Abstract—The nature of the daily security business at airports (e.g. fast changing regulations) demands more and more flexible training and communication solutions for security officers at airports. Classical classroom training is a proven way for (re-)training, but alternative tools, in particular e-solutions, could be taken into account more often to support the classical method of training.

In this paper, the high potential of learning content management systems for increasing airport security from a human factors perspective is discussed. Using e-solutions for (re-)training, as a tool for supporting briefings, or as a quality control tool (e.g. the implementation of computer-based knowledge tests) is not only cost saving. It is also a fast and highly adaptive procedure, which should be integrated within the daily routine of a security officer’s working day (similar to the computer-based training for the detection of forbidden items in baggage (e.g. X-Ray Tutor [1], [2]) which was implemented at Zurich Airport several years ago).

One of the most obvious advantages of e-solutions is the fast and broad accessibility for security officers, provided that the necessary infrastructure is available. Another advantage is that security officers can take a training module whenever workload is low. Moreover, individual training progress can be taken into account and users are free to repeat a training module as often as desired. Quality tests can be implemented at each step during the training course in order to make sure that the content is fully understood. Thus, controlling of training progress and recurrent training modules gets simplified.

In large organizations, where personal communication inevitably gets more and more complicated, e-learning systems form an especially strong management instrument, provided that they are used in a didactically meaningful manner and that usability criteria are considered. One important insight gained by using e-learning for (re-)training is – as for other technical tools, e.g. X-ray equipment – that the benefit of e-solutions is limited by the end users’ individual computer skills and not by technical constraints.

Keywords- Airport security; e-learning; self-assessment; human factors; learning content management systems; OLAT

I. INTRODUCTION

The demands of the security officer’s job have increased dramatically since security measures at airports have become more and more important due to different terrorist attacks (e.g. the ones on 9/11/2001). In addition, sudden changes of regulations, such as the liquid ban introduced in November 2006 in Europe, challenge not only the employees at the checkpoint, but whole airports and security organizations to a high degree. Such famous incidents form only the tip of the iceberg of the dynamics within airport security. In order to cope with the requirement of being most flexible, a modern organization should reassess known and successful procedures from time to time. An example is the classical classroom training for initial and recurrent training purposes. The value of e-solutions for supporting or even replacing the classical training procedures to some degree should not be neglected within airport security. Fast changing regulations and threats, as well as the need of a highly adaptive and reliable top-down information flow from the management to security officers, suggest including e-learning tools into the daily routine of a security officer’s job.

For part-time employees, e-solutions provide a very reliable tool to keep their knowledge up-to-date with regard to regulations and instructions. In addition, from an economical perspective, the use of e-learning is valuable as well, because security officers can learn individually during off-peak hours (“dead” hours), so that learning can be integrated in the daily routines in a most efficient way. Therefore, high and efficient
accessibility of the security officers is one of the obvious strengths of e-learning systems.

Another major advantage is testing possibilities integrated within e-learning courses. The security organization gains the possibility to efficiently monitor and control the knowledge of an employee. Through individual feedback after a learning course or testing module, the employee gets to know his or her own weaknesses and can therefore eliminate them by adjusting the learning strategy. Thus, the use of an e-learning system within airport security should result in an improvement in working quality at the checkpoint. There are many open-source learning content management systems (LCMS) available that can be customized according to the needs of an organization. We used OLAT (“Online Learning and Training”, http://www.olat.org), an open-source learning platform, which was launched in 1999 by the Computer Science Department [http://www.ifi.uzh.ch/] of the University of Zurich (UZH) [http://www.uzh.ch]. It has been used as a comprehensive learning platform at UZH since 2004 and is nowadays used in various departments and faculties of UZH and ETH Zurich. OLAT serves to deliver learning content to learners, to organize participants and their learning activities, as well as to create and edit learning contents.

OLAT organizes learning contents as individual units of learning (UOL) within an e-learning course, conforming to the eLML specification [3]. When building an e-learning course, course authors have the possibility to import and export parts of the learning content and various learning sources defined by learning objects standards, such as SCORM 1.2 [4], IMS-QTI [5], and IMS-CP [6].

Particularly, OLAT integrates assessments as part of the learning content by involving IMS-QTI nodes either as summative assessments or formative assessments. Summative assessments are often given at the end of a course to evaluate the students’ final amount of learning, whereas formative assessments are inserted into each section of a UOL to offer a constructive guideline for students throughout the courses.

In this paper, two applied e-learning pilot studies are presented. The first study was carried out during the initial training of employees, which lasts four weeks and is a prerequisite to the employment of a security officer. The objective of this study was to investigate whether e-learning in general provides an efficient means to support classical classroom training during the initial training phase of a security officer. We compared the learning progress of two groups – both groups received classical training, while one group then repeated the learning content going through an e-learning course, while the other group of participants repeated the content by self-studying their notes as well as the training documents.

The second pilot study investigated the effect of an “e-self-assessment test” on the learning progress within an e-learning module. It is well known that self-assessment provides a valuable means to improve learning in general, and not only in the context of e-learning systems (e.g. [7], [8]). The available research on the effect of self-assessment within e-learning courses has primarily been done with students or pupils, who are often very familiar with the use of computers and e-learning (e.g. [9], [10]). Zakrzewski & Bull [11] have pointed out that online assessment has at least three advantages compared to traditional classroom assessment: students can take the assessment at any time; they can repeat it whenever they want, and instant feedback helps to detect individual weaknesses.

Nowadays, e-courses or e-tutorials are very often taken for granted at academic institutions. Despite the great success of e-learning in the academic context, it remains to be investigated whether it e-learning provides an efficient and effective way for supporting (re-)training of security officers. After the introduction and first trials with e-learning as a tool for supporting training, we were confronted with the fact that experience with computers and e-tools varies a lot between security officers. We observed huge differences between security officers with regard to their computer skills and familiarity with e-solutions. In addition, many employees claimed that they were not used to studying or memorizing in general. Therefore, research should also focus on such aspects; in order to make sure that the use of e-learning sustainably increases quality of work at the security checkpoint, didactical-pedagogical expertise should form the basis of the learning content to optimally assist learning. In addition, prior to the comprehensive deployment of e-learning tools, the management should make sure that no employee is discriminated or at a disadvantage because of differences in computer skills or other aspects by providing the necessary infrastructure and (technical) support.

Both e-learning courses used in the studies conducted were built based on the E-CLASS model [12], consisting of the classical steps Explain, Clarify, Look, Act, Share and Self Evaluate/Submit. A modified model was used, which did not include the Share-step, but repeated the steps Act and Self Evaluate/Submit in the second study for group 1.

II. PILOT STUDY 1

This study was carried out with new security personnel during the initial training, which consists of a theoretical and a practical part. In order to get an employment as security officer and thus being allowed to work at the checkpoint, each trainee has to pass a final examination. Within the initial training phase, a major training module deals with explosive material in general and improvised explosive devices (IED) in particular.

In order to find out if supporting classical classroom training with an e-learning module could be an efficient means for future training courses, we compared the learning progress of two groups of trainees. One group was provided with an e-learning module immediately after the classroom training, whereas the other group repeated the training content immediately after the classroom training by self-studying their notes and training documents.
A. Method

1) Participants
In total, 18 trainees (8 females) participated in this pilot study. All participants were naive with regard to the research question. The participants’ age ranged between 21 and 53 years ($M = 35.9, SD = 10.4$). The participants were divided into two groups: the self-study group and the e-learning group (see section 2c) for details).

2) Materials and procedure
a) Learning content
The initial training course of security officers consists of classical classroom training and is constructed on a modular basis. Several different topics relevant to the security officer’s job are integrated, e.g., X-ray image interpretation, pat-down search, the use of trace detection systems, etc. The module chosen for this study covered information about explosive material and the detection of it in an X-ray image. This module is given by an expert in the field of explosives. The training focuses on the different essential features of an improvised explosive device (IED), their variety, as well as their different visual appearance on an X-ray screen.

b) Visual knowledge tests – Before and after initial classroom training
In order to match both groups with regard to their knowledge about the topic prior to the classroom training, each participant had to take a baseline computer test. This test consisted of 10 multiple-choice questions, in which a marked feature of an IED had to be identified by clicking on the correct answer.

Fig. 1 shows an example of an item of this baseline knowledge test.

![Figure 1. Example of an item of the visual knowledge test.](image)

Based on the test results, participants were subsequently divided into two groups, so that there was no significant difference between the two groups with regard to the test results ($t(16)= 4.21, p = .68$).

The same test was used to measure the learning progress of both groups of participants. Therefore, each participant took this visual knowledge test a second time after the classical classroom training.

c) Chronological procedure of the study
Between the two knowledge tests, both groups of participants attended the classical classroom training course (2 hrs) on IEDs. The self-study group was then instructed to repeat the learning content by self-studying their training documents and notes. They were allowed to discuss questions within the group. The e-learning group was instructed to go through the e-learning course immediately after the classroom training. Both groups were given 30 minutes for the repetition of the content before they had to take the visual knowledge test a second time. Fig. 2 shows the chronological procedure for both groups.

![Figure 2. Chronological procedure for both groups.](image)

3) Results
For each participant, the number of correctly answered questions in the knowledge test was calculated before and after the training phase. Fig. 3 shows the results for both groups separately.

![Figure 3. Number of correct answers prior to and after the classroom training and repetition of the content for the two groups separately (self-studying vs. e-learning). Error bars indicate standard deviations (SD).](image)
The number of correct answers was subjected to a two-way analysis of variance (ANOVA) with group (self-study, e-learning) as between-participants factor and test date (baseline test, 2nd test) as within-participant factor. The results of this analysis showed no significant difference of the two groups (self-study, e-learning), \( F(1, 16) = 0.06, p = .81 \), whereas there was a significant learning progress for both groups (within-participant factor test date), \( F(1, 16) = 26.83, p < .001 \). No significant interaction between group (self-study, e-learning) and test date was observed, \( F(1, 16) = 0.97, p = .34 \).

Discussion

This pilot study compared the effect of self-studying vs. guided e-learning in combination with classical training on the learning progress. The two-way analysis of variance (ANOVA) showed a learning progress over time, which is not surprising, but shows the expected training effect in general. However, we found neither a difference between the groups, nor a significant interaction between group (self-study vs. e-learning) and test date. These results should not be overestimated because of the relatively small sample size; though it can be interpreted as evidence that the participants in the e-learning group did not have too many difficulties using OLAT. They were not instructed how to use the tool because we wanted to find out how well they manage to go through the course without any instruction. This is especially important for employees that are not used to computers in general and e-learning for learning purposes. In Fig. 3, it is obvious that the tendency of the interaction goes into the right direction, namely that the e-learning group profited more than the self-study group. A retrospective power analysis could have been calculated, but the critique expressed by other researchers (e.g. [13]-[15]) made us refrain from that. They have pointed out that retrospective power analyses are based on the assumption that the sample effect size is essentially identical to the effect size in the population from which it was drawn. The calculated effect size corrected for possible baseline differences in this sample is \( d = 0.8 \) (see [17] for more details on effect sizes and their calculations).

A further critique that could emerge is the fact that taking the same test twice could per se have lead to the observed learning progress and not the training and repetition of the content. This possibility can be ruled out because we could show that the average number of correctly answered questions in the visual knowledge test is comparable to the one in this study even when the e-learning course is taken without the baseline test in advance (\( M = 8.73, SD = 1.42, N = 778 \), two-tailed t-test for independent samples, \( t(794) = 0.36, p = .72 \)).

Pilot Study 2

The second pilot study investigated how self-assessment within e-learning can affect the learning progress. As described in the introduction, several researchers could show a benefit of self-assessment with regard to the learning success, (e.g. [7]-[10]). However, these results were mainly obtained with students or pupils in academic institutions, and the same studies should be replicated with security officers in order to develop best practices for supporting e-tools for (re-)training within a security organization. The effort of developing self-assessment questions should result in a benefit as for example in an increased training effect.

1) Participants

All of the participants were supervisors leading 20 to 30 security officers in their daily work. In total, 24 supervisors (10 females) took part in this study. All participants were naive to the research question. Age of participants ranged between 24 and 56 (\( M = 41.96, SD = 8.8 \)).

The participants were randomly assigned to two groups of 12 participants: Group 1 (with self-assessment) and group 2 (without self-assessment). See section 2)d) for more details of the two groups.

2) Materials and procedure

a) Learning content

After investigating the need for retraining at the supervision level, we decided to develop an e-learning course on the national weapons law. This law has changed on the eve of conducting this study and its complexity asks for a well-organized refresher training. Supervisors are reliant on a thorough knowledge of and clear instructions about which items fall within the regulation and which items do not. When confronted with a prohibited item or weapon at the checkpoint, this knowledge is a prerequisite for a supervisor in order to decide within a very short time if further measures should be initiated or whether the standard procedure is appropriate (which is to simply confiscate the forbidden item).

The e-learning content was organized in three chapters: Chapter 1 contained general information about the weapons law, chapter 2 comprised the most important items according to the weapons law, and chapter 3 summarized the most important items that are not prohibited by the weapons law but can be harmful nevertheless.

b) Self-Assessment Tests

For participants of group 1, self-assessment tests were integrated after each chapter of the e-learning course as summative assessments. In total, these self assessment parts contained 16 questions. Different types of questions – open questions, single- and multiple-choice questions – were implemented within the self-assessment parts. 5 questions after chapter 1 (3 open, 2 single-choice questions), 8 questions after chapter 2 (1 open, 7 multiple-choice questions) and 3 questions after the last chapter (1 open, 2 multiple-choice questions). In order to be able to proceed to the next question, participants had to answer each question. They received immediate feedback to their answers. For correct and wrong answers, an explanation was displayed subsequently, stating why the answer was (not) correct.

Participants had the possibility to revisit those topics within the chapter for which the results of the self-assessment test showed weaknesses, thus enabling them to learn in a highly adaptive and efficient way.

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1 Please note that the number of participants in this study is very small for statistical analysis and its interpretation.
c) Knowledge Tests – Version A and B

In order to measure the learning progress of both groups, a knowledge test was implemented at the beginning and the end of the e-learning course. Two versions of the test were created: test versions A and B. Both test versions consisted of a total of 37 items. The tests were divided into a theoretical and a rather practical part. The theoretical part contained 7 items that were classical multiple-choice items. In the 30 items of the more practical part of the test, an image of an object (e.g., taser) was presented and participants had to decide whether it is prohibited according to the weapons law or not.

In both versions, the maximum number of points a participant could reach was 51: the maximum points of each theoretical question were 3, whereas the practical items were evaluated with 1 point if the answer was correct. False answers resulted in penalties on the score.

d) Chronological procedure of the study

Fig. 4 shows the chronological procedure of this study. Both groups of participants first took the baseline knowledge test. Half of the participants of each group took test version A, the other half test version B, so that test versions were equally distributed within both groups. Thereafter, both groups of participants went through the three chapters of the e-learning course, whereas for group 1, each chapter was complemented with the self-assessment questions. At the end, all participants took both versions of the knowledge tests. This was done because we wanted to avoid that a better result in the 2nd test could occur primarily because of the fact that the same test was done twice.

3) Results

The rate of correctly answered questions (percent correct) in the knowledge test was calculated before (baseline test) and after the training phase (2nd test, separately for versions A and B after the training phase).

Fig. 5 shows the percentage increase of the test results (learning progress) for both groups and test version combinations separately.

In order to find out whether both baseline test versions were equally difficult, we calculated a t-test for independent samples (two-tailed). No significant difference was observed, \( t(22) = 1.57, p = .13 \). There was also no difference with regard to the test versions after the e-learning course, as suggested by a t-test for paired samples (two-tailed), \( t(23) = 0.47, p = .64 \).

The rate of correctly answered questions was subjected to a two-way analysis of variance (ANOVA) with group (with self-assessment, without self-assessment) as between-participants factor and test date (baseline knowledge test, 2nd test) as within-participants factor for both test version combinations (same test version, different test versions) separately. We obtained the same results for both analyses: There was a main effect of test date (same test version: \( F(1, 22) = 110.33, p < .001 \); different test versions: \( F(1, 22) = 97.36, p < .001 \)). No main effect of the between-participants factor group could be observed, neither for the same test version, \( F(1, 22) = 0.86, p = .37 \), nor for different test versions, \( F(1, 22) = 0.62, p = .44 \). Neither did the interaction between the two factors reach significance (same test version: \( F(1, 22) = 1.37, p = .25 \); different test versions: \( F(1, 22) = 1.43, p = .25 \)).

In addition, a one-tailed t-test for independent samples with the percentage increase of correctly answered questions (= learning progress) between the baseline and 2nd test neither revealed a significant difference between the two groups (with and without self-assessment), nor for the same test version, \( t(22) = 1.46, p = .08 \), nor for different test versions, \( t(22) = 1.41, p = .09 \).

The percentage increase of correctly answered questions (= learning progress) correlates with \( r = .87, p < .001 \) between the two test version combinations for group 1 (with self-assessment) and \( r = .85, p < .001 \) for group 2 (without self-assessment).
Using correlation analyses, we investigated whether the time spent in the self-assessment parts (group 1) had an effect on the learning progress. As can be seen in Fig. 6, we found a highly significant correlation for both test version combinations (same test version: \( r = .65, p < .05 \); different test versions: \( r = .79, p < .01 \)).

In contrast to this high correlation, the correlation between time spent within the e-learning chapters and the learning progress was \( r = .07, p = .82 \) (same test version) and \( r = .03, p = .94 \) (different test versions) for group 1 (with self-assessment) and \( r = .50, p = .10 \) (same test version) and \( r = .39, p = .21 \) (different test versions) for group 2 (without self-assessment).

4) Discussion

The second study compared the learning progress within an e-learning course with and without a possibility for self-assessment. Half of the participants had the possibility to use the self-assessment test as a diagnostic tool in order to identify their weaknesses within the learning content. This knowledge about own weaknesses, obtained from instant feedback, is most important in order to adjust the learning strategy and thus to learn in a highly adaptive manner. We found a general learning progress for both groups of participants and no effect of group. Although the interaction between group and test date did not reach significance for neither test version combination, Fig. 5 reveals that there is a trend in the way that the learning progress is higher for participants that had the possibility to self-assess their knowledge status compared to the other participant group. As for study 1, a retrospective power analysis could have been calculated for the t-test comparing the percentage increase between the two learning groups, but, as argued earlier, retrospective power analyses are based on the assumption that the sample effect size is identical to the effect size in the population from which it was drawn [16]. The calculated effect sizes based on [17] revealed medium effect sizes of \( d = 0.61 \) for the same test version and \( d = 0.58 \) for the different test versions. Research literature (e.g. [7], [8]) clearly shows a substantial benefit of assessments. Therefore, the small sample size could be the cause for the lack of significance in this pilot study. We plan to extend the study in a further step with a larger sample size.

IV. SUMMARY AND GENERAL DISCUSSION

Security organizations operate within a fast changing environment, in which flexibility and efficiency are two main prerequisites for maintaining high-quality work. Fast and reliable information channels, adaptive and efficient training methods, as well as monitoring the knowledge status of the workforce are some key factors that account for high quality in such dynamic environments. E-tools, e.g. learning content management systems, provide a powerful and effective means for supporting and maintaining high flexibility for the management, even in large organizations with a lot of part-time employees. The use of e-tools at universities and other academic institutions has become self-evident within the last decade. E-learning is becoming more and more prominent in other organizations as well, as for example in the field of airport security. The advantages are obvious: security officers can use off-peak hours for individual (re-)training, they can repeat a course as many times as they like, controlling and monitoring functions can be integrated within the system, and, last but not least, learning strategies can be dynamically adjusted based on instant feedback from self-assessment. Therefore, learning can occur in an adaptive and highly efficient way.

Although these advantages are obvious, possible dangers or restrictions could limit the use of e-learning tools. Therefore, in order to develop best practice guidelines for airports on how to use e-learning tools, empirical research should focus on the deployment of e-learning tools that support (re-)training and information spreading. It is crucial that research identifies whether there are dangers that could limit the obvious benefits, e.g. a possible danger of disadvantaging people with limited computer skills. It is likely that most of the results of the research on the use of e-learning done in the academic environment can be transferred to other environments, e.g. to airport security. However, the diversity of the security control staff should always be taken into account. We are convinced that selected research questions should be investigated directly with security control staff.

In this paper, two pilot studies are described; one was done with future security officers, the other with security control supervisors. In the first study, the learning progress of two groups was compared: While one group had the possibility to use an e-learning course to repeat the content immediately after a classroom training module, the other group was instructed to repeat the content via self-study. We could show a training effect for both groups. The lack of a significant interaction should not be overestimated because of the low statistical power within this study. The e-learning group was at least not disadvantaged with regard to the learning progress, what could have been the case because of the technology used for the e-learning chapter. Although most of the participants claimed that they were unfamiliar with that kind of studying, we did not give any hints on how to use the system.

The second pilot study compared the learning progress of two groups of participants: Group 1 had to go through self-assessment questions, whereas group 2 did not have this possibility. Many researchers (e.g. [7] - [10]) point out that assessment possibilities have beneficial effects on the learning
progress. By comparing the learning progress of the two groups of participants, we investigated whether this beneficial effect can also be observed with security control staff, which were not educated within a technologically supported learning environment and that show a huge variability with regard to their educational background in general and their computer skills in particular. In contrast to other studies, we could not show the benefit of self-assessment tests statistically, but looking at Fig. 5 clearly shows that the tendency goes into the right direction. As in study 1, statistical power was probably too low to show the interaction. We did not conduct retrospective power analyses because of the prominent critique in this area (e.g. [13] - [15]), but the small sample size and the research literature suggest that power was too low to show an interaction between the factors group and test date. We are planning to continue this research in order to get an answer to this open question.

In general, we strongly recommend security organizations to reassess their well established procedures of (re-)training, communication, and information spreading from time to time. Based on our first experiences with the use of e-learning as a tool for supporting (re-)training, we are convinced that this is a possible way for (security) organizations to remain most flexible and highly adaptive to future requirements. It should be mentioned that both studies were done without the possibility to share information among learners. Future research on the use of e-learning should be done at many different airports in order to collect empirical evidence with regard to the benefits and limitations of e-learning tools.

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