JJMIE

Volume 11 Number 3, September. 2017
ISSN 1995-6665
Pages 155 -164

Jordan Journal of Mechanical and Industrial Engineering

Fire Extinguisher Training: Subjective Assessment of a Newly Developed Method by Expert and Novice Firefighters

Awwad J. Dababneh [a], Manar M. Ajlouni [b *]

[a] Department of Industrial Engineering, Faculty of Engineering and Technology, The University of Jordan, Amman, 11942, Jordan.
[b] Department of Civil Defense, Amman, Jordan

Received Feb 20,2017 Accepted June 10,2017

Abstract

The present article reports an evaluation study of a newly developed fire extinguisher training program that contained a video in Arabic, and a novel hands-on training apparatus. Fire extinguishers are an important part of the overall strategy for fire protection; however, its effectiveness depends on the availability of competent and willing users. Fire extinguisher training is important and should include both theoretical and hands-on training. Traditional hands-on training methods expensive and has adverse effects on the environment. New apparatus has been developed (the "Honeycomb" fire simulator); it uses a combination of propane clean fire, and inexpensive air-pressurized water extinguishers. Complementary to the new apparatus, a training video has been developed in Arabic that explains the fundamentals of fire extinguishers. Thirteen expert and fourteen Novice firefighters from the General directorate of Civil Defense in Jordan subjectively assessed the training video and apparatus. After watching the video and practicing/experimenting with the new hands-on apparatus they answered questionnaires, and indicated their likes, dislikes, and other comments in designated areas on the study forms. Expert and Novice firefighters indicated that the video contained important, comprehensive, and well-presented information, and they endorsed it for training employees and school students. The new apparatus were preferred by to the traditional fire-pan method by13 firefighters, and only 5 preferred by 5 the traditional method. Also, with the advantages of low cost and low environmental impact, the new method is obviously superior to the traditional method. The findings of the present study endorse the newly developed training program for Arabic speaking countries. In addition, it can be projected that following the same structure program, effective programs may be established with different languages.

Keywords: ...

1. Introduction

The use of portable fire extinguishers is an important part of the overall strategy for fire protection. It is designed and used to put out small fires before becoming too big. Handheld fire extinguishers are extremely common in public and work places worldwide, but for it to work a competent and willing person is needed. Improper use of fire extinguishers may cause more harm than good. Also, most extinguishers discharge its content in 10 to 30 seconds, which leaves no room for experimentation in an emergency situation. Advances have been made to the design of fire extinguishers, making it more easy and intuitive to use. However, training is still very important for developing the necessary Skills, Knowledge, and Understandings (SKUs). Classroom presentations, online classes, and videos have been used for developing the knowledge and understanding of employees and prospective users. Practice or hands-on training is essential for developing and verifying the necessary skills for safe and effective use. This report presents a fire extinguisher training program that was developed in Arabic, and it included both theory and hands-on components. A video was produced to present and explain the necessary knowledge and understandings, and a novel design fire simulator was developed for hands-on training. The program was evaluated by expert and novice firefighters from the General Directorate of Civil Defense/Civil Defense Training Center in Jordan.

Many countries have regulations that mandate fire extinguishers training. In the United States, Occupational Health and Safety Administration (OSHA) regulations require "hands-on" fire extinguisher training for all workplace employees who have been designated to use fire extinguishers. These standards also require that employers provide educational programs (which may, or may not, include hands-on training) to familiarize employees with the general principles of fire extinguisher [13] (see OSHA 1910.157 (g) (1, 3)). Notably, firefighters and safety

* Corresponding author e-mail: manaromhy@hotmail.com.

professionals associations (e.g., the National Safety Council (NSC) and the National Fire Protection Association (NFPA)) view hands-on training as the only viable option that can ensure all employees can use extinguishers safely and effectively [7,11].

The traditional method for hands-on extinguisher training includes the use of actual extinguishers and a fire pan. Typically, the fire pan is a metallic flat pan about 5-10 cm (2-4 inches) deep. The pan allows trainers to start, contain, and control a liquid fuel fire for training. The pan is usually half filled with water, and a small amount of a gasoline and diesel fuel mixture is poured over the water in the pan. The fuel mixture is lighter than water and floats on top. The water helps keep the overall temperature of the fuel low, and thus slows evaporation and keeps fire size under control. The resulting fire is a class B fire for which foam, powder, or CO2 fire extinguishers maybe used to put it out. However, because of the mess and the difficulty in quickly re-igniting the fire, foam and powder extinguishers are rarely used. The CO2 extinguishers, in contrast, leave no residue and allow for quick re-ignition, and are, thus, the preferred choice to use with the fire pan method. The major challenges for using the traditional fire pan method include cost and the negative impact on the environment. Although the pan itself is not expensive to construct, re-charging the fire extinguishers can be expensive and time-consuming, and, therefore, often limit the amount of practice a trainee receives. Furthermore, foam, powder, and CO2 fire extinguishing agents have negative impacts on the environment, ranging from being "dirty and messy" to contributing to global warming by releasing CO2 into the air.

Driven by the increased demand for hands-on training and by the shortcomings of the traditional fire pan method, several hands-on training apparatuses have been developed and commercialized in the past decade. Review of patents revealed clear design trends; protecting the environment, simplifying operations of apparatuses, and reducing cost of training. Design solutions included real and virtual simulation of fire. Real fire simulators used propane fuel to produce a clean fire [3, 4, 5, 9, 16], while virtual simulators used equipment similar to those used with electronic games [1, 2, 5, 6, 10]. Unfortunately, little viable research has been published investigating the effectiveness of these training methods.

A study [15] at Eastern Kentucky University investigated the effects of hands-on fire extinguisher training on the ability of ordinary people to put out small fires. The results demonstrated that subjects were able to operate a fire extinguisher without prior training. However, their conclusion might have been biased somewhat by the subject demographics: subjects were students recruited voluntarily from the campuses of Worcester Polytechnic Institute and Eastern Kentucky University, both of which have firefighting/safety educational programs and which raises a plausible concern that the subjects may have had higher average interest and knowledge regarding portable extinguishers than that of the general public. Another possibility for bias is the fire simulator used in the study; participants did not actually putout flames, rather a fuel solenoid valve closed if sensors picked up that the participant was doing the right sweeping motion. Also, participants were required to keep a distance of 2.44 m (8 ft.) away from the fire at all times, which is unrealistic and counter to common professional practices and reliable standards. NFPA recommends starting the extinguisher at a safe distance of 2.44 m (8 ft.) and gradually closing on the fire until it is out [7,11]. On the upside, the apparatus in the Poole's study includes an air pressurized water extinguisher that can be charged easily on site using an ordinary air compressor. Regardless the shortcomings, the present study has important findings; it reports that participants showed improved performance and confidence as a result of hands-on training.

In a study [14] that used an electronic fire simulator, to assess the learning curve for fire extinguisher training; showed that subjects' performance improved with practice. On average it took participants five to six successful training attempts until there performance leveled, which implies that hands-on training must allow each trainee to practice 5 to 6 times to ensure full development of skills. Practically, it means that a trainee must empty 5 or 6 extinguishers, which may makes training costly and further limit access to hands-on training.

The use of virtual reality and electronic flame simulators are not widely spread; they may have low running cost, but the initial investment is considerable. Besides, they may require trainers with special skills in order to operate the equipment. Furthermore, trainees would not feel the fire heat even with the best designed virtual reality training apparatus.

Due to their very low environmental impact and low operational costs, propane gas fire simulators, and easily rechargeable water extinguishers, provide excellent solutions for hands-on training. However, propane gas fire does not normally extinguish with water. the fire simulator is designed in a specific way to produce flames that can be extinguished by the training extinguisher commercially available hands-on extinguisher training apparatus use either a simple propane burner with CO2 extinguishers, or air pressurized water extinguisher with a complex burning system that has sensors and computer controlled valves to shut down the fuel line whenever the proper sweeping motion, are registered [3, 4]. In an unpublished study at the University of Minnesota-Duluth, done by the corresponding author of the present article, expert firefighters indicated that a commercially available computer controlled fire simulator had unrealistic and misleading flame-behavior.

The present study reports on a new fire simulator that was developed to address the aforementioned shortcomings of current fire simulators. It uses propane fire and air-pressurized water extinguishers. It is believed that the new design better simulates real fire, and is inexpensive to produce. The new design is called the "Honeycomb" fire simulator (Figure 1).

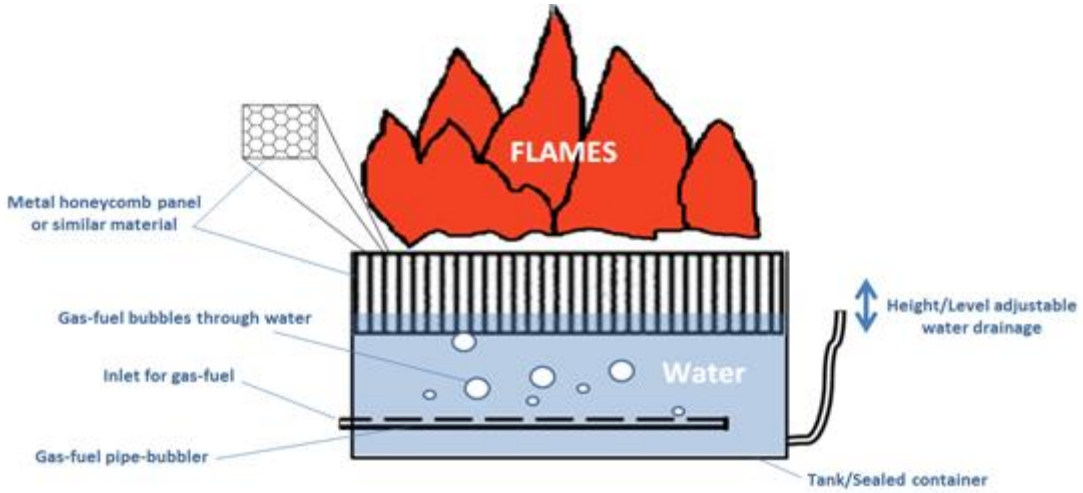

Figure 1. The "Honeycomb" fire simulator

Figure (1) illustrates the parts and construction of the honeycomb fire simulator. The largest part of the simulator is a leak-proof tank or container. The top side of the tank is open while the cross section of the tank may be any shape: circular, oval, rectangular, etc. The tank is partially filled with water, and a height adjustable drainage pipe is used to control the water level. Propane gas enters the simulator at the bottom of the tank through a dedicated pipe which is perforated to allow the gas to bubble up through the water. A metal honeycomb panel is installed at the top of the tank, completely covering the open side of the tank. The honeycomb panel is 5 cm (2-inch) thick, entirely comprised of vertical hexagonal 6 mm (1/4-inch) openings. The honeycomb grid is partially submersed in the water. As the propane bubbles up, it gets divided through the honeycomb panel into many smaller bubbles. Once the simulator is lit, the flames flicker vertically through and above the honeycomb grid. When using the air-pressurized water extinguisher with the honeycomb simulator, flames are extinguished by the combined actions of cooling the fire and blowing the flames off the top of the honeycomb panel. This creates a flame front that behaves like flames in an actual liquid fuel fire. As a result, the trainee has to direct the extinguishing stream at the flame front and use sweeping motions to chase the flames off their bases and extinguish it. The difficulty in extinguishing the flames can be controlled by adjusting the level of the water; as the level of water rises inside each of the honeycomb tubes, the base of the flames rise with it and become easier to blow off. A low water level will leave more space for flames to hide inside the honeycomb tubes and become harder to extinguish. For safety, the simulator is equipped with a dead man switch that is held by the trainer; it will close a solenoid valve that will block the flow of fuel to the simulator and, also, to reduce the burden of dealing with electrical hazard controls, an operating voltage of less than 50 volts maybe used; a 12 volt was used in the present study.

A video was produced to be used for theoretical training prior to having trainees practicing/experimenting with the new hands-on apparatus. The audience of the video was defined as the general public. The main objective of the video was to provide scientific and easy to follow study material for employees and students. No specific educational rubric was found for extinguisher training, and, therefore, the contents of the video were set based on experience as described in Table (1).

Table 1. Detailed description for video's segments

#	**Title**	**Content**	**Duration (min)**
1	Fire fundamentals	Brief outline of the whole movie. Fire triangle. Stages and spread of fire and smoke. Effects of fire on human.	6.5
2	Overall fire protection strategy	Fire prevention: Recognition and control of ignition sources. Proper storage and handling of combustibles. Automatic sprinkler systems. Role of potable fire extinguishers as a part of the overall protection strategy. Emergency and evacuation planning and exercises.	7.5
3	Fire extinguishers use	Types of fire and extinguisher classifications. Extinguishing agents and its suitability for use. Extinguisher components and structure Method of operation (PASS) Safe and effective fighting distances	11.5
4	Fight or evacuate decision	5-point list to help make the decision of fighting a fire or evacuating: warning others, small fire, availability of proper extinguisher, confidant user, having an escape route if failing to extinguish the fire.	2
5	Introduction to the hands-on training	Description of the training apparatus, how to carry and operate a training fire extinguisher, what to do when fire goes out, and how to back up if fire is not extinguished.	2

As mentioned earlier, the objective of the present research effort is to evaluate the newly developed fire extinguisher training program; theoretical (video) and hands-on (training apparatus).

2. Methodology

The methodology depended on the subjective assessment of two groups of evaluators: expert trainers and novice firefighting students. Both groups watched the video, and practiced putting out fires using the newly developed apparatus, prior to providing their assessments. The assessment had two components: a structured feedback using a specially constructed questionnaire and a semi-structured feedback where participants wrote in designated blocks titled "likes", "dislikes", and "other comments".

2.1. Participants

The present study was carried out at civil defense training center .Thirteen expert trainers and fourteen firefighting students participated in this study; all were males. Students were in their first year of study to become firefighters or paramedics. Students' ages ranged from 20 to 23, with an average of 20.6 years. Although, they were chosen because they had not received fire extinguishers training yet, they reported having ample knowledge, but lesser experience. None of the novice participants had had used the fire extinguisher to put out a fire in a real emergency situation. Also, none of the novice participants had trained anyone on the use of fire extinguishers.

All experts were firefighting trainers at the training center, and their years of experience ranged from 7 to 15 with an average of 10.6 years. Experts' age ranged from 29 to 35 with an average of 31.7 years. Eleven of the trainers reported they had trained more than 100 people on fire extinguishers, and the other two trained 50 to 100. Also, eleven out of the thirteen experts had used extinguishers in real emergency situation. All experts reported they were knowledgeable and had a practical experience with fire extinguishers. Table (2) shows the questions, and frequencies and averages of the participants' responses related to experience and knowledge.

2.2. Training Video Evaluation

The video was divided into five segments for evaluation, as shown in Table (1). All segments were evaluated the same way. After watching each of the segments, participants were asked to answer five questions on a five-point agreement scale, and to provide their semi-structured feedback by writing likes, dislikes, and other comments. The five questions are listed in the first column of Table (3). Researchers explained that although all were gathered in one room, that the study is interested in the opinion of each individual; therefore, participants were asked not to discuss their thoughts and opinions about the study, and only write them on the study form.

2.3. Apparatus Evaluation

After using the training extinguisher to put out the simulator fire, participants were asked to answer seven questions on a five-point agreement scale, and to provide their semi-structured feedback by writing likes, dislikes, and other comments. The seven questions are listed in the first column of Table (4).

Table 2. frequencies and averages of the participants' responses related to experience and knowledge

	Expert / Novice	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Average
I have comprehensive theoretical knowledge about how fire extinguishers work	E				7	6	**4.46**
	N		1	3	10		**3.64**
I have comprehensive practical experience about how fire extinguishers work	E				6	7	**4.54**
	N	1	1	2	7	3	**3.71**
Fire extinguishers theoretical training is important for employees and students	E				1	12	**4.92**
	N				7	7	**4.50**
Fire extinguishers hands-on training is important for employees and students	E					13	**5.00**
	N				7	7	**4.50**

Bold average numbers indicate statistically significant difference between Experts and Novice with P<0.05.

2.4. Equipment and Study Protocol

A third generation prototype of the Honeycomb fire simulator and ten training extinguishers were used in the study (see Figure 2). First, all participants were gathered in one of the classrooms at the training center. Before starting to watch the training video, the objectives and procedure for the study were explained. After each of the five segments of the movie, the showing stopped and the participants were given enough time to complete the associated part of the study form.

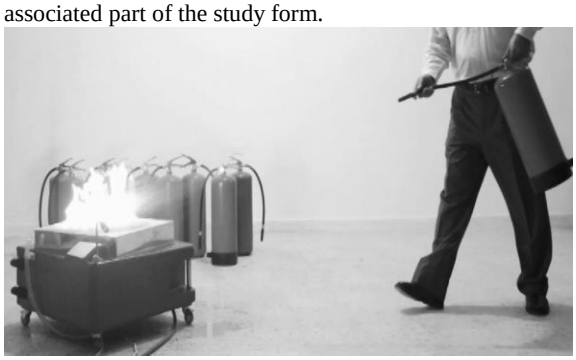

Figure 2. Third generation prototype of the Honeycomb fire simulator, and training extinguishers

The segmental evaluation was followed by two questions. In the first one, participants were asked to rate the suitability of the whole movie for training employees and students. Secondly, to indicate what the youngest school grade was that would benefit from the training video.

Next, all participants moved to an outside open court where the fire simulator and training extinguishers were set. One by one, all participants practiced putting out the simulator fire. Each participant completed the study form directly after his practice.

2.5. Analyses

Basic descriptive statistics were calculated by using Minitab software for each of the questionnaire items, while analysis of variance and pairwise comparisons were used to investigate differences between experts and students. Correlation analyses were done between all items on the questionnaire. The participants' comments, criticisms and suggestions were also reviewed, categorized, and summarized.

3. Results

Frequencies and averages of responses to questionnaire items for all segments of the training video are shown in Table (3). Statistically significant differences between experts' and novices 'responses are indicated by bold average numbers for P<0.05, and by italic average numbers for P<0.10.Overall assessment of the video was highly positive among both experts and novices. Frequencies and averages of participants' overall ratings are shown in Table (5).

Table 4. Frequencies and averages of responses to questionnaire items for evaluating the training apparatus

	Expert / Novice	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Average
Method to operate training extinguisher is the same as for real ones.	E		2	2	6	2	3.67
	N	1		2	9	2	4.00
Training fire reacts to extinguishment in the same way like in real situation.	E		4	2	6	1	3.31
	N	1	1	3	7	1	3.38
Using this hands on training method will develop the trainees' skills essential to put out a fire in a real emergency	E			3	7	3	4.00
	N		1	2	5	5	4.08
Using this hands on training method may lead to trainees having wrong impressions about fire and extinguishment.	E	2	4	4	3		2.62
	N	4	6	2		1	2.08
Using this hands on training method does not provide any additional benefits over classroom training.	E	4	4	3	2		2.23
	N	4	4	2	3		2.31
Hands on training cancel the need for classroom training.	E	7	4	2			1.62
	N	6	3	2	1		1.69
In general, the traditional method of burning a mixture of gasoline and diesel in a fire pan, and using real extinguishers is better than the method used for this study.	E	2	4	4	2	1	2.69
	N	3	4	4	1	1	2.46

Bold average numbers indicate statistically significant difference between Experts and Novice with P<0.05.

Table 5. Frequencies and averages of the overall ratings for the training video

	Expert / Novice	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Average
Overall the movie is suitable for training employees and students.	E			2	6	5	4.23
	N				10	4	4.28

Twenty-five participants either strongly agreed or agreed that the video was suitable for training employees and school students, and only two experts neither agreed nor disagreed. Consistently, the ratings of the video by novices were more positive than those of experts. Significant differences at P<0.05 were found for the video segments number 4 and 5.

In reference to segment-4, fight or evacuate decision, the ratings for containing comprehensive information were significantly different between experts (average rating 3), and novices (average rating 4.5). Review of comments indicated that some experts were against including the "fight or evacuate decision"; they stated that it was the responsibility of firefighters to fight.

Segment-5 was relatively short (2 minutes) and introduced the hands-on training part; however, differences in ratings between experts and novices were significant; three out of the five questionnaire items were significantly different at P<0.05, and two were significant at P<0.10.

Segment-3 was the longest at 11.5 minutes (39% of the total time), and it explained the types of fire extinguishers and how to use it safely and effectively. Ratings of this segment were mainly positive and there were no significant differences between experts and novices. However, and in regards to that, segment-3 contained comprehensive information, the average ratings for novice and expert were 4.60, and 3.38, respectively.

Although the difference was not statically significant, it is large. Review of study forms revealed that experts who gave low rating for this item wrote comments about not including information on the "need to stand up wind from the fire", "use of personal protective equipment PPE", and the "need to shake the extinguisher before use".

Segment-2 was the second longest at 7.5 minutes (25.4% of total time), and it contained vast information on the general strategy for fire protection. Nevertheless, it was rated the least for containing comprehensive information. Also, the average rating for "containing important information" was 4.07 for novices and 4.00 for experts. There were no significant differences between experts and novices in the ratings for this segment.

Segment-1 was 6.5 minutes (22.0% of total time) and it contained fundamentals of fire. Overall, the ratings for this segment were positive. It had the highest scores for "containing important information", and for having "clear and acceptable presentation ".

There was a significant difference at P<0.10, between experts and novices in regards to "suitability of the segment for training employees and school students"; novices had higher ratings (4.36) than experts (3.85).

In response to the question of what was the youngest school grade that can benefit from the training video, novice participants reported younger school grade than of that reported by the experts (P= 0.08). Novices' answers ranged from 3rd to 10^{th} grade with an average of 5.75, and experts' answers ranged from 4^{th} to 11^{th} with an average of 7.8.

Frequencies and averages of responses to questionnaire items for evaluating the training apparatus are shown in Table (4). Novices' ratings of the apparatus were more positive than the ratings of experts; however, differences were not significant statistically. There was an overall agreement in regards to the following statements: "Method to operate training extinguisher is the same as for real ones", "Training fire reacts to extinguishment in the same way like in real situation", and "using this hands-on training method will develop the trainees' skills essential to put out a fire in a real emergency".

Also, there was an overall disagreement to the following statements: "Using this hands-on training method may lead to trainees having wrong impressions about fire and extinguishment", "using this hands-on training method does not provide any additional benefits over classroom training", and "Hands-on training cancels the need for classroom training".

Concerning the comparison between hands-on training using this apparatus and using the traditional method, ratings spread overall the five-point scale. The averages favored the new method. A closer look at the frequency of responses indicated that six experts favored the new method, three did not, and four were hung between the two methods. Also, novice participants had similar assessment.

Significant correlations were only found when combining the data of both experts and novices. Table (6) shows the person correlation factor and corresponding error probability value (P) for questionnaire items that had at least one statistically significant correlation.

There was a positive strong correlation (r= 0.864, P= 0.035) between ratings for "having comprehensive knowledge about fire extinguishers", and ratings for "theoretical training is important". Also, there was a significant correlation (r= 0.497, P= 0.008) between the ratings for "having comprehensive knowledge about fire extinguishers", and ratings for "having hands-on experience". This can be understood as those who had hands-on experience with fire extinguishers also had good knowledge about how it works, indicating that theoretical training is important, and favored the new apparatus.

Similarly, those who preferred the new training apparatus to the traditional method, liked the training extinguisher, thought that simulated flames reacted as real fire, and that is good for developing necessary skills.

Table 6. Correlations of questionnaire items that had at least one statistically significant correlation

	Experience	Knowledge of theory	Theory importance	Hands-on importance	Traditional better	Developing skill	Fire real behavior
Knowledge of theory	**0.497** **0.008**						
Theory importance	0.708 0.075	**0.864** **0.035**					
Hands-on importance	**0.511** **0.006**	0.276 0.164	0.171 0.393				
Traditional better	-0.128 0.562	-0.355 0.097	**-0.440** **0.036**	0.139 0.526			
Developing skill	0.195 0.373	-0.077 0.728	-0.176 0.423	0.145 0.508	0.335 0.127		
Fire real behavior	0.158 0.460	-0.350 0.093	0.000 1.000	0.260 0.219	**-0.682** **0.000**	**0.430** **0.040**	
Operation of training extinguisher	0.251 0.236	0.022 0.919	0.219 0.304	0.204 0.339	0.198 0.365	0.354 0.097	**0.622** **0.00**

* Cell Contents: Pearson correlation

P-Value

** Bold numbers indicate statistically significant difference between Experts and Novices with P<0.05.

Participants wrote many comments; the most frequent one was that water is not suitable extinguishing agent for propane. They also indicated the video was missing instructions in regards to standing upwind when fighting a fire, and to shake the extinguisher prior to use. Others wrote that they favored the fire pan since it was closest to a real fire scenario, commenting that the actual smoke and fire make it superior to any simulated fire. Two, suggested adding smoke to the fire simulator as an improvement. Many comments praised animations in the movie, and that it contained segments of all types of fire extinguishers being properly used. Also, few wrote positive comments about including a segment of females using fire extinguishers. There was a comment praising the movie for including male and female, as well as young and old people.

After completing the study, there were casual discussions with participants and administrators at the academy. Several comments were noted, mainly concerning the design of the fire simulator, and the suitability of water for extinguishing gas fires.

4. Discussion

The ultimate goal of fire extinguisher training is to enable trainees to react in a manner that would reduce the overall risk of loss of life, injury, and/or property damages in real emergency situations. Therefore, evaluating the effectiveness of any fire extinguisher training program is limited, because it is not practical to create repeatable real emergency situations for testing. In the present study, measuring the effectiveness of the new program was done through subjective assessments of the study participants. Their feedback was in reference to what they knew and/or believed in. No participant mentioned any other movie, nor indicated that they knew of other types of fire simulators. On the contrary, there were comments that explicitly mentioned the lack of training movies in Arabic, and that the fire pan was the method they always used. Basically, participants compared the video training to expert-instructions in a classroom setup, and compared the new apparatus to the fire pan. Also, trainers in the present study were not directly responsible for the cost of training; therefore cost was not a concern for them. In contrast, participant's comments indicated they were concerned about the impact of training on the environment. They reported that powder and foam make a substantial mess, and sometimes the use of powder extinguishers was problematic for trainees with pulmonary issues.

Almost for all questionnaire items, responses spanned over all the agreement scale. Responses indicated clear trends; however, variability was high. Causes for such variability include a negative disposition of some participants, caused by their strong belief that water is not suitable to put out gas fires in real situations. Although it was explained to participants that the fire simulator is designed in a specific way to produce flames that can be extinguished by the training extinguisher, some were doubtful about and not completely convinced in it. Another reason that may explain the high variability relates to the culture and norms within General directorate of Civil Defense in Jordan. Basically, Civil Defense in Jordan is a military organization and they pride themselves in their selfless and tireless efforts especially in dealing

with hazardous events and accidents. Quitting or backing up from danger is not an option for them. This was clear in the ratings of the video segment concerning the fight or evacuation decision. Many experts indicate that fleeing was not an option for them or for their trainees. Although such attitude is prideful, it indicates a distortion in the perception of the study objectives. The target of the study program was the general public and not professional firefighters.

Segment-2 presented the overall strategy for fire protection, and the role of fire extinguishers in it. It received a very good score for "importance to include", but much lesser score for "including comprehensive information". Actually, the intention was to include minimum information about fire prevention, automatic sprinkler systems, and emergency planning, and explain the role of portable fire extinguishers. It is not possible to include comprehensive information in a short video, but at the same time the intention was to explain that protecting against the hazards of fire requires a systematic approach.

There were differences between experts and novices in regards to the importance of the different video segments. For example, there were significant differences in the ratings of the fifth video segment; novices appreciated it more than experts. It was short and contained an introduction to the hands-on training: How the fire extinguisher should be carried, and instructions for safe backup if fire did not go out. Also, there were significant differences concerning the importance and completeness of the fourth segment. These differences highlight the need to consider how students learn, and maybe more than what the teachers think is important. Failing to address the needs of students would result in ineffective teaching.

Participants' comments indicated that the video did not include instructions to stand upwind when fighting a fire and it is true. Such instructions were discussed at the beginning of the hands-on training. However, the video might be used without the hands-on training segments, and then these instructions are lacking from the video. Ultimately, this will be fixed in future versions of the video. For the short-term, written instructions can be combined with the video to resolve this issue.

Participants also commented that instructions should include shaking the extinguisher before use; however, this is not within standard procedure. On the one hand, shaking a dry chemical fire extinguisher may help prevent the powder inside from settling or packing, but shaking is not always recommended by manufactures. On the other hand, lifting, turning upside down, and shaking the extinguisher require a significant strength and effort. Weaker people, such as the elderly and women, may shy away from attempting to use the extinguisher if the required effort is excessive for them. In general, firefighters have more strength than the average person and are experienced in the extinguisher-operating methods; hence, shaking the extinguisher for them maybe beneficial and would not cause harm. An NFPA standard does not include any requirements for shaking the extinguisher before use, and it is rarely recommended by extinguisher manufactures. Therefore, if shaking the extinguisher is recommended by the manufacturer, it should be done during monthly inspection and not before use.

Few participants from both groups raised the issue that the hands-on training was being carried out without (PPE). This also indicates that some participants had a distorted perception about the study objectives. While it is a requirement for firefighters to wear PPEs, it is not practical to impose the same requirement on the general public, employees and students. This distortion in the perception of few participants may make them undervalue the new apparatus.

The suitability for training of each of the video segments received a high score from novices (4.29 to 4.66), and positive scores from experts (3.46 to 3.92). Also, twenty-five out of the twenty-seven participants agreed or strongly agreed that the video was suitable for training employees and students. These scores indicate somewhat strong endorsement from both experts and novices.

Videos have been effectively used in trainings covering topics ranging from instructions for surgical procedures to vocational training [1, 8, 12]. Videos allow trainees to view the study material according to their own schedule and for as many times as they may need. For some topics, the use of animations and illustrations make videos superior to other methods of presentations. For example, the training video subject of the present study included clips of water, foam, powder, and CO_2 extinguishers being used. Some clips were shown from two different camera angles, and one was shown at slow speed allowing trainees to see comprehensive and detailed views. Creating the same effect through expert-instructions in a classroom setup might be impossible, or, at best, very time consuming and expensive. Therefore, the video is an effective and efficient presentation method to train the general public on the principles of fire extinguishers.

The need for training, in both theory and practice, was clear; experts indicated that a theoretical training was important with a score of 4.92, and hands-on training was important with a perfect score of 5. Also, after they practiced with the new apparatus, experts disagreed that hands-on training would eliminate the need for theoretical training. Novices' indications were similar to those of the experts'.

As mentioned earlier, there were few participants who had a strong disposition to undervalue the new apparatus because of their strong belief that water should not be used to extinguish gas fires. These participants voiced their doubts few times, which most likely affected the scores of other participants. Four to eight of the participants adopted the midpoint of the scale neither agreed nor disagreed on every issue. One way for reading rating scores is to exclude those neither agreed nor disagreed to determine trends. For example, there were 19 participants who agreed or strongly agreed that the operation of the training extinguisher was the same as regular ones; only 3 disagreed. Similarly, 15 agreed to 6 disagreed that training fire reacted to extinguishment in the same way like in real situation, and 20 agreed and one disagreed that using this hands-on training method will develop trainees' skills essential to put out a fire in a real emergency. Overall, the new apparatus received good ratings and it was favored over the traditional method by a ratio of 13 to 5. Given the obvious benefits in regards to low cost and low

environmental impact of the new apparatus, use of such should be encouraged.

5. Conclusions

Expert and novice firefighters indicated that both theoretical and hands-on fire extinguisher training are important. They also indicated that hands-on training does not cancel the need for theoretical training.

The training video, the subject of the present research study, includes important, comprehensive, and well-presented information on the fundamentals of fire extinguisher use. Expert and novice firefighters indicated its suitability in its current version for the training of employees and school students.

The combination of propane fire simulator and the training air-pressurized water extinguisher provides acceptable means for hands-on training; it has a relatively low cost, and has no, or very low, impact on the environment. The training apparatus, the subject of the present study, provides an effective means for hands-on training, as indicated by expert and novice firefighters.

Limitations and Future Studies

Findings and conclusions of the present study are important for establishing effective fire extinguisher programs. The study is important specifically for Jordan. The involvement and endorsement of civil defense in Jordan is essential for the people of Jordan as they consider it as the technical and ethical authority on fire protection. However, the present study was limited because it did not include the targeted audience: employees and students. Also, it was not possible to increase the number of participants because it included all expert trainers and students at the college of the Jordanian Civil Defense.

There were no established and verified standards for fire extinguisher training; thus, the standard achievement test is also lacking. In order to carry out future studies, that involve students and employees, an educational rubric must be established.

Table 3. Frequencies and averages of responses to questionnaire items for all segments of the training video

		Video Segment 1 Characteristics of fire						Video Segment 2 Comprehensive strategy for fire protection.						Video Segment 3 Portable fire extinguishers						Video Segment 4 Fight or flight						Video Segment 5 Introduction to hands on training					
	Expert / Novice	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Average	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Average	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Average	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Average	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Average
Containing important information	E			1	6	6	4.38		1	2	8	3	4.00		1	1	7	4	4.08		1	3	7	2	3.77		3	4	5	1	**3.31**
	N				5	9	4.64			2	9	3	4.07			1	6	7	4.43			1	10	3	4.14			1	9	4	**4.21**
Presentation is clear and acceptable	E				5	8	4.62		1	3	7	2	3.77		1	1	8	3	4.00		1	5	6	1	3.54		4	3	5	1	**3.23**
	N				9	5	4.36		2	1	8	3	3.86		1		8	5	4.21	1		2	8	3	3.86			3	9	2	**3.93**
Containing comprehensive information	E		1	4	6	2	3.69		4	5	3	1	3.08		3	4	4	2	3.38		5	3	5		**3.00**		5	6	2		**2.77**
	N		1	4	6	3	3.79		2	6	5	1	3.36		1	2	7	2	4.60			4	7	1	**4.50**			3	7	3	**4.33**
Containing unnecessary information that can be taken out to reduce the video time	E	3	6	2	1		2.08	2	7	3	1		2.23	2	7	3	1		2.23	1	5	5	2		*2.62*	1	3	6		3	*3.08*
	N	3	2	6	1	1	2.50	3	7	1			2.50	3	7	2			2.30	2	8	3			*2.45*	3	5	3	2		*2.50*
In general the video is suitable for training employees and student	E	1		2	7	3	*3.85*		2	1	9	1	3.69		2	2	4	5	3.92		1	5	4	3	*3.69*		4	3	2	4	*3.46*
	N			1	7	6	*4.36*			3	4	7	4.29			1	6	7	4.43			2	5	6	*4.66*		1	1	5	7	*4.29*

Bold average numbers indicate statistically significant difference between Experts and Novice with P<0.05.
Italic average numbers indicate statistically significant difference between Experts and Novice with P<0.10

References

[1] Anna Maria Giannini, Fabio Ferlazzo, Roberto Sgalla, Pierluigi Cordellieri, Francesca Baralla, Silvia Pepe. (2013) the use of videos in road safety training: Cognitive and emotional effects. Accident Analysis & Prevention 52.

[2] Blackburn *et al*., Flameless fire extinguisher training methods and apparatus, United States Patent 7748983, July 6, 2010.

[3] BullexITS User Reference Guide, 2012. (Provided by the manufacturer with Bullex Intelligent System fir simulators).

[4] Darois *et al*., Training device for extinguishing fires, method and system of use thereof, United States Patent 7175439, February 13, 2007.

[5] Deshoux *et al*., Teaching installation for learning and practicing the use of fire-fighting equipment, United States Patent 6129552, 2000.

[6] Hoglund, R.W., Firefighter's training simulator, United States Patent Application 233289, October 20, 2005.

[7] Hughes Associates, Inc., Measuring the Impact of Fire Extinguisher Agents on Cultural Resource Materials. Report prepared for the National Fire Protection Association - Fire Protection Research Foundation. Hughes Associates, Baltimore, MD, 2010.

[8] Isiaka, B. (2007, October 30). Effectiveness of video as an instructional medium in teaching rural children agricultural and environmental sciences. *International Journal of Education and Development using ICT* [Online], 3(3) Available: http://ijedict.dec.uwi.edu/viewarticle.php?id=363.

[9] Joynt *et al*., Portable firefighter training system for fire extinguishing training, United States Patent 5447437, September 5, 1995.

[10] Moore, W.T., Electronically simulated flame, United States Patent 6688752, February 10, 2004.

[11] National Fire Protection Association (NFPA), Standard for Portable Fire Extinguishers, NFPA 10, 2007 Edition, Quincy, MA, 2007.

[12] Nousiainen, Markku *et al*. "Comparison of expert instruction and computer-based video training in teaching fundamental surgical skills to medical students." Surgery 143.4 (2008): 539-544.

[13] Occupational Safety and Health Administration. "Fire Protection, 1910.157, Portable Fire Extinguishers", U.S. Department of Labor, OSHA Web. 18 Nov. 2013.

[14] Oviedo-Trespalacios, O., R. Manjarres, and R. PeñabaenaNiebles. "The Learning CurveAppliedto Fire Extinguisher Training: A ComparisonAmong Different Type of Fires." 22nd International Conference on Production Research (ICPR 22) 2013.

[15] Poole, B. Ordinary People and Effective Operation of Fire Extinguishers.
Unpublished dissertation, Eastern Kentucky University, 2012.

[16] Williamson *et al*., Dispersion burner for firefighter training, United States Patent 7744373, June 29, 2010