safety spotlight

converting classrooms to makerspaces or STEM labs:

design and safety considerations

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Makerspaces and areas to conduct collaborative STEM activities are becoming increasingly popular in schools, libraries, media centers, and community centers. There are numerous examples of rooms that were originally designed as traditional classrooms being converted into makerspaces or collaborative STEM work areas. This also involved the use of not only hazardous materials but also hand and power tools. Similar to a portable classroom being utilized to facilitate STEM classes during a renovation, the following are some important safety and design features that should be considered prior to converting a classroom to a makerspace or STEM lab.

Tools, Equipment, and Furniture

One of the first things to consider is what types of tools, equipment, and furniture will be used in the newly designed instructional space. This should be driven by the curricular objectives and goals of the program or organization. Items such as soldering irons pose both heat and ventilation hazards, which are much different than the hazards inherent with tools such as coping saws. Placement and security of tools, equipment, and furniture should also be considered to help plan for proper engineering controls as discussed in the next section. There should not be activities using chemicals or paints near a soldering station because of the potential fire hazard. Selecting the appropri-

Figure 1 (above). An example of a computer lab at the University of Maryland Eastern Shore that was converted into a small makerspace for independent study projects. *Note: Due to size constraints, the machine work zone is labeled for only one student to occupy when a piece of equipment is in use. Photo Credit: University of Maryland Eastern Shore, Department of Technology.*

ate furniture for the activities to be performed (e.g., large work benches with vises versus study lab tables) is important and will help in calculating how much usable square footage there is for determining occupancy load (how many individuals can be in that room at the same time).

Engineering Controls

After identifying the placement and types of tools, equipment, and furniture that will be used in the space, appropriate engineering controls need to be planned. Most traditional classrooms will not have the necessary engineering controls installed because they were not part of the original building plan. However, in most cases the proper controls can be added by working with your building facilities supervisor. Engineering controls do not eliminate hazards, but rather they help isolate people from hazards (Roy & Love, 2017). They are relatively effective over time provided proper maintenance is performed. Various types of engineering controls should be considered pending the types of activities to be performed in the area. Ventilation is a major concern to ensure that appropriate and separate systems are installed where necessary (e.g., air filtration for 3D printer particles [University of Florida Environmental Health and Safety, 2016], dust collection for sawdust, soldering fume extractors, laser engraver filter system, or direct exhaust to the outside). At least one emergency power switch should be included at the entrance/exit, and two or more depending on ease of access are needed in separate parts of the room if it is over 1,000 square feet. Eye wash and shower stations should be installed if hazardous chemicals or other materials will be used that could get into occupants' eyes (it is recommended to also include a drain and a sink for general cleanup purposes if possible). Again, there must be a 10-second access time to these engineering controls, or additional units will be needed. Additionally, the appropriate fire extinguisher should be included in the event that a piece of equipment or material catches fire. Wherever flammables are present, ABC type extinguishers are required on-site. All engineering controls should have clear access at all times in the event of an emergency. Further guidelines for engineering controls are described by West and Motz (2017).

Materials Storage

Adequate storage is often lacking when classrooms are converted to makerspaces or STEM labs due to the size and hazardous nature of materials stored. Separate storage areas may be needed pending the materials being stored (e.g., chemicals for chemistry classes need to be stored in a separate room with continuous non-recirculating ventilation (NFPA 45 – 2015 Standard on Fire Protection for Laboratories Using Chemicals, 2015 Edition, Section 7.2.2). Storage of hazardous chemicals like paints, solvents, epoxies, and acids, should be in flammable liquid and acid storage cabinets that can be locked. Solid materials

Figure 2. Laser and CNC station. *Photo Credit: University of Maryland Eastern Shore, Department of Technology.*

such as wood, plastic parts, and student projects can be stored on secured shelves in the makerspace or lab as long as they are at least 18 inches below any fire sprinklers. Additional sprinkler heads may need to be placed at shelf levels. Consult with the local fire marshal. Large materials that pose a risk of falling or are heavy should either be secured or not placed in open areas where they could fall on occupants. In addition to the proper storage of materials, hazardous tools and expensive equipment need to be securely stored.

Security and Supervision

Securing hi-tech equipment and hazardous tools or materials is paramount for a few reasons. First, it deters theft that can be costly, but it also limits the chance of the instructor and facility being held liable for injuries students sustain from stolen items. Hazardous chemicals should be locked up in appropriate fireproof storage cabinets unless being used by a trained instructor. Any sharp or dangerous tools (e.g., screwdrivers, saws, box cutters, scissors, soldering irons) should be secured in lockable cabinets or on a cart that can rolled into a lockable closet. These types of materials can remain in open containers if the facility is always under close supervision by a trained employee and the entrance is locked when not in use. Instructors can remove the lock-out power switch inserts to allow larger equipment to sit out while ensuring it is not used until ready.

Regarding supervision, minors and untrained adults should never be allowed to work in a makerspace or lab unsupervised. At a minimum, all participants should be required to submit a safety acknowledgement form, receive safety demonstrations/training from a properly trained employee, and complete the required safety tests before using any tools or equipment (Love & Roy, 2017). Appropriate personal protective equipment (e.g., safety glasses or goggles, gloves) should be provided, and proper use should be modeled and enforced at all times by the instructor. Love and Roy (2017) provide additional information regarding appropriate training, supervision, and security for makerspaces and labs in nontraditional spaces.

Figure 3. Soldering station. *Photo Credit: University of Maryland Eastern Shore, Department of Technology.*

Occupancy Load

One of the most common questions related to this topic is in regard to occupancy load. When the classroom was originally built, the fire marshal provided a certificate of occupancy for that space. A certificate of occupancy is issued by a local government agency or building department certifying a building's compliance with applicable building codes and other laws. It basically indicates that the building is in a condition suitable for occupancy. Included in this should be the determination of specific occupancy loads for instructional and assembly areas based on the National Fire Protection Association (NFPA) 101 Life Safety Standard. In other words, it signifies how many occupants could safely be in that area based on various factors such as the types of activities to be performed and the type/location of furniture or equipment present. Once a classroom has been converted to facilitate hazardous makerspace or lab activities, it requires increased square footage per occupant as mandated by the NFPA. NFPA 101 requires classrooms to have 20 net square feet per occupant, and areas where lab activities are being performed (e.g., makerspace) to have 50 net square feet per occupant. Introducing new furniture or hazardous tools and materials in a room may require more square footage per occupant to ensure safer working conditions. Additionally, appropriate safety work zone perimeters need to be established to provide safer tool/machine operator clearances.

If there is a discrepancy regarding the number of occupants you believe should be allowed in the converted makerspace or STEM lab, request that your school system call the fire marshal to recalculate the occupancy load level. The fire marshal's calculations for occupancy load will be based on the net square footage (determined by gross square footage of the room minus areas taken up by counters, desks, tables, chairs, equipment, and other items occupying floor space). More detailed information about occupancy load is provided by West (2016).

Conclusion

While there are many educational benefits to having a makerspace or collaborative STEM activity area readily accessible for students, these spaces require diligent planning and close attention to safety issues. It is recommended that when converting a classroom into a makerspace or collaborative STEM activity area, you first meet with your school system's safety compliance office, administrators, and any teachers in the school who use STEM laboratories. This should help articulate the school's vision for the space while also identifying the types of hazards that need to be addressed through engineering controls, personal protective equipment, security equipment, the fire marshal, instructor training, and school safety policies/procedures (Love & Roy, 2017). Although it will take longer to form such a committee and could initially be more costly to address all safety concerns, it should mitigate the risk of an accident occurring and place both the school system and instructor in a much better position if an accident does occur. Bottom line, it would help to provide for a safer teaching/learning instructional space!

References

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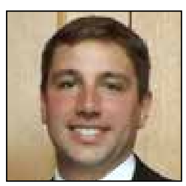

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