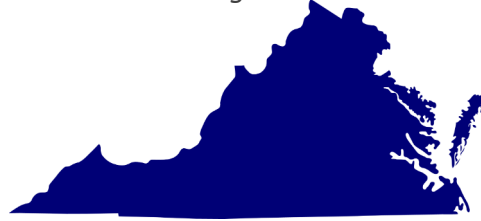


**Safety in
STEM
Education:
Recommend-
ations
Informed by
Virginians'
Responses to
a National
Safety Survey**

*How Does Virginia Compare to the
National Averages?*



*What are the Implications for School
Systems?*

Tyler S. Love, Ph.D., DTE
Ken R. Roy, Ph.D.

VTEEA conference
July 26-28, 2022
Winchester, VA

Permissions

These findings were derived from:

Love, T. S., & Roy, K. R. (2022).
*Safer engineering and CTE
instruction: A national STEM
education imperative.* International
Technology and Engineering
Educators Association.

<https://www.iteea.org/SafetyReport.aspx>

FREE Download!



Safer Engineering and CTE Instruction



**A National STEM
Education Imperative**
What the Data Tells Us



Tyler S. Love, Ph.D., DTE

Kenneth Russell Roy, Ph.D.

Author: Tyler Love, Ph.D., DTE

CURRENTLY

- Assistant Professor of Elementary/Middle STEM Education at Penn State Harrisburg
- Safety Editor for ITEEA
- NSTA Safety Advisory Board Member
- OSHA Authorized Trainer for General Industry
- 2018 CareerSafe® Safety Educator of the Year



PREVIOUS EXPERIENCES

- Coordinator and Associate Professor of T&E Ed in MD
- Technology and Engineering teacher in Maryland's Public School System

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Author: Ken Roy, Ph.D.

CURRENTLY

- ON STAFF AT Glastonbury Public Schools (CT)
 - Director of Environmental Health & Safety/Chemical Hygiene Officer

PRIVATE SAFETY PRACTICE

- National Safety Consultants, LLC – General Manager/Senior Safety Consultant
- National Science Teaching Association (NSTA)
 - Chief Science Safety Compliance Adviser and Blogger
- National Science Education Leadership Association (NSELA)
 - Safety Compliance Officer
- International Council of Associations for Science Education (ICASE)
 - Safety Committee Member



-Author of over 10 safety books and ~ 800 Professional Journal Articles on Safety

Background Info

- Last national survey on T&E safety is unknown
- Large focus on safety in T&E education due to:
 - Potential hazards, resulting risks, and teacher liability
 - Increase in alternative certifications
 - Collaborative STEM/Makerspaces
 - After school clubs taught by various teachers

Previous Research - CTE

- Recent studies on safety in various CTE areas by Threeton and Evanski (2014, 2015, 2019)
 - 57 CTE teachers from 30 counties in PA
 - 93% had safety plan in place
- Top 5 obstacles to implementing safety in CTE classes
 1. Chronic student absences
 2. SPED modifications/accommodations
 3. Lack of funding
 4. High class enrollment surpassing legal occupancy loads
 5. Small classroom/lab space

Previous Research - Science Ed

-Stephenson, West, Westerlund, & Nelson (2003)

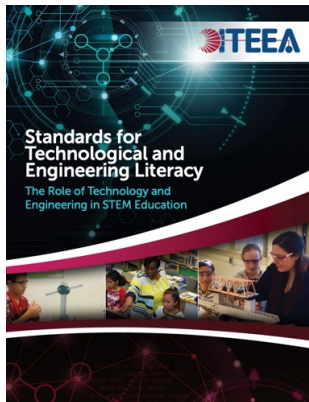
- 856 science teachers in TX
- 81 incident/accident report forms returned

-Incidents/Accidents increased:

1. 8% to 62% as **class size** increases from <14 to >24 students
2. 11% to 66% as **room size** decreased below 60 sq. ft per student
3. 11% to 47% as **room size** decreased below 800 sq. ft
4. 35% did not have adequate training
5. Only 69% had a written safety policy

-Study redone in 2014, similar findings

Safety – Embedded in Standards and State Guides!



Love, T. S., Duffy, B. C., Loesing, M. L., Roy, K. R., & West, S. S. (2020). Safety in STEM education standards and frameworks: A comparative content analysis. *Technology and Engineering Teacher*, 80(3), 34-38.



VA Department of Education:
https://www.doe.virginia.gov/instruction/career_technical/technology/index.shtml

T&E 2020 National Safety Survey

-**TEE-FASS** (T&E Ed Facilities and Safety Survey)

Adapted from Stephenson et al. study

April 2020 - sent out to VTEEA/TEEAP members

718 responses from 42 states, 99 Virginia educator responses

-Questions on:

- Info and Demographics
- Experience and Certification
- Classroom Conditions
- T&E facilities
- Teacher and Student Safety Training
- Recent Incidents/Accidents

Demographics

Gender and Race

Virginia

Answer	%	Count
Male	77%	76
Female	23%	23
Total	100%	99
White	84 %	83
Black	11 %	11
Two or More Races	2 %	2
Asian	2 %	2
Hispanic or Latino	1 %	1
Native Hawaiian or Pacific Islander	0%	0

National - 74% male; 90% White, 5% Black (718 total responses)

Certification(s)

Virginia

Answer	Percent	Count
Alternative or Emergency	1%	2
Elementary Education	3%	5
Technology Ed or T&E Education	58%	90
A Science Education area	4%	7
CTE area	16%	25
Other (please specify)	17%	27

National – T&E = 78%, Elementary = 3%, CTE = 8%

Total Years Teaching T&E/Tech Ed/Indust. Arts

Virginia

Answer	%	Count
0-3	11%	11
4-8	13%	13
9-15	23%	23
16-25	25%	25
26+	27%	27

National

0-3	10%	70
4-8	20%	142
9-15	20%	143
16-25	28%	201
26+	23%	162
Total	100%	718

Grade Level Taught

Virginia

Grade Level	%	Count
K-5	2%	2
Middle School	39%	39
High School	54%	53
6-12 (Middle & High School)	4%	4
K-12	1.01%	1

National

Grade Level	%	Count
K-5	3%	21
Middle School	29%	207
High School	55%	394
6-12 (Middle & High School)	11%	82
K-12	2%	14

Courses and Enrollment

Course Preps

<u>Preps</u>	<u>Virginia</u>	<u>National</u>
1	4%	3%
2	14%	14%
3	37%	31%
4	10%	25%
5	24%	13%
>5	10%	14%

Primary Focus of Your Courses

Virginia

1. Engineering Design, T&E Literacy
2. CAD/3D Modeling
3. Tie – Materials Processing (woods)
Electronics/Programming/Robotics

National

1. Engineering Design, T&E Literacy
2. Tie - Materials Processing (woods and metals combined)
CAD/3D Modeling
Electronics/Programming/Robotics
3. Pre-engineering (ex. PLTW)

Enrollment in your classes: Average and Largest Class sizes

Virginia

Average: 45% said 16-20
24% said 21-24
19% said 25-30
5% said more than 30

Largest: 31% said 25-30
17% said more than 30

National Comparison

Average: 33% said 16-20
25% said 21-24
22% said 25-30
8% said more than 30

Largest: 34% said 25-30
23% said more than 30

Percentage of students in your classes this past year that had special needs?

Virginia

Answer	%	Count
0-5%	22%	22
6-15%	37%	37
16-25%	28%	28
26-50%	11%	11
More than 50%	1%	1

National

0-5%	20%	146
6-15%	41%	297
16-25%	27%	191
26-50%	10%	73
More than 50%	2%	11
Total	100%	718

Administrative and District Support

Administration's progressive disciplinary support?

Virginia

Answer	%	Count
Poor	17%	17
Fair	23%	23
Good	33%	33
Excellent	26%	26

National

Poor	12%	79	
Fair	21%	152	
Good	42%	303	
Excellent	26%	184	

Have a sufficient budget to maintain safety

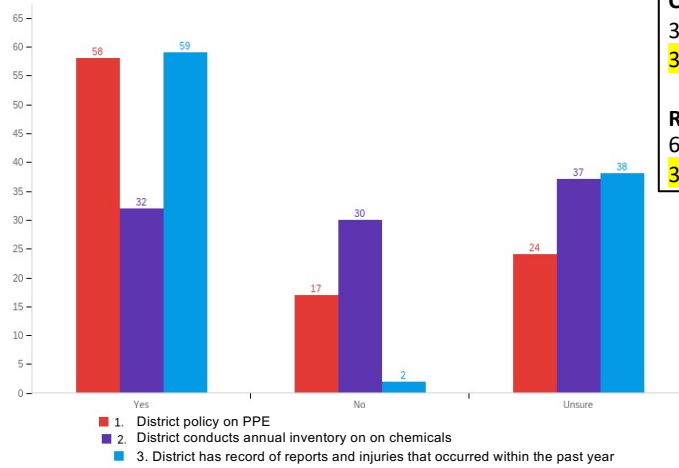
Virginia

Answer	%	Count
Yes	59%	44
No	41%	31

National

Answer	%	Count
Yes	53%	380
No	47%	338

District Safety Practices



Virginia

District PPE policy:
59% Yes
24% Unsure

Chemical Inventory:
32% Yes
37% Unsure

Records of accidents:
60% Yes
38% Unsure

Does your district conduct annual safety audits of T&E facilities?

Answer	Virginia	National
Yes	44%	43%
No	36%	37%
Unsure	19%	21%

Do the Following Have A Written Safety Policy?

Answer	Virginia	National
T&E Classes	88%	82%
T&E Department	62%	56%
School District	41%	44%

How does your district dispose of hazardous chemicals?

Answer	Virginia	National
Hazardous waste contractor	16%	26%
Green disposal methods	2%	2%
Municipality	10%	11%
Down the drain/trash	6%	6%
Unsure	43%	37%
Do not use hazardous chemicals	22%	18%

Recommendations

- Work with your district safety compliance officer, legal counsel, fire marshal, administrators/supervisors, and teachers to **develop a written safety program**, including protocols, inspections, training, etc.
- Work with your **Board of Education** to help develop a written safety policy.
- Ask your district's chemical hygiene officer or safety officer how to properly **dispose of chemicals**
- Refer to **legal resources** (e.g. OSHA, NFPA) and professional resources (e.g. ITEEA, NSTA) for additional information in developing the safety program.
- Enforce safety **consistently and fairly**

Further Recommendations

Virginia has adopted the federal OSHA rules by reference, and also adopted several rules that are stricter than federal standards. These rules apply to public-sector (state and local government offices and operations) and private-sector workplaces within the state with some limited exceptions. Contact the Virginia Department of Labor and Industry to inquire about the Virginia Occupational Safety and Health (VOSH) Program and its applicability to schools.

<https://www.osha.gov/stateplans/va>

Safety Training

Did you receive any form of safety training during the following?

Answer	Virginia	National
UG tech/eng or lab courses	59%	62%
UG teaching methods courses	51%	54%
Grad tech/eng or lab courses	31%	28%
Grad teaching methods courses	30%	32%

When initially hired did your district provide safety training?

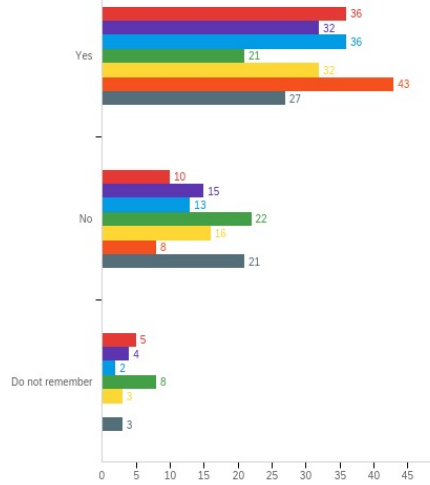
Answer	Virginia	National
Yes	29%	32%
No	71%	68%

How long has it been since your district last offered you safety training?

Answer	Virginia	National
<6 months	17%	15%
6 months -1 year	19%	21%
1-2 years	6%	7%
2-5 years	4%	5%
>5 years	5%	7%
Never received training from my district	48%	44%

Did the training mentioned in the previous question provide information on the following:

Virginia



*National = Greater focus on reading chemical/SDS labels. Virginia had a greater focus on First-Aid procedures.

- 1. Federal or state OSHA regulations
- 2. Training about your school's Hazard Communication Plan
- 3. SDS (Safety Data Sheets)
- 4. Reading Chemical/GHS Labels
- 5. Proper storage and disposal of chemicals/paints/solvents
- 6. First Aid procedures
- 7. Dealing with unsafe behavioral issues

Have you participated in any T&E safety training provided by someone other than your district within the last 12 months?

Virginia

Answer	%	Count
Yes	23%	12
No	76%	63

*National = 18% said Yes

Who delivered the safety training you attended within the past 12 months?

VA Answer	VA%	VA Count	National %
Local training source (not my school district)	22%	5	26%
State teacher's association	9%	2	12%
State department of education	9%	2	6%
National teacher's association	9%	2	3%
A university	30%	7	11%
OSHA	9%	2	17%
Other (ex. PLTW)	13%	3	25%
Total	100%	23	

Recommendations

According to Federal OSHA

-Safety Training must be administered **upon initial hire**, again any time a **new hazard is introduced** (chemical, equipment, etc.), **change in teaching assignment**, and/or updates in safety plans

-Under duty or standard of care the employer (school) has a legal and professional responsibility to **provide these trainings**

-Employee can **request in writing** to receive these trainings

Facility Characteristics

In what type of room did you primarily conduct your T&E activities this past year?

Answer	Virginia	National
Portable Classroom	0%	0.28%
Regular Classroom/computer room	16%	17%
T&E classroom/lab combo	68%	66%
T&E Lab	11%	12%
Makerspace	2%	2%
Varied due to floating	2 %	3%

Approximate size of the instructional area?

Answer (NFPA 101 Fire Code Capacity)	Virginia	National
Less than 600 square feet (<12 students)	5%	8%
600-800 square feet (12-16 students)	14%	20%
800-1,000 square feet (16-20 students)	25%	22%
1,000-1,200 square feet (20-24 students)	14%	24%
Greater than 1,200 square feet (>24 students)	5%	26%

Review:

VA Average Enrollment:
24% said more than 24

VA Largest Enrollment:
48% said more than 24

Soldering Ventilation

	<u>Virginia</u>	<u>National</u>
Do soldering activities	43%	52%
Under external vented fume hood	13%	15%
Under internal fume extractor	18%	12%

3D Printer Ventilation

	<u>Virginia</u>	<u>National</u>
Have 3D printer(s)	77%	75%
Built in filter (HEPA)	16%	17%
Used inside of a fume hood	0%	2%
Used near internal vent system (ex. electrostatic air filter)	9%	6%
No ventilation used	75%	75%

Laser Engraver

	<u>Virginia</u>	<u>National</u>
Have a laser engraver	38%	44%
Internal Exhaust	45%	31%
External Exhaust	50%	64%
No ventilation	5%	5%

Recommendations

Fire code NFPA 101 Life Safety Code requires **50 sq. ft. per student** (net square footage) in academic **labs and shops**

Research suggests at a minimum 60 sq ft. limits accident rates

Conduct at a minimum **annual safety inspections** to make sure your facilities have proper safety controls and space (ITEEA website and NIOSH have excellent checklists)

Make sure the **instructional space meets all** OSHA, NFPA, and other legal safety **standards** and better professional safety practices like ANSI/ISEA, ITEEA, etc. to make it safer for both teachers and students.

Use non-lead based **solder** when possible with ventilation at the source.

Source: <https://www.iteea.org/102756.aspx>

Classroom Management Safety Practices

How often are all students in your T&E class required to:

Question	Never	Rarely	Usually	Always
1. Sign a safety acknowledgement form ?	11% (VA) 16% (US)	6% 6%	5% 10%	78% 69%
2. Be tested for their knowledge of safety procedures prior to participating in new hazardous T&E activities/using new hazardous equipment?	6% 8%	5% 5%	8% 12%	80% 76%
3. Safely demonstrate a new procedure or use of a new tool/piece of equipment while directly supervised?	5% 5%	1% 3%	6% 16%	88% 76%
4. Be tested on safety knowledge on their quizzes/exams?	9% 10%	13% 15%	22% 24%	56% 52%
5. Be provided both written and oral safety precautions by the instructor prior to each lab?	5% 7%	2% 14%	20% 24%	73% 52%

How often are all students in your T&E class required to:

Question	Never	Rarely	Usually	Always
6. Secure long hair /tie it back?	5%(VA) 6% (US)	2% 2%	16% 14%	77% 78%
7. Remove loose jewelry , roll up long sleeves, secure baggy clothing?	5% 7%	3% 3%	15% 14%	77% 76%
8. Wear close toed shoes?	8% 7%	2% 4%	22% 20%	68% 69%
9. Wear safety glasses when working with solid hazards	9% 11%	1% 3%	14% 10%	76% 77%
10. Wear safety goggles when working with liquid hazards	33% 31%	13% 13%	10% 12%	43% 44%

Recommendations

Have all students be safety **trained, tested** and sign a **safety acknowledgement** form before starting any work involving hazards (ex. hand and/or power tools)

All students need **safety glasses with side shields** on when an activity is being conducted in a room or lab (**indirectly vented chemical splash goggles** for liquid hazards)

Students should be **directly supervised** when using any equipment (after meeting all other criteria like safety tests)

Include some key safety questions on unit tests/quizzes

Provide written and oral forms of safety instruction/reminders

No **open toed shoes or flip flops** allowed during lab activities

Always require students to **tie back** long hair/**secure** loose clothing and jewelry



Safety tests and posters used with students?

Answer	Virginia	National
ITEEA's safety website	15%	10%
Virginia Tech's lab safety resource website	7%	1%
Power Tool Institute resources	3%	3%
School district/department developed resources	18%	15%
State developed resources	1%	4%
Student developed safety resources	1%	1%
Teacher (my own) developed resources	47%	58%
I do not use safety tests or posters	8%	8%

Teachers Reported Having the Following:

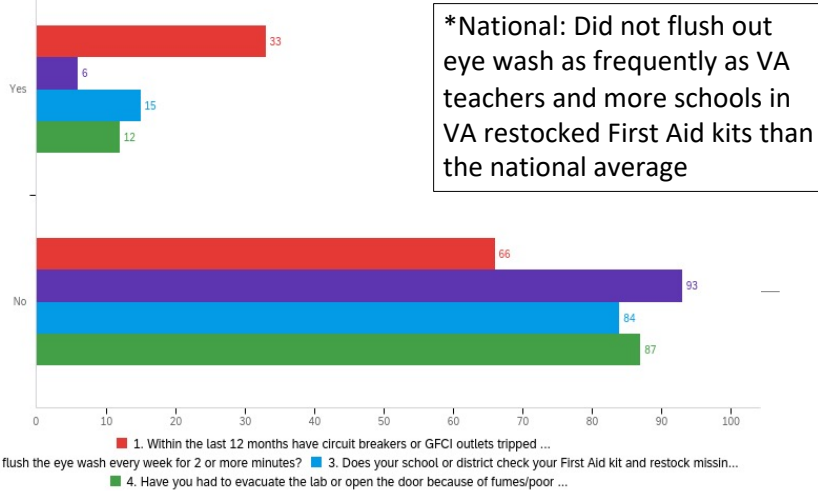
	<u>Virginia</u>	<u>National</u>
Safety Zones on Floor	73%	48%
Non-skid strips near machines	32%	27%
Eyewash w/in 10 second access		
Plumbed	32%	47%
Portable	32%	22%
Adequate Ventilation	44%	45%
Workspace accessible to wheelchair bound students	45%	47%
Accessible master power shut offs	56%	61%
Sufficient number of outlets	68%	61%

Teachers Reported Having the Following:

	<u>Virginia</u>	<u>National</u>
Lockable tool storage	84%	78%
Sufficient work space per student	72%	60%
Sufficient project storage	68%	61%
ANSI Z87.1 glasses for entire class	80%	83%
Cabinet to sanitize goggles	60%	50%
A sink in the facility	84%	76%
First Aid Kit	55%	61%
Lockable chemical storage cabinet	65%	67%
Fire extinguisher	81%	86%
Dust collector for woodworking	62%	64%

Have any of the following occurred/do they occur?

Virginia



Recommendations

Flush out emergency eye wash & shower once a week for 1-3 minutes

Check first aid kit each semester to **restock**, work with school nurse

Use a U-V goggle **sanitizer** with a UV-C Germicidal bulb to sanitize eye protection devices after each individual's use.

Have at least one or more **sinks** with running cold and hot water sources dependent on class enrollment

Have a **lockable/secure** finishing or chemical storage room and chemical storage cabinet to prevent student access.

Have a **lockable/secure tool cabinet** to prevent student access when not in use instructionally.

Recommendations

Have appropriate taped or painted safety **work zones** near all machines.

Have **non-skid strips** near machines to prevent slip/fall hazards.

Have appropriate **ventilation** to accommodate particulate and aerosol hazards.

Have a **wood dust collection system** with the intake vent placement **at the machine source** of wood dust production to prevent exposure to air-borne wood dust.

Have **workspace accessible to wheelchair** bound students per ADA requirements.

Have all electrical receptacles **GFCI** protected and ensure that they **work properly**.

Have easily accessible **emergency power shut-off** switches.

Have a **sufficient number of electrical receptacles** to eliminate use of extension cords.

Have a **lockable/secure tool cabinet** to prevent student access when not in use instructionally.

Accidents

During your time of employment, has your school district been involved in litigation or a settlement because of a T&E laboratory accident?

Virginia

Answer	%	Count
Yes	4%	10
No	53%	55
Unsure	43%	10

National

Yes	7%	51
No	62%	444
Unsure	31%	223

Within the last 12 months, how many T&E safety incidents (no injury) have occurred in your classes?

Virginia

Answer	%	Count
0	36%	36
1-10	60%	60
11-20	3%	3
21-30	0%	0
More than 30	0%	0

National

0	38%	274
1-10	60%	427
11-20	2%	15
21-30	0%	0
More than 30	0.3%	2

If a T&E safety incident has occurred, did it involve any of the following?

Virginia

Question	Involved	
1. Hot glue gun	40%	14
2. Broken glass	9%	4
3. Spills/splashes (of any kind)	9%	12
4. Student Operated Equipment/Machinery (ex. scroll saw, band saw, etc)	18%	30
5. Automated equipment (ex. CNC, laser cutter, 3D printer, robotics, etc.)	6%	1

Question	Involved	
6. Hand or portable power tools (ex. cordless drill, Dremel, etc.)	20%	20
7. Fumes	9%	7
8. Fires	3%	2
9. Projectiles	16%	10
10. Electrical Short	5%	3
11. Outdoor activities	1%	0

National = Hot glue guns 38%, Equipment 23%, Hand/portable power tools 21%, Projectiles 14%

How many T&E lab accidents occurred within the past year in your classes?

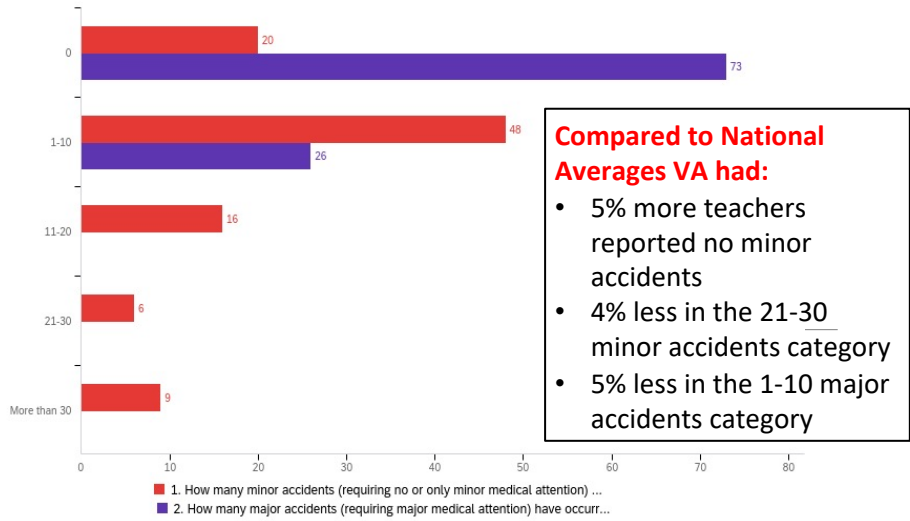
Virginia

Question	0		1-5		6-10		11-15	
1. How many minor accidents in the past 12 months?	25%	7	57%	50	11%	11	4%	4
2. How many major accidents (requiring major medical attention) occurred in your classes within the past 12 months?	89%	40	11%	4	0%	0	0%	0

National = 20% had no minor accidents and 62% had 1-5 minor accidents; 88% had no major accidents and 12% had 1-5 major accidents

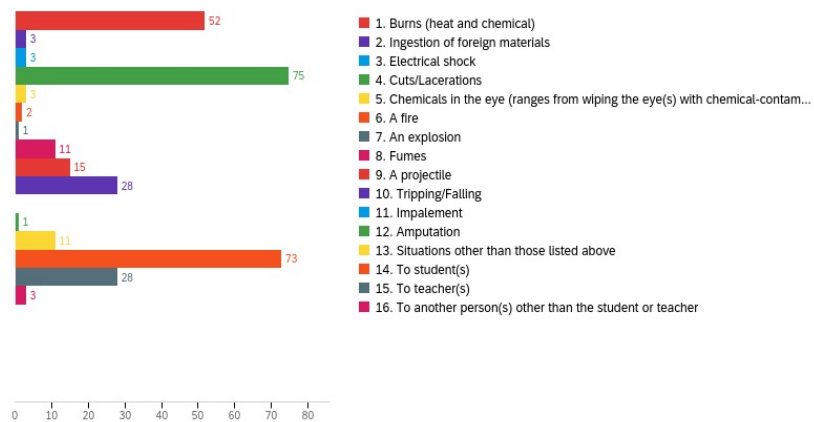
How many T&E lab accidents occurred within the past 5 years in your classes?

Virginia



If an accident (minor or major) has occurred in your classes within the past 5 years, did it involve any of the following:

Virginia



Virginia

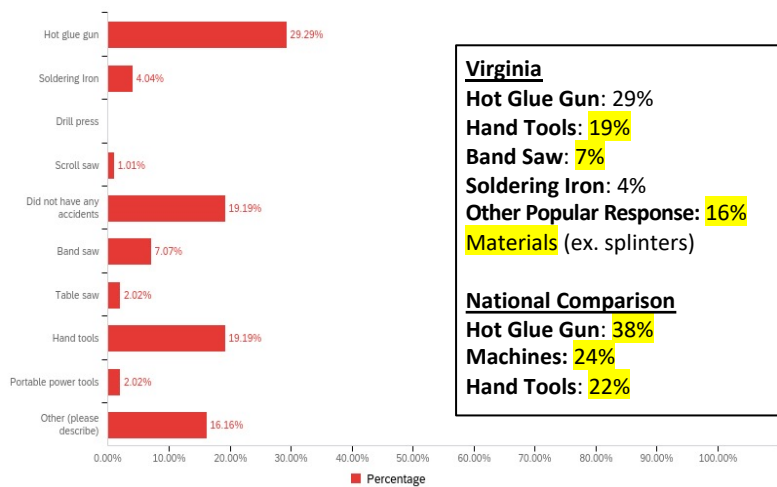
Most commonly injured body part?

Answer	%	Count
Did not have any accidents	18%	18
Fingers/hands	80%	79
Eyes/face	1%	1
Arms	0%	0
Legs	0%	0
Other body part	1%	1

National

Did not have any accidents	13%	93
Fingers/hands	86%	615
Eyes/face	0.4%	3
Arms	0.1%	1
Legs	0%	0
Other body part	0.8%	6

Of all accidents that have occurred during the past 5 years in your classes, what was the most common tool/equipment that caused injury?



Virginia
 Hot Glue Gun: 29%
 Hand Tools: 19%
 Band Saw: 7%
 Soldering Iron: 4%
 Other Popular Response: 16%
 Materials (ex. splinters)

National Comparison
 Hot Glue Gun: 38%
 Machines: 24%
 Hand Tools: 22%

Table Saws

	<u>Virginia</u>	<u>National</u>
Have a table saw	72%	65%
SawStop brand	39%	56%
Instructor only use	45%	34%
Student use with strict guidance	37%	31%
Student use with Teacher in Lab	18%	35%

Top 3 Factors for Unsafe Conditions/Accidents in a T&E lab?

Virginia

1. Student Failure to follow safety protocols
2. Overcrowding
3. Classroom management/discipline
4. Percentage of Students with Disabilities in class
5. Inadequate facilities

National

1. Student Failure to follow safety protocols
2. Overcrowding
3. Classroom management/discipline
4. Percentage of Students with Disabilities in class
5. Inadequate facilities

Correlations and Predictors of Accidents

*Derived from the national results of this study. More details about the analyses and results can be accessed at: https://www.researchgate.net/publication/356186501_Examining_Factors_Associated_with_Accidents_in_CTE_and_STEM_Education_Labs_A_National_Safety_Study

Statistically Significant Factors Contributing to Accident Rates

Polychoric correlation tests ($p = 0.05$)

Contributing Factors
Type of course taught (more hazardous, greater risk) Ex. 24% more likely to have minor accident, 30% more likely to have major accident
Greater than 25% of class doing hands-on T&E activities
Hybrid classroom/lab higher than other facility designs
Independent student use on table saw

Statistically Significant Factors Reducing Accident Rates

Polychoric correlation tests ($p = 0.05$)

Protective Factors
Safety glasses for every student in class Ex. 16% less likely minor accident, 25% less likely major accident
Dust collection connected directly to equipment
Fire extinguisher within 25 feet
Circuit breakers that had tripped
Have GFCI outlets
Lockable flammables cabinet
Lockable tool storage cabinet
Master shut off switch

Statistically Significant Factors Reducing Accident Rates cont.

Polychoric correlation tests ($p = 0.05$)

Protective Factors cont.
Safety zones on the floor around equipment
Non-skid strips on the floor around equipment
Type of Table Saw: SawStop
Finishing/chemical storage room separate from lab/classroom and secure (locked)
Appropriate gloves for all students when needed
Appropriate aprons for all students when needed
Sinks in lab/classroom

Statistically Significant Predictors of Accidents

Logistic regression tests ($p = 0.05$)

Contributing Factors cont.	Statistically Significant?
Undergraduate T&E methods course	N
Comprehensive training (undergrad or graduate safety coursework + training from district upon initial hiring + training updates from district within past 5 years)	Y*
*37% lower odds of ≥ 1 accidents occurring	
Comprehensive training + years of teaching experience	N

Questions?

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Additional Results:

<https://www.iteea.org/SafetyReport.aspx>

