

Original Article

Health and Safety Education in Auto Body Collision and Machine Tool Technology Programs in Vocational Colleges: Challenges and Opportunities

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Abstract

Collision repair, machining, and metal manufacturing are industries with a large percentage of small businesses whose owners face unique challenges implementing health and safety regulatory requirements. Previous research found that 72% of collision repair technicians and 47% of machinists attended some classes or graduated from vocational colleges. Although health and safety is a mandatory part of the curricula for post-secondary vocational education, little is known about what, how, and when health and safety is taught and if teaching is effective. Surveys and discussion groups were used to evaluate health and safety education in two vocational colleges in Minnesota. Six instructors and 76 students in collision repair, and 6 instructors and 130 students in machine tool technology programs participated. Instructors had no formal training in health and safety, few teaching materials, and lacked opportunities to learn about safety in their trade. Teaching was unscripted and heavily influenced by each instructor's™ industry experience, knowledge, perceptions and attitude towards safety, with little or no guidance from school administration, or safety professionals. Student survey results show that graduates have significant gaps in safety and health knowledge. Standardized trade-specific curricula and instructor training are needed to ensure students receive adequate health and safety education.

Keywords: curricula; instructors; safety and health; students; technical college; vocational education

Introduction

Small businesses make up a large percentage of the collision repair, machining, and metal manufacturing (US Census Bureau, 2015). Our previous research and that of others demonstrates that small businesses lack the

resources, administrative infrastructure, and technical knowledge to improve health and safety (Barbeau *et al.*, 2004; Hasle and Limborg, 2006; Eakin *et al.*, 2010; Parker *et al.*, 2012, 2014). Technicians working in metal fabrication trades experience amputations (1 versus 0.5),

eye (4.1 versus 2.3), and hand (22.4 versus 12.2) injuries at higher rates per 10 000 full-time equivalents (FTEs) than in general industry (US Department of Labor, 2016). Assessments of 2632 machines randomly selected from 221 shops found that 33% of machines had missing or inadequate point-of-operation guards, and 28% of the machines were missing guards for other mechanical hazards. Moreover, only 122 businesses (55%) had a basic lockout program, and fewer than 22 shops had adequate lockout procedures (Parker *et al.*, 2015). Surveys completed by 2164 machinists indicate that 47% attended some classes or graduated from vocational college programs in their trade (Parker *et al.*, 2017).

Technicians working in auto body shops experience higher rates of injuries than in general industry for head (15.8 versus 7.7), eye (9.7 versus 2.3), and hand (35.3 versus 12.2) per 10 000 FTEs (US Department of Labor, 2016) and a 9-fold higher prevalence of asthma (Whittaker and Reeb-Whittaker, 2009). Surveys conducted in 49 body shops found numerous uncontrolled hazards (isocyanates, fire, electrical, noise) and a lack of compliance with regulatory requirements related to employee training and written safety programs (Brosseau *et al.*, 2014). While 72% of the 199 repair technicians in these shops attended some classes or graduated from a vocational college, Bejan *et al.* (2011) found no differences in self-reported work practices used by technical college graduates ($n = 95$) compared with those who attended some college ($n = 46$) or did not attend technical college ($n = 57$). With regard to health and safety, these results warrant a closer look at the effectiveness of safety and health education delivered in vocational colleges.

The National Institute for Occupational Safety and Health (NIOSH) has been engaged in efforts to develop and implement health and safety curricula for young workers since the early 1990s. A review of national initiatives designed to ensure that vocational education programs incorporate health and safety information emphasized the need for systematic evaluations of these programs (Schulte *et al.*, 2005). Other studies identified gaps in health and safety knowledge and work practices among vocational students (Wong *et al.*, 2005; Löffler *et al.*, 2006; Kaskutas *et al.*, 2010). In Minnesota, even though safety and health is considered a core competency for all careers (MN Department of Education, 2016), the extent to which vocational colleges use trade-specific performance indicators and performance measures (MN State, 2016, 2017) is unknown.

The Technical Education for Health and Safety (TECHS) study, a NIOSH-funded project, aims to: (i) document what, how, and when workplace safety and health is taught and assessed during 2-year vocational college

programs in Auto Body Collision Technology (ABCT) and Machine Tool Technology (MTT); (ii) identify gaps and needs; (iii) design and implement new curricula; and (iv) evaluate the effectiveness of the new curricula at the end of each academic year and 1 year post-graduation.

This article presents the findings of instructor discussion groups and instructor and student surveys conducted as part of baseline TECHS activities carried out from February to May 2015.

Methods and materials

All methods and materials were approved by HealthPartners Institute's Institutional Review Board. All instructors (6 ABCT and 7 MTT) and students (98 ABCT and 195 MTT) from two Minnesota colleges were invited to participate.

Instructors

Question development

A preliminary assessment of health and safety teaching materials used in the ABCT and MTT programs was conducted in February 2013. It was followed by a review of published materials (e.g. peer-reviewed journal articles, trade journals, regulatory reports) addressing health and safety in each trade. Study staff used the findings to design questions for instructor discussion groups and surveys.

Discussion group questions covered five topics: (i) instructor background and transition from industry to teaching; (ii) methods and materials used for teaching and testing safety; (iii) graduates' skills and safety-related challenges in the workplace; (iv) employee-employer communication about safety; and (v) the type and format of additional safety and health teaching and testing materials that instructors want. Questions were open-ended to encourage participant interaction. The same questions were used with ABCT and MTT instructors.

Written survey questions covered four topics: (i) sources of safety and health information that instructors use; (ii) time allocated to teaching safety; (iii) importance of safety topics that graduates should know about in order to be successful on the job; and (iv) 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.

Recruitment

Four discussion groups (two each with ABCT and MTT instructors) were held in February and March 2015. Instructors were eligible to participate if they taught full-time and had at least 1 year of teaching experience at the

college. Meetings were held in each college, separately for each trade. Participants signed informed consent forms and were compensated for their time.

Data collection and analysis

Discussion groups 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 2–4 participants, and lasted about 1.5 h. At the end of each session, a short debriefing was held. Two investigators independently and jointly reviewed and analyzed transcripts using the methods described by Krueger and Casey (2000). Notes available for each session were also reviewed. The analysis followed an iterative pattern; as new themes emerged, discussions were re-examined for further insights. The trade-specific findings were then compared and contrasted within each of the four topic areas of interest.

Surveys were administered in paper form at the end of each discussion group. Answers were entered into an Excel database. Percent of respondents who selected each answer was calculated for individual questions.

Students

Question development

Instructors and study staff collaboratively identified and prioritized the safety topics on which students' knowledge would be evaluated. The topics for ABCT students were isocyanates, respirators, solvents and acids, fire and electrical safety, and eye and hearing protection. The topics for MTT students were machine guarding, lockout/tagout (LOTO), materials handling, and eye and hearing protection. A databank of questions was created and prioritized by the study staff and reviewed by at least one instructor in each trade. In addition to demographic questions (age, gender, work history), ABCT student surveys had 21 and MTT surveys had 20 true/false or multiple choice health and safety questions.

Recruitment

All students pursuing diploma or associate degrees in the ABCT and MTT programs were eligible to participate. Instructors administered the surveys in April and May 2015. Students were informed about the nature of the study and told that participation was voluntary and that the surveys were anonymous. No compensation was provided.

Data collection and analysis

Student survey answers were entered into an Excel database. A survey score was calculated for each student based on the percent of questions answered correctly.

College, trade, and class-specific results included an overall mean, median, range, and scores by safety topic. Differences between the first- and second-year students within each school were evaluated using the Mann-Whitney nonparametric test. SAS (version 9.4, SAS Institute Inc., Cary, NC, USA) was used for analyses.

Results

Instructors

Demographics

Six of six 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 for, on average, 22 years (SD = 12, range = 2–33 years) and teaching at their current college for, on average, 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 seven 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, on average, 13 years (SD = 7, range = 3–22 years). They had been teaching for, on average, 13 years (SD = 11, range = 2–26 years) and teaching at their current college for, on average, 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.

Discussion groups findings

Transition into teaching

Instructors transitioned from industry to teaching for a wide range of reasons, including personal health, desire for a career change, or being recruited by other college instructors. Two individuals made a deliberate decision to become college teachers. All instructors were hired a few days before school started and had little time to prepare for the classes assigned. Instructors were given a list of tasks to be covered in each course. Two instructors explicitly mentioned that they did not know how to develop a syllabus. Even when teaching materials existed, selecting what to include in a lesson was a frustrating and time-consuming task. The excerpts below illustrate the experiences encountered:

[...] when I came in I had a week and a half notice that I got the job, and 'here's the book, here's the workbook,

and these are the classes you're teaching. Good luck! (Instructor 4, MTT; hired in 1996)

I had no clue what a syllabus was. I didn't know it when I went to college. I didn't know there was such a thing. I got hired a week and a half before school started, I think. About a week and a half to start and, plus, I was still working at my other job, gave a week and a half notice. So I didn't have any prepared time, and I basically winged it for quite a while. (Instructor 6, ABCT; hired in 2013)

Teaching of health and safety knowledge and skills

Although all instructors had vocational college degrees in their trade, no instructor had formal training in health and safety. Knowledge gaps and misunderstandings related to chemical exposures and health effects, Occupational Safety and Health Administration (OSHA) standards, and respiratory protection were evident during the discussion:

[...] not all of us are safety experts. I mean, I know I'm not a safety expert, and I can say 'that looks unsafe.' Well, maybe it is, maybe it isn't. (Instructor 1, MTT)

There's no regulation that I know of about welding fume. Welding fume can be horrendous in a shop. It's metal in the air. Now if you want to know which fumes you can get from welding. You can get a film from galvanizations that poisons us. (Instructor 1, ABCT)

When asked about the most important safety issues they always teach, ABCT instructors mentioned body parts or organs (e.g. eyes, ears, lungs), personal protective equipment (PPE), and hazards such as solvent mists, isocyanates, arc flash, and electrocution. MTT instructors mentioned hazards (e.g. sharp cutting tools, moving parts, rings and long hair, lifting, noise), equipment (e.g. lifting devices, wrenches), PPE, and work practices (e.g. use of compressed air, proper use of machine shields, and guards).

MTT instructors considered 'horseplay' and distracting a machine operator critical workplace hazards. Two MTT instructors taught students to be alert to feeling uncomfortable when programming or operating a machine as indicative of not being in control, which instructors considered a '*prelude to an accident*'. MTT instructors spoke of several hazards that graduates encounter in the workplace (e.g. coolant mist, manufacturing of parts weighing hundreds of pounds, large machines) that were not present in the school shop and not addressed in class. Instructors in both trades believed it was not their responsibility to teach OSHA standards or inform students that they have the right to refuse unsafe work. Instructors consistently reported

that workplace safety and compliance with OSHA standards were entirely the employer's responsibility.

The most common teaching methods were: (i) storytelling related to personal experience with injuries and workplace accidents; (ii) demonstrations (e.g. how to put on PPE, how to load a car onto a car rack, how each machine button or lever works, proper lifting techniques); (iii) discussion of accidents and unsafe work practices observed in the shop and identification of accident prevention strategies; (iv) giving students examples of what to say in specific situations (e.g. how to respond when they are operating a machine and cannot engage in a conversation); and (v) shop walk-throughs to locate fire extinguishers and first-aid kits. Repetition and enforcement of shop rules regarding eye protection and appropriate attire and footwear were considered methods for teaching safety.

ABCT instructors spoke about dramatizing some safety information with the intent of scaring the students into complying with the safety rules:

I pick up this can of paint and I go 'this can of paint, it doesn't say 'may' cause harmful effects. This will kill you. You will die from it. Period. If you do not handle it properly. It will kill you. Maybe not instantaneously, but it in the long-term, you will die from it. (Instructor 2, ABCT)

MTT instructors taught the importance of using auditory feedback during machine operation ('*and I tell the student "listen to it. If it doesn't sound like this, something is wrong"*') and spoke about teaching a number of safety-related rules of thumb. For example, '*the chuck wrench, that's part of your hand. It always comes off*', indicating that the chuck wrench will fly off when a machine is started if not removed after setup. MTT instructors recommend that students learn in pairs and advise each other. In one MTT program enrolling primarily older adults already working in the trade, students could complete a safety module at their own pace.

Educational materials mentioned during the discussion were textbooks, PowerPoint presentations, videos (a 1967 film showing the removal of a metal chip from a worker's eye, employee Right-to-Know, isocyanates), CDs with industry-prepared educational materials, and machine set-up checklists. One MTT program had a custom-designed shop safety module.

Several times during each discussion group, it was pointed out that the materials and methods used to teach and test safety were chosen by each instructor with no guidance or oversight from the school's administration. With one exception, materials were not shared between instructors—even within the same college.

Assessment of student health and safety knowledge and skills

ABCT instructors assessed students by asking them to demonstrate the use of PPE and specific operations (e.g. how to use a battery charger or assemble a supplied-air respirator) and complete quizzes. One instructor required all new students to take a safety test during the first week of school. Students repeated the test until they scored 100%. Tests were kept on file to cover what instructors perceived as their personal liability. MTT instructors assessed students by asking them to demonstrate the steps for the set up and proper use of each machine before operating it independently. In one college, MTT students were required to pass a safety quiz prior to being allowed to operate equipment in the shop. Aside from completing the tasks described above, students' safety knowledge and skills were not formally or comprehensively assessed at other times during a 2-year program.

Anticipated safety-related challenges in the workplace

When asked about the safety-related challenges graduates would encounter in the workplace, ABCT instructors spoke about: (i) a lack of clear safety rules and/or lack of enforcement of rules in shops; (ii) peer pressure to use *unsafe* work practices. Senior technicians may laugh at a new employee for using safe work practices; (iii) risk of exposure to hazards generated by other employees (e.g. flying particles, isocyanates). ABCT Instructors believed that graduates could overcome these challenges by being a *'strong-willed person and somebody who is adult enough to say "I don't care what you think, I want to protect myself"'*, thereby assuming personal responsibility for their own safety.

MTT instructors spoke of challenges such as: (i) being assigned to work the second or third shift, when help and resources are less available; (ii) peer pressure related to production speed; (iii) poor safety culture (e.g., lack of management commitment to safety, variable enforcement of safety rules, lack of clear communication between shifts); (iv) repetitive jobs that may lead to lack of attention to the task; (v) long shifts; (vi) improper or insufficient training; and (vii) hazards and equipment not previously encountered. Instructors suggested that graduates could overcome these challenges by making a personal commitment to safety:

Make a personal choice. You need to leave at the end of the day like you arrived, to make a conscious decision to walk home. (Instructor 5, MTT)

One MTT instructor mentioned that once an employee signed the handbook acknowledging the safety rules, *'then that's your liability'*.

Employee-employer communication about safety

Instructors rated communication skills as critical to success on the job. However, when asked to describe how they teach students to communicate safety concerns to a shop owner, it was apparent that this issue was never addressed in class. This omission was primarily the result of instructors' beliefs that questioning safety in the workplace would lead an employee to be fired.

Yeah, if you bring problems into a body shop, how long do you think you're going to be around? I tell them '[...] Work hard. Shut your mouth. Open your eyes. And open your ears'. (Instructor 2, ABCT)

All of the MTT but none of the ABCT instructors mentioned experience in the trade as a prerequisite to approaching a supervisor or shop owner with concerns about safety:

I can mention a young guy going into a shop, he just got the job and you're not going to make a whole lot of waves because you want that paycheck, so you'll do what the boss tells you to do. Maybe if you've been in the industry a few years, then you've got some experience behind you coming into a job. Say you work at a place for 10 years, and you got hired in, then you might have little more pull. But as the new guy coming in? (Instructor 4, MTT)

Instructors' perception of students

Although no specific questions about students were asked during the group discussion, several issues were considered barriers to academic and professional success. ABCT instructors in both colleges expressed disappointment that their students had little or no experience in working with tools and appeared poorly prepared to study at college level. Instructors felt that students *'are not at college level'* and *'nobody reads.'* Students' attitudes towards learning were often portrayed as negative: *'they don't want to listen and don't want to learn'* and *'think they can come to school 1 day a week'*. Instructors noted that some students had insufficient verbal skills or confidence to participate in class activities. The MTT instructors in one college also mentioned that their students had little work experience and that skills that were not at the expected level (*'even basic blueprint reading skills aren't there yet'*). This was thought to be because many high schools have discontinued *'technical programs like the metals'*. Instructors noted that students showed different levels of motivation to learn the trade and that some students, *'were still in high school mode'* while others enrolled, *'because Mom and Dad said so'*.

Survey findings

All ABCT instructors agreed that graduates need to know about the OSHA Respiratory Protection, Right-to-Know, and PPE standards. Three of the six instructors thought that knowing how to select safety glasses was

very important, and four indicated that knowing how to properly fit safety glasses was very important (Table 1). For MTT, six of the seven instructors considered knowledge about machine guarding set-up, validating the function of an E-stop, and selecting safety glasses to be very

Table 1. ABCT ($n = 6$) instructors' rating of safety items graduates need to know.

	Very important (%)	Important (%)	Somewhat important (%)	Not important (%)
Facility and equipment safety				
Set-up for working under cars	83	17	0	0
Evaluation of eye wash stations	83	0	17	0
Spray paint booth safety	67	33	0	0
Storage of compressed gas cylinders	67	17	17	0
Evaluation and maintenance of emergency exits	67	17	17	0
Evaluation of fire extinguishers	67	17	17	0
Evaluation of paint mixing room ventilation	50	17	33	0
Grounding and bonding of flammable liquid containers	33	33	33	0
Ground fault circuit interrupters (GFCIs)	33	33	33	0
Evaluation of electrical wiring in the shop	33	33	33	0
Evaluation of compressed air guns	33	50	0	17
Health effects of:				
Isocyanates	100	0	0	0
Solvents	100	0	0	0
Acids	100	0	0	0
Noise	83	17	0	0
Personal protective equipment				
How to fit test a respirator	100	0	0	0
How to select a respirator	83	17	0	0
How to clean and maintain a respirator	83	0	17	0
How to determine if earplugs fit correctly	83	17	0	0
How to determine if safety glasses fit correctly	83	17	0	0
How to select earplugs	80	20	0	0
How to use a chemical glove selection chart	67	17	17	0
How to interpret the NRR number	50	17	33	0
How to select safety glasses	50	50	0	0
OSHA standards and requirements				
Respiratory protection	100	0	0	0
Right-to-Know	100	0	0	0
Personal protective equipment	100	0	0	0
Flammable and combustible liquids	83	17	0	0
Portable fire extinguishers	50	50	0	0
Spray finishing using flammable materials	50	50	0	0
Machine guarding	50	33	17	0
Lockout/tagout	50	33	17	0
Occupational noise exposure	50	50	0	0
Compressed gasses	50	50	0	0
Portable powered tools	50	33	17	0
Emergency action plans	33	50	17	0
Injury reporting requirements	33	33	33	0

important (Table 2). Time allocated to teaching safety, opportunities to learn about safety, and the most often-used sources of safety information are shown in Table 3.

Students

Demographics

Surveys were distributed to 58 ABCT and 137 MTT students in year 1 (Y1) and to 40 ABCT and 75 MTT students completing year 2 (Y2) at colleges A and B, respectively. Survey return rates for each class ranged from

41% to 100%. The overall return rate for the entire sample was 66.5%. No information was available for non-respondents. Most students were 18- to 24-year old men, had no experience in their trade, and had not had a work-related injury. Additional information is available in Supplementary Table 1.

Survey findings

Fifty-one ABCT students from College A and 25 from College B completed surveys (Table 4). Individual survey

Table 2. MTT ($n = 7$) instructors' rating of safety items graduates need to know.

	Very important (%)	Important (%)	Somewhat important (%)	Not important (%)
Facility and equipment safety				
Machine guards set-up	86	0	14	0
How to validate an E stop function	86	0	14	0
Lockout/tagout (LOTO) procedures	71	29	0	0
Different forms of hazardous energy	57	14	29	0
Requirements for locks and tags used for LOTO	57	43	0	0
Evaluation and maintenance of emergency exits	43	0	57	0
Evaluation of fire extinguishers	43	29	14	14
Evaluation of electrical hazards in the shop	43	43	14	0
Inspecting the guarding on foot controls	43	29	29	0
Ground fault circuit interrupters (GFCIs)	29	14	57	0
How to inspect a power transmission guard	29	29	29	14
How to adjust light curtains	29	14	14	43
Robotic safety	29	14	43	14
Evaluation of machine-specific electrical wiring	14	29	29	29
Health effects of:				
Noise	71	29	0	0
Metal working fluids	57	43	0	0
Solvents	43	43	14	0
Acids	43	14	43	0
Personal protective equipment				
How to select safety glasses	86	14	0	0
How to determine if safety glasses fit properly	71	29	0	0
How to select ear plugs	71	14	14	0
How to determine if the earplugs fit correctly	71	14	14	0
How to interpret the NRR number	43	29	14	14
OSHA standards and requirements				
Right-to-Know	71	29	0	0
Machine guarding	71	14	14	0
Personal protective equipment	57	43	0	0
Portable fire extinguishers	57	14	29	0
Lockout/tagout	57	29	14	0
Occupational noise exposure	57	43	0	0
Emergency action plans	43	57	0	0
Portable powered tools	43	43	14	0
Accident reporting requirements	43	57	0	0

Table 3. Instructor time allocated to teaching safety, learning opportunities, and sources of safety and health information.

	Trade	Strongly Agree (%)	Agree (%)	Disagree (%)	Strongly Disagree (%)
I have enough time allocated to teaching safety	ABCT ^a	17	33	50	0
	MTT ^b	0	83	17	0
I have enough opportunities to learn new things about safety in my trade	ABCT	33	17	50	0
	MTT	0	100	0	0
I have enough opportunities to learn about new OSHA standards and standards updates that apply to my trade	ABCT	33	33	33	0
	MTT	0	33	50	17
Sources of health and safety information used 'often' by 50% or more of instructors	ABCT	School's health and safety office			
	MTT	Other instructors			
Sources of health and safety information used 'sometimes' by 50% or more of instructors	ABCT	Other instructors, shop owners, trade magazines, trade association newsletter, advisory board members, OSHA inspectors			
	MTT	Shop owners, trade magazines, trade association newsletter, advisory board members, OSHA website, safety consultants, and school's safety and health office			

^aABCT = Auto Body Collision Technology (*n* = 6 instructors).

^bMTT = Machine Tool Technology (*n* = 7 instructors).

Table 4. Auto Body Collision Technology student survey scores (% correct answers).

Survey section (<i>n</i> questions)	College A, Y2		College A, Y1		College B, Y2		College B, Y1	
	<i>(n</i> = 12)		<i>(n</i> = 39)		<i>(n</i> = 11)		<i>(n</i> = 14)	
	Mean (%)	SD (%)	Mean (%)	SD (%)	Mean (%)	SD (%)	Mean (%)	SD (%)
Overall (21)	76 ^a	10	66 ^{a,c}	13	72 ^b	10	81 ^{b,c}	7
Score range (%)	57–91		29–90		57–91		67–91	
Isocyanates (5)	72	26	71	21	71	21	81	21
Respirators (2)	63	23	66	24	56	17	75	26
Fire and electrical safety (9)	81 ^d	10	69	19	88 ^d	6	86	7
Eye and hearing protection (3)	81 ^e	22	65	26	58 ^c	22	67	23
Solvents and acids (2)	82	25	79	25	75	27	88	22

^{a–e}Significantly different.

P < 0.05.

scores ranged from 29 to 91%, and group mean scores ranged from 66 to 81%. Y1 students' lowest scores were in the 'Eyes and Hearing Protection' section of the survey, while Y2 students had the lowest scores in the 'Respirators' section. Y1 students attending College B correctly answered significantly more questions (mean = 81%, SD = 7%) than students attending College A (mean = 66%, SD = 13%, *P* < 0.001). The number of years of instruction made a significant difference in the survey scores in each college (*P* = 0.02); however,

the difference was not always in the expected direction. For example, in College B, Y1 students had better survey scores than their Y2 peers.

Seventy-eight MTT students from College A and 52 students from College B completed surveys (Table 5). Individual survey scores ranged from 35 to 100%, and group mean scores ranged from 67 to 81%. Y1 and Y2 students in both colleges had the lowest scores in the 'Machine Guarding' section of the survey. There were no significant differences between the scores of students

Table 5. Machine Tool Technology student survey scores (% correct answers).

Survey section (n questions)	College A, Y2		College A, Y1		College B, Y2		College B, Y1	
	(n = 24)		(n = 54)		(n = 29)		(n = 23)	
	Mean (%)	SD (%)	Mean (%)	SD (%)	Mean (%)	SD (%)	Mean (%)	SD (%)
Overall (20)	67 ^a	14	74	14	81 ^a	10	75	15
Score range (%)	45–90		35–95		55–100		45–90	
Machine guarding (6)	51 ^b	19	61	20	69 ^b	17	65	21
Eye and hearing protection (4)	66 ^c	21	68	22	84 ^c	18	68	22
Lockout/tagout (4)	84	19	82	17	83	20	75	21
Materials handling (6)	74 ^d	21	86	14	90 ^d	13	89	13

^{a-d}Significantly different.
 $P < 0.05$.

Table 6. Examples of safety knowledge gaps among graduating students in each trade.

% Graduates responding incorrectly	Safety issue not known
ABCT ^a	
78%	A tight-fitting respirator fits well only if the user shaved the same day
57%	Bonding clamps are not effective if placed on painted metal surface
48%	Safety glasses are marked with Z87 on lens or temple
48%	Removing tape and sanding recently applied clear coat leads to exposure to uncured isocyanates
30%	Isocyanates induce asthma, and the main routes of exposure are inhalation and skin contact
MTT ^b	
68%	A pressure mat is not an acceptable way to guard the point of operation
40%	Safety glasses are marked with Z87 on lens or temple
38%	Noise-induced hearing loss does not depend on whether the exposure occurs at work or at home
30%	Coolants can cause skin rashes and lung problems
30%	The purpose of outage protection is to prevent machine restart when electricity is restored

^aABCT = Auto Body Collision Technology ($n = 23$ graduates).

^bMTT = Machine Tool Technology ($n = 53$ graduates).

attending college for 1 versus 2 years. The graduating class (Y2) of College B had significantly higher survey scores (mean = 81%, SD = 10%) than the graduating class of College A (mean = 67%, SD = 14%, $P < 0.001$).

Graduating class survey scores were not significantly influenced by previous employment in the trade or by employment in the trade during the academic year 2014–2015 (data not shown). Examples of safety and health issues unfamiliar to graduating students in each trade are shown in Table 6.

Discussion

Guided group discussion have been shown to be optimal means of gathering data to identify needs for and inform

the development of health and safety materials and activities (Fonteyn *et al.*, 1997; Goldenhar *et al.*, 1999; Parker *et al.*, 2012). Despite having been hired over a 30-year period, from 1982 to 2013, instructors reported similar experiences—that their job was awarded only days before school started and they were expected to teach with minimal guidance and materials.

Ten of 12 (83%) of instructors had less than a bachelor's degree, compared to, on average, 58% of instructors nationwide (IES-NCES, 2008). Instructors without a degree in education completed a week-long teacher preparation program required by the Minnesota Department of Education (2017). Short-duration courses in assessment and training have been found to be insufficient in imparting the skills and knowledge needed to teach in

vocational education (Williams, 2010). This may partly explain the difficulties instructors expressed in developing and evaluating new curricula.

Instructors had no training in trade-specific health and safety and reported insufficient opportunities to learn about safety issues and OSHA standards applicable to their trade. In contrast, Salminen and Palukka (2007) reported that 73% of 691 Finnish vocational instructors surveyed had safety and health training. Pisaniello *et al.* (2013) reported that formal safety and health training was critical to instructors' confidence in teaching this topic. Other studies (Greenan *et al.*, 1998; Drage, 2010) showed that vocational college instructors recognize a need for and are motivated to take professional development courses. Participants in both studies highlighted the importance of a supportive school environment, teacher-administration collaboration, and clear guidance for program improvement.

Instructors' lack of training in adult education in general and health and safety in particular, combined with the time pressure to teach a specified amount of material in a 2-year program, may play a role in their perception of students. In our study, instructors expressed negative opinions about students' motivation and readiness to study and learn at a college level. Previous studies on teacher perceptions of student engagement and effectiveness of safety education found that perceptions improved as teachers developed confidence in their own pedagogical, didactic, subject matter, and interpersonal competencies (Pisaniello *et al.*, 2013; van Uden *et al.*, 2013).

When asked about the most important hazards they teach, both MTT and ABCT instructors emphasized the use of PPE, followed by rules for both equipment operation and conduct in the shop. Health effects and symptoms of exposure to workplace hazards did not appear to be addressed, and ABCT instructors do not appear to fully understand the health effects associated with chemical exposures. ABCT instructors did not mention issues such as fire safety, electrical safety, or welding fumes. MTT instructors did not mention machine guards, LOTO awareness, crushing hazards, metalworking fluids, fire hazards, or electrical hazards. Discrepancies between what was stated in discussion groups and survey data likely reflected instructors' uncertainty about what constitutes appropriate safety and health education and their belief that business owners are responsible for facility and equipment safety. For example, during the discussion, instructors mentioned that teaching OSHA standards was not their responsibility. However, in the surveys, all six ABCT instructors agreed that graduates should know about the Respiratory Protection,

Right-to-Know, and PPE standards, and five of seven MTT instructors considered knowledge of Right-to-Know and machine guarding standards important components of job success. Educating students about the requirements of trade-specific OSHA standards is critical. Our previous research shows that health and safety is inadequately addressed by most small businesses in these trades, and owners rely on employees to recognize and report hazards.

Despite rating communication skills as important for a successful career, none of the instructors taught communication skills or strategies for approaching a supervisor or business owner with safety-related questions or concerns. Instructors believed that, as new workers, graduates would never dare engage in such an interaction. However, self-advocacy is a critical component of a young-worker training program (Chin *et al.*, 2010).

Instruction in health and safety was usually unscripted, task-centered, and usually 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. Although each college has health and safety professionals on staff, their input, guidance, and feedback did not appear to be sought. Instructors reported formally teaching and testing students' knowledge of health and safety during the first week of the first year of instruction; however, most hazards are not encountered until later in the program. Little was known about students' retention and understanding of safety and health information, and safety-related skills were not evaluated beyond an initial demonstration of equipment use.

Our findings are similar to those reported by others who recommend updating safety and health teaching strategies to reflect modern principles of adult education (Luskin *et al.*, 1992; Shearn, 2006; Schulte *et al.*, 2005; Salminen and Palukka, 2007; Pisaniello *et al.*, 2013). More than 100 studies of worker safety and health training reviewed by Burke *et al.* (2006) and Robson *et al.* (2012) found that the more engaging the training method, the better the learning outcomes. Methods of engagement include requiring trainees' active participation, behavior modeling, and student feedback and reflection. Other researchers demonstrated the success of using student-centered, trade-specific, active learning methods, and delivering information within a relevant and applicable context (Wong *et al.*, 2005; Löffler *et al.*, 2006; Nickolaus *et al.*, 2007; Liao and Chung, 2008; Evanoff *et al.*, 2012).

Our results show that students graduate with gaps in safety and health knowledge, a problem previously

documented by Wong *et al.* (2005), Löffler *et al.* (2006), Kaskutas *et al.* (2010), and others. We agree with Shearn (2006), Pisaniello *et al.* (2013), and Rohlman *et al.* (2016) that changing behaviors involves more than simply increasing hazard-related knowledge. During a 2-year program, students should have opportunities to master safe work practices as well as improve their attitudes and beliefs towards health and safety.

In 2013, nearly 200 000 of the 1.5 million sub-baccalaureate occupational educational credentials awarded were in manufacturing, construction, repair, and transportation (IES-NCES, n.d.). It is forecasted that, by 2020, 45% of manufacturing jobs will require at least a 2-year associate degree (Georgetown University, 2011). The expansion of technical education programs gives an urgency to finding solutions to the educational challenges identified to date. We believe that this can be achieved through committed partnerships between college administrators, instructors, education specialists, and safety and health professionals.

Limitations

Our study has several limitations. The sample of 12 instructors was small and limited to two colleges. However, subsequent conversations indicate that similar conditions are present in other vocational colleges in Minnesota. Instructors' knowledge and skills related to safety in their trade were not formally evaluated because we were concerned about alienating our study partners. Instructors' knowledge of existing curricula guidance documents at the state level was not assessed. Students' skills related to specific safety issues and their work practices were not evaluated due to the tight timeline between project funding (September 2014) and students' completion of their studies (March–May 2015).

Recommendations

Additional research is needed to better understand the practitioners, practices, and effectiveness of health and safety education delivered to students attending vocational colleges across the USA. 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.

Supplementary Data

Supplementary data are available at *Annals of Work Exposures and Health* online.

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Conflict of Interest Statement

The authors declare no conflict of interest relating to the material presented in this article. Its contents, including any opinions and/or conclusions expressed, are solely those of the authors.

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