DEVELOPING THE SITUATIONAL AWARENESS OF INCIDENT COMMANDERS: EVALUATING A TRAINING PROGRAMME USING A VIRTUAL SIMULATION

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ABSTRACT

Life, property, and the effectiveness of efforts involved in saving the environment depend upon the situational awareness of incident commanders. However, so far, the impact of situational awareness training for working rescue incident commanders has not been studied in Estonia. This study aims to evaluate situational awareness training that has currently been implemented as an overall part of the dynamic decision-making model for all rescue incident commanders in Estonia. The new training curriculum, plus training materials and methods, were developed for situational awareness training using the virtual reality software, XVR On-Scene, and the Moodle e-learning environment. Assessors were trained and certified to apply the effective command behavioural marking framework to measure situational awareness. The Kirkpatrick training programme evaluation model was adopted to measure the SA training outcomes. Based on the Kirkpatrick model, Level 1 trainee reactions indicated that Estonian rescue incident commanders were able to accept a new approach to their decision-making training as a purposeful and engaging way of completing their attestation. Their basic psychological needs were supported during the training process, and participants achieved higher-than-threshold results in all SA levels, as is shown in Level 2 of the Kirkpatrick model. Training programme evaluation model Level 3 behaviour, and Level 4 results, need to be further studied. Suggestions have been provided in improve the virtual simulation-based training and assessment of situational awareness.

INTRODUCTION

Rescue incident commanders (henceforth referred to as ICs) are first responders. They need to make independent and effective decisions in time-critical and life-threatening situations (Allas *et al,* 2018). The fact has been highlighted in several studies that decision-making experiences which ICs gain from their work are limited, and the consequences of dynamic decision-making can be life-threatening (Cohen-Hatton, Butler and Honey, 2015; Lamb, Boosman, and Davies, 2015). Endsley stated that '*Situational awareness is knowing what is going on around you*' (Endsley, 2000). The situational awareness of ICs (with situational awareness henceforth being referred to as 'SA') can determine the chances of survival both of rescuers and those they are rescuing, as well as the extent of property and environmental damage. An SA has three levels: perception, comprehension, and projection (Endsley, 2000). To be able to train and assess SA levels is a complex task. ICs with good levels of SA can produce safer decisions if they have previously practiced dynamic decision-making while using virtual simulations (Williams-Bell *et al,* 2015). To train and assess SA, realistic rescue events can be represented using various virtual simulations (Polikarpus, Bøhm, and Ley, 2019).

The Estonian Rescue Board, together with the Estonian Academy of Security Sciences (henceforth referred to as the EASS), has developed and implemented working SA training and assessment for ICs to ensure better decision-making. All tactical level incident commanders in Estonia take part in the training programme. The aim of the study is to evaluate the situational awareness training as part of the dynamic decision-making training and assessment programme that is being implemented for rescue incident commanders. The training and assessment programme's evaluation work is carried out based on Kirkpatrick's well-known and long-used four level model which consists of levels covering trainee reactions, learning, behaviour, and results (Kirkpatrick and Kirkpatrick, 2006, p. 21). The same model was recently used to evaluate a simulator-based ambulance driver training day (Prohn and Herbig, 2020), and therefore is well suited to the needs of the current study.

Until 2016, the annual assessment of working ICs in Estonia was carried out by using a multiple-choice question format. Dynamic decision-making skills and SA as part of this was not something that was provided for in training and neither was it measured. During 2016, the student-centred training programme was developed with the aim of training and assessing IC decision-making skills. As part of the new training programme, the SPAR decision-making model (which stands for Situational awareness, Plan, Action, Review) was introduced (Launder and Perry, 2014). The SPAR dynamic decision-making model helped to train and assess SA using virtual simulation.

Virtual simulation-based training is considered to be a flexible, student-centred way of training internal security staff for joint response actions to accidents (Põder, Savimaa, and Link, 2015). Training and assessment of and for dynamic decision-making skills could be carried out using virtual simulations (Lamb, Boosman, and Davies, 2015). Endsley, the author of the SA construct, advises on the use of simulations to measure SA levels (Endsley, 1995a). At the same time, not enough empirical studies have been carried out that show how the use of virtual simulations improves learning (Girard, Ecalle and Magnan, 2013). There is lack of guidance regarding how to integrate a virtual simulation-based SA training systematically into IC training.

Effective use of virtual simulations to improve SA training requires it to be integrated systematically into an approach to training and assessment. Therefore, our research question is how can situational awareness training be provided to ensure different levels of situational awareness as part of dynamic decision-making training using virtual simulations? In order to address this question, we first give an overview of the development of the training programme. Then, we evaluate outcomes of the programme that used the e-learning course, the XVR On-Scene virtual simulation software, and the effective command behavioural marking framework to be able to train and assess SA as part of the dynamic decision-making process.

1. SITUATIONAL AWARENESS

Models are required to be able to carry out decision-making training. '*Specific kinds of expertise requires specific mental models that are assumed to develop over time and with experience*' (Chermack, 2003, p. 416). Until now in Estonian Rescue Board incident command documentation, use has been made of the decision-making model that is known as 'Observe, Decide, Command and Control' (in Estonian, this is LOKK: *Luure, Otsustamine, Käsklemine, Kontroll*). There are several other decision-making models that are available, such as, for example, OODA ('Observe, Orientate, Decide, and Act'), or DOODA ('Dynamic OODA'), or FORDEC ('Facts, Options, Risks (or benefits), Decide, Execute, and Check'), or FADCM ('Factfinding, Analysis, Decision-making, Communication, and Monitoring') (Groenendaal, 2015, pp. 58–59). However, none of them includes SA. Therefore, as part of the new training programme for working ICs in Estonia, the selection was made of SPAR ('Situational awareness, Plan, Action, Review') (Launder and Perry, 2014) to be used for training and assessment in terms of SA.

The creators of the SPAR model identified five key dynamic decision-making behavioural elements: 1) Situational awareness; 2) Decisions; 3) Plan; 4) Action; 5) Review. They claim that all these behaviours are associated with effective command competence in urban fire settings (Launder and Perry, 2014). The effective command behavioural marking framework assesses all of these behaviours (Lamb *et al,* 2020).

Endsley defines SA as: '*the perception of the elements in the environment within a volume of time and space, comprehension of their meaning, and the projection of their status in the near future*' (Endsley, 1995a). The measurement of SA depends upon the circumstances, time, place, and person (Endsley, 1995b). In this article, we focus only on first behaviour in the SPAR dynamic decision-making model in regard to SA. The SA levels are as follows: Level 1 covering information collection by ECs, or Endsley names perception; Level 2 covering comprehension in ECs; and Level 3 covering evaluation by ECs or prediction (Endsley, 2000).

Situational awareness as part of dynamic decision-making training is important for all first responders, as they need to make decisions in highly challenging environments and high stakes situations under considerable time pressure (Cohen-Hatton, Butler, and Honey, 2015). In such situations, it is not only the responders themselves who are at risk, but also members of the public, plus property and the environment. SA is indispensable in the decision-making process (Endsley, 1995b). Unfortunately, dynamic rescue incidents always bring with them high levels of risk for the participants, so they cannot be systematically used to train SA.

2. RESCUE INCIDENT COMMANDER TRAINING IN ESTONIA

The SA construct was not used in Estonia rescue service until the year 2016. Tactical level rescue ICs in Estonia are referred to as 'rescue unit leaders' and 'rescue leaders'. There are vocational occupation standards for both of the jobs, having been developed in 2013 and updated in 2018 (Kutsekoda, 2020). In 2018, there were 409 ICs working in shifts that provided cover twenty-fours hours a day and seven days a week (Tammik, 2019). All tactical level rescue ICs in Estonia are male.

Before 2016, the command knowledge of ICs in Estonia was assessed every year using computer-based multiple answer tests. For IC trainers in the EASS, it seemed that this form of attestation was not especially motivating or engaging for commanders. Based on research, we know that if the psychological needs of trainees are fulfilled (covering areas, such as autonomy, competence, and relatedness) then the trainee in question will feel motivated and engaged (Ryan and Deci, 2000), with higher motivation and engagement levels supporting the learning process (Knight, 2016). Therefore, the new training programme for practising and measuring dynamic decision-making, which includes SA, was developed based on three principles. Each rescue IC in Estonia should have an opportunity to take command at an incident within a virtual simulation. Virtual simulation can be used to create time pressure and high stakes situations for ICs, providing engaging learning experiences (Polikarpus, Bøhm and Ley, 2019). To implement, this the widely used XVR On-Scene virtual reality software was selected (henceforth referred to as XVR OS) (XVR Simulation, 2020).

Secondly, the decision-making skills of each rescue IC should be assessed based on a virtually simulated incident command. In order to be able to implement this, the effective command behavioural marking framework was selected as an assessment tool (Effective Command, 2020). The framework was developed to align with the UK National Fire Service competency role maps (Fire Central Programme Office, 2020). This is used in several countries in Europe, such as, for example, the UK, Portugal, France, and Italy (Lamb *et al,* 2020).

Thirdly, the e-learning platform for all ICs in Estonia should be applied in order to bring together theory, documentation, and computer-based testing of knowledge. To be able to implement this, Hitsa Moodle was selected (Hariduse Infotehnoloogia SA, 2020).

Based on three earlier-named principles, the student-centred training programme known by the name 'Training and Assessment Day' (henceforth referred to as TAD) was developed in the year 2016. The aim of TAD is to evaluate whether the command competence of working ICs was at the level required by a 'Rescue Unit Leader' in terms of the occupational qualification standard (Polikarpus, 2016). This is targeted towards a tactical level working IC across the entirety of Estonia. We hereby explain the design steps used in TAD.

1) Mapping the EC with the Level 5 vocational occupation standard required for a rescue unit leader. From the mapping perspective, it was concluded that the EC measures only those commanding competences that are based on the SPAR decision-making model.

2) EC licences were purchased for the web-based tool and for assessor training. The EC assessment tool divides SPAR into eight sections, with SA having three subsections: 1) information gathering; 2) comprehension; and 3) evaluation. Every section has nine criteria, which are assessed on a sliding scale of five points, from dark red to dark green. The yellow in the middle refers to the threshold. The EC tool scale is positioned on yellow (3), in the middle of the five-point scale (see Figure 1). The dark red (1) and light red (2) are seen as providing an under-achieving learning outcome, and the light green (4) and dark green (5) are seen as providing an over-achieving learning outcome (Effective Command, 2020).

Assessor training was carried out first in English and later in Estonian. To be able to start to work as assessor, it was obligatory to take part of XVR OS user training together with work experience from incident command situations. All of the assessors are certified and re-certified by the EC organisation on an annual bases (Effective Command, 2020). The certification process is required to ensure competence in external evaluations for assessors, and it also ensures the validity of the assessment instrument and the reliability of the assessments themselves.

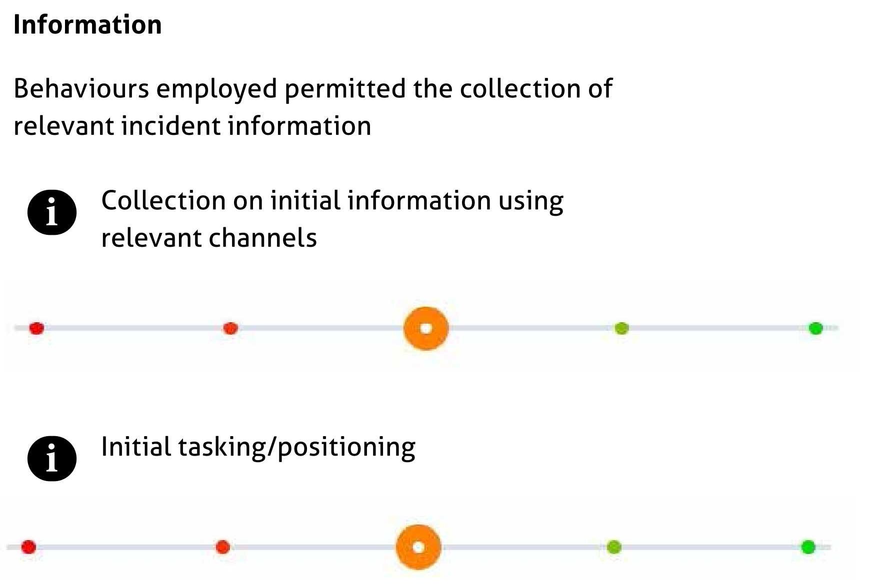

FIGURE 1: The scale used in the framework assessment tool for effective command behavioural markers.

3) Assessment scenarios are composed on the XVR OS platform. It is a challenging and time-consuming task. Each year, twelve new scenarios need to be created. In EASS-implemented pair-authoring, a seven step procedure is required to build assessment scenarios. First, the scenario map is presented to start the procedure of building and each scenario are drawn up in the form of the XVR OS fail and scenario user manual. The procedure ensures that the XVR OS fail and storyline comply with the EC framework and that the virtual simulation is as authentic as possible.

4) The TAD training curriculum was written out (Polikarpus, 2016). The curriculum was coordinated with the Estonian Rescue Board and the EASS additional training centre.

We now explain the TAD implementation. First TAD was completed on 4 April 2016. Last TAD included in the study was carried out on 21 February 2020.

1) The TAD started with a ninety minute lecture in which an SA construct was discussed with a group of four trainees.

2) The training scenario lasted for ninety minutes. Joystick exercises and full dynamic play of the training scenario was carried out in the form of one-to-one training.[1]

3) The formal assessment was carried out over the course of between 90–120 minutes. Two certified assessors handled the SA assessments in three phases: a) a dynamic assessment phase in which one assessor took on the roll of a technical instructor who was manipulating the XVR OS software. The other provided voices for avatars and checked that important changes in the situation were played out based on the scenario user manual. In this phase, the ICs review of the situation is tested to make sure that the IC in question can update their SA throughout the incident response. The virtual simulation allows the IC to execute their incident response plan. The dynamic phase ends with the IC's higher level commander arriving on scene. The trainee provides an overview of the situation to an assessor so that their SA can be checked. Phase b) involves a feed-forward conversation between the trainee and their assessors. The aim of the reflective dialogue is to find out how the IC themselves evaluate their SA in the response phase. Phase c) is when the EC certificate is filled out by both assessors. This is submitted to the EC database after the assessors have jointly marked each assessment criteria.

4) Formal assessment results are sent to the Estonian Rescue Board. There are three summative assessment outcomes that are coded by colour: green means excellent, yellow means threshold, and red means under the threshold. An IC who achieves a green summative assessment result is assessed again after a space of three years, while a yellow result will mean a reassessment after two years, and a red result means a repeat assessment at a point between just six months later and a year.

After piloting the TAD in spring 2016, trainee feedback and learning was analysed and the following changes were made to the programme:

1) The TAD curriculum was changed from six contact classes to a course lasting 52 hours, because it became clear that more theoretical input is needed for any implementation of SPAR and SA. There were a total

[1] The training scenario being used is fully described in article: 'A training incident commander's situational awareness – a discussion of how simulation software facilitates learning' (Polikarpus, Bøhm, and Ley, 2019).

of eight threshold-level-phrased learning outcomes for each EC section (Polikarpus, 2016). Three learning outcomes were related to SA (Polikarpus, Bøhm and Ley, 2019).

2) An e-learning course was developed to support preparation for TAD, utilising Hitsa Moodle. The e-learning materials were designed for 46 hours of work. The e-learning course is targeted at rescue unit leaders. However, it is suggested that rescue leaders also take part.

3) The re-assessment curriculum for ICs was developed for ICs who had already been assessed once. It covers four academic hours and has the same SA learning outcomes and e-learning course (Polikarpus, 2017).

Since 2019, the six hours curriculum has been stopped because all of the ICs in Estonia had already completed it. Only the re-assessment curriculum is now being used in EASS for the attestation of Estonian tactical level ICs.

To be able to evaluate SA at different levels of training as part of the implemented dynamic decision-making for rescue incident commanders during TAD, we conducted the study based on the Kirkpatrick training programme evaluation model.

3. METHODOLOGY AND DATA COLLECTION

To be able to evaluate the effectiveness of TAD, Kirkpatrick's well-used training programme evaluation model was used, which has four levels: Level 1 covers trainee reactions; Level 2 covers learning; Level 3 covers behaviour; and Level 4 covers results (Kirkpatrick and Kirkpatrick, 2006, p. 21). A literature review regarding the implementation of the Kirkpatrick model claims it to be suitable for the evaluation of any training programme from two perspectives: organisation when implementing training; and those members of staff who will participate (Smidt *et al,* 2009). We report the views of TAD participants in the years 2016–2020 and our sample covers entirely tactical-level rescue ICs in Estonia.

The Level 1 trainee reactions can, typically, be measured by allowing them to complete a post-training evaluation to discover their impressions of the programme (Smidt *et al,* 2009). To measure trainee reactions, we asked the following questions, starting with: how purposeful and challenging is SA training during TAD when SPAR and virtual simulation is used? An additional question covered: how engaging and motivating is TAD for ICs?

To evaluate trainee reactions to TAD, use was made of survey results covering anonymous training feedback from 2016–2020. There are twelve predefined multiple-choice questions available, with the option of being able to add personal comments to each question (see Table 1). This was sent to the official e-mail addresses of ICs after they had participated in TAD. Altogether 196 responses were received via LimeSurvey. Unfortunately, not all ICs responded. After the full sample of ICs in Estonia had at least one opportunity to participate in TAD, the study bases for the master theses were undertaken (Tammik, 2019). The study worked out the engagement and motivation levels for trainees during TAD. The research proves that learning is supported by ensuring high engagement levels with trainees, along with fulfilling their basic psychological needs (Ryan and Deci, 2017). Therefore, in this paper, the study is referred to as the engagement and motivation study (see Table 1). The sample basis for the study was a total of 393 ICs, all of whom had participated in TAD at a point between 2016–2018. The anonymous self-reported web-based

Estonian language survey via LimeSurvey was sent to ICs via their official work email addresses. The survey had various parts that needed to be completed and which evaluated motivation, engagement, the purposefulness of TAD, and the difficulty level of the scenarios (see Table 1). No comments could be added to the statements. A total of 224 respondents correctly filled out their responses and all of these were collected. Not all data from the study is presented in this paper. The study as a whole can be found in the master theses (Tammik, 2019).

The second level of the Kirkpatrick model is learning (Kirkpatrick and Kirkpatrick, 2006). On that level, measurements that are used to quantify learning include knowledge tests or skills demonstrations in the form of roll-plays (Smidt *et al,* 2009). We asked whether ICs in Estonia where able to learn about SA at different levels during TAD.

Evidence that ICs have indeed learned about SA were collected from two sources: EC formal assessment results and e-learning course test results (see Table 1). Formal assessment results were downloaded on 28 February 2020 from the EC database. There were altogether 533 formal assessment certificates in the dataset from between January 2017 and February 2020. The reason for such a high number of such record in the EC is that several commanders had been assessed twice. Formal assessments included (in Table 1) a total of 305 one-off formal SA assessment results and 114 that were assessed twice. Formal assessment results from 2016 were not included in the study. It should be remembered that EC measures are included in coloured scoring for all five of the key-behaviours of dynamic decision-making. The summation assessment outcome colour takes into account all eight parts of the assessment. However, in the current study, only the first three parts of the EC are reported upon. Formal assessment SA levels in EC are measured with nine assessment criteria on the five-point scale (see Figure 1, above). If five points (using the dark green colour) are marked out in each criterion, this means that the assessment results in a straightforward score of one hundred points on that level. If one point (in the dark red colour) is marked out in each criterion, a total of twenty points are still awarded in the overall assessment result for that SA level. Yellow, in the middle of the scale, is a threshold (Figure 1). If all of the criteria are left unmoved, a total of sixty points are calculated for the overall score. The ‘excellent’ SA level starts from a score of seventy points.

TABLE 1: Kirkpatrick model levels and the measurement instruments that were used.

Kirkpatrick evaluation levels	Measurement instrument	Data collection	Example statements or questions
Level 1: reactions	The engagement and motivation study based on self-determination theory. 224 respondents (Tammik, 2019)	Anonymous survey via LimeSurvey in year 2019. Parts of the used survey: 1. Autonomy need: measured with 6 statements in scale 1–7. Adopted from (Williams and Deci, 1996); 2. Competence need measured with 6 statements in scale 1–7. Adopted from (Jang, Reeve and Deci, 2010). 3. Relatedness need measured with 4 statements including 2 reversed ones in scale 1–7. Adopted from (Chen et al., 2015) 4. Engagement during TAD was measured with 12 statements, including 3 reversed ones in scale 1–7. Adopted from (Knight, 2016, p. 147)	1. "I felt assessors gave me choices" "I felt during the assessment that assessors understand me." 2. Choose on the scale to fit: (1) "TAD was an incomplete learning experience" and (7) "TAD was a perfect learning experience." 3. "I felt assessors were friendly" or reversed statement "I felt my communication with assessors was superficial." 4. "I paid attention during TAD" and reversed statement "I felt often disappointed during TAD"
	TAD feedback survey 196 respondents	Anonymous survey via LimeSurvey in years 2016–2020. There were 12 predefined answers questions with the possibility to add comments to each question.	"On what level you were engaged while responding to the incident in the virtual simulation?" "Did assessors' competence meet your expectations?"
Level 2: learning	533 EC assessment results	EC framework based formal assessment results from January 2017 – February 2020. Each SA level is scored from 20 to 100.	533 certificates were downloaded from the EC database. (28.02.2020.)
	Moodle situational awareness self-check test 672 completed test attempts	6 multiple choice questions in the SA self-checking knowledge test on Hitsa Moodle platform. Correct answer gave one point per question. All questions had four choices.	See Table 4 below for questions asked in the test. A number of correct answers for question 1 to 4 and 6 were three. Question nr 5 had one correct answer.

Level 3: behaviour	114 EC assessment results	Two times TAD participants formal assessment results. See above in this table.	See above in this table.
	TAD feedback survey 196 respondents	See above in this table.	"On what extent the response to the incident using virtual simulation developed your commanding competences?"
Level 4: TAD results were not analysed based on Kirkpatrick			

SA self-checking test results were downloaded from the Hitsa Moodle platform on 30 April 2020 (Table 1). One trainee could do the test as many times as they liked without a time limit being imposed. There were a total of 672 completed test attempts.

The Level 3 behaviour in the Kirkpatrick model measures trainee ability in the use of newly learned knowledge or skills in the workplace, and Level 4 results evaluates the overall process, including any financial or moral impact of training (Smidt *et al,* 2009). As stated in the introduction, assessing SA is a complex task. Due to this, it is very difficult to make any claims on Levels 3 and 4. Nonetheless we did ask whether TAD served to develop the command competences of ICs, and whether there was a significant change between two different SA level assessments.

We used a total of 114 formal IC assessments from between 2017–2020 for those ICs who had participated twice in TAD so that we could measure any potential behavioural change. The SA level means that the results from two separate assessments were compared. In the TAD feedback survey, the question was asked regarding competences development (see Table 1). This allowed trainees to subjectively report TAD effects on the behavioural level. The Kirkpatrick Level 4 results which measure overall training impact, including financial or moral impact, are outside the scope of this study. Table 1 presents the measurement instruments and datasets that were used for the TAD evaluation, based to the Kirkpatrick training evaluation model.

When it came to handling the data, descriptive statistical analyses were carried out using Microsoft Excel. Variables were described in terms of percentages or by the usual means and standard deviations. Formal SA assessment results were analysed using a single-factor ANOVA test, while for any *post hoc* testing the paired T-test was used.

4. RESULTS

Based on the Kirkpatrick model, when it came to evaluating trainee reactions to TAD, we asked how purposeful and challenging was SA training during TAD when SPAR and virtual simulation is being used.

IC reactions to TAD clearly indicate that 90% of trainees see the new form of attestation as being a purposeful and positive change (see Figure 2), while 97% saw the e-learning course as being useful. Unfortunately, no research has been carried out in regard to how purposeful ICs thought the computer-based multiple-choice tests would be for their command competence attestation. Altogether, a total of 202 individuals (or 90%) evaluated the use of virtual simulations as being purposeful or rather purposeful (see Figure 2). The purposefulness of using SPAR differed by only one individual, resulting in a total score of 203 individuals or 91%. Only four commanders did not consider the virtual simulation to be a

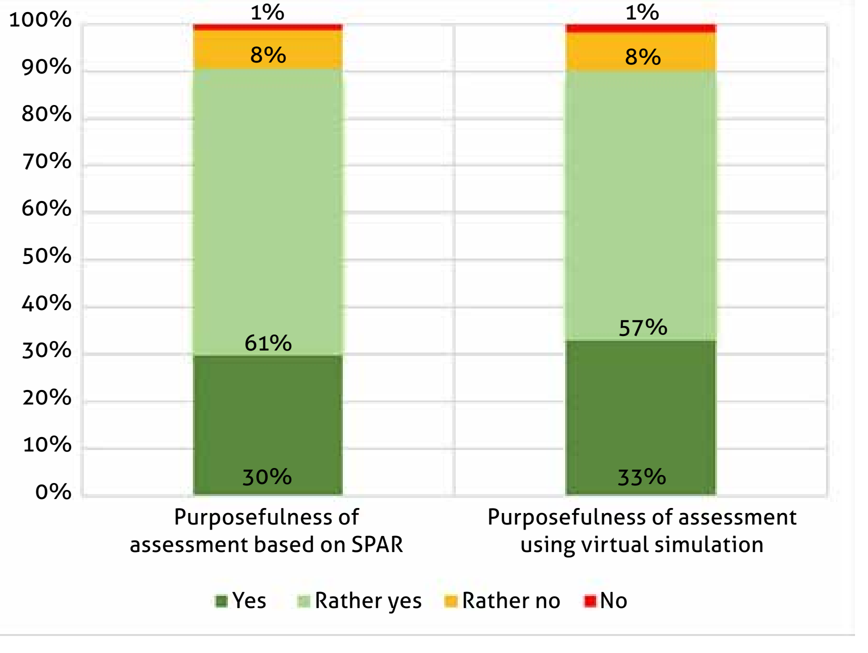

FIGURE 2: The purposefulness of the assessment method (self-reported; N = 224).

purposeful environment in which to carry out assessments, and three did not find the SPAR to be useful for assessments. In the TAD feedback survey, one IC commented on the purposefulness of the test: '*There is the possibility of being able to experience in a very short time various incidents in the simulation which could develop much more than just theory alone instead of simply providing a stock range of exercises. At the same time, any potential weak spots can be uncovered which require further development', while others stated: 'It was quite close to real life*'.

From 2017 onwards, an extra question was included in feedback survey regarding the e-learning course in Moodle. Only those ICs who had first indicated that they had been on the course and had been questioned about the usefulness of that course were asked the new question (N = 85). The e-learning course was stated to have been very useful a total of twice 39 times (46%) out of a total of 85 answers, and rather useful 43 times (51%). One person (1%) said it was rather useless, and two (2%) said it was completely useless.

If we looked at the reactions of other trainees to TAD using feedback survey responses (N = 196), it was encouraging to see that 92% (180) indicated that they did receive feedback from the assessors in regard to their SA. Even so, a total of 7% (fourteen) were not sure they had received any feedback about their SA, and two (1%) said they did not get any feedback at all from their assessors. Comments on the feedback that was provided included the following responses: '*A discussion following the dynamic phase of the incident response helped to find bottlenecks, and I received suggestions which would be useful in my own future development*'. Furthermore, 76% (149) of trained ICs indicated that the competence levels of the assessors fully met their expectations during TAD, and 21% (41) said it 'rather' did. Only the expectations of four individuals in regard to the competence levels of their assessors were classed as rather not having been met (2%), and two stated that the assessors did not at all meet their expectations.

In addition, Estonian ICs found a degree of challenge when it came to solving the virtual simulation-based scenarios. The self-reported TAD participants (N = 224) indicated on a scale of 1–7 that the response to the incident in the virtual simulation (M = 4.79; SD = 0.98) was slightly more challenging for ICs than were the scenarios for the incidents (M = 4.70;

SD = 0.97). In the TAD feedback survey (N = 196) half of the participants (53%; 104) said that the difficulty levels in the scenarios in the virtual simulation suited them, and 65 (33%) reported that it was rather difficult for them. It was commented upon that the virtual simulation made it somewhat challenging to gather information.

A second question we asked to be able to evaluate trainee reactions to TAD was how engaging and motivating the TAD was for the ICs.

Based on the engagement and motivation study, ICs found TAD to be engaging (M = 5.43 out of seven), and their psychological basic needs (autonomy needs of M = 5.77; competence M = 6.03; and relatedness M = 6.16, all out of seven) were well met (see Table 2). This means that their study-motivation levels were high during TAD. The engagement and motivation study that was used in the Survey 4 sections could be marked on a scale of 1–7. Firstly, an average was calculated for each participant's answers in every part of the survey. The overall mean and standard deviation for engagement and psychological needs is presented in Table 2.

TABLE 2: Engagement levels and psychological needs during TAD.

Part in study	Self-reported means (N=224)	Standard Deviation
Engagement	5,43	0,78
Autonomy need	5,77	1,13
Competence need	6,03	0,91
Relatedness need	6,16	0,99

We could conclude from Table 2 that all three psychological needs (autonomy, competence, and relatedness) are well met during TAD. The TAD feedback survey conforms well with this conclusion (N = 196). In regard to the question: '*On what level were you engaged while responding to the incident in the virtual simulation?*', a total of 148 participants (76%) responded with the following: '*I was fully engaged while responding to the incident*'. The answer was: '*I was partially engaged while responding to the incident*', was given a total of 44 times (22%), and the answer: '*I was not at all engaged while responding to the incident*' was ticked only by four persons (2%).

From the reactions of trainees, it could be concluded that the new training curriculum has been accepted very well by working ICs in Estonia. Trainees feel that their basic psychological needs (autonomy, competence, and relatedness) are being met during TAD. They showed positive reactions towards the new training programme, including e-learning and trainer competence and feedback received following their SA. The new training methods and tools being used for SA training were engaging for them.

Based on the Kirkpatrick model to evaluate trainee learning, we asked whether ICs in Estonia were able to learn about SA at different levels during TAD? To answer this, we analysed the formal assessment and the e-learning course self-check test results.

We wanted to evaluate whether all three SA levels are successfully being taught during TAD. Therefore, we have reported on the mean SA level assessment results in Table 3. Means and standard deviations were calculated for all ICs in Estonia, taking their last assessment result into account (the second column in Table 3).

TABLE 3: Average scores for situational awareness levels in rescue incident commanders.

Endsley SA levels	All ICs last assessment mean and SD (N=419)	ICs assed once mean and SD (N=305)	ICs assessed twice mean and SD (N=114)	
			First time	Second time
SA level 1: perception	68,50 (8,04)	69,39 (8,27)	67,78 (9,32)	66,11 (6,88)
SA level 2: comprehension	67,60 (8,38)	68,56 (8,61)	65,24 (10,72)	65,02 (7,13)
SA level 3: prediction	65,74 (8,98)	66,61 (9,39)	62,40 (10,60)	63,40 (7,32)

Firstly, we asked whether the assessment scores were valid indicators to allow a claim to be made that ICs have been taught in all of the SA levels. Based on learning outcomes in the SA levels and on previous IC training, we hypothesised that ICs with SA-level comprehension are better at collecting together the required information (at SA Level 1) than they were in predicting the situation (SA Level 3). In Table 3, we can see that the average score for SA Level 1 is 68.50, while the SA Level 2 average is 0.9 oints lower, and the SA Level 3 average is 1.86 points lower than the SA Level 2. SA levels 1 and 3 differ from each other by a total of 2.76 points. As well as this, a growth of SD could be observed. Thanks to the average results being ascertained, the variety of gaps between the different SA levels could be seen in the expected order. To be able to find out whether the differences were significantly important, an ANOVA test was carried out in Excel. The results of a single-factor ANOVA test on the most recent assessment of all Estonian ICs (N = 419) indicated that there is a statistically significant difference between the averages for different SA levels ($F = 11.54$, $p < 0.001$). Post hoc paired t-test results fell between SA levels 1 and 2: $t = 3.02$; $p < 0.003$; SA levels 2 and 3: $t = 6.90$ $p < 0.001$; and SA levels 1 and 3: $t = 8.58$; $p < 0.001$. ANOVA and post hoc tests confirmed that there is a statistically significant difference between the different SA levels. Analyses of formal assessment results showed that EC formal assessments are valid when it comes to measuring all three SA levels.

Additionally, we asked how good an SA level did ICs in Estonia have according to their formal assessment results. Earlier, under data collection conditions, the coloured scoring in the EC framework was explained. Compared to the threshold in the summative assessment results, all three means for SA levels are on the threshold. None of the SA level means are at a level that could be considered excellent in the EC framework (seventy points). Because all three SA level means exceeded the threshold of sixty points, we can conclude that training for three SA levels is being provided during TAD at least at a level that provides a reasonable learning outcome. Previous training for ICs and the use of the decision-making *LOKK* model which was used in incident command guidelines could explain why there are significant differences between the scores being achieved for SA levels 1 and 3. For example, until 2016, a dynamic risk assessment was not supplied as part of the training programme. Furthermore, a dynamic risk assessment at an incident plays an important role in predicting the development of the situation.

To be able to measure theoretical knowledge in relation to the SA construct, the Moodle test results were used (Table 4). The test-taking times for trainees varied from just a minute to more than a year. Out of 672 test results, 620 attempts were made which took less than fifteen minutes, while 484 took less than five minutes, and 248 less than three minutes. Self-checking test attempts showed that 205 trainees took the test just once and 164 took it more than once in the years 2016–2020. The average score for one-time test-takers out of the six-point multiple-choice test was 5.53. Trainees who have taken the test several times have done so between two and thirteen times. The maximum score had been achieved 218 times. After taking the test, trainees could see their overall rating and their correct answers for each question. There was no threshold for the test. The minimum score for one-time test-takers (N = 205) was 2.62, and test-takers who took part in the test several times made 467 attempts with a minimum score of 2.29. From the test attempts that have been logged, we argue that those ICs who got lower scores tended to retake the test. This highlights the importance of feedback in the learning process.

In Table 4, all the average and standard deviations for each question can be seen, complete with overall test results. The question: '*When you start to construct your SA*', had the lowest mean (M = 0.763). This is a disputable question in the test because, before the SPAR model was implemented, ICs were trained to carry out a 360 degree reconnaissance as part of the *LOKK* decision-making model (see Chapter 1). However, in the test scoring that answer did not provide any points because the entire SA construct was associated purely with 360 degree reconnaissance. The SA construct is more than simply carrying out a 360 degree reconnaissance, and this was the reason that the start of the SA was not associated with carrying out a 360 degree reconnaissance alone.

From the self-check tests and formal assessments, we were able to conclude that TAD has helped not only in terms of learning the SA theoretical concept but has also aided in the implementation of all SA levels during virtual simulation-based assessments.

As stated previously, evaluating the TAD in relation to the Kirkpatrick levels 3 and 4 is rather difficult, and TAD results for participants could not be measured because the SA levels are challenging if not impossible when it comes to measuring them in the real life work of ICs. However, based on the Kirkpatrick model in terms of evaluating trainee behaviour, we asked whether TAD had served to develop IC command competences,

TABLE 4: Knowledge test results for self-checking one's situational awareness.

Questions in the SA self-checking knowledge test	All attempts Mean and SD (N= 672)	Mean one-time test-takers (SD) (n = 205)	Max	Min
1. When you start to construct your SA?	0,763 (0,281)	0,743 (0,288)	1	0
2. When you start your shift what you do for your SA?	0,936 (0,164)	0,942 (0,150)	1	0
3. What are the levels of SA?	0,953 (0,153)	0,968 (0,119)	1	0
4.From whom IC can ask information?	0,915 (0,164)	0,908 (0,159)	1	0,33
5. What needs to be done if you have received the information you do not understand?	0,969 (0,174)	0,990 (0,099)	1	0
6. Why is it important to predict the situation development?	0,968 (0,118)	0,976 (0,098)	1	0

and was there a significant change between the assessments of SA levels for two-times takers?

TAD has served to develop IC command competences. This can be seen in the feedback survey (N = 196) with a figure of 95 (48%) of TAD participants indicating that they felt training helped to develop their command competences enough so that they were able to reach better decisions at work. Almost the same amount of commanders – 93 (47%) – ticked the box to say that TAD had 'rather' developed their command competences. Only six said that TAD rather did not develop their competences, and two said that it did not at all develop their competences. One trainee compared the virtual simulation-based training to be like a real incident. Another commented that, '*Because there are few available practise opportunities, all kinds of command training is very much expected and is highly useful*'. This goes along with IC expectations that have been expressed in the engagement and motivation study (N = 224), which showed that 59% of them would like TAD-style training days once a year, and 24% preferred twice a year. Contradictory to this was the 5% who in the same study expressed their view that this form of training experience is not required.

Earlier, Table 3 in its final two columns provided average figures for IC simulation-based assessment results. We analysed this using a paired T-test to show that IC SA levels average scores that are significantly different between the first and second time of participating in a TAD. There was no statistically significant difference between the averages for SA levels. On the one hand, it shows that ICs do not get to practice SA enough, and more training opportunities are required in order to improve SA. On the other hand, it shows that the assessment process is carried out consistently by certified assessors, so the results do not differ due to the measurement instrument. In addition, the absence of a significant difference could be positive. It shows that sufficient experience from real life incidents or training are gained, so SA levels have not dropped significantly between assessments.

Due to the fact that TAD is in line with the rescue unit leaders occupational qualification standard, it continually measures the command competences of ICs in the Estonian Rescue Board. Some ICs have left their job after new attestation was implemented, and novices have started to work in their place. TAD allows the service being offered to the public to be screened through a process of monitoring the commanding knowledge and skills of the ICs. Furthermore, from the Estonian Rescue Board perspective, TAD ensures that the occupational qualification command competences of rescue unit leaders are monitored in a systematic way. This allows virtual simulation-based scenario topics and e-learning self-check test questions to be tailored to organisational needs.

5. STUDY LIMITATIONS

The study has several limitations. TAD participants who responded to surveys may have answered as would have been expected or they may have answered with a presumption towards correctness rather than relying on their own feelings. In the survey, to measure trainee reactions, respondents could not provide reasoned argument to support the answers, which could have led to extreme high or low results with no qualitative reasoning behind them. The feedback questionnaire made it possible to comment on the answers being provided. However, only some respondents made use of this opportunity. For this article, the full qualitative analyses behind all of these answers has not been included.

Consideration needs to be taken of the fact that IC answers in the engagement and motivation study did not have the normal level of distribution due to the ceiling effect. It is impossible to distinguish whether a high engagement level and potential well-met psychological needs were the result of there being only a small group of participants, or whether this was due to the efforts of the instructors, or to new methods and tools being used, or due to the assessment at the end of the training session, something that is part of any obligatory work-based attestation.

Another limitation of the study is also the fact that the surveys and assessments were all carried out in the Estonian language. The results are presented in English, and some meanings may be lost in translation. Likewise, in some cases more than two years had passed between taking part in the TAD and filling in the engagement and motivation survey. This may influence answers, as participants had to remember events from a training course from some time previously.

Over 114 ICs in Estonia have twice taken part in TAD, but only those assessment results starting from 2017 have been analysed in the study. This means that the evaluation of TAD participant reactions and learning is not entirely accurate because pilot year assessment results from 2016 were not used. The assessment certificates are always signed by two assessors although, even so, they are filled in using a single EC assessor account. This could lead to a situation in which one assessor has influenced the scores more than the other assessors. Certain assessor pairs may be able to measure SA levels differently from other pairs of assessors.

CONCLUSIONS AND RECOMMENDATIONS

The research question for the study was how can situational awareness training be provided to ensure different levels of situational awareness as part of dynamic decision-making training using virtual simulations?

In the article, a step-by-step overview was designed and implemented regarding how best TAD can teach about SA levels. We have highlighted the fact that assessor training is key to building engaging virtual simulation-based scenarios and in delivering training that supports all of the psychological basic needs (autonomy, competence, and relatedness). The study proved that TAD is engaging and that it supports trainee psychological needs. XVR OS is used during TAD in a way that means it has allowed ICs to feel engaged and that it supports the learning of SA. Unfortunately, the TAD is not easily scalable, as there are two trainers for each trainee to be able to train and assess SA levels.

Analyses which were based on the Kirkpatrick training programme evaluation model showed that TAD meets Level 1 reactions in a highly positive way. Compared to the motivation and engagement study in clinical settings (Knight, 2016, p. 92) where the clinical engagement mean for students was 5.88 and the SD was at 0.85, TAD showed similar engagement means (M = 5.43 and SD 0.78). We concluded that all three psychological needs (autonomy, competence, and relatedness) are well met during TAD and this serves to support learning in all three SA levels (Kirkpatrick Level 2). From an SA perspective, the Level 3 behaviour and Level 4 results were hard to measure. Other researchers have come to a similar conclusion about simulation-based training (Prohn and Herbig, 2020). Further research is needed in this area. As simulations can be used to measure SA levels (Endsley, 1995a), the EC formal assessment results could be used to evaluate the behavioural changes of participants. As the real-life incident rate is dropping, it is rather difficult to measure IC SA levels during accidents. In future research, which is conducted to discover real-life SA levels, footage could be analysed from the helmet-cams that are worn on IC helmets during incident command situations (Boehm, 2017).

Some trainees found the virtual simulation to be hard to use during TAD. As SA also depends upon the space in which it is taking place (Endsley, 1995a), more research is needed on the area in which virtual simulations are being used to measure different SA levels. Meanwhile, as ICs would expect, more practice opportunities in virtual simulation-based SA training should be provided to them.

Moodle tests are useful when it comes to assessing theoretical knowledge about SA. This is an easily-scalable and standardised way in which to train and to carry out e-assessments (Koneru, 2017). However, it could be argued that computer-based testing is very efficient at supporting trainee psychological needs (Hsu, Wang and Levesque-Bristol, 2019), and how engaging a form of learning this is (Yang, Lavonen, and Niemi, 2018). At this point of the development of Moodle and virtual simulations for SA training and assessment, computers are not able to answer IC questions or dynamically adapt the scenario based on IC decisions. Due to this shortfall, human interaction is still needed in the testing of all SA levels. New training tools will have to be constructed to provide engaged learning in online learning platforms that can take into account trainee cognitive, social, and emotive factors (Wang and Kang, 2006). To extend options and opportunities in terms of online learning, virtual reality technology can be used for multi-disciplinary emergency management training (Prasolova-Forland *et al,* 2017).

Because Moodle self-check tests are an efficient way of testing IC knowledge in regard to SA, new questions should be developed for use in self-check tests. The study showed that even simple feedback from the computer prompts the learner to retake the test. Various e-learning scenarios could improve SA levels 1 and 2, as those average figures were still on the threshold. We suggest that the Moodle platform should be studied in relation to training for command competences that are based on scenarios where the standard operational procedures are applied. With such use, scenarios could be assessed by computer and automatic feedback can be provided for trainees. More research is needed in this area, though, such as how different SA levels may be evaluated via e-learning. When focusing on how assessment results could be used to frame new personal learning-goals and to provide ICs with more options when it comes to reflecting on the e-learning platform before their face-to-face assessment day takes place. One reason for developing e-learning-based training and the assessment of SA is that it is an easily-scalable way of being able to train ICs in a standardised way.

We concluded that TAD has succeeded in outcome-based, student-centred, virtual simulation and scenario-based training and assessment for all three SA levels. TAD offers a motivating and engaging way in which to train, while the full command competence of ICs can still be challenged. TAD should be continued to assess IC SA levels in virtually-simulated complex incidents. Further research needs to be carried out to be able to find ways in which different SA levels can be taught and assessed in more scalable ways with the aid of virtual simulations.

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