Final Report

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Technical Education: Bridging the Gap in Health and Safety in Small Businesses

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Table of Contents

List of Terms and Abbreviations

ABCT: Auto body collision technology

CTC: Career and technical college

CTE: Career and technical education

HCTC: Hennepin Community and Technical College

Lockout and tagout: LOTO

MTT: Machine tool technology

OSH: Occupational safety and health

OSHA: Occupational Safety and Health Administration

Personal protective equipment (PPE)

RC: Ridgewater College

SCCTC: Saint Cloud Community and Technical College

TECHS: Technical Education for Health and Safety

Abstract

Background: Public technical colleges enroll and educate more than half of the nation's 11 million technical students and play a critical role in providing young workers with the skills required to obtain high-paying employment in competitive job markets. However, technical colleges do not adequately prepare students to recognize and protect themselves from workplace hazards. After graduation, young workers in hazardous trades such as metal fabrication and auto collision repair are employed primarily in small enterprises where they rarely receive health and safety training. TECHS was designed and implemented in order to develop and assess a new model provide and assess a new model for health and safety education at the post-secondary level.

Methods: Four discussion groups (2 each with ABCT and MTT instructors) were held at HTC and SCTCC. Groups assessed barriers and facilitators to teaching health and safety in CTCs. Instruction was usually unscripted, task-centered, and generally consisted of ad hoc teaching moments triggered by near-misses, incidents, or unsafe acts observed in the shop. In spite of their lack of training, instructors acted as health and safety experts and the sole source of knowledge and feedback for students. With input from faculty, curricula were subsequently developed for both trades. Initially, curricula were implemented in HCTC and SCTCC and subsequently expanded to RC. New curricula consisted of 15 and 9 modules respectively in ABCT and MTT. Each module includes classroom presentation(s), student handout(s), lab activities, homework, and a quiz. Prior to use, instructors attended a paid training on content and delivery.

Results: Curricula were implemented in three colleges. Health and safety knowledge was survey among students who received none, one, and two years of TECHS training. Even though instructors participated in each step of curricula development the new materials were rarely delivered in their entirety or as planned during the school year. During the 1st year of instruction, student mean knowledge scores increased by 4 to 30 (ABCT), and 3 to 10 (MTT). During the 2nd year of instruction the mean knowledge scores changed by -2 to 13 (ABCT), and 0 to 5 (MTT). Skills and work practices scores improved by less than 10 in each trade during a 2-year period. Instructors cited lack of time and concern for their students' workload as primary barriers to curricula adoption. A follow-up survey of instructors in ABCT revealed that a lack health and safety knowledge among instructors is a serious national problem.

Conclusions: Instructors are often hired directly from businesses and enter a new teaching environment with substantial misinformation. It should not be expected that problems related to training new workers will be resolved absent a substantial national effort to ensure that faculty at both the secondary and post-secondary levels receive training about the hazards faced by workers. Efforts should be made to develop standardized trade-specific curricula that can used by instructors. Curricula should include competency-based testing that will guide faculty.

Section 1

Significant or Key Findings:

- Instructors in vocational colleges are expected to teach all aspects of their trade, including safety and health, with little coaching, feedback, or oversight. Even when instructors participate in developing trade-specific safety and health curricula, they are only partially successful in using it as designed. As a result, generations of students continue to graduate with incomplete knowledge of safety and health issues and sub-optimal skills and work practices. College instructors need additional support in their role as adult educators and should be encouraged to monitor their effectiveness by using meaningful student success indicators. Since most of the ABCT graduates and many MTT graduates are working in small or very small businesses with few resources and incentives to train their employees on safety issues, a successful intervention at the vocational college level is critical. Successfully bringing safety and health expertise into the college classroom is neither simple nor straightforward, but can be accomplished when effective collaboration and engagement strategies are employed.
- There is a need to find better methods to incorporate safety and health curricula into CTE programs. This will help overcome barriers described by instructors such as fewer teaching hours and increased demands to teach trade-specific technical skills. We must remain aware that graduates' ability to use their knowledge and mitigate risks is mediated by a social context, and the organizational and environmental constraints that mitigate new employee's intentions to work safely once they enter the workforce. This is often referred to as self-efficacy. Most instructors were reluctant to help student learn how to question supervisors about perceived risks and hazards.
- A national survey of technical-vocational faculty in ABCT shows wide gaps in safety-related knowledge and a high prevalence of misinformation.

Translation of Findings:

- Vocational education institutions that plan on adopting a safety and health curricula must ensure that the instructors have the motivation, skills and organizational support needed to succeed. Institutional commitment to safety and health education is central to both implementation and sustainability of adoption. Institutions need to formalize their commitment to teaching safety and health by ear-marking teaching time for this subject and providing assistance to instructors to facilitate curricula integration. We recommend that instructors: (1) attend courses in trade-specific safety and health, adult education, and methods of instruction; (2) are given opportunities to observe teaching safety and health concepts; and, (3) receive feedback from education specialists and safety professionals.
- Gaps in instructors' knowledge and skills have a direct impact on their proficiency and success in using TECHS materials. In preparation for dissemination activities of TECHS curricula within Minnesota and beyond, it is critical that we understand the educational needs of the instructors. These needs ought to be put at the forefront of safety and health education in technical trades. In the absence of greater instructor knowledge it will be difficult if not impossible to improve the quality of safety and health education. This is especially true given the apparent misinformation seen among faculty members.
- Curricula modules for each trade are seen in Table 1. These curricula are now licensed through creative commons and are found at: https://www.votechsafety.net/. Materials are available to all faculty on a national basis.

Research Outcomes/Impact

- The TECHS curricula had little positive impact on student knowledge and work practices. Outcomes appear to be related to a lack of baseline knowledge among vocational school faculty. This problem is present at both the secondary and post-secondary levels.
- Since most ABCT graduates and many MTT graduates are working in small or very small businesses with few resources and incentives to train their employees on safety issues, a successful intervention at the vocational college level is critical.
- Additional research is needed to better understand the practitioners, practices, and effectiveness of health and safety education delivered to students attending CTE across the United States. We recommend that vocational colleges give instructors trade-specific health and safety information and coaching and support

to ensure that they improve their ability to effectively communicate this information to students. Institutions should create formal plans for teaching safety and health and documenting student progress using rigorous knowledge and skills assessments.

- Finally, longitudinal studies are needed to understand the factors that influence the work practices of vocational college graduates, particularly those employed in small businesses in which they are unlikely to receive on-the-job safety and health training.

Table 1. Safety topics for which TECHS materials were developed

Auto Body Collision Technology (ABCT)	Machine Tool Technology (MTT)
Shop Safety Rules	Shop Safety Rules
Eye Protection	Eye Protection
Hearing Protection	Hearing Protection
Solvents	Machine Guarding
Acids and Bases	LOTO Awareness
Isocyanates and Respirators	Materials Handling
Fire Safety	Electrical
Electrical Safety	
Dusts and Fumes	

Scientific Report

Background: CTE programs prepare students to succeed in building rewarding careers in various trades. The number of sub-baccalaureate occupational credentials awarded in the United States increased by substantially between 2003 and 2015, from 1.01 to 1.46 million. Credentials in manufacturing, construction, repair, and transportation accounted for just over 20% (80,400 credentials) of this increase. As of 2015, 64% of credentials were awarded by 2-year public institutions such as technical and vocational colleges (Zhang and Oymak, 2018). By 2020, some forecast 45% of the manufacturing jobs will require at least a 2-year degree (Georgetown University, 2011).

In vocational colleges, students acquire trade-specific knowledge, skills, and other competencies through classroom instruction and hands-on practice in workshops and laboratories. Students are introduced in a step-wise fashion to the tools, concepts and principles of their trade, and develop their skills by performing tasks under the auspices of their instructors. National skills standards define industry-validated expectations about what vocational students should know and be able to do after completing a career program (Advance CTE, 2008). These standards serve as a guide for curriculum development, assessment, and program planning.

Safety and health knowledge and skills are foundational for all career fields (MN Department of Education, 2016). The inclusion of safety and health as a separate subject in the national skills standards presents a unique opportunity to stimulate safety and health education in vocational programs (Palassis *et al.*, 2004), as well as to research and to evaluate safety and health educational interventions (Schulte *et al.,* 2005; Runyan *et al.*, 2012).

Studies conducted in vocational programs in Germany (Löffler *et al.*, 2006) and Taiwan (Wong *et al.*, 2005) show that college-based safety and health education improves new workers' knowledge of hazards, behaviors, and rates of work-related injuries and illnesses. A 2-year prospective study conducted in France found that vocational college graduates (n=744 from 204 institutions) who reported receiving safety and health training in school experienced half as many injuries as their peers who did not receive this training (Boini *et al*., 2017). A U.S. study of a union-based apprentice carpenter education program identified gaps in safety and health knowledge and work practices among apprentices. Recommendations were made to modify the materials and instruction methods to match the diversity of job-related situations encountered (Kaskutas *et al.,* 2010). The number of job-related falls decreased post-intervention, but the safety climate in the workplace influenced the magnitude of improvements (Evanoff *et al.,* 2012).

ABCT vocational programs prepare technicians for careers in collision repair. ABCT technicians are exposed to chemicals such as isocyanates, physical hazards such as noise or adverse shop conditions such as wet floors, as well as electrical and fire hazards (Bejan *et al.,* 2011; Ceballos *et al., 2014;* Rheeb-Whitaker *et al.,* 2012; Samant *et al.,* 2006; Yamin *et al.*, 2016). ABCT technicians usually work in small businesses that rarely provide OSHA-mandated safety and health training, work with little supervision, and are expected to know how to work safely (Brosseau *et al.,* 2014; Burt *et al.,* 2012; Eakin, 1992; Hassle *et al*., 2009; Parker *et al.,* 2012). MTT vocational programs prepare students for careers in metal fabrication. This includes the use of complex machines and methods of advanced manufacturing. MTT students and workers are exposed to numerous hazards including lack of lockout, moving parts, heavy objects, particulates, and noise.

CTE students have an opportunity to learn about safety and health in their trade, as well as learn and practice safe behaviors. As such, the quality and effectiveness of this education is critical. Previous work highlights the lack of information on safety and health training in CTE, calling for quality research in this area (Bush and Andrews, 2013; Bejan et al., 2018). However, there little is known about how, when, or if safety and health are taught or about the quality of such teaching apart from the construction industry (UCB-LOHP, 2017; Bush *et al.,* 2019).

TECHS is a multi-part research study the aims of which were to: (1) document the teaching and evaluation of workplace safety and health in two-year ABCT and MTT vocational college programs; (2) identify training gaps and improvement needs; (3) develop, implement and evaluate new safety and health curricula; and, (4) determine the impact of the new curricula on graduates' safety and health knowledge, skills, and work practices at one year after graduation.

Aim 1: Conduct a detailed analysis of existing curricula for two trades—metal fabrication and auto-collision repair to determine how to best incorporate competency-based safety and health training.

Aim 2: In partnership with faculty, students, and business owners, develop, implement, and evaluate the adoption of competency-based safety and health curricula.

Aim 3: Evaluate the effectiveness of, and compile feedback on new training materials by: (a) assessing student knowledge of, and skills related to, identification and remediation of workplace hazards; (b) collecting information on graduates' self-reported work practices; and (c) conducting focus groups.

Aim 1: **Conduct a detailed analysis of existing curricula for two trades—metal fabrication and auto-collision repair-- to determine how to best incorporate competency-based safety and health training.**

At the outset of the TECHS project the following activities were completed in fulfillment of Aim 1.

- Educational and project goals were presented at 4 college Advisory Board meetings attended by industry stakeholders.
- All instructors completed course-specific reports regarding the extent to which they teach about hazards in collision and metal fabrication trades, and self-reported the types of materials used for teaching and testing safety concepts in each course.
- All instructors participated in one-on-one interviews with the project manager and discussed core concepts related to key hazards in each trade.
- Examples of teaching materials and resources used in classes as well as student tests were gathered as references.
- Six collision and seven metal fabrication instructors completed surveys eliciting information about their confidence in graduating students' ability to perform specific safety-related behaviors as well as knowledge of work-related hazards.
- Key informant discussion groups were conducted with faculty at HTC and SCTC.

Key informant interviews covered 5 topics: (1) instructor background and transition from industry to teaching; (2) methods and materials used for teaching and testing safety; (3) graduates' skills and safety-related challenges in the workplace; (4) employee-employer communication about safety; and (5) the type and format of additional safety and health teaching and testing materials that instructors wanted/needed. Questions were open-ended to encourage participant interaction. The same questions were used with ABCT and MTT instructors.

Written survey questions covered 4 topics: (1) sources of safety and health information that instructors use; (2) time allocated to teaching safety; (3) importance of safety topics that graduates should know about in order to be successful on the job; and (4) instructors' confidence in graduates' ability to properly carry out safety-related tasks such as inspecting an eye-wash station or machine guards. Surveys were anonymous.

Key informant interviews were led by a trained moderator. One additional researcher and a designated note taker were also present. Sessions were recorded and transcribed. Discussion groups had 2 to 4 participants, and lasted about 1.5 hours. At the end of each session, a short debriefing was held. Two investigators independently and jointly reviewed and analyzed transcripts. Notes from each session were also reviewed. The analysis followed an iterative pattern. And, as new themes emerged, discussions were re-examined for further insights. The trade-specific findings were then compared and contrasted within each of the topic areas of interest.

Six of 6 ABCT instructors participated in group discussions and completed surveys. Before teaching, they had worked in the industry for, on average, 13 years (SD = 7, range = 4-21 years). Instructors had been teaching an average of 22 years (SD = 12, range = 2-33 years) and teaching at their current college an average of 19 years (SD = 12, range = 2-33 years). Two instructors had previously owned their own collision repair shops. A third instructor owned a collision shop at the time of participation. Six of 7 MTT instructors participated in group discussions and completed surveys. The seventh instructor completed only the survey. Demographic information was obtained during the discussions. Before teaching, instructors had worked in the industry for an average, of 13 years (SD = 7, range = 3-22 years). They had been teaching an average of 13 years (SD = 11, range = 2-26 years) and teaching at their current college an average of 8 years (SD = 8, range = 2-19 years). Two instructors

had a bachelor's degree in education. A third instructor was working full-time for a machining company in addition to teaching.

Aim 2: In partnership with faculty, students, and business owners, develop, implement, and evaluate the adoption of competency-based safety and health curricula.

As a result of activities conducted to achieve Aim 1, we identified gaps in health and safety information currently delivered to students, and established a fruitful dialog with technical college instructors. Decisions were then made regarding how to effectively integrate new safety and health materials into existing course lectures and activities. These decisions included: safety issues to be addressed, format of training materials such as PowerPoint presentations, videos, fact sheets, exercises, quizzes, length of didactic lectures, and lesson plans.

In consultation with instructors, the following modules were developed for ABCT: safety rules, acids and bases, electrical safety, eye protection, fire safety, hearing protection, isocyanates, respirators, and solvents (Table 1). The following modules were developed for machine tool technology: shop safety rules, electrical safety, fire safety, hearing protection, lockout and tagout (LOTO). Each module has an instructor guide, classroom presentation, student handouts, lab activities, homework, and a quiz. In addition, there are refresher modules for use during the second of the two-year programs. There are also extensive resources for instructors and students. Materials are found at: https://www.votechsafety.net/techs/.Table 2 shows topic content areas identified as important during key informant interviews.

Table 2: Items considered important by faculty at two technical vocational colleges

Item	Collision	Metal fabrication
Safety items	Set-up for working under cars Spray painting booth safety Evaluation and maintenance of emergency exits Evaluation of fire extinguishers Evaluation of eye wash stations	Machine guard set-up How to validate an E stop function LOTO procedures Requirements for locks and tags Forms of hazardous energy
Health effects	Isocyanates Solvents and acids Noise	Metal working fluids Noise
PPE	Respirators - selection, fit test, maintenance Earplugs - selections and fit Safety glasses - selection and fit	Earplugs - selections and fit Safety glasses - selection and fit
OSHA standards	Respiratory Protection Right-to-Know PPE Flammable and combustible liquids	Machine guarding Right-to-Know PPE LOTO

Instructors were trained in the use of new teaching materials prior to the start of the academic year. Instructors attended a ½ day session. Each session consisted of:

- An overview of all materials included within each module including the Instructor's Guide, Student Guide, Homework, Lab Activities, Quiz, and "I want to know more" The latter is a collection of additional information on each topic;
- A Shop Safety Rules module was developed for each trade. Shop safety rules were developed in order to bring about consistency regarding shop safety requirements and student behavior expectations within the training facility and a focused approach to safety and health. Included with the shop safety rules was an instructor guide for PPE provided in table format. This served to guide instructor-based assessment of PPE needs and requirements in the shop.
- Instructor practice time that gave each faculty member an opportunity to become familiar with the presentations and associated scripts

- Planning and integration of TECHS modules delivery during the fall 2015 semester;
- How to track the TECHS materials delivery during the academic year; and
- A hands-on training on how to transfer the materials using the school-specific education software, Desire to Learn (D2L). Materials were transferred from a centralized storage to each instructor's D2L site.

ABCT and MTT instructors in three colleges in Minnesota participated in the development and implementation of the Technical Education Curricula for Health and Safety (TECHS) curricula. Instructors attended training sessions before each academic year, tracked their use of TECHS materials during three academic years (2015 - 2018) and provided feedback in bimonthly meetings. At the end of each academic year, students completed surveys with questions on safety-related knowledge, skills, beliefs, and work practices.

Full modules were taught in the fall, and refresher modules were taught in the spring semesters. Instructors were consistent in embedding the TECHS modules in courses for which the safety hazards addressed were immediately relevant. The shop safety rules module was taught at the beginning of each semester. As the study progressed, more of the curricula materials were used. Only two instructors (MTT program, college C) achieved 100% implementation fidelity during the spring semester in the 3rd year of the study. Classroom presentations and lab instruction were not observed due to the inability to ascertain the dates on which TECHS-related teaching activities took place.

During the first year (2015-2016), the following issues arose: (1) ABCT instructors did not know how to use their college virtual learning platform; (2) lab activities were considered too time consuming and were not completed; (3) instructors were reluctant to assign and verify homework; (4) quizzes were rarely discussed. These challenges were only partly remedied though additional instructors training and coaching. During the second year (2016-2017), completion of lab activities increased, however, instructors remained reluctant to assign and verify homework, and quizzes were rarely discussed. During the third year (2017-2018), instructors discussed the quizzes and completed some homework assignments in class. During the 2nd and 3rd year, ABCT programs in colleges B and C experienced high staff turnover.

Student access to the TECHS materials varied with instructors' knowledge of their college online learning platform, and ranged from none (ABCT, all colleges) to nearly complete access (MTT, college B). Analysis of student online access of the TECHS materials in MTT programs (2016-2017) showed that fewer than 30% of students accessed any documents.

Summary of Aim 2: Instructors in vocational colleges are expected to teach all aspects of their trade, including safety and health, with little coaching, feedback, or oversight. Even when instructors participate in developing trade-specific safety and health curricula, they are only partially successful in using it as designed. College instructors need additional support in their role as adult educators and should be encouraged to monitor their effectiveness by using meaningful student success indicators. Successfully bringing safety and health expertise in the college classroom is neither simple nor straightforward, but can be accomplished when effective collaboration and engagement strategies are employed.

Additional challenges were lack of familiarity with some safety and health information, nearly no knowledge of adult teaching principles and effective teaching strategies, and lack of oversight from college administration. Instructors' beliefs related to the amount of safety and health already incorporated in their teaching (as assessed at baseline) was predictive of their engagement in the study and the use of the TECHS curricula. Some but not all instructors used student surveys scores as means of feedback.

Aim 3: Evaluate the effectiveness of, and compile feedback on new training materials by: (a) assessing student knowledge of, and skills related to, identification and remediation of workplace hazards; (b) collecting information on graduates' self-reported work practices; and (c) conducting focus groups.

During the 1st year of instruction, student mean knowledge scores increased by 4 to 30% (ABCT), and 3 to 10% (MTT). During the 2nd year of instruction the mean knowledge scores changed by -2 to 13% (ABCT), and 0 to 5% (MTT). Skills and work practices scores improved by less than 10% in each trade during a 2-year period. Instructors cited lack of time and concern for their students' workload as primary barriers to curricula adoption.

Table 3 shows student demographics for the 346 individual who completed the study. Of these, approximately ½ are shown in subsequent tables due to changes in the end of the year survey that were made in 2016. Table 4a shows end of the year student test scores for ABCT by topic for students with no TECHS curriculum training compared to those with 1 and 2 years of training. There were no differences in overall knowledge ($p = 0.23$) or self-reported skills ($p = 0.81$) and work practices ($p = 0.85$) for those with 1 and 2 years of TECHS training and these groups were subsequently combined. Overall knowledge and work practices scores were higher among those who had received TECHS-related training. Scores were also better in 5 of 14 subcategories (e.g., knowledge related to eye protection). No improvements were seen for hearing protection and respiratory protection.

Table 4b shows end of year scores for students enrolled in the first cohort during study development. The final (end of year) survey was modified after its first use. This modification included several changes: (1) most true/false questions were eliminated; (2) additional questions were added to assess self-reported skills and work practices; and (3) several questions were modified to make them more difficult with the intent of increasing the range in scores. All questions used in 4b had an identical counterpart in Table 4a. No intervention effect was seen in the larger cohort.

Tables 5 shows follow-up responses for ABCT graduates one year after graduation. ABCT graduates with 1 or 2 years of TECHS instruction had significantly better overall knowledges scores than their peers with no TECHS instruction overall (0.79 vs 0.63, $p < 0.01$), and in the topics of eye protection (0.85 vs. 0.57, $p < 0.01$) and respiratory protection (0.80 vs 0.64, $p < 0.01$). No statistically significant improvements were observed in skills and work practices scores. Work practices scores for the “detailer” job category should be interpreted with caution, as only one technician with 0 years of TECHS completed this section of the survey.

Table 6 shows ABCT graduate scores for those who returned work practices surveys post-graduation. These scores reflect responses to questions related to knowledge, skills, and work practices for young workers who graduated with and without TECHS training. There were few differences between work practices and knowledge between graduates who did and did not have TECHS-related training. While some categories should positive changes these were often slight and many others showed negative changes. For example, while overall knowledge increased, self-reported skills and work practices decreased. Many of the positive changes did not reach statistical significance (e.g., knowledge related to fire and electrical hazards).

Graduates with TECHS instruction working as *painters* improved in 5 of 8 work practices: use of eye protection when spraying, not cleaning their hands with lacquer thinner, being clean-shaven when using a tight-fitting respirator, not spraying isocyanate-containing products outside the paint booth, and attaching the grounding and bonding wires to bare metal. However, 35% of painters with TECHS instruction reported forgetting to perform a seal-check when putting on their respirator and 50% or more of all respondents wore a tight-fitting respirators without being clean-shaven (Table 6).

We are unable to ascertain whether responses accurately describe the unsafe use of air-purifying tight-fitting respirators, or are due to use of a different type of respirator (loose-fitting; supplied-air). Respondents were not asked about the type of the respirator used. Although improved, the practice of spraying isocyanate-containing products outside the paint booth was reported by 53% of graduates with TECHS instruction. It is possible that shop-related factors such as high production rates, lack of a prep station, or lack of safety rules make this practice acceptable, in spite of the health risk entailed by exposure to isocyanates.

Table 7a shows differences in scores between MTT students with none, 1 year, and 2 years of receiving TECHS curricula. Comparisons are only made between those with 1 and 2 years of TECHS because of the small number of students in the group with no TECHS training. Overall knowledge, skills, and work practices showed improvements. In addition, there were improvements in knowledge, skills, and work practices in most categories (e.g., eye protection, hearing protection). Table 7b shows data for the first cohort of student enrolled in TECHS. The numbers seen in Table 7b are greater because the survey was modified after year one to include more difficult questions and eliminate most true/false questions. No intervention effect was seen in the larger cohort.

Table 8 shows MTT student scores by topic area one-year post graduation. There was a slight improvement in overall knowledge (6%) as well as knowledge related to hearing protection, machine guarding, and LOTO awareness. However, none of these improvements were reflected in improved self-reported skills. As seen in

Table 9 there was minimal improvement in self-reported work practices related to specific activities such as the use of protective eye wear (-6%) or use of hearing protection (-2%).

Summary– Aim 3: Vocational education institutions that plan on adopting a safety and health curricula must ensure that the instructors have the motivation, skills and organizational support needed to succeed. Institutional commitment to safety and health education is central to both implementation and sustainability of adoption. Institutions should formalize their commitment to safety and health education by ear-marking teaching time for this subject and providing assistance to instructors to facilitate curricula integration. We recommend that instructors: (1) attend courses in trade-specific safety and health, adult education, and methods of instruction; (2) are given opportunities to observe teaching of safety and health concepts; and, (3) receive feedback from education specialists and safety professionals. We recommend new curricula are implemented through a step-wise approach that gives instructors adequate time to hone their skills and develop appreciation for the materials. Lastly, we recommend future studies explore implementation supports and barriers at institutional and instructor levels, and assess educational effectiveness beyond the end of the academic program.

Instructors' level of engagement in the study varied with their perception of teaching an adequate amount of safety and health as documented in baseline interviews and surveys. Instructors who believed they were already teaching an adequate amount of safety information displayed low enthusiasm for using new materials and made limited efforts to integrate it in their teaching (low engagement; ABCT – colleges A and C; MTT – college B). Instructors that recognized a need for a comprehensive safety curricula were more likely to use materials provided (high engagement; ABCT – college B; MTT – college C). College administration did not appear involved in guiding their staff through the implementation process. Instructors indicated that as their confidence in using new classroom presentations increased during the 2nd and 3rd year of use, they were more likely to incorporate other curriculum elements in their practice. Despite these improvements, instructors' level of engagement did not change during the study period. Instructors cited a lack of time, not knowing how to complete some lab activities, and concern for their students' workload as the most common barriers to curriculum implementation. Instructors' use of the school's online learning platform was the key factor determining student access to the TECHS materials.

Survey of CTC faculty: Surveys were distributed to a national sample of CTE faculty. Data were collected via email by the Collision Repair Education Foundation (CREF), a nonprofit organization that works closely with vocational institutions to ensure programs have the equipment and materials needed to train ABCT workers. Data collection occurred over a 4-week period in July and August of 2019. Four hundred and six (406) instructors teaching in vocational colleges and high schools across the country were invited to participate. CREF assigned an unique ID to each respondent and forwarded de-identified responses to TECHS staff for analysis. The survey was closed after receiving 125 responses.

The survey was completed by instructors teaching only at the high school level, only in college, or in both high school and college. For each group, knowledge scores were summarized using mean, standard deviation, and range. Normality of knowledge scores was assessed and differences between groups were evaluated using a two-sample t-test or equivalent Mann-Whitney u-test if data were not normally distributed. Univariate regression was used to evaluate the association between knowledge scores and factors such as years of teaching (<1, 1-5, 6-15, and >15), years of experience in collision repair prior to teaching (<1, 1-5, 6-15, and >15), and previous role as an ABCT business owner or manager (yes or no). Statistical analyses were conducted using SAS (version 9.4, SAS Institute Inc., Cary, NC, USA).

Surveys were completed by 125 instructors from 36 states. Of these 125 instructors, 20% taught only in high school, 55% in colleges, and 25% in both high school and college. The largest numbers of responses were from Texas and California with 9 and 8 participants respectively. Nearly all respondents were male, and 44% were between 55 and 64 years old. For respondents with only one degree or certificate, 33% had an associate degree or diploma in collision repair, 17% had a vocational certificate in a trade other than ABCT, and 14% had a 2- or 4-year degree or certificate in teaching or adult education. The remaining 45 (36%) of individuals had two or more degrees or certificates. The majority of instructors (89%) had worked in collision repair for 6 or

more years before teaching, and 61% had been shop owners or managers. Nearly 40% of the instructors were still working part time in collision repair.

With regard to learning about OSH, just over 50% of faculty thought 75% or more knowledge was learned at school and not on the job, and 9% felt that safety was primarily learned on the job. Eighty-five percent (85%) of instructors were satisfied with the amount of time they spent teaching OSH. The other 15% (N = 19) of respondents did not spend enough time teaching OSH and cited reasons such as the large amount of technical material that must be covered, a short academic year, and students thinking safety is boring. Only one instructor felt he did not have the necessary expertise to teach OSH. The majority of respondents rated their teaching skills as good (29%), very good (45%), or excellent (25%) for both classroom and lab instruction.

Overall knowledge scores ranged from 22% to 78%. As seen in Table 10, years of teaching, years of working in collision repair, or having been a shop owner or manager did not have a significant impact on instructor knowledge of OSH. Respondents with an Associate of Applied Science (AAS) degree or a diploma in collision repair had slightly but significantly higher scores than their peers (50% vs 46%, $p = 0.03$). This relationship did not change with the number of degrees held. A weak positive association ($p = 0.05$) was seen between knowledge scores and instructors' perceptions of the percentage of safety issues that can be identified and corrected before an injury occurs (data not shown in Table). There was no association between overall knowledge and the instructors having been an owner or manager or the number of years they had taught.

High school instructors' overall knowledge scores were significantly lower than those of postsecondary instructors (42% vs 50%, $p \leq 0.001$). Their scores were also lower in two categories: hazard recognition (44% vs 54%, $p \leq 0.05$) and hazard control and shop equipment (30% vs 37%, $p \leq 0.05$). The score differences between the two groups approached statistical significance (59% vs 69%, $p=0.06$) for the personal protective equipment category. Some respondents in both groups correctly answered all questions related to medical services and training and personal protective equipment. However, the highest scores in the remaining categories were 85% (hazard recognition by postsecondary instructors) and 73% (health effects by secondary instructors). Two instructors did not correctly answer any questions in the health effects category, and 1 instructor did not correctly answer any questions in the personal protective equipment category.

Summary of survey findings: the results of this survey demonstrate substantial gaps in the OSH-related knowledge among ABCT instructors at the secondary and postsecondary levels. Vocational instructors play a central role in preparing the new generation of collision repair technicians; however, they cannot teach what they don't know. They are also likely to be less effective when teaching concepts they don't understand. A recent survey conducted in vocational colleges in Minnesota found that graduates have significant knowledge gaps regarding safety and health in their trade.[18] Without addressing instructors' safety and health knowledge gaps, successful implementation of safety and health curricula developed specifically for collision repair programs is likely to be incomplete and ineffective. As a result, new generations of technicians will continue to enter the workforce poorly prepared to protect their health and safety, missing the chance to have fulfilling and successful careers.

TABLE 3 Demographics for 346 student who completed the study

ABCT demographics: n=174		N	%
Gender (missing=6)	female	10	6.0
	male	158	94.0
Race (missing=4)	white	109	64.1
	non-white	61	35.9
Age (missing=2)	under 18	2	1.2
	18 to 24	119	68.4
	25 to 34	30	17.2
	35 to 44	12	6.9
	45 to 54	4	2.3
	55 or older	5	2.9
Working in the trade during the school year? (missing=3)	no	77	45.0
	yes	94	55.0
Working in the trade before attending college? (missing=2)	Did not work	106	60.9
	Less than 1 year	37	21.3
	1-4 years	16	9.2
	5 or more years	13	7.5
Ever had a work-related injury (missing=2)	no	149	86.6
	yes	23	13.4
Received worker compensation? (missing=2)	no	162	94.2
	yes	10	5.8

MTT demographics table: n=172		N	%
Gender (missing=3)	female	3	1.8
	male	166	98.2
Race (missing=5)	white	140	83.8
	non-white	27	16.2
Age (missing=4)	under 18	1	0.6
	18 to 24	89	52.0
	25 to 34	49	28.6
	35 to 44	13	7.6
	45 to 54	12	7.0
	55 or older	4	2.3
Working in the trade during the school year? (missing=4)	no	52	31.0
	yes	116	69.0

Working in the trade before attending college? (missing=4)	Did not work	96	56.1
	Less than 1 year	29	17.0
	1-4 years	29	17.0
	5 or more years	14	8.2
Ever had a work-related injury (missing=3)	no	151	89.3
	yes	18	10.7
Received worker compensation? (missing=3)	no	156	92.3
	yes	13	7.7

Table 4a. ABCT end of year student test scores by topic and TECHS instruction

Topic	Domain	Years of Techs								p-value between None and 1 and 2 years of TECHS
		No (0 years) TECHS (n=21)		1 year TECHS (n=28)		2 years TECHS (n=44)		1 and 2 years of TECHS (n=72)		
		%	SD	%	SD	%	SD	%	SD	
Overall	Knowledge	56	15	76	16	72	14	73	15	<0.0001
	Skills	85	14	89	9	89	11	89	10	0.18
	Work practices	66	20	80	22	80	16	80	18	0.003
Eye Protection	Knowledge	57	15	78	17	72	18	74	18	0.0001
	Skills	87	12	90	10	88	13	89	12	0.45
	Work practices	93	24	93	22	97	13	95	17	0.68
Hearing Protection	Knowledge	90	30	96	19	100	0	99	12	0.23
	Skills	88	23	92	17	91	15	91	16	0.55
	Work practices	86	36	86	36	93	25	90	30	0.55
Skin Protection	Knowledge	50	39	88	22	81	31	83	28	0.001
	Skills	86	14	90	12	89	14	90	13	0.32
	Work practices	43	33	71	32	65	23	67	27	0.0007
Respiratory Protection	Knowledge	48	22	58	34	53	26	55	29	0.27
	Skills	74	27	82	18	85	16	84	17	0.13
	Work practices	57	35	76	28	73	34	75	32	0.03
Fire and Electrical Safety	Knowledge	52	51	93	26	98	15	96	20	<0.0001
	Skills	95	10	96	10	91	18	93	15	0.44
	Work practices	No questions asked								

Table 4b. ABCT end of year student test student scores by topic and TECHS instruction using data from the first survey

Domain	No TECHS (n = 60)		1 Year of TECHS (n= 45)		2 Years of TECHS (n= 42)		P-value between 1 and 2 years	P-value between 0 and 1 year	P-value between 0 and 2 years
	Percent	**SD**	**Percent**	**SD**	**Percent**	**SD**			
Knowledge	**73**	**12**	**79**	**12**	**76**	**12**	0.28	0.05	0.32
Skills	**89**	**11**	**90**	**9**	**89**	**11**	0.77	0.73	0.95
Work practices	**82**	**19**	**78**	**19**	**81**	**15**	0.49	0.49	0.71

Table 5. ABCT graduates scores by topic and TECHS instruction

Topic	Domain (number of questions)	Respondents (years of TECHS)		Score Difference
		N = 14[a] No TECHS	N = 27[b] 1 or 2Years	
		Percent (SD)	Percent (SD)	
Overall	Knowledge (15)	63 (0.12)	79 (0.14)	+ 16[c]
	Skills (10)	92 (0.11)	91 (0.09)	- 1
	Work practices (16)	82 (0.20)	79 (0.23)	- 3
Eye Protection	Knowledge (2)	57 (0.33)	87 (0.28)	+ 30 [c]
	Skills (3)	94 (0.11)	91 (0.10)	- 3
	Work practices - Painters (1)	38 (0.52)	59 (0.51)	+ 21
	Work practices - Body Techs (2)	92 (0.29)	88 (0.27)	- 4
	Work practices - Detailers (2)	100 (n/a)	80 (0.35)	- 20
Hearing Protection	Knowledge (1)	100 (0)	96 (0.19)	- 4
	Skills (1)	96 (0.09)	98 (0.07)	+ 2
	Work practices – Body Techs (1)	92 (0.29)	92 (0.28)	-
	Work practices – Detailers (1)	100 (n/a)	70 (0.48)	- 30
Skin Protection	Knowledge (1)	86 (0.36)	100 (0)	+ 14
	Skills (1)	91 (0.12)	97 (0.08)	+ 6
	Work practices – Painters (1)	88 (0.35)	94 (0.24)	+ 6
	Work practices – Body Techs (2)	67 (0.25)	77 (0.30)	+ 010
	Work practices – Detailers (1)	0.00 (n/a)	80 (0.42)	+ 80
Respiratory Protection	Knowledge (7)	64 (0.17)	80 (0.17)	+ 16 [c]
	Skills (3)	92 (0.12)	92 (0.11)	-
	Work practices – Painters (4)	69 (0.22)	62 (0.28)	- 7
Fire and Electrical Safety	Knowledge (4)	50 (0.26)	63 (0.28)	+ 13
	Skills (2)	86 (0.20)	81 (0.22)	- 5
	Work practices – Painters (2)	75 (0.27)	88 (0.28)	+ 13
	Work practices – Body Techs (1)	83 (0.39)	92 (0.29)	+ 9
	Work practices – Detailers (2)	100 (n/a)	75 (0.42)	- 25

a Respondents with 0 years of TECHS by job category: 8 Painters, 12 Body Techs, 1 Detailer

b Respondents with 1 or 2 years of TECHS by job category: 15 Painters, 21 Body Techs, 8 Detailers

c indicates significant change ($p < 0.01$)

Table 6. ABCT graduates' work practices by topic, job title, and TECHS instruction

Topic/Work Practice	Job Title[a]	Respondents (years of TECHS)		Difference ()
		N = 14[b] None	N = 27[c] 1 or 2	
		Yes		
Eye protection				
I always use eye protection when spraying.	P	38	59	+21↗
I always use safety glasses while grinding, cutting and drilling.	BT	92	96	+4↗
I always use safety glasses when working under cars.	BT	92	79	-13
I always protect my eyes when I handle corrosives or spray any chemicals.	D	100	70	-30
I never block access to the emergency eyewash in the shop.	D	100	90	-10
Hearing protection				
I always use hearing protection when using pneumatic tools.	BT	92	92	-
I always wear hearing protection when I use compressed air to clean or dry a car or car items such as rugs.	D	100	70	-30
Skin Protection				
I sometimes clean my hands with lacquer-thinner.*	P	12	6	-6↗
	BT	17	8	-9↗
I never use medical-grade latex gloves when handling chemicals.†	D	0	80	+80↗
	BT	50	62	+12↗
Respiratory Protection				
I sometimes spray isocyanates without using a respirator.*	P	0	12	+12
I am NOT always clean-shaven when wearing a tight-fitting respirator.*†	P	50	41	-9↗
I sometimes spray isocyanate-containing products outside the paint booth or prep station.*†	P	62	53	-9↗
I sometimes forget to perform a seal check when I put on a tight-fitting respirator. *†	P	12	35	+23
Fire and Electrical Safety				
I sometimes block access to fire extinguishers.*	P	0	12	+12
	BT	17	8	-9↗
	D	0	20	+20
I always attach the grounding and bonding wires on the bare metal of flammable liquid drum.	P	50	88	+38↗
I always plug electrical tools in an outlet with GFCI when I use them in wet areas.†	D	100	70	-30

a P= painter, BT = body technician, D= detailer

b Respondents with 0 years of TECHS by job category: 8 Painters, 12 Body Techs, 1 Detailer

c Respondents with 1or 2 years of TECHS by job category: 17 Painters, 24 Body Techs, 10 Detailers

* indicates an unsafe work practice; a *decrease* in yes respondents constitutes improvement

† indicates a work practice that depends on the equipment available in the shop or the shop layout

↗ indicates improvement

Table 7a. MTT end of year student test student scores by topic and TECHS instruction

Topic	Domain	Years of Techs						p-value between 1 and 2 years of TECHS
		No TECHS (n=7)		1 year TECHS (n=45)		2 years TECHS (n=42)		
		%	SD	%	SD	%	SD	
Overall	Knowledge	68	19	77	18	91	9	<0.0001
	Skills	92	8	86	18	93	10	0.04
	Work practices	82	16	67	29	82	19	0.006
Eye Protection	Knowledge	64	38	88	29	100	0	0.004
	Skills	96	9	89	18	96	9	0.04
	Work practices	79	27	73	33	85	26	0.1
Hearing Protection	Knowledge	43	53	67	48	90	30	0.007
	Skills	100	0	89	18	96	9	0.01
	Work practices	Questions not asked						
Material Handling	Knowledge	100	0	89	32	100	0	0.02
	Skills	91	6	87	18	93	11	0.11
	Work practice	57	53	58	50	64	48	0.53
Machine Guarding	Knowledge	62	13	62	26	79	21	0.001
	Skills	93	12	85	20	92	11	0.04
	Work practices	89	13	67	35	85	20	0.007
LOTO Awareness	Knowledge	86	38	100	0	100	0	1
	Skills	75	25	84	20	86	21	0.31
	Work practices	86	18	67	37	84	24	0.01

Table 7b. MTT end of year student test student scores by topic and TECHS instruction using data from the first survey

Domain	No TECHS (n = 60)		1 Year of TECHS (n= 45)		2 Years of TECHS (n= 42)		P-value between 1 and 2 years	P-value between 0 and 1 year	P-value between 0 and 2 years
	Percent	**SD**	**Percent**	**SD**	**Percent**	**SD**			
Knowledge	75	13	77	16	7	7	<0.0001	0.59	<0.0001
Skills	90	16	87	17	10	10	0.15	0.27	0.15
Work practices	75	20	75	18	18	18	0.99	0.84	0.84

Table 8. MTT graduates scores by topic, domain and TECHS instruction

Topic	Domain (number of questions)	Respondents (years of TECHS)		Score Difference
		N = 48 No TECHS	N = 55 1 or 2 years	
		% (SD)	% (SD)	
Overall	Knowledge (8)	77 (17)	83 (15)	+6[a]
	Skills (8)	93 (9)	93 (11)	-
	Work Practices (9)	83 (13)	83 (15)	-
Eye Protection	Knowledge (2)	91 (22)	86 (28)	-5
	Skills (1)	96 (9)	96 (9)	-
	Work Practices (2)	83 (26)	82 (28)	-1
Hearing Protection	Knowledge (1)	63 (49)	84 (37)	+21[a]
	Skills (1)	95 (10)	98 (7)	+3
	Work Practices (1)	98 (014)	96 (19)	-2
Material Handling	Knowledge (1)	100 (0)	100 (0)	-
	Skills (2)	94 (12)	92 (16)	-2
	Work Practices (2)	92 (28)	84 (27)	-8
Machine Guarding	Knowledge (3)	60 (32)	72 (25)	+12[a]
	Skills (3)	93 (11)	92 (13)	-1
	Work Practices (3)	76 (21)	7 (28)	+11[a]
LOTO Awareness	Knowledge (1)	88 (33)	95 (23)	+7
	Skills (1)	89 (18)	89 (15)	-
	Work Practices (1)	96 (20)	86 (18)	-10

a indicates significant change ($p < 0.05$)

Table 9. MTT graduates' work practices by topic and TECHS instruction

Topic/Work Practice	Respondents (years of TECHS)		Difference
	N = 48 No TECHS	N = 55 1 or 2 years	
	Yes		
Eye protection			
I use safety glasses regardless of the task I perform.	96	91	-6
I sometimes clean machines with compressed air above 30 p.s.i.* †	29	27	-2↗
Hearing protection			
I wear hearing protection when doing a noisy task.	98	96	-2
Material Handling			
I ask for help when I have to lift an object heavier than 50 pounds.	92	93	+1↗
I sometimes remove chips using my hands without wearing gloves.*	29	25	-4↗
Machine Guarding			
I remove guards if they get in the way of production work.*†	12	15	+3
I sometimes bypass the interlocks to inspect a part in a CNC machine.*	25	15	-10↗
I tell my supervisor when a guard is missing or is broken.	96	89	-7
LOTO Awareness			
I would never remove locks placed by a LOTO "authorized" person.	96	89	-7

* indicates an unsafe work practice; a *decrease* in yes respondents constitutes improvement

† indicates a work practice that depends on the equipment available in the shop

↗ indicates improvement

Table 10. Knowledge score comparison by select demographic variables

	N	Mean (SD)	Range	p value
Years of teaching				
≤ 5	26	47 (8)	28-62	
6 - 15	47	49 (11)	22-78	0.65
≥ 16	52	48 (11)	24-71	
Years of working in collision repair before teaching				
≤ 5	14	51 (8)	37-64	
6-15	47	48 (10)	26-70	0.29
≥ 16	64	48 (11)	22-78	
Business owner or manager				
yes	76	48 (11)	24-78	0.96
no	49	48 (10)	22-64	
Education				
AAS/Diploma in ABCT	70	50 (10)	26-78	≤.05
Other education	55	46 (11)	22-71	

Table 11. Instructors' knowledge scores by category and institution

Category (number of questions)	**Post-secondary** (N=100) Mean (SD) {range}	**Secondary** (N=25) Mean (SD) {range}	p values
All questions	**50 (10)** {26 – 78}	**42 (9)** {22 – 56}	≤.001
Hazard recognition (12[a])	**54 (15)** {15 – 85}	**44 (14)** {13 – 67}	≤.05
Health effects (5[b])	**42 (18)** {0 – 80}	**37 (17)** {0 – 73}	0.27
Hazard control and shop equipment (10[c])	**37 (11)** {15 – 67}	**30 (11)** {5 – 48}	≤.01
Personal protective equipment (4[d])	**69 (24)** {0 – 100}	**59 (23)** {25 – 100}	0.06
Training and respirator clearance (3[e])	**64 (19)** {17 – 100}	**62 (18)** {25 - 100}	0.63

a Question count by topic: isocyanates (2), solvents (1), acids and bases (2), dust and fumes (2), electrical safety (3), fire safety (2)

b Question count by topic: isocyanates (2), solvents (1), hearing protection (2)

c Question count by topic: respirators (2), acids and bases (1), electrical safety (3), fire safety (3), other (1)

d Question count by topic: respirators (2), eye protection (2)

Cumulative Inclusion Enrollment Table

	Not Latino						Latino			
	Female	Male	Unknown	Female	Male	Unknown	Female	Male	Unknown	
American Indian	0	1	0	0	1	0	0	0	0	2
Asian	0	17	1	0	0	0	0	0	0	17
Native Hawaiian	0	2	0	0	0	0	0	0	0	2
Black	0	21	0	0	0	0	0	0	0	21
White	12	236	3	0	1	0	0	0	0	252
More than one race	0	7	0	0	2	1	0	0	0	10
Unknown	1	14	3	0	22	1	0	0	0	41
Total	13	298	7	0	26	2	0	0	0	**346**

Inclusion of Children: As seen in Table 3, most study participants were younger. As such, all findings presented earlier in this report should be considered applicable to youth and young workers.

Materials available to other investigators: TECHS materials are available under a creative commons license and found at: https://www.votechsafety.net/techs/. This is an extensive library of educational materials and supportive documents that are free and open to use by anyone wishing to do so.

Publications:

Parker DL, Bejan A, Xi M. A National Survey of Health and Safety Knowledge and Beliefs Among Technical Vocational Faculty in Autobody Collision Repair Technology. In review, January 2020df. American Journal of Industrial Medicine.

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