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Examining the Influence that Safety Training Format Has on Educators' Perceptions of Safer Practices in Makerspaces and Integrated STEM Labs

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Abstract

Introduction

The rising popularity of makerspaces and integrated science, technology, engineering, and mathematics (STEM) education labs has increased the safety/health hazards and resulting potential risks which schools, libraries, community centers, and educators must be prepared to address. Previous studies have demonstrated that adequate safety training can enhance educators' safety perceptions and reduce accident rates.

Method

Safety trainings were conducted in three different U.S. states for 48 educators working in K-12 STEM areas. Differences in the mode of delivery, length of the training, and types of hands-on activities instituted at each training site were examined in relation to the level of influence these factors had on educators' safety perceptions. A modified version of the Science Teaching Efficacy Belief Instrument (STEBI) was utilized, which had been previously adapted for similar safety studies and showed strong reliability measures.

Results

The pre- and post-survey responses revealed that educators at the fully online and shortest training session did not experience significant changes in their safety perceptions. However, participants at the two face-to-face sites demonstrated significant gains in their safety perceptions. Most notably, the site that offered the longest training and integrated the most hands-on lab activities recorded the greatest gains. Additionally, correlational analyses corroborated that as the amount of hands-on activities and length of the trainings increased, there was a positive significant association with changes in educators' safety perceptions.

Conclusions

This research helps bridge the gap between industry and K-12 STEM education research regarding better safety training practices. The findings from this study can help promote safer teaching and learning environments while also reducing liability and the chance of a serious accident.

Practical Applications

State departments, higher education institutions, teacher education programs, school districts, and others providing STEM safety training to K-12 educators should utilize this research to reexamine their safety training policies and practices.

Keywords: Engineering Education, Science Education, Libraries, Integrated STEM Education, STEAM, Lab Safety, Liability, Self-Efficacy

References

Alyammahi, A. R. (2015). *The current status of safety in high school chemical laboratories in Kentucky* (Publication No. 331). [Master's thesis, Eastern Kentucky University]. Encompass. https://encompass.eku.edu/etd/331

Bandura, A. (1997). *Self-efficacy: The exercise of control.* W.H. Freeman and Company.

Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual Review of Psychology, 52*(1), 1-26.

Bowen, B. (2013). Measuring teacher effectiveness when comparing alternatively and traditionally licensed high school technology education teachers in North Carolina. *Journal of Technology Education, 25*(1), 82-100.

Burke, M. J., Salvador, R. O., Smith-Crowe, K., Chan-Serafin, S., Smith, A., & Sonesh, S. (2011). The dread factor: How hazards and safety training influence learning and performance. *Journal of Applied Psychology, 96*(1), 46-70.

Burke, M. J., Sarpy, S. A., Smith-Crowe, K., Chan-Serafin, S., Salvador, R. O., & Islam, G. (2006). Relative effectiveness of worker safety and health training methods. *American Journal of Public Health, 96*(2), 315-324.

Cannon, J. G., Kitchel, A., Duncan, D. W., & Arnett, S. E. (2011). Professional development needs of Idaho technology teachers: Teaching and learning. *Journal of Career and Technical Education, 26*(1), 32-47.

Çikrıkci, Ö. (2017). The effect of self-efficacy on student achievement. In E. Karadag (Eds.), *The factors effecting student achievement: Meta-analysis of empirical studies* (pp. 95-116). Springer. https://doi.org/10.1007/978-3-319-56083-0_6

Cohen, A., & Colligan, M. J. (1998). *Assessing occupational safety and health training* (NIOSH Publication No. 98-145). National Institute for Occupational Safety and Health.

Colligan, M. J., & Cohen, A. (2004). The role of training in promoting workplace safety and health. In J. Barling & M. R. Frone (Eds.), *The psychology of workplace safety* (pp. 223–248). American Psychological Association. https://doi.org/10.1037/10662-011

Dee, T. S., & Goldhaber, D. (2017). The Hamilton Project: Understanding and addressing teacher shortages in the United States. Brookings Institution.

DeLuca, V. W., Haynie, W. J., Love, T. S., & Roy, K. R. (2014). *Designing safer learning environments for integrative STEM education*. International Technology and Engineering Educators Association.

Ernst, J. V., & Williams, T. O. (2015). The "Who, what, and how conversation": Characteristics and responsibilities of current in-service technology and engineering educators. *The Journal of Technology Studies, 41*(1), 48-56.

Ferguson, K., & Reed, P. A. (2019). How can career switchers and teachers without formal training be quickly prepared to teach engineering and technology education? *Paper presented at the 106th Mississippi Valley Technology Teacher Education Conference*. Nashville, TN. http://www.mississippivalley.org/wp-content/uploads/2019/11/Training-Career-Switchers-Ferguson-and-Reed.pdf

Fuller, E. J., Picucci, A. C., Collins, J. W., & Swann, P. (2001). *An analysis of laboratory safety in Texas*. Charles A. Dana Center of the University of Texas at Austin.

Gerlovich, J., McElroy, D., Parsa, R., & Kidwell, K. (2008). The status of science safety in Kentucky secondary schools. *Journal of the Kentucky Academy of Science, 69*(1), 19-28. https://doi.org/10.3101/1098-7096(2008)69[19:TSOSSI]2.0.CO;2

Gerlovich, J. A., & Parsa, R. (2002). Surveying science safety. *The Science Teacher*, *69*(7), 52-55.

Gerlovich, J. A., Whitsett, J., Lee, S., & Parsa, R. (2001). Surveying safety: How researchers addressed safety in science classrooms in Wisconsin. *The Science Teacher*, *68*(4), 31-35.

Gerlovich, J. A., Wilson, E., & Parsa, R. (1998). Safety issues and Iowa science teachers. *Journal of the Iowa Academy of Sciences, 105*(4), 152-157.

Gill, M., Koperski, K, Love, T. S., & Roy, K. R. (2019). Developing a culture of safety through departmental planning. *Technology and Engineering Teacher*, *79*(1), 22-25.

Grossman, R., & Salas, E. (2011). The transfer of training: What really matters: The transfer of training. *International Journal of Training and Development, 15*(2), 103-120. https://doi.org/10.1111/j.1468-2419.2011.00373.x

Grubbs, M. E., Love, T. S., Long, D. L., & Kittrel, D. (2016). Science educators teaching engineering design: An examination across science professional development sites. *Journal of Education and Training Studies, 4*(11), 163-178.

Holzberger, D., Philipp, A., & Kunter, M. (2013). How teachers' self-efficacy is related to instructional quality: A longitudinal analysis. *Journal of Educational Psychology*, *105*(3), 774-786.

Hynes, M. M., & Hynes, W. J. (2018). If you build it, will they come? Student preferences for makerspace environments in higher education. *International Journal of Technology and Design Education*, *28*(3), 867-883.

Katz-Navon, T., Naveh, E., & Stern, Z. (2007). Safety self-efficacy and safety performance: Potential antecedents and the moderation effect of standardization. *International Journal of Health Care Quality Assurance, 20*(7), 572-584.

Kirkpatrick, J. D., & Kirkpatrick, W. K. (2016). *Kirkpatrick's four levels of training evaluation*. ATD Press.

Love, T. S. (2013). Addressing safety and liability in STEM education: A review of important legal issues and case law. *The Journal of Technology Studies*, *39*(2), 28-41.

Love, T. S. (2014). Safety and liability in STEM education laboratories: Using case law to inform policy and practice [Electronic supplement]. *Technology and Engineering Teacher*, *73*(5), 1-13. http://www.iteea.org/File.aspx?id=86487&v=52ffd40f

Love, T. S. (2015). Examining the demographics and preparation experiences of foundations of technology teachers. *The Journal of Technology Studies*, *41*(1), 58-71.

Love, T. S. (2017a). Perceptions of teaching safer engineering practices: Comparing the influence of professional development delivered by technology and engineering, and science educators. *Science Educator*, *26*(1), 1-11.

Love, T. S. (2017b, July). Tools and materials in primary education: Examining differences among male and female teachers' safety self-efficacy. In L. Litowitz & S. Warner (Eds.), *Technology and engineering education – Fostering the creativity of youth around the globe.* Proceedings of the 34th Pupil's Attitude Toward Technology Conference, Philadelphia, PA: Millersville University. https://www.iteea.org/File.aspx?id=115739&v=21dfd7a

Love, T. S. (2018a). *Perceptions of safety in makerspaces: Examining the influence of professional development.* Paper presented at the 105th Mississippi Valley Technology Teacher Education Conference, Nashville, TN. Retrieved from http://www.mississippivalley.org/wp-content/uploads/2018/11/Perceptions-of-Safety-in-Makerspaces-Love.pdf

Love, T. S. (2018b). The T&E in STEM: A collaborative effort. *The Science Teacher, 86*(3), 8-10.

Love, T. S. (2019). STEM education safety: Temporary concern or enduring practice? Examining the progress of safety in STEM education. *Technology and Engineering Teacher, 78*(6), 15-17.

Love, T. S., & Roy, K. R. (2017). Tools and equipment in non-traditional spaces: Safety and liability issues. *Technology and Engineering Teacher, 76*(8), 26-27.

Love, T. S., & Roy, K. R. (2018). Who should make your maker spaces? *ASEE Prism, 28*(2), 54.

Love, T. S., & Roy, K. R. (2020). *K-12 technology and engineering education safety and facilities survey*. [Data set]. National Safety Consultants, LLC. https://sites.google.com/view/2020-te-safety-study/

Love, T. S., & Roy, K. R. (2021). Key findings from Wisconsin's responses to the 2020 national T&E education safety survey. *Interface: Journal of the Wisconsin Technology Education Association, 61*(1), 22-23.

Love, T. S., & Roy, K. R. (2022). *Safer P-12 engineering and CTE instruction: A national STEM education imperative.*

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

Love, T. S., Roy, K. R., & Marino, M. T. (2020b). Inclusive makerspaces, fab labs, and STEM labs. *Technology and Engineering Teacher, 79*(5), 23-27.

Love, T. S., Roy, K. R., & Sirinides, P. (2021). What factors have the greatest impact on safety in Pennsylvania's T&E courses? *Technology and Engineering Education Association of Pennsylvania Journal, 69*(1), 5-22.

Love, T. S., Sirinides, P., & Roy, K. R. (2022). *Examining factors associated with accidents in CTE and STEM education labs: A national safety study.* Paper presented at the annual meeting of the American Educational Research Association, San Diego, CA.

Luft, J. A., Firestone, J. B., Wong, S. S., Ortega, I., Adams, K., & Bang, E. (2011). Beginning secondary science teacher induction: A two-year mixed methods study. *Journal of Research in Science Teaching, 48*(10), 1199-1224.

National Academies of Sciences, Engineering, and Medicine. (2019). *Science and engineering for grades 6-12: Investigation and design at the center.* The National Academies Press. https://doi.org/10.17226/25216.

National Research Council (NRC). 2006. *America's lab report: Investigations in high school science*. The National Academies Press. https://doi.org/10.17226/11311.

National Science Teaching Association (NSTA). (2020). Safety and the next generation science standards. [White Paper]. NSTA Safety Advisory Board. https://static.nsta.org/pdfs/Safety%20and%20the%20Next%20Generation%20Science%20Standards_29Oct2020_FINAL.pdf

NGSS Lead States. (2013). *Next generation science standards: For states, by states.* The National Academies Press.

Nykänen, M., Puro, V., Tiikkaja, M., Kannisto, H., Lantto, E., Simpura, F., Uusitalo, J., Lukander, K., Räsänen, T., Heikkilä, T., & Teperi, A. (2020). Implementing and

evaluating novel safety training methods for construction sector workers: Results of a randomized controlled trial. *Journal of Safety Research, 75*, 205-221.

Nykänen, M., Salmela-Aro, K., Tolvanen, A., & Vuori, J. (2019). Safety self-efficacy and internal locus of control as mediators of safety motivation – randomized controlled trial (RCT) study. *Safety Science, 117*, 330-338.

Nykänen, M., Sund, R., & Vuori, J. (2018). Enhancing safety competencies of young adults: A randomized field trial (RCT). *Journal of Safety Research, 67*, 45-56.

Occupational Safety and Health Administration (OSHA). (2020). *Occupational safety and health standards: General industry regulations and standards* (Standard No. 1910.29 CFR). https://www.osha.gov/laws-regs/regulations/standardnumber/1910

Occupational Safety and Health Administration (OSHA). (2021). *Resource for development and delivery of training to workers* (OSHA 3824-05R 2021). https://www.osha.gov/sites/default/files/publications/osha3824.pdf

Pallant, J. (2020). *SPSS survival manual: A step by step guide to data analysis using IBM SPSS* (Seventh ed.). McGraw-Hill Education.

Reed, P. A., & Ferguson, M. K. (2021). Safety training for career and content switchers. *Technology and Engineering Teacher, 80*(7), 16-19.

Rose, M. A., Shumway, S., Carter, V., & Brown, J. (2015). Identifying characteristics of technology and engineering teachers striving for excellence using a modified Delphi. *Journal of Technology Education, 26*(2), 2-21.

Roy, K. R., & Love, T. S. (2017). *Safer makerspaces, fab labs and STEM labs: A collaborative guide!* National Safety Consultants, LLC.

Saks, A. M., & Belcourt, M. (2006). An investigation of training activities and transfer of training in organizations. *Human Resource Management, 45*(4), 629-648. https://doi.org/10.1002/hrm.20135

Saks, A. M., & Burke, L. A. (2012). An investigation into the relationship between training evaluation and the transfer of training: Training evaluation. *International Journal of Training and Development, 16*(2), 118-127. https://doi.org/10.1111/j.1468-2419.2011.00397.x

Sheskin, D. J. (2011). Handbook of parametric and nonparametric statistical procedures (5th ed.). Chapman and Hall.

Shidler, L. (2009). The impact of time spent coaching for teacher efficacy on student achievement. *Early Childhood Education Journal, 36*(5), 453-460.

Stephenson, A. L., West, S. S., Westerlund, J. F., & Nelson, N. C. (2003). An analysis of incident/accident reports from the Texas secondary school science safety survey, 2001. *School Science and Mathematics, 103*(6), 293-303. https://doi.org/10.1111/j.1949-8594.2003.tb18152.x

Stroud, L. M., Stallings, C., & Korbusieski, T. J. (2007). Implementation of a science laboratory safety program in North Carolina schools. *Journal of Chemical Health & Safety, 14*(3), 20-30. https://doi.org/10.1016/j.jchas.2006.11.001

Threeton, M. D., & Evanoski, D. C. (2014). Occupational safety and health practices: An alarming call to action. *Career and Technical Education Research, 39*(2), 119-136.

Threeton, M. D., Kwon, K., Fleck, J. A., Ketchem, R. B., & Farzam, L. (2021). An investigation of instructional practices which promote occupational safety and health. *International Journal of Occupational Safety and Ergonomics, 27*(3), 902-910.

Tonhäuser, C., & Büker, L. (2016). Determinants of transfer of training: A comprehensive literature review. *International Journal for Research in Vocational Education and Training, 3*(2), 127-165. https://doi.org/10.13152/IJRVET.3.2.4

Volk, K. S. (2019). The demise of traditional technology and engineering education teacher preparation programs and a new direction for the profession. *Journal of Technology Education, 31*(1), 2-18.

West, S. S. (2016). Overcrowding in K-12 STEM classrooms and labs. *Technology and Engineering Teacher*, *76*(4), 38-39.

West, S. S., Westerlund, J. F., Stephenson, A. L., Nelson, N. C., & Nyland, C. K. (2003). Safety in science classrooms: What research and best practice say. *The Educational Forum, 67*(2), 174-183. https://doi.org/10.1080/00131720308984555