Comparing the use of a 'tabletop' experiment and a collaborative desktop virtual environment for training police officers to deal with traffic accidents

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Abstract *— The Dubai police force currently trains its accident investigators using a mixture of theoretical training and on-the-job practical training. In this paper, we investigate the suitability of a virtual environment (VE) for training and performance testing traffic accident investigators. To justify the investment for virtual training we compare trainees' performances against the less expensive method of using a tabletop exercise.*
Our results show that both our proposed training methods managed to improve the overall trainees' performances. However, overall we have not found a significant difference in performance that could be clearly attributed to one method rather than the other. There are some indications that there is an advantage for one method of training over another according to the task required at a particular investigation stage. Subjective comments from the trainees favoured the use of the virtual environment. Both environments received positive remarks from the trainers who saw the potential of using them as training and testing environments before sending the trainees to real traffic accidents.

Index Terms *— traffic investigators training, tabletop training, virtual environment training.*

INTRODUCTION

The increase of computing power and its wide availability has raised interest in the use of VEs. A number of environments have been developed over the years, looking at such things as training fire-fighters [1], police officers [2] and navy personnel [3]. We have noticed that the focus of many of the environments built for the traffic accidents investigation field concerns accident reconstruction such as [4,5]. Our work differs from these environments by focusing on the accident investigation for which we have not yet found any virtual training environment. In this work we examine the suitability of such environments in training traffic accident investigators for the Dubai police force. Currently students at Dubai Police Academy receive theoretical training material on accident investigation during their course, followed by on-the-job training after the graduation under the supervision of an experienced officer. Some students also have the option of attending two specialized modules on traffic investigation.

We hypothesize that there exists a large gap between theoretical and practical training which needs to be bridged by another form of training environment. We also hypothesize that the current on-the-job training on its own is not sufficient, for three reasons. First, the students get exposed to a limited range of accident types while under supervised training. According to the on-the-job training each student is assigned to work in a patrol unit under an experienced investigator, and each unit has a specific jurisdiction assigned to it in a specified area of the city. This approach for student assignment is not ideal as the accident types and frequency differs from one area to the other which means that some students might only be supervised on limited type of accidents and might never get exposed to others. Second, the evaluation of each student is done in a subjective manner by relying on the supervisor's views. We believe that a more objective evaluation mechanism needs to be put in place to get a fairer evaluation for each individual. Third, there is no agreed period for the supervision period or the number of accidents the trainee has to investigate. The non-existence of a supervision period can be understood as it is very difficult to predict the accidents that might occur during a specified training period. However, the number of accidents can be a more accurate measure and possibly putting a minimum number on the different types of accidents that a trainee has to investigate before completing the supervised training period.

Our case study was conducted over a period of two months and it was separated into two main phases: gathering knowledge and running the experiments. The first phase consisted of interviews, on-the-job observations, exercising the expert, and material analysis. The second phase involved running the experiments and the debriefing sessions that followed.

The rest of the paper is organized as follows. The next section gives the reasons for the need for a practical training environment by giving real examples. This is followed by a section which describes the virtual traffic accident scenario used, the experiments design approach, the stages an investigator must complete in the scenario, and how the scoring system works. Afterwards, we present the results and discuss their implications. We also compare our results with the

only similar literature we found, where the use of a computer screen-based simulator is compared with a mannequin-based simulator for training anaesthetists [6]. Finally, we present conclusions and future work.

IS ANOTHER FORM OF PRACTICAL TRAINING NEEDED?

We needed to find supporting reasons to justify the need for another type of practical training and we wanted these reasons not only to be based on the findings of our experiments but also to come from real cases. The examples we present here are gathered from travelling to real accidents with the investigators, from observing stationed investigators, and from a traffic investigation training session we attended. Attendees at the training session included novices and experienced investigators.

Figure 1 shows an example of a truck which was involved in a collision with another car on a highway. The truck's final rest position is shown by the left image in the figure. The truck was carrying goods and some of the goods fell outside the truck and others on the side railing of the truck. The in-charge investigator should have made sure that the goods were offloaded and secured before asking for the truck to be moved. Failing to do this task resulted in three of the boxes falling dangerously when the truck was turned over, as captured by the right image in Figure 1. Other common mistakes observed were (i) not marking the position of clues on the drawing map, which is critical for conducting the appropriate calculation needed to estimate the vehicle speed at the point of contact, and (ii) failing to mark the accident point, which makes the task of resolving any dispute between the parties involved in the accident much harder.

We spent two weeks working with the stationed investigators at Bur Dubai Police station. These experienced investigators have two main roles: (i) to resolve conflicts that arise between the parties involved in the accident if the patrol investigator can not resolve them and (ii) to travel to serious accidents when there are severe injuries or fatalities. For the first role they rely fundamentally on the patrol investigator's findings from the accident scene. Any clues that are missed or not collected could result in the wrong conclusion being drawn. In a number of cases we found that the patrol investigator missed crucial evidence which resulted in the stationed investigator requesting him to go back to the accident scene and try to find it. A regular example was failing to pinpoint the first contact point of the accident, which is crucial for understanding the location of each vehicle when the accident happened. Combining this with the nature of damages on both vehicles could provide a strong indication of who is at fault. Having the patrol investigator revisiting the accident scene results in resources being wasted, not to mention the frustration this can cause to the parties involved who have to wait for a longer period than necessary because of a basic but crucial oversight from the patrol investigator side.

Finally, while attending the training session with the trainer, we observed that he was surprised with two findings: one from a novice investigator (6 months) and another one from an experienced investigator (15 years). The novice when questioned about the accident scene drawing (required for stage 5 of an investigation as shown in Table 1) admitted that during the six months he had worked as an investigator he had not done a single drawing and usually the person more experienced assumed the role. This strengthens the call for a practical environment which the investigator can use regularly to exercise his knowledge away from the constraints of the real accident scenes. The other surprised finding emerged when the trainer asked for a volunteer to come to the front of the class to solve a virtual accident (this practice was suggested to see if the tabletop training method could be taken into the classroom – the suggestion was made in the group debriefing session described later in this document). The volunteer investigator showed similar underperformances to those exhibited by the subjects who took part in the experiment (discussed later in this document). For example as part of receiving the incident call the investigator should have asked seven questions (as shown in Table 1) but he only got the accident location. Additionally, when dealing with the witness the investigator should have inquired about seven things but he managed only two. These two isolated points with one subject do not merit any conclusion to be drawn. However, combining them with the results described later, we see that they are indicative of the type of commonly underperformed tasks.

FIGURE 1
(LEFT) THE TRUCK ON ITS SIDE; (RIGHT) TRUCK BEEN TURNED OVER WITHOUT TAKING CARE OF ITS GOODS RESULTIING IN SOME BOXES

VIRTUAL TRAFFIC ACCIDENT SCENARIO

We asked a trainer at Dubai Police to select subjects for the experiment who share the same training background. He selected six male trainees for the experiment who all had similar training backgrounds of four years of academy and two specialized courses in traffic accident investigation. The subjects were randomly divided into two groups of three who completed two experiments – the tabletop experiment (T) and the VE experiment (V) – for the same scenario. Group A did T, followed by V. Group B did V, followed by T.

Each experimental session involved five investigative stages for the subject to complete and marks were allocated to each successful task within a stage. In both environments actors were used to fulfil the role of the drivers and the operator in the operation room. Each actor was given a script to work from which included a description of the accident from the actor's perspective, answers to common questions, and his details. When using the scripting approach the obvious problem is that the trainee might ask questions that are not in the script and the actors needed to make up answers for them. We dealt with this issue in two ways: first by instructing each actor to reply with a common answer to questions not scripted when possible (e.g. I can't remember that), and secondly by monitoring the actor's answers and if during the dialogue with the investigator they had to make up an answer other than the instructed one then that answer would be added to the script for the next trainees' sessions thus preserving the consistency of each actor's narrative.

Figure 2 shows the scenario accident scene layout. It involves a crash between two vehicles resulting in one severely injured passenger and no injuries to the drivers. Both vehicles have leaked hazardous material at the scene. The investigator needs to collaborate with the two drivers and the operator in the operation room to attend and investigate the accident. The role of the drivers is to explain to the investigator what happened and answer any questions put to them. The role of the operator is to act as a stage manager to direct the scenario by initiating events based on time or trainee's request. For instance, when the trainee requests an ambulance for the injured or requests the removal of the vehicles from the road then it is the role of the operator to send the ambulance or the towing truck. To limit the number of actors required we decided to allow one of the actors to play the role of both the operator and one of the drivers. At the start of the scenario the trainee is given a unit number (i.e. police car number) to be identified with when communicating with the operator and this is how the actor who plays the two roles knows when the communication is targeted to the operator or the driver as the investigator normally starts a communication by relaying his unit number first.

We wanted to compare the trainees' performances when using both environments and to be able to do that we needed a scoring system which scores the individual tasks carried out by the investigator in the investigation process. There was no such scoring system currently used at Dubai Police and thus we have worked with experts in the domain to build the scoring system. The overall process of acquiring the domain knowledge which helped in allocating scores to individual tasks took two months during which we have used a series of knowledge acquisition techniques ranging from interviews, tasks observations, exercising the expert, to material analysis. We found that there are five commonly identified stages in any traffic accident investigation. Each stage has a number of tasks to be performed. Table 1 shows the five investigative stages and part of the scoring system developed. The part shown includes tasks related to the virtual scenario used in our experiment. The scoring system is a result of collaborative work between the trainers, quality officers, police station managers, and the authors.

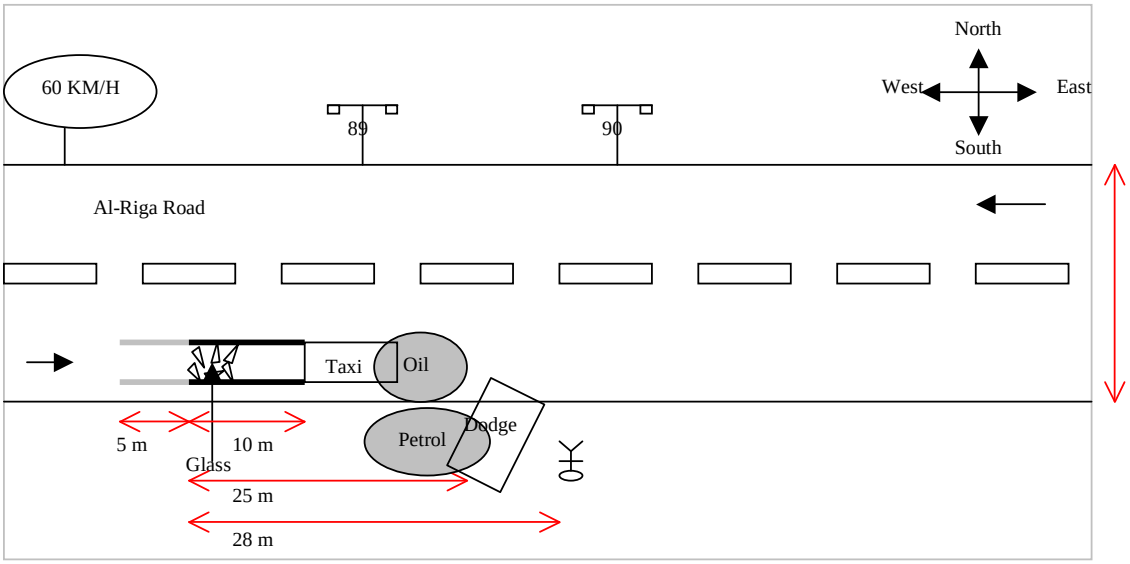

FIGURE 2
ACCIDENT SCENE LAYOUT

Stage	Task/s	Score
1: Receiving the incident call	Ask about the accident location, accident time, accident type, vehicles involved, traffic flow at the scene, and emergencies dispatched.	7
2: Arriving at the accident scene	*Attending the injured:* ask people at the scene about the injured, call appropriate emergencies, comforting the injured, and attempting to ask him questions if he is able to talk	4
	Requesting assistance from the public: ask if anybody saw the accident, ask who was the first person at the accident scene, ask if anybody provided help, and ask if any vehicles have moved from the accident scene	4
	Identifying the two danger sources (oil and petrol leakage)	2
	Securing the two danger sources	2
	Identifying the vehicles' drivers	2
	Identify the clues (glass and skid marks)	2
3: Conducting initial investigation	*Questioning the drivers: w*here were you coming from, where were you going to, which lane were you in, where is the accident point, what was your speed, how did the accident happen, was there anybody with you, and were there any witnesses	8
	Confiscating the driver documents	1
	Photographing the final rest place of the vehicles	2
	Photographing the vehicles from all directions	5
	Photographing the clues	2
	Measuring the distance of the vehicle rest place from the accident point	2
	Measuring the skid marks and the broken glass from the accident point	2
4: Finalizing the data collection	Identify who is at fault	1
	Identify the fault type	1
	Pinpointing the exact location with regards to a landmark	1
	Photographing the scene from an angle showing the whole scene	1
	Photographing the road condition	1
	Measuring the road width	1
	Requesting the appropriate authority to clean the road	1
5: Accident drawing form	Accident point	1
	Skid mark length	1
	Vehicles distances	2
	Injured distance	1
	Street width	1
	Distance of any landmark from the accident point, e.g. lamppost with a number on it	1
Total score		59

TABLE 1
SCORING SYSTEM

In the tabletop experiment (Figure 3) the user was presented with a 2D map of the accident scenario which had movable stickers on top of it that can be moved around the scene to represent each of the drivers, the injured person, and the vehicles. If the investigator, for example, wants to move somebody away from a danger zone he could move the representative sticker of that person to a safe location. The two actors required for the scenario sat across the table from the trainee. The operator controlled the moving of the stickers representative of the resources requested by the investigator such as the ambulance, and the towing-trucks.

FIGURE 3
TABLETOP SETUP

The virtual experiment setup consisted of three desktop machines networked together as shown in the left image in Figure 4. Each was equipped with a headset used for communications between the users in the environment. The trainee could use a joystick or the mouse and keyboard to navigate a shared virtual environment where he could see the other drivers' avatars. Figures 4's right image shows the user setup in the desktop environment and the centre image shows the virtual environment from the trainee's perspective.

Each simulation session started with a familiarization period where the trainee is introduced to the environment, shown how to operate it, allowed to practice in it and any question he had was addressed then. There was no time limit enforced on the familiarization period. Once the trainee was satisfied with how to operate the environment and how to collaborate with others the experiment session began. All

experimental sessions were videotaped and analysed afterwards to measure the performance. The trainee's performance was measured using two variables: the investigative score (Table 1) and the investigation duration.

FIGURE 4
LEFT: VIRTUAL EXPERIMENT NETWORK SETUP; CENTER: THE ACCIDENT SCENE IN THE VIRTUAL ENVIRONMENT; RIGHT: VIRTUAL EXPERIMENT

RESULTS AND DISCUSSIONS

We have measured two variables for the experiments: performance and time. The performance average is measured in percentage and the time average in minutes. Table 2 shows the groups results of doing both experiments where group A started with tabletop followed by VE and group B did them in the reverse order. In the following sections we will try to analyse the results and since the number of our subjects is small we compensate for that by comparing our results to the results of another experiment [6] conducted in the field of anaesthesia training. In this experiment they compared the use of a computer screen-based simulator against the use of a mannequin-based simulator. They ran the experiment with 40 subjects divided into two groups of 20 subjects each. One group ran the same scenario twice with a time gap between the two runs of one month, the second group ran two different scenarios again with the same time gap between the two runs. The second scenario of the second group was similar to the first group scenario.

Our results show that both environments manage to improve the trainees' performances on the second run of the scenario. Group A's performance average increased by 12.4% and group B's performance average increased by 8.1%. A similar finding backs this result from the anaesthesia experiment which also showed performance increases on the second run. In that experiment the mannequin-based simulator increased the performance by 7.3% and the computer-based simulator increased it by 17.6%. The average performance increase is 12.5% compared to our average increase of 10.3%.

Additionally, our results show that the time was reduced on the second run of the experiment. Group A's time average was reduced by 36.2% and group B by 54.2%. The average in time reduction is 45.2%. Again, contrasting this with the anaesthesia experiment we see that the time also shortened there. It was shortened by 29.6% on the computer experiment and by 36.5% on the mannequin-based simulator which makes the average reduction 33.1%.

Our earlier suspicion of the adequacy of the current training approach is confirmed when checking the average score of all the trainees. This score was below half of the maximum score one could obtain, which suggests that further training is still required, and perhaps in practical form. However, we have not found a significant difference in performance that could be clearly attributed to one method of training rather than the other. One group performed better in all tests than the other group. Such results could be attributed to the method of training as well as personal differences in the individuals in each group, which we have not accounted for. There is some indication that there is an advantage for one method of training over another according to the task required at a particular investigation stage, including better spatial awareness for VE subjects and better overall performance of the group that performed tabletop first and then VE.

	Group A	Group B
	Tabletop	VE
Stage 1 (%)	28.57	0.0
Stage 2	39.58	39.58
Stage 3	46.97	42.42
Stage 4	28.57	28.57
Stage 5	33.33	71.43
Performance	37.1	36.56
Time (minutes)	19.33	16
	VE	Tabletop
Stage 1 (%)	28.57	0.0
Stage 2	47.92	45.83
Stage 3	66.67	57.58
Stage 4	42.86	33.33
Stage 5	47.62	71.43
Performance	49.46	44.62
Time (minutes)	12.33	7. 33

TABLE 2
RESULTS

We held two types of debriefing session after the experiment, an individual debriefing and a group debriefing. The individual debriefing was conducted on one-to-one basis between the trainee and one of the authors at the end of the experiment session. The aim of this debriefing was to get general feedback of the two types of training, recommendations for improvements, and difficulties faced when using the environments. The group debriefing was conducted on another day and two trainers were invited to attend as

well. The aim of this debriefing was to engage the trainers and trainees in an open discussion about the trainees' experiences of the two environments and what worked for them. We also wanted the trainers to see if there is anything they can take with them to the classroom. One of the six participants failed to attend the group meeting. All debriefing sessions have been videotaped.

One of the trainers who attended some of the sessions gave the following remarks regarding the tabletop experiment (all the remarks quoted here have been translated from Arabic). "The benefit of using it is big since we only give theoretical training in our courses, but here in this experiment although the trainee might have been immersed for about 30% only he still has to do the tasks sequentially and the performance can be measured and any weaknesses identified at different stages of the investigation". One of the trainees remarked the following about the overall experience: "I preferred the computer experiment because I managed to see things and live the incident more" " I think I concentrated more during the computer experiment because I managed to walk around and examine the details more closely". Two other trainees subscribed to this remark. One trainee observed that the tabletop experiment added a burden of imagination on the tasks since the scene is not as detailed as the computerized virtual environment.

Given the small number of participants in the experiments the results can only be considered indicative and make us question the costs and effort of using a VE for training as a replacement for tabletop exercises. They may only be justifiable in some cases. Finally, the overall performance and time reduction indications seem to match the results presented in the anaesthesia experiment. In the next section we describe some of the improvements we are working on to strengthen the need for a virtual environment.

CONCLUSIONS AND FUTURE WORK

We had two aims for the work presented here. The first was to examine the current training practice employed at Dubai Police to train traffic investigators and find a way to automate it and possibly improve it. The second aim was to compare two training methods to see if there is a justification for using a costly virtual environment compared to the less expensive use of a simple tabletop environment. The results show that both environments have improved the trainees' performances and shortened the time it takes to complete the tasks. Furthermore, it has shown the trainers that an alternative environment to the on-the-job supervised training can be adopted and it is practical to measure the trainees' performances. Our future work will concentrate on investigating the different factors that could justify the need for a virtual environment. One issue we have started working on is automating the role played by the actors and the trainer to make the system fully automated. We are also looking at building a system which records each trainee and suggests different scenarios based on any training weakness identified.

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