A LITERARY REVIEW OF EFFECTIVE INSTRUCTIONAL METHODS AND USE OF COMPUTER-AIDED INSTRUCTION IN POST-SECONDARY AUTOMOTIVE TECHNICAL COURSES

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Abstract

A lack of relevant literature exists on the subject of automotive technology pedagogy and the use of computer-aided instruction in post-secondary automotive technology programs. Due to this lack of information, much of automotive instruction has not changed in many years. The onset of various computer-aided instruction tools and technology, such as virtual and augmented reality, may provide instructors with the tools to reach newer generations of automotive technology students. This article serves as a literature review to determine the possible effectiveness of the use of these technologies. It looks at examples of other technical industries and professions that have implemented computer-aided instruction.

Keywords: automotive education, online technical courses, online automotive technology, computer-based learning, and computer-based technical instruction

Background

The automotive industry is changing at a rapid pace. As both students and instructors change, so will the instructional methods. According to Hoskyns-Long (2009), "many blended learning strategies can be integrated into a course to help meet the expectations and needs of the new generation of learners" (p. 27). As the new generation of students develops their learning preferences, they rely more and more on online searches and web-based training. Developing training that combines modern training methods with more traditional training will become vital as time and technology progress. "Vocational teaching is a blend of academic theory and practical skills leading towards real-world expertise" (Simons, 2014, p. 1). Automotive theory may be capable of being taught through computer-based training methods, but many of the practical skills will be lost due to the inability to practice in a real-world situation.

Programs such as Ford MLR (Maintenance and Light Repair), Chrysler MCAP (Mopar Career Automotive Program), and Subaru University are online programs designed to work with existing programs to teach students theory and to build upon laboratory exercises (Manchester Community College, 2019). These programs by themselves may be capable of granting manufacturer-specific certifications but do not present students with hands-on applications. While instructors may have the knowledge and ability to implement computer-based training, relationships found between the instructor's knowledge of technology and the implementation of technology are not known (Johnson-Martin, 2013, p. 161).

With the increased need for a skilled workforce in the automotive industry, primarily due to the retirement of older workers, practical training for new technicians is imperative. According to the U.S. Bureau of Labor Statistics, the automotive repair industry will need nearly 46,000 more technicians by 2026 to meet anticipated demand. Additionally, in any given year, there are as many as 75,000 job openings, due in large part to the retirement of the last generation of technicians… (Icahn, 2019, para. 5). It is seen that there is a need for current and future training. Halzack (2013) stated:

> Innovations in the automotive industry have gradually transformed what it means to be an auto repair worker. As the cars on our streets have become more computerized, so, too, has the job of maintaining and fixing these vehicles. And

> so, a trade that was once largely mechanical is today primarily technical, and therefore requires workers to be skilled computer users, strong readers, and able mathematicians (para. 4).

As technology progresses further, we will see a rise in computer-aided instruction. This, however, should not solely replace a hands-on lab experience. Many theoretical skills can be learned, but true hands-on experience cannot be replaced.

Statement of the Problem

With a lack of relevant literature regarding computer-aided instruction (CAI) in automotive technical education, instructors are implementing CAI without fully knowing the implications. Trinidad (2008) found in his research that automotive students preferred kinesthetic learning styles. Freund (2013) stated, "In order for the students to perceive they are making progress throughout the program, the instructors should encourage and reinforce their participation at every step" (p. 141). To develop a successful automotive technician, the instructor, as well as the student, should be prepared for the class. Though there has been much research on adult workforce education, there has been little done on effective teaching styles or pedagogy for vocational education programs such as automotive technology (Lucas, Spencer, Claxton, 2012, p. 13).

Literature Review as a Method

The literature review method was utilized for this paper to compile information about methods and pedology for post-secondary automotive technology instruction. Due to a lack of publications of post-secondary automotive technology computer-aided instruction, a more generalized review of online technical courses was conducted. According to Nelson (2007), "Having adequate and accessible research resources are essential to students' research preparation." Finding and utilizing appropriate sources for a literary review will help to fill in the gaps of previous research. Fitt (2011) states, "…the literature review allows them to showcase their ability to critically analyze what work has already been done in the field" (page 69).

Utilizing literature review as a method of research will compile many sources from academic journals, theses and dissertations, industry publications, and articles. This literature review relies solely on secondary sources. "Secondary sources summarize, review, analyze, or discuss primary source information as well as what is contained in other secondary sources. There is no firsthand gathering of data" (McMillan & Schumacher, 2010, p. 74). This literature review contains no firsthand data.

Purpose of the Literature Review

The purpose of this literature review is to examine the training methods of post-secondary automotive technology programs and the application of computer-aided instructional methods. Additionally, this study will contribute to filling in gaps in the research of automotive technology training pedology.

Review Questions

With the onset of computer-aided instruction, several questions arise when discussing post-secondary technical education.

1. What is the most effective training method for preparing post-secondary automotive
   technology students for the workforce?
2. How can computer-aided instruction benefit post-secondary automotive technology students?

Significance of the Problem

Students who have simply been taught the theory of how to perform the task may not be capable of physically executing the task. "Once mostly self-taught, car servicing has become an occupation that requires not only mechanical skills but also sophisticated knowledge of the computer systems that now drive automobiles" (Boss-Bicak, 2004, para. 6). As the need for training increases, many people and companies have begun utilizing online training without the support of a laboratory section to emphasize the theories further. This may be due to the cost of the facility and staff to manage such laboratory practices. However, theory without application may tend to cause the student to miss critical concepts that cannot be taught through a computer-based training session. Over time, while people may have the basic knowledge of automotive technology, if they do not understand how to do the work, the industry may see a reduction in qualified technicians.

There is an increasing demand for quality vocational education. Many programs have become theory-based and leave physical applications behind due to increased class sizes. While many diagnostic procedures have become digitalized with the use of scan tools and lab scopes, there is a distinct gap between having the knowledge to perform a task and having the ability to perform the task. "…the psychomotor skills data may have reflected evidence of shortcomings of the CAI content" (Gilbert, 2006, p. 85).

Definitions

MLR - Maintenance and Light Repair

CAI - Computer-aided Instruction

Virtual Reality – A three-dimensional computer-generated simulation

Augmented Reality - A composite view of an image displayed over the real world

Post-secondary Education – Formal education after high school

Automotive Technology – The study of the practical and theoretical operation of automobiles

Databases/Search Engines Used and Key Terms Searched

This literature review utilized several search engines to find journal articles, theses, and dissertations. Google Scholar, ProQuest, and the SIUC Morris Library website were used as sources of data for this literature review. Key terms that were searched are as follows: online technical courses, online automotive technology, computer-based learning, and computer-based technical instruction. The search was further limited to articles written after 2003, and that supplied the full text. Callahan (2014) states, "Literature reviews should be concise syntheses of a broad array of literature on a given topic." Taking this into consideration, only articles that discussed learning technical skills via computer-based instruction in the abstract were chosen for use. Several industry publications and websites were selected for use in this literature review. These publications were selected due to their use of technology in training and instruction.

Review of Literature

Effective Training Methods

Effective training methods are important for training future automotive technicians. "The auto repair industry worries there won't be enough qualified mechanics to take the place of retiring baby boomers, a demographic that makes up an estimated half of all U.S. service technicians" (Cox 2017, para. 2). Computer-aided instruction can be utilized effectively for training post-secondary and industry automotive technicians in simple repetitive tasks. It is not a guarantee that the technician or student will be more capable of diagnostic procedures. Using computer-aided instruction as an aid to typical classroom lectures and lab experience will better suit the students and the instructor.

In his study, Hess (2012) found that technology is a defining characteristic of many Millennials stating, "Technology is not something Millennials have to learn; technology defines who Millenials are in most cases" (p. 104). Virtual reality and augmented reality have the ability to train many people in similar environments to the real experience. According to Castellanos (2017), the United Parcel Service, Inc. had a goal of training over 4,000 delivery drivers utilizing virtual reality headsets by the end of 2018. "Through this technology, we'll be able to immerse our UPS drivers and service providers in all kinds of situations that will get them to think about safety and reacting to safety hazards ... in much more effective ways" (Castellanos, 2017, para. 3). Training drivers is very similar to training automotive technology students. Each topic has many different tasks that the student would need to perform, and utilizing an immersive program can help to prepare the student for work in the physical world.

In building courses directed to new students coming into the automotive technical field, care is needed to ensure that the students are being taught effectively. In the past, students entering post-secondary automotive programs had learned many essential skills from secondary education programs. In recent years many students have been entering post-secondary programs with little knowledge about basic automotive functions or tools (Porter, 2018, p. 105). This lack of knowledge and preparedness becomes a strain on the instructor and other, more experienced students. In preparing students for the workplace, not only do effective teaching strategies need

to be discussed, but the instructor's ability to manage the classroom, lab activities, and technology, both in late-model vehicles and training equipment.

A large part of effective training methods is the effectiveness of the instructor. To ensure that the various automotive technology and career and technical education (CTE) programs are teaching the required skills, the National Automotive Technicians Education Foundation was created. "NATEF was founded in 1983 to evaluate technician training programs against standards developed by the automotive industry and recommend qualifying programs for certification by ASE" (Cravey, 2003). This program serves to ensure that the appropriate skills and knowledge are being instructed but does not have oversight for the methods for which these are being taught.

As new information and technologies are developed for automobiles, training practices must also change. "CTE teachers are taught to relate the background experiences, languages, abilities, and skills of students to the most suitable pedagogical practices…" (Bice, 2019, p. 50). Just like with any training program, the instructor must be able to work with the student to ensure that the most appropriate teaching and evaluation method is used. In many ways, effective instruction begins with the dedication and understanding of the instructor. Thornton (2010) found that "…full-time vocational, technical faculty members are responsible for 30 contact hours of classroom teaching per week at the technical college" (p. 32). This number of student-to-teacher contact hours is rarely seen at non-technical programs across college and university campuses. This would leave little time to prepare various lab-based activities as well as continuing education and development.

According to the Bureau of Labor Statistics (2019), "… career and technical education teachers, especially those in post-secondary schools, teach courses and develop lesson plans during evening hours and on weekends" (page 3). This places an extraordinary amount of strain on post-secondary career and technical education instructors. "Career technical programs are known for experiential learning. Because of this, CTE teachers can utilize constructivist and contextual learning approaches" (Bice, 2019, p. 29). Due to the extensive use of laboratory exercises, optimizing both the instructor's and students' time and is of critical importance.

Automotive Technology is no longer for those who grew up working on cars. Those entering the field may have backgrounds in computer sciences, engineering, and automotive. Many of these people may struggle to communicate as each will tend to have a different learning style and personality. "Thus, learning styles, as well as personalities should be accounted for when considering the topic of pedagogy." (Threeton, 2008, p. 60). Each class changes with a variety of personalities and learning types. While each course will cover the same basic materials, the teaching style and methods of the instructor will have to change to become effective.

Effective instruction often relies on the instructor's pedagogy. Lucas (2014) describes vocational pedagogy as "…The sum total of the many decisions which vocational teachers take as they teach, adjusting their approaches to meet the needs of the learners and to match the context in which they find themselves" (p. 2). Vocational programs such as automotive technology require knowledge of both the subject matter but also the occupational goals of the student. Barnett (2006) states, "… vocational pedagogy occupies a space between subjects and jobs…" (p. 145). This requires both the student and instructor to be aware of future occupational opportunities. The subject

matter is simply one part of the equation. Having a firm understanding of how the subject matter fits into the student's future employment opportunities is required.

Computer-Aided Instruction

Many industries have begun to utilize computer-based, virtual reality, and augmented reality training. "VR is a technology that recreates the feeling of reality by using three-dimensional (3D) images" (Ng, 2011, para. 1). Virtual Computer-aided instruction can provide interaction with various parts and pieces of complex machinery or tasks. "…industries that have already taken the step into using VR and AR have implemented the technologies" (Cave, para. 5). These industries include the medical field, aviation, automotive manufacturing, and many more. These technologies have seen a significant uptake in the industry "… global augmented reality automotive market size is expected to surpass USD 90.0 billion by 2024, growing at a compounded annual growth rate of +32% during the forecast period 2016-2024" (Goldstein Research, para. 1). Several colleges and universities are already utilizing VR in their training programs and courses. Kelly (2017) discusses that the Northern College's new VR facility "will be used to train students in the college's signature array of trades programs: construction, maintenance and electricity; industrial, mechanic and millwright; heavy-duty equipment technician; general carpentry; and automotive technician."

"Advances in technology such as the use of computers, web-based training, and the use of digital media; have created many new ways for students and employees to have better and more user-friendly training opportunities" (Jumper, 2012, p. 8). Fager (2013) states, "…it has become increasingly important for technicians to continue their training. Technicians spend time throughout the year training and participating in new and refresher courses to obtain the most current information in their practice." Utilizing these technologies can serve to reduce the number of hours needed to produce a well-qualified technician.

The automotive industry has begun to utilize virtual reality and augmented reality to verify designs and train technicians. "General Motors, for example, utilizes virtual reality to view car designs before they begin to produce them" (Hardin, 2018, para. 4). This technology has begun to replace many of the previous computer-based training activities. Nuttal (2019) states, "Retail assistants are already donning virtual reality headsets to learn how to manage the shop floor, while surgeons sharpen their skills in a risk-free environment." Much like with surgeons, and the military, automotive technology students may be allowed to train in low-risk situations before they ever begin working on live vehicles.

"The innovative use of instructional technologies can lead to significantly better results on examinations, indicating improved learning outcomes, in addition to improvements in problem-solving skills" (Markova, 2011, p.29). These technologies are shaping the way career and technical education will be viewed in the future. There are many advantages to virtual reality training. "What virtual reality headsets have over computer-based and classroom training is people's attention." (Jacobs, 2019). Capturing the students' attention for extended periods can be problematic at best. The fully immersive VR system can help to cut out outside distractions such as other students and electronic devices.

There are several virtual reality games that pertain to the automotive education market. One such game is Wrench, where "players are responsible for maintaining a growing number of car systems" (Missing Digit, 2018). This game provides users with an immersive simulation that offers detailed use of a variety of automotive tools to assemble various systems, including the engine, suspension, and cooling system. Wrench is available for purchase for use with virtual reality systems or gaming computers. This game has the potential to become a valuable tool for automotive students and instructors. The game can be used to familiarize students with complex parts and procedures without the risk of damaging a costly engine or injuring a student with sharp or heavy parts. In discussing immersive virtual reality, Freina and Ott (2015) say, "…it supports training in a safe environment avoiding real potential dangers" (p.139).

Using computer-aided instruction can prepare students for their future in the workplace. More and more companies in the automotive and other industries are utilizing virtual and augmented reality in training and production efforts. Virtual reality provides the instructor with the ability to provide the same simulation to many students, who may not have been able to complete exercises previously. Various virtual and augmented reality training systems have been produced, such as the Miller AugmentedArc® Augmented Reality Welding System and Stihl's AR 2 Go and Chainsaw Simulator. These programs allow for students or employees to learn how to utilize various equipment without possible harm (Miller Welding, 2019; Stihl, 2018). Augmented and virtual reality can provide the needed training without the cost of consumable materials like fuel, welding wire, or hardware. As technology progresses and costs decrease, the use of virtual reality will become more available for use in many vocational programs in the coming years (Blümel & Haase, 2009, p.6).

Many students who are entering the post-secondary educational system have accepted technology as a part of their culture and lives. "In the United States, students tend to be the most willing to do as much as possible online – they trust technology" (Connet, 2019, p.18). These students expect to see a certain level of technology present at the college and university level. They understand the technology, and many of them have experienced virtual and augmented reality games. "Technology based on augmented reality has come into general use recently due to the fact that users are surrounded by digital tools on a daily basis, such as smartphones, tablets, and game consoles" (Molnár, 2019 para. 17).

With the continued use of various computer-aided instructional methods in multiple industries and educational disciplines, there will be evident advantages and disadvantages. Croom (2013) found that a virtual reality experience can be an effective teaching tool if paired with physical lab experiences. For many automotive instructors, the development of a blended classroom may help to increase their effectiveness. Simple and complex tasks would be able to be taught and experienced utilizing computer-aided instruction where a student can practice an exercise many times before attempting the real-world exercise (Mitchell, 2016, p.2).

Discussion, Conclusions, and Recommendations

To assist the continuing research into post-secondary automotive technology pedagogy, this literary review examined if there is an optimal training method for post-secondary automotive students. This review also served to review how computer-aided instruction, including virtual and augmented reality, can benefit post-secondary automotive technical students in their education.

Discussion

Automotive Technology students come from many diverse backgrounds. Many of these students tend to learn kinesthetically, but other learning styles will be present (Lee, 2019, p.2). Developing an appropriate pedagogy for technical courses has proven difficult through the history of automotive technology. As technology progresses with time, so must the pedagogy. Students entering post-secondary automotive programs are not as prepared as they have been historically. This requires an adjustment to the current teaching styles and practices of many instructors. Computer-aided instruction, including virtual and augmented reality, may prove to be a highly useful tool to prepare students for courses as well as their future advancement into the automotive industry.

An essential part of effective technical education is the effectiveness of the instructor. Due to the number of student-to-teacher contact hours, there is little time left during the week to prepare various lectures and lab activities. The utilization of virtual reality can allow students to practice various lab activities in a safe environment without the potential to break or damage components. This would enable the instructor to focus on new lab activities rather than merely maintaining vehicles, systems, and components in their laboratory.

Computer-aided instruction has been proven in many industries, including the medical field, military training, and automotive production. These fields can train individuals to perform highly complex, hazardous, or stressful procedures without risk of damage to themselves or others. Much like these various fields, automotive students have the potential to encounter hazardous situations. Potential hazards may be discussed and simulated, with the utilization of virtual and augmented reality, prior to the student facing the situation. This type of training has been proven in various other occupations and fields, as seen in the literature.

With the varied use of computer-aided instruction, there is a continued need to investigate these technologies to improve the educational experience for students. Technical training now has the ability to be not only an on-campus program, but the students can utilize computer-aided instruction to learn the basics of engine repair from the comfort of their dorm rooms. These students use their electronic devices for much more than merely writing notes and papers. Technology is a part of their life and should be utilized to begin their lifelong learning.

Conclusions

Effective Training Methods

What is the most effective training method for preparing post-secondary automotive technology students for the workforce? Effective training methods are a multi-faceted problem. Many automotive students tend to be kinesthetic learners. This requires instructors to develop lab activities while still lecturing and providing visual

demonstrations to those whose primary learning style is not kinesthetic. Technical courses require the instructor to develop new teaching strategies for each class and person in the class. Providing students with various and repetitive opportunities to learn is the best way to ensure that the automotive student is adequately prepared for placement in the automotive industry. Ultimately it is vital to develop teaching methods that include the entire class and appropriately interacts with the students learning styles and personalities.

Computer-Aided Instruction

How can computer-aided instruction benefit post-secondary automotive technology students? With incoming students experienced with the use of technology, it is evident that technology and computer-aided instruction should be used as a supplemental learning experience. There are many opportunities for the use of virtual and augmented reality, and many industry leaders have begun to utilize this technology for training. With the many advancements that have been made, there lies an interesting developmental change for technical education. There will still be a need for students to attend and participate in lab activities, but this may happen after the student has passed a simulation covering the topic. The literature and many industries, such as the medical, aviation fields, as well as the military, have shown that simulations can be used to begin shaping the general cognitive skills that are required for complex and potentially hazardous tasks.

Recommendations

Recommendations for Practice

1. Not all students fall under one general learning style. While many post-secondary automotive technology students tend to be kinesthetic learners, not all are. Instructors should attempt to base their teaching style to fit with their students' learning styles and personalities.
2. Faculty should be aware of new teaching methods. New students have lived the majority of their lives utilizing technology, and it has become a large part of their identity. Education must change to incorporate various computer-aided instructional methods.
3. Faculty should be provided training opportunities to learn to effectively use and develop computer-aided instruction, including virtual and augmented reality. With the increased strain on faculty due to long working hours and increased student contact hours, computer-aided instruction can assist not only the faculty but also their students.
4. Automotive technology students should be offered the option to utilize computer-aided instruction, including the possibility of virtual and augmented reality to increase their understanding of basic or repetitive tasks.

Recommendations for Further Study

1. Post-secondary automotive technology pedagogy is a topic that requires further study. Much of the previous research involves students who are pursuing a bachelor's degree in automotive technology from Southern

Illinois University at Carbondale. Other four-year automotive programs, such as those at Ferris State and BYU Idaho, as well as the many two-year automotive programs, can provide much-needed data for future research.

2. Further studies should also be conducted to determine the effectiveness of augmented and virtual reality training for use in post-secondary automotive technology training. This technology is still relatively new in terms of general education and should be explored. Courses utilizing this technology may provide students with an option to perform a range of lab activities from basic to complex from the comfort of their own home prior to working in a laboratory course.
3. Research should be conducted to observe the use of a blended classroom where computer-aided instruction, including virtual and augmented reality, is used in conjunction with traditional automotive lab experience. Early use of these technologies may assist students in learning necessary skills that had not been taught in previous secondary or post-secondary training.
4. Finally, research should be conducted on how to improve instructor effectiveness. A large part of effective teaching strategies can be the way an instructor presents information. Determining effective teaching strategies will encompass studies about the faculty, courses, and students.

Final Recommendations

As the automotive industry changes, so must automotive education. Many companies have begun using computer-based instruction as well as virtual and augmented reality in the design, production, and aftersales stages of a vehicle's development. To ensure that post-secondary students are appropriately prepared for today's workplace, automotive programs, faculty, and coursework will have to adapt. Determining optimal teaching strategies for post-secondary automotive technology students will take a multi-faceted approach. Working with students, faculty, and the industry will assist in developing a true pedagogy for the automotive education field. Institutions need to be prepared for emerging technologies to teach future generations of automotive students effectively.

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