is of interest to students that are interested in aspects of technology and of science, notably chemistry. This paper details the duties of chemical engineer, their work environment, the steps to take to become a chemical engineer, and their pay and job outlook.

Duties of a Chemical Engineer

A chemical engineer uses the principles of chemistry and other related sciences to solve problems related to the use of chemicals, whether it be in food, production, fuel, drugs, or many other fields. The field of chemical engineering is a broad one that can describe a number of types of work. The chemical engineer can manufacture new chemicals, or create new applications for chemicals, or create new machinery to manufacture chemicals and byproducts (U.S. Department of Labor, 2014).

One of the main roles of chemical engineers is to develop, maintain, and improve chemical manufacturing processes. They can develop processes for many industries, working with chemicals to separate components of liquids and gasses, or to generate electricity using chemical processes, for example. This includes creating new technologies and machinery to implement the manufacturing of products. Their job also commonly involves developing safety procedures for the new chemicals and chemical processes that they work with. They test the equipment and processes and make sure that everything is up to optimal efficiency. Chemical engineers are often responsible for estimating the production costs and other aspects of the manufacturing processes for their management (U.S. Department of Labor, 2014).

Many chemical engineers pick a specialization and work in a setting according to their specialization. They could specialize in a specific process, such as oxidation reactions, which uses oxygen to react with other chemicals, or polymerization, which is the process of making plastics and resins. They can also specialize in a specific chemical field, such as nanomaterials, or very small substances, biological engineering, or in the development of specific types of products (U.S. Department of Labor, 2014).

Chemical engineers do not just have to produce new chemicals. They can work in many industries, such as producing electricity, making electronics, food, clothing, or even paper. They can also work in fields other than manufacturing, such as life sciences, biotechnology, or business. No matter what fields a chemical engineer works in, they need to be aware of all aspects of the manufacturing process and how it influences the products, workers, and the environment (U.S. Department of Labor, 2014).

Work Environment of Chemical Engineers

Most chemical engineers work in office or laboratory settings, though they can work in industrial settings if they are overseeing the setup and workings of a manufacturing process. They usually work with other scientists and the technicians that create and operate the manufacturing equipment. Some chemical engineers have to travel around the world for their job. Most chemical engineers work full time (U.S. Department of Labor, 2014).

There are a number of industries that hire chemical engineers. The industry that hires the most chemical engineers is the architecture and engineering industry, followed by the chemical manufacturing industry. The industry that hires the next largest amount of chemical engineers is the scientific research and development industry. Next is the artificial synthetic fibers and filaments manufacturing industry, which also includes the resin and synthetic rubber industry. Finally, the petroleum and coal products manufacturing industry hires the next largest number of chemical engineers (U.S. Department of Labor, 2014).

How to Become a Chemical Engineer

The minimum education requirement to become a chemical engineer is a bachelor's degree. The degree should be in chemical engineering. A graduate degree, up to a PhD is needed for the chemical engineer to work in research, or to teach at a university. Having practical experience is key, so many programs at universities offer co-ops with local engineering firms to get students the experience while they are still learning. (U.S. Department of Labor, 2014). Engineering programs at a university are often accredited by ABET. ABET is an independent accreditation organization that makes sure that a university's degree program prepares students for life as a chemical engineer and that they have all of the needed skills to become chemical engineers, once they receive their degree (ABET, 2013).

Some people also believe that the education of chemical engineers needs to be geared towards the future, so they often take sustainable engineering courses. Instructors in these courses teach the chemical engineer how to make sustainable technology, and they teach how to design processes that are safe and sustainable on the environment. These skills will be important in the near future, and it is more beneficial to chemical engineers to have these skills when they get their degrees, rather than having to learn them on the job (Byrne, 2010, p. 28).

There are a few skills that are necessary for the chemical engineer to have. They need to have analytical skills so that they analyze data and explore problems. Chemical engineers need to be creative so that they have inspiration to design new chemicals, materials, and machinery. Chemical engineers need to have ingenuity so that they can apply the concepts of chemistry and engineering in new ways to create new products. A chemical engineer must have good interpersonal skills so that they can communicate with the people that put their solutions into production. Math skills are needed for the analysis of solutions and for designing machinery. Problem solving skills are integral for a chemical engineer because they must be able to look at a problem and analyze and come up with ways of solving it (U.S. Department of Labor, 2014).

While licensure is not necessarily needed for chemical engineers, it is encouraged for advancement. To become a licensed professional engineer, a chemical engineer has to go through the following steps. First, they need a degree in chemical engineering from an ABET accredited school. Then, they need to get a passing score on the fundamentals of engineering exam. Finally, after they have gained sufficient work experience, they need a passing score on their professional engineering exam (U.S. Department of Labor, 2014).

Pay of Chemical Engineers

The median pay of chemical engineers in 2012 was $95,350. This means that the lowest 10 percent of chemical engineers earned less than $58,830 and the highest 10 percent earned more than $154,840. The pay for chemical engineers also varies according to their education levels. The chemical engineers that reported a bachelor's degree as their highest education level had a media salary of $67,800. Some chemical engineers also receive benefits such as stock options or profit sharing rewards from their company (U.S. Department of Labor, 2014). The pay of chemical engineers continues to climb because of how competitive the industry is (Jenkins, 2014, p. 17).

The pay for chemical engineers varies according to what industry they are working in. A chemical engineer working in the petroleum and coal manufacturing industry makes a median salary of $105,840, while one working in basic chemical manufacturing has a median salary of $99,510. A chemical engineer that works in the scientific research and development industry has a median salary of $97,800. A chemical engineer working in the resin, synthetic rubber, and synthetic fiber manufacturing industry has a median salary of $94,810, while one working in the architecture and engineering industry has a median salary of $93,390 (U.S. Department of Labor, 2014).

Job Outlook for Chemical Engineers

The employment of chemical engineers is expected in increase by 4% from 2012 to 2022. This equates to 1,500 new jobs being created. The demand for chemical engineers is largely based on the demand for the products of the industries they work for. This means that employment growth can be assured if chemical engineers can continue to innovate and improve to make sure that their industries stay on the forefront of new technology (U.S. Department of Labor, 2014). Growth is already increasing because there is increasing demand in multiple areas, and because there are more complex projects going on around the globe (Jenkins, 2014, p. 17).

Many chemical engineers work in industries that supply to the manufacturing industry. This means that as demand for their products in the manufacturing industry changes so does the demand for chemical engineers. However, many chemical engineers are joining

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new and developing fields such as nanotechnology and biotechnology, which will help sustain the demand for chemical engineers (U.S. Department of Labor, 2014).

Conclusion

Chemical engineers are one of the most important parts of the manufacturing processes. They create the technologies that allows the manufactures to produce their products. They develop new materials and drugs, and new technology for chemical processes (U.S. Department of Labor, 2014). Even though chemical engineers are so critical to the manufacturing process, they are relatively unmown. This can be changed if more students learn about the career path of chemical engineering.

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