122nd ASEE Annual Conference & Exposition
June 14 - 17, 2015
Seattle, WA
Making Value for Society
Paper ID #14367

Safety training system design for student teams

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Safety training system design for student teams

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Abstract

Many approaches exist for the creation of safety training programs. Systems have been created for both large and small businesses that vary in complexity. Few of these approaches however are simple enough to be used on student design teams, which are made up of young adults who are also full time students. These student teams are student driven and apply classroom knowledge to real world work under limited faculty supervision, specifically when hands-on work is being executed. As student focused organizations, these teams often rely on their university's or college's guidelines to develop a set of standard operating procedures. Though these set a base for the team, the guidelines are no substitute for training that is specific to the safety risks associated with the work the team is doing. It is also difficult to convince student team leaders to invest time into training team members who may not participate on an ongoing basis.

By developing a hierarchical level based safety training system with the principals of gamification, the needs of all participating stakeholders, regulations, and guidelines are met. Students are required to show certain levels of commitment before advancing in their training and involvement in team activities. They are thus also limited to certain lower risk tasks at each level. This leveled system, with a combination of other factors, motivates students to become more involved with the team and shows them the reward of completing additional training. This process allows the student's team leads conducting the training to make sure there is commitment from the participating students before dedicating valuable time to safety training. In the case presented the team has had over 100 students participate in the program and team leaders have seen drive to continue their training in order to grow in responsibility ad activity within the team.

Introduction

Safety training is an important aspect of any organization and is a legislative requirement in most jurisdictions. Safety training itself is described as a way of helping workers become more skilled and prepared in seven key areas of hazard control and reduction; hazard seeking, hazard recognition, assessment of importance, allocation of responsibility, knowledge of action, decision to act, and action sequence, Figure 1 [1]. This multistage process can be too cumbersome for student teams which participate as full time students often with limited training in industrial organization structures.

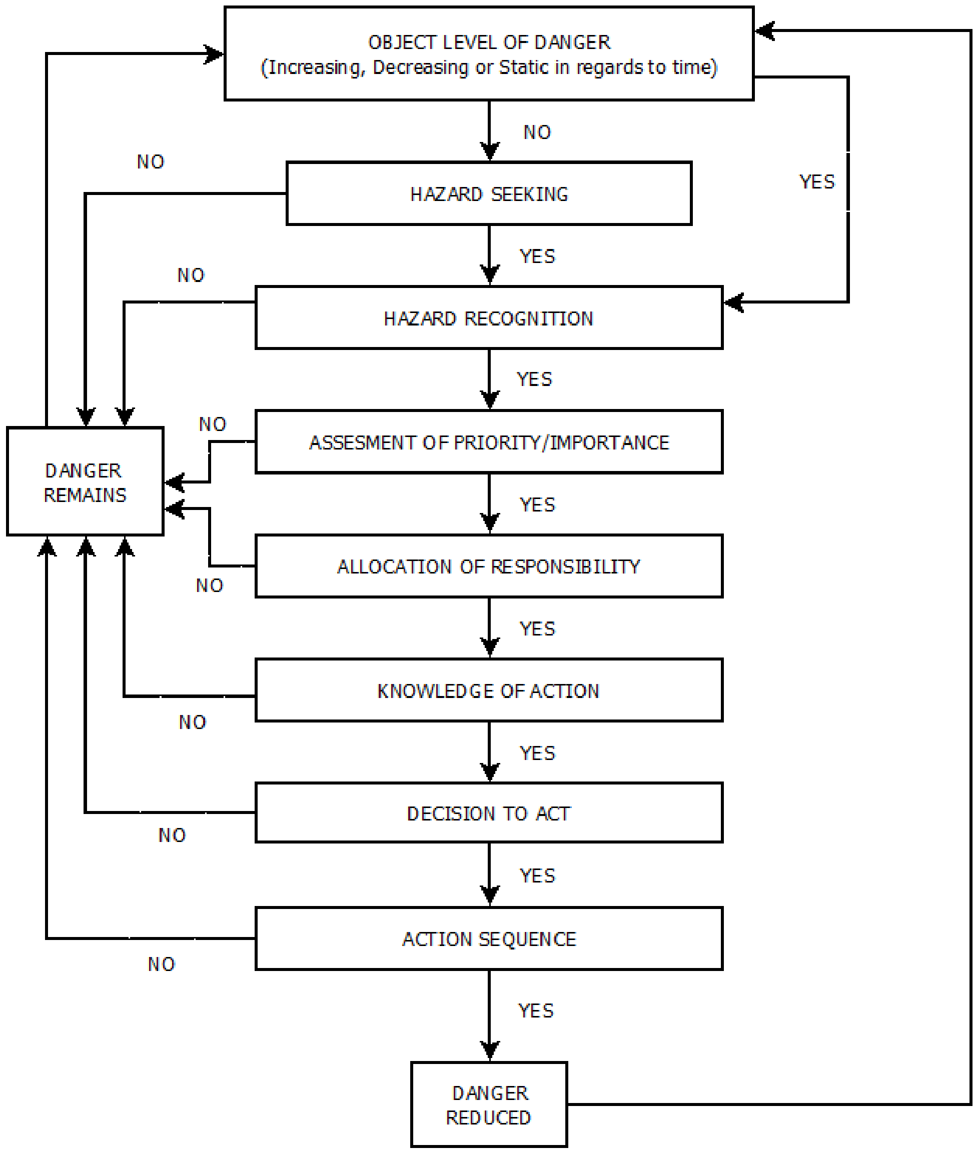

Figure 1: Classification of the stages of perception and response to danger [1]

Though this classification can be used to determine how employees view safe working procedures and has been heavily reviewed. The traditional approach has been to train employees retroactively based off of events that direct proceed an accident [2]. However, in order to be proactive in safety training, a more systematic approach is required [3]. Though a systematic safety management system can be used its complexity can be beyond the scope of what is achievable on a small scale of a university student design team composed of young adults (17-26 years old). This is especially appropriate since such teams do not have dedicated safety training staff.

Small business approaches attempt to simplify the approach by creating systems that focus on three principal areas: safe persons, safe systems, and safe places [4]. This approach, though simplified, can still be a challenge for student teams as there is no monetary motivation which can be important for young workers [5]. Nevertheless, it is in the interest of the institution and any competitions that the students may be associated with to ensure all activities are undertaken in a safe and environmentally responsible manner. Studies have shown that socioecological approaches are effective for young workers as both teaching paradigms and learning paradigms are disconnected from actual work context [5]. All of the approaches summarized in Table 1 have important aspects but none form a complete structure which can be utilized by student teams.

Table 1: Summary of safety training program styles

Safety Training Program Type	Approach	Shortfall
Traditional	Retroactive training	Does not address proactive measures for high risk activities till injury occurs
Large Systematic	Fully examine all "environmental" factors directly and indirectly relating to work	Complex system beyond the capabilities of student teams
Small Business Simplified	Examine ways to make safer persons, safer systems and safer places.	Simplified structure but no motivational factors needed for young workers
Socioecological	Experiential based training putting an emphasis on the learner role	Complex system with no simplified framework that can be used

In Ontario safety training is covered by the Occupational Health and Safety Act (OHSA) (Ontario Regulation 297/13) [6]. This regulation outlines the required training for full time, part time, seasonal and any other worker regardless of their employment status. A worker under OHSA is described as someone who supplies a service for monetary compensation [7]. Universities however have policies in which it states that students are also workers and therefore regulated by OHSA [8] [9]. The awareness programs for students must therefore include the same information as a worker receiving compensation. In Ontario specifically, according to Ontario Regulation 297/13, workers of any type require at the very least a basic safety training that covers the following:

1. The duties and rights of workers under the Act.
2. The duties and rights of employers and supervisors under the Act.
3. The roles of health and safety representatives and joint health and safety committees under the Act.
4. The roles of the Ministry, the Workplace Safety and Insurance Board, etc. with respect to occupational health and safety.
5. Common workplace hazards.
6. WHMIS safety training with respect to information and instruction on controlled products.
7. Occupational illness, including latency. [12]

At the local level most universities have a policy on health and safety. The University of Waterloo has both a Health, Safety, and Environment policy (Policy 34) but also a Health, Safety, and Environment Management System (HSEMS) [9] [8]. It is under the HSEMS where students are described as “persons on the university premises, whether for monetary compensation or educational or other purpose” [9]. This includes a variety of persons, including students, for which the university offers awareness training to comply with OHSA.

As previously described, students must know what the duties and rights are under OSHA as well as the duties of supervisors. Note in the case of student teams, the student team leaders often provide the onsite supervision of the physical activities and as such assume some of the responsibilities of the supervisor. Their knowledge must also include the role of governing bodies such as the Ministry of Labour, common hazards, Workplace Hazardous Martials Information System (WHMIS), and occupational illness [7].

This awareness training is the minimum safety training required by law for any worker, which as discussed includes students. However, this does not entail specific training for specific hazards one might encounter as a member of these teams. Thus, as mentioned earlier, most student teams adopt their respective institution's guidelines for their safety training. These guidelines however are not always sufficient enough to create a reliable system for training new recruits to the team.

Student teams allow engineering students to apply classroom theories on real world projects involving design and build phases, and as such significant safety risks are associated. As student driven organizations, these teams often rely principally on their university’s or college’s guidelines to develop a set of standard operating procedures. Though these set a base for the team, the guidelines are no substitute for training that is specific to the safety risks associated with work the team is doing. At times, there is limited faculty supervision for such teams in the actual work bays and laboratories, unlike a lab associated with a class which will have onsite staff, teach assistant or faculty oversight when the physical work is being executed. It is also difficult to convince student team leaders to invest time into training team members who may not participate on an ongoing basis. In this work a safety training system was implemented at a university for further refinement and preliminary feedback from the students, faculty, as well as any associated competition organizers. A case study associated with the Advanced Vehicle Technology Competition is outlined. As such this case demonstrated that there is a need for development of a system of safety training for all those involved in order to meet safety regulations and guidelines, as well as demonstrate to all interested stakeholders that safety risks are appropriately addressed. Most importantly such a system ensures safe conduct of all activities.

Young Adult Safety Training

Safety training is important no matter the age of the worker. However, the attitude towards safety training is generally not positive, especially in young adults. In a study from 2012, it was found that teenagers largely thought they did not require safety training as it was deemed “common sense” [10]. However within the same group of teenagers 52 % had some form of workplace related injury [10].

This observation is supported by the statistics which show that the highest injury rate in the United States was 18-24 year olds in 2007 [11]. Both the fatality and emergency department visit injury rate for this age group were higher from 1998-2007, with the emergency department visit injury rate being double that of those greater than 25 (5.0 per 100 full time equivalents) [12]. This trend shows that there is a strong need for safety training for students that attempts to combat the “common sense” mentality.

For this training system to work, students will need to be motivated to participate in it. To encourage this motivation in students, the University of Waterloo Alternative Fuels Team (UWAFT) has implemented a strategy for safety training which includes gamification. Gamification is defined as the process of “enriching products, services, and information systems with game-design elements in order to positively influence motivation, productivity, and behaviour of users” [13]. It has been successfully implemented in academic settings to increase student learning, as well as in many familiar companies for things such as customer engagement, customer loyalty, goal tracking, and motivation. A relatively well-known example of gamification in action is the way Nike+ motivates its users [13]. Participants in the Nike+ program earn a certain amount of Nikefuel for the amount they move. With the Nike+ Fuel application for the iPhone and a Fuelband, a physical wristband participants wear, users can track how much Nikefuel they have earned. Users work towards achieving their fitness goals, while earning badges when they hit milestones along the way. Not only do participants experience the satisfaction of earning badges at milestones when they put in enough work, but they also get a visual representation of the progress they have made. This program has helped over two million people burn upwards of 68 billion calories, making it a very successful program and a great example of gamification at work [13].

In the training system proposed here, students will be able to visualize their progress based on the level of training they have reached. These levels track students so that as they increase their training level they can increase their hands-on involvement with the design project. This way, if a student wants to get more involved in the project they need to complete another level of safety training first. With each level comes more responsibilities and status in the team, making it desirable for students to “level up”. Like earning a badge in Nike+, students who complete a higher level of training will feel a sense of satisfaction with the new tasks they are allowed to engage in and the increased trust they are given. This I turn motivates students to reach the next level to gain even more trust and responsibility.

For example, if a student wants to get more involved heavily to lead a project, they can complete the next level of training and have the experience and satisfaction of being able to work on the project themselves. Since, in this scenario, the students themselves want to be more involved, their motivation to complete the training can be categorized as integrated regulation. Their goal by completing the training is to become more involved in the team, a goal that is fully integrated with the student’s values [14]. This makes their motivation to complete the training more internalized than if the students were forced to complete all the training or suffer some kind of punishment or tangible reward, like external regulation. The goal is to make students as motivated as possible to complete their safety training, so that more students are able to participate and learn within the design and build team in a safe environment. Therefore, the more internalized the motivation, the more safety training the students will complete. Introducing levels into the training system will, in theory, help teams reach this goal.

Student Design Team Safety Training

Student teams at the University of Waterloo employ a variety of safety training programs and structures. Students are surveyed to determine what level of safety training existed on their team. Of the 18 teams that have an association with the Sendra Student Design Centre at the University of Waterloo, nine submitted responses.

On laboratory based teams, the level of safety training is already substantial. This observation however could be due to the structure already in place for laboratory training for graduate and undergraduate students. The training offered by these groups covers all awareness requirements from the Ministry of Labour and the University of Waterloo [7] [8]. Team members also complete supervisor training and have laboratory supervisors who work with new team members.

Teams outside of a laboratory structure had a wide range of programs. The majority of student teams complete basic modules completed by the university such as Workplace Hazardous Material Information System (WHMIS) training. However, additional training is largely provided on an as needs basis with limited formal structure. Additional training is not even offered on some teams which utilize a “learn as you go” program. No teams in this category provided training to those who supervise the new recruits and the work that is completed in the garage space.

The safety training program structure that is described in this work is targeted towards teams that do not already work inside an existing supervision university framework. The programs attempt to integrate sociological and psychological factors to create a socioecological program that has been suggested in other works [5]. It is meant as a framework that student teams can use to address what safety is required on their team, and to gradually conduct safety training as students become more active members.

It is important to understand the structure and work that is completed on the UWAFT to comprehend both the safety training program and hierarchy that is discussed in this work. UWAFT is a multidisciplinary automotive student team made up of undergraduate and graduate students at the University of Waterloo (UW) and Wilfrid Laurier University (WLU)[15]. The team has a technical (mechanical, electrical, mechatronics, chemical, and systems), project management, and communications sub-teams. The team competes in Advanced Vehicle Technology Competitions, and in this case EcoCAR 3, to reengineer a Chevrolet Camaro to reduce emissions while maintaining performance [16]. Not all members of the team require advanced safety training as they do not work directly on the vehicle. Some baseline training is however required for educational purposes as all students participate in outreach events and show the vehicle in the community.

Design and Application of Innovative Student Safety Training Program

The safety training for the student team is a progressive multi-tier system that is separated into four levels. The four different levels are used to reflect the role, responsibility, and legislative requirements for each student and the tasks they complete. This system is designed such that students can be eased into the team while meeting specific safety targets, increasing the overall team safety standard, and motivating them to become more involved. As students move through the safety training levels and become more active participants on the team, they move through legislative, school specific, team specific, task specific, and supervisor training that is represented in Figure 2. This approach helps to lay a foundation of safe practices that can grow as the student grows within the team.

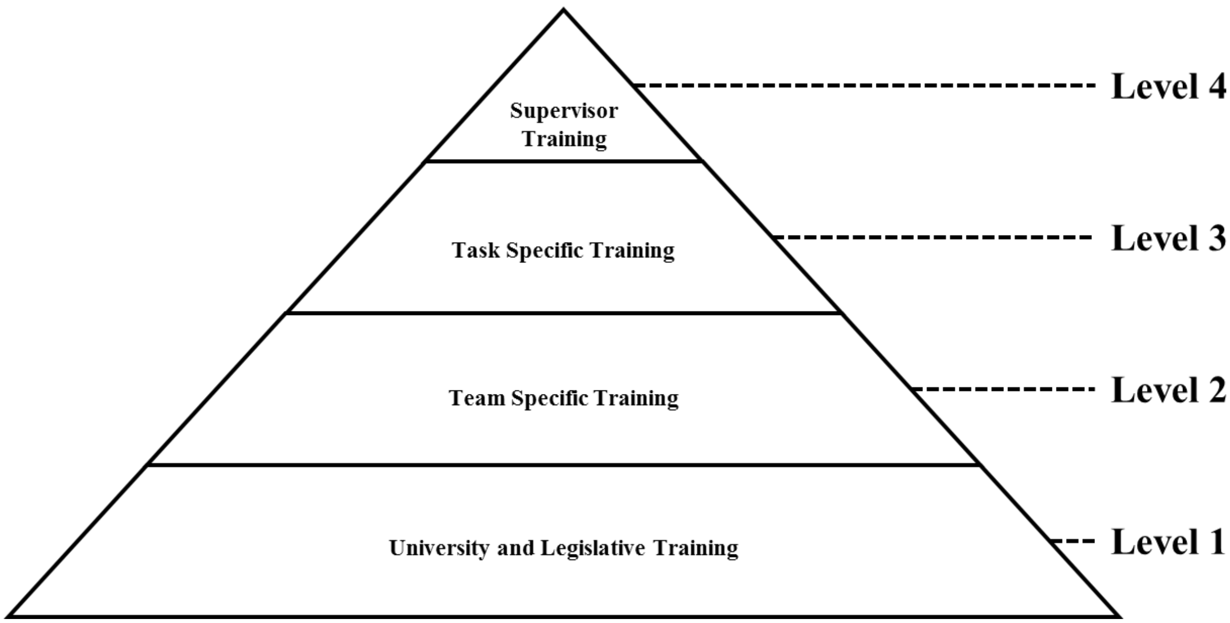

Figure 2: Hierarchy of safety training system

Level One Safety Training

To become level one certified on the team, the student must complete all university modules pertaining to workers and students. Level one is used as an introductory period, and is the first step for students who want to join the team. In addition to the safety training, students must be aware of emergency procedure outlined in team documentation, where the documentation exists, and sign all Non-Disclosure Agreements pertinent to the team. All team members must complete level one training regardless of the work they will do on the team, even if they will never complete any technical work.

As level one training only covers awareness, students at this level are limited in their team participation. Once level one is complete, students are able to access all information on computer servers and use any team computers that have specific software pertinent to the team's day-to-day function. This level allows students to participate immediately upon level completion. Students however have not yet had training on specific equipment, nor safe work and operating procedures and are therefore prohibited from participating in hands on work.

Level Two Safety Training

Level two training extends the awareness knowledge beyond the legislative and university level, to information that is specific to the risks associated with student team. This information includes commonly used tools, machines, and facilities and is taught by team members or university staff who know either the specific equipment or how the team functions. This training is meant to be introductory and the first step to more active team participation.

Within UWAFT, there are three main modules that are part of level two safety training. The first module is a training session on general shop safety and facilities. This session includes basic training on Personal Protective Equipment (PPE), shop layout, emergency equipment and exits, and other pertinent information to day-to-day hands-on activities. The second module is on basic electrical safety. This module covers information for low voltage (12V) electrical work, including best practices and safe operating procedures. The final module is on general mechanical work and procedures, covering commonly used tools and best practices. All modules together form a foundation for team specific training that address risk for common activities on the team.

Once all practical hands-on training modules have been completed, students are now able to complete hands-on work and become more active participants on the team. As they are new team members, they are still limited to the work that they can complete. Some tasks which are deemed of greater risk or severity of injury are reserved for higher levels. These tasks include the operation of heavy lifting equipment and high voltage design, construction, and operation. In order to further reduce the risk of injury, level two students must always be supervised and work in groups with higher level students. This stipulation on supervision ensures that more trained individuals are always around making sure best practices and safe procedures are being observed.

Level Three Safety Training

Level three training is meant to give students more in depth knowledge on specific tasks that are completed on the student team. Level three training becomes much more specialized and is meant for students who have proven their dedication to the team. These students are therefore trusted with higher risk work within UWAFT including advanced mechanical work, engine emissions and hazards, and high voltage.

The advanced mechanical training is meant to give students more knowledge and to give students more responsibility within the groups in which they work. The training includes a review of PPE and best practices as level three students may be required to help supervise students if only indirect supervision is possible by a level four student. Training on heavy lifting equipment such as a vehicle lift and engine crane is also completed at this stage.

Engine emissions and hazard training is meant to give students who will be working with the engine dynamometer. Engine testing can produce emissions that can cause fatalities if not configured properly. The operating temperature of engines can also cause severe burns and the high velocity of the rotational components of engines can cause severe injury. It is due to these characteristics that task specific safety training is required for this type of work.

High Voltage training is meant to train students on the hazards of working with or near high voltage. For UWAFT this involves working with vehicle powertrains and battery systems. It is not meant to train students on how to design, build, and commission the high voltage systems in the vehicle, as this is a higher level of risk and is reserved for a certification. Hands-on awareness training and best practices for working on and near high voltage is completed at this stage. This training is completed by reviewing the required PPE and emergency procedures that are specific to this type of work.

Completion of the training modules does not directly allow students to become a level three student. In order to show dedication to the team and in order for current team members to begin to see how the student works a time requirement in place. In addition to the training students must complete 15 hours of practical hands-on work with the team in addition to the training requirements to fully become level three certified.

Level Four Safety Training

Level four is meant to be the final layer of training for students who are the main supervisor for the day-to-day activities and work completed by lower levels. Level four students have the highest level of responsibility and therefore must be approved by the faculty advisor for the student team in addition to meeting the requirements. To meet the legislative requirements students must complete the safety training modules for supervisors which are provided at the university level. In addition to the completion of these modules team members must complete six hours of high voltage work, six hours of mechanical work, and eight hours of aiding an already certified level four student in the supervision of group work. The hour requirements are to ensure that the student has the diverse knowledge base that can be required for a multidisciplinary team like UWAFT. It is only after students meet the learning and hour requirements and obtain faculty approval that students can become level four and have completed all level based safety training outlined in Table 2.

Table 2: Summary of safety levels for student teams

Safety Training Level	Training Requirements	Allowable work	Restricted work
Level One	• Computer based awareness training	• Computer based design work • Community events	• Hands-on work in any form
Level Two	• Team specific awareness training • Hands-on general training	Level one plus: • Hands-on work • Low voltage work	• High voltage • Heavy lifting equipment • Engine dynamometer
Level Three	• Task specific awareness training • Hands-on specific task training • 15 hours of Level Two work	Level two plus • Aid in supervision • Work on commissioned high voltage • Heave lift equipment	• Direct supervision • High voltage design, build, and commissioning
Level Four	• Supervisor training • 20 hours of Level Three work	Level three plus: • Supervise work	• Specialized work if not certified

Additional Safety Training Certifications

Extremely high risk tasks are given even more attention within the four level training program and have specific certifications that can be obtained at the appropriate level. There are two certifications that are employed on UWAFT: High Voltage, and Prototype Vehicle Driving.

High Voltage certification is meant for students that will design, construct, and install any high voltage equipment. This certification can be completed by students who have already completed the level three task specific training which includes the basics of high voltage work. The certification for high voltage tries to align the team's training to issues discussed in the Canadian Standard Association's Workplace Electrical Safety Standard (CSA Z462) which is similar to NFPA 70E in the USA. Though hazards involving working around high voltage and required PPE are discussed in level three, the certification allows students to design, build, and commission the high voltage systems within the vehicle. This certification involves working with a High Voltage certified student for a minimum of 20 hours. Additional training is conducted on how to work with potentially energized systems and how to prove their isolation from other components of the vehicle is provided as part of the certification process. Best practices and safe operating procedure for high voltage design are also reviewed with the student.

Prototype Vehicle Driving certification is meant to allow students to drive the prototype vehicle on public roads after it has been approved to do so by the AVTC organizers. This certification can be completed by students who have completed all four safety levels and is both meant to reward students for their dedication to the team, and recognize the added responsibility that they have taken on. To obtain this certification, students must complete two practical tests. The first is to prove that the student has an advanced understanding of the components and how they are integrated into the vehicle. This test is to ensure that should an event occur while driving the vehicle the student can perform a preliminary diagnostic. The second test is to prove that the student is a good and responsible driver when driving the prototype vehicle. A standard road test is completed with a Prototype Vehicle Driving certified team member. Upon completion of these two tests, students are able to drive the prototype vehicle on the road. It is important to note that the student must also have a full license to drive according to the jurisdiction in which they live.

Table 3: Summary of certifications for student teams

Certification	Training Requirements	Certified Skill	Minimum Level
HV Certification	• High voltage design best practices • High voltage construction safe operating procedures	• Design high voltage systems • Build high voltage systems • Commission high voltage systems	Level 3
Prototype Vehicle Driving Certification	• Prototype vehicle awareness training • In vehicle drive testing	• Drive the prototype vehicle	Level 4

Program Implementation

There are three main components that are required for the implementation of this type of safety training program:

(1) documentation of the safety training program modules,
(2) document templates used for proof of completion of the modules, hours, and level achieved for each student; and,
(3) a safety board for visial representation is required to aid with the motivation and gamification of the safety program.

Documentation is always an important aspect. As part of the EcoCAR 3 competition, the current AVTC, a facilities binder must be created and prominently displayed within the student team's facilities. This facilities binder is similar to a safety management system. It contains all information pertaining to the safety program: emergency response plans and procedures, workplace hazards, best practices, safe operating procedures, material safety data sheets, in addition to all training documentation. This document also has proper change management procedures to ensure that the documents are updated as the scope of the team evolves. This documentation is required as it not only is a reference for any student but also can be used by existing team members for training purposes.

If an incident were to occur it is important to show that students have met all of the safety requirements. This situtaion is why the templates are required for implementing this program.

Each safety level has a signoff for each module and the hour requirements. These signoff sheets are stored with the signed NDAs and other forms specific to each student. Should an incident occur on campus, the team will have the supporting documentation to confirm that the student completed the necessary training modules to complete the work.

The safety training level board is a requirement as it benefits both the students and the team. The board is a visual representation of the team as a whole and what training each student has completed to date, Figure 3. This vidusl allows higher level students and team leaders to recognize who has received what training. IT also provides a location to post all information influding: emergance contact information, emergancy action nplans, hazardous material information, and other pertinent infomration.

The safety board is also part of the gamification of the safety training; students see which level they are, and want to improve to obtain a higher level. By limiting what each level can do, students also must take time to observe some advanced tasks, such as removing a high voltage battery, is completed. This time where student are limited to observing further motivates students to try to achieve a higher level.

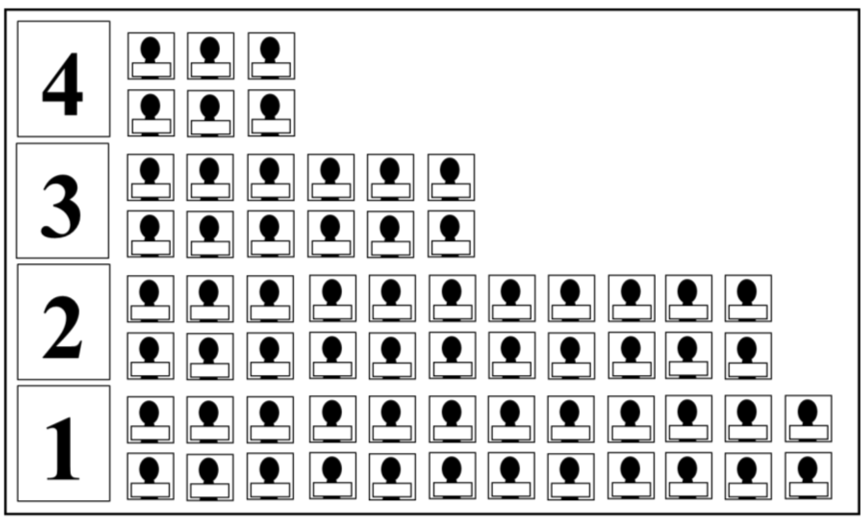

Figure 3: Motivational safety training level board

UWAFT Implementation

UWAFT has had a large amount of success with the development and integration of the safety training system within the team. To date, over 100 students have participated in varying levels, with 73 students completing all requirements and the remaining in transition. The team currently has 29 level one students, 27 level two students, 11 level three students, and 6 level four students. In addition to the level requirements, four students have achieved high voltage certification and five students have achieved prototype vehicle driving certification. A number of specific benefits have been seen from the implementation, and are further discussed below.

First, the safety management system allows UWAFT administrators to have a more organized system to track team member progression through the team, and safety information in case of an emergency. In the past, it was difficult for team leaders to know and track the amount of information for each team member, such as the execution of Non-Disclosure agreements, and specific training. With the new system, each team member's information is stored in a central place, which can be easily accessed should the need arise. The system has also helped to encourage growth within the team, pushing younger members to get more involved and progress through the safety training levels.

Second, training is being conducted on a regular basis to all members involved in the project. Prior to the safety management system, training would be given sporadically from senior team members to junior members as tasks were encountered. This process would be a large time commitment, as the training would be repeated multiple times for different members. Additionally, seeing as it was on a case-by-case basis, some members would not be trained in all areas of the car. With a standardized system, all students receive required baseline hazard awareness and educational training on the vehicle.

Some modifications have been made to the program since its inception in September, 2014. High Voltage certification was separated from level three specific task training by recommendation of the competition. This separation is because it would be possible that too many students would learn high voltage design. Due to the potential serious injury that can be associated with this type of work, the team would like to limit the amount of people with this certification to ensure that safety is maintained at all times with these components. This recommendation was implemented and has further improved the system, providing more detailed and advanced training to those doing the work.

Conclusion

Utilizing a simple hierarchical structure, a successful safety training program for student teams can be created. This structure still allows students to gradually be trained as they get more involved in the team but provides formal structure for this to occur. Locally, 67 students are officially recorded in the program and nine certifications have been given. The safety training program has proven valuable for its motivational characteristics and is commonly used as a reference to get to know new team members and monitor that their team activity corresponds to their safety level. By utilizing gamification principals, students are motivated to become more involved and want to complete the safety training to be able to complete additional tasks. This approach is in line with new thinking for training your workers which moves away from traditional training and creates a more socioecological system. This system helps to grow the team in both numbers and skills, as well as development of commitment to the team project as a whole.

By utilizing this system, all documentation is also on file and readily available. In the event that an incident were to occur on campus, the student team would be able to show both the university and any government body what training the injured student received. The documentation is also readily available for review which is a crucial component to any safety training program and safety management system.

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