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Using learning styles to enhance the training effects of pilots in simulation based training

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ABSTRACT

Training methods in the aviation industry (CRM) are aimed at enhancing the performance of pilots by reducing human error and increasing the effectiveness of crews. Most of these programs show enhancement in the performance of pilots, however learning processes and training methods are often being criticised and not always effective (Mueller & Oppenheimer, 2014). Instead of innovating and introducing new training methods to increase training effectivity, there seems to be a much cheaper solution within reach. This solution uses the learning preferences of a learner to enhance its learning effects. This research was conducted to assess the learning preferences of 395 pilots using the Learning Style Questionnaire by Honey and Mumford (2000). It was followed by an experiment to match, or mismatch the instruction strategies with the learning preferences of pilots, to enhance the training effectivity of 42 pilots in simulation-based training. No significant effects of matching, and mismatching, were found on training effectivity ($p>0.05$), although notably higher performance scores in two of five conditions. To find other possible opportunities to enhance training effectivity, other variables were briefly tested apart from this result, showing that a more experienced instructor enhances the performance scores of pilots.

1. INTRODUCTION

We live in a world in which we are constantly looking for opportunities to innovate and improve. We strive to maximize our potential (Maslow, 1943). We go to school, to university, apply for jobs, and even when we achieve that dream job, we never stop learning.

The path that leads to that dream job can be very costly and time-consuming. It can take more than 26 years to educate a child to become a doctor and completing the pilot training will cost you around €150,000. Making related training methods more effective through improvement and innovation could therefore lead to big profits. In the aviation industry, training programs are aimed at enhancing the performance of pilots by reducing human error and increasing the effectiveness of crews. These training methods are generally called ‘crew resource management’ (CRM). Most of them have shown some enhancements in the learning of participants (Salas et al., 1999). However, the processes of learning are still far from perfect and the methods have been criticised (Mueller & Oppenheimer, 2014). Instead of introducing new training methods, there could be a much cheaper solution at hand to increase the effectiveness of aviation training: ‘matching’. Empirical studies that have recently researched this ‘solution’ define it as the ‘matching hypothesis’ (Ford & Chen 2001; Reynolds 1997; Smith, Sekar & Townsend, 2002). This hypothesis describes that the match between learning styles and learners can be used to enhance learning. The results of related studies are unambiguous, including recommendations to match, mismatch, or not use learning styles at all (Ford & Chen 2001; Reynolds 1997; Smith, Sekar & Townsend, 2002). These studies are, in addition, usually performed with children in classroom settings. There is therefore a gap in the literature for the effects of matching in a crew and training settings. KLM and NLR (a Dutch research institute) have commissioned this study to research whether the match between learning styles and pilots can be used to enhance their training methods. This study may therefore be able to answer the research question: can the learning preferences of pilots be used as a tool to enhance the training effect of type recurrent training?

1.1 Pilot performance

For a pilot operating in a crew in highly uncertain and dynamic settings, it is a challenge to perform decisively and synchronously (Hess, Freeman & Coover, 2008). The capacities of pilots determine for a great part the performance of a crew. However, many other factors influence how problems are solved and what decisions are made. Airlines have their own standards of behaviour in the cockpit and towards passengers. Although standards vary, models of desired behaviour divide pilot performance mainly into technical, and non-technical skills (Flin & Martin, 2001; Flin et al., 2017; Gontar & Hoermann, 2014; O'Connor et al., 2002). Technical skills include knowledge of aircraft procedures and manual handling skills; these skills are acquired in pilot training programs. Non-technical skills, such as communication, problem solving, situational awareness and decision-making are harder to train due to their indistinctness. These 'human' factors can be affected by stress, a high workload or fatigue, which cause human error and negatively affect the ability to make decisions and communicate – and thus affect performance (Salas et al., 1999). In the domain of applied psychology, human factors are usually examined to enhance pilots' performance. This applied cognitive psychology study is therefore focused on the training of pilots' non-technical skills.

1.2 Training in aviation

The aim of training in high-risk settings, such as that of a KLM pilot, is to reduce errors and improve performance. In these settings, CRM is a common design to enhance the non-technical skills of participants. In CRM training, cognitive and interpersonal skills (non-technical skills) need to be enhanced in order to reduce human error and improve performance, and thus improve air safety (Salas et al., 1999). Ideally, they are taught in training settings that share significant similarities with their working environments, (such as the cockpit for pilots). CRM training is therefore given in simulation-based training (SBT) in so-called 'high-fidelity training simulators' that are identical to the cockpit of an airplane. In simulation-based training, a crew performs several scenarios to solve problems that may possibly occur while flying, or trains skills such as a take-off and a landing. This training design aims to result in effective transfer from training towards performance in the real world, as transfer is the ultimate goal that can be achieved with training (Salas & Burke, 2002; Salas et al., 2009; Salas, Tannenbaum, Kraiger & Smith-Jensch, 2012). In other words, the transfer of effects is an index of training effectivity. Moreover, simulation-based training is effective when it is built on an underlying theory, uses structured exercises, and assesses performance and provides feedback (Salas & Burke, 2002). To determine these results of training – training effectivity – the performance of a pilot must be measured (Salas et al., 2009).

1.3 Learning styles

Learning takes place when the performance of a pilot is increased through training. The most cited learning theories derive from studies by Kolb (1984) and Honey and Mumford (1986). Moreover their number of citations, the focus of an extended review on learning theories (Coffield, Moseley, Hall & Ecclestone, 2004) relied on the visions of Kolb, Honey and Mumford. For these reasons, their theories, despite criticism (Duffy & Duff 2002; Freedman & Stumpf, 1978), are used as a starting point in this study. Kolb (1984) defines learning as 'the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping experience and transforming it', so-called 'experiential learning'. Both theories describe the process of learning as a cycle that can be divided into 4 stages or phases. The experiential learning cycle described by Kolb (1984), shown in Figure 1, consists of two continuums to perceive and process experiences. The approach to perceiving experience consists of (1) concrete experience and (3) abstract conceptualisation, and the approach to processing experience consists of (2) reflective observation and (4) active experimentation. Ideally, all four modes are engaged during a learning process. However, due to a combination of our present environment, our hereditary equipment (nurture), and life experiences that form our nature, most people develop preferences towards perceiving and processing experiences. A combination of two preferences for each continuum results in a 'learning style'.

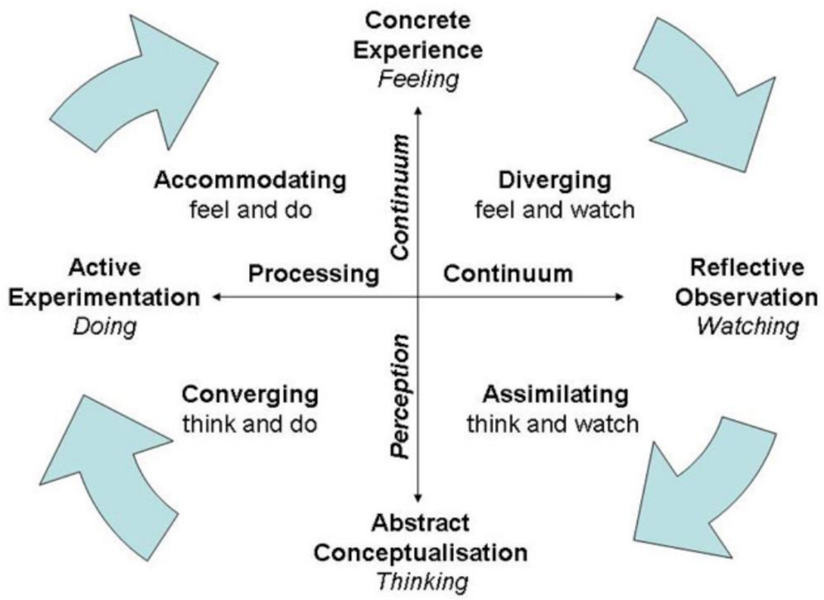

Figure 1. Experiential learning cycle (Kolb, 1984). The arrows represent a learning phase. Each learning style consists two continuum preferences for each phase. Retrieved from: http://www.nwlink.com/~donclark/hrd/styles/kolb.html.

Four basic learning styles are derived from this cycle: '(a) an accommodating, (b) a diverging, (c) a converging, and (d) an assimilating style. The model by Honey and Mumford (1986) is a revision of Kolb's (1984) cycle to describe the process of learning, using the same continuums to perceive and process experiences. Goldstein and Bokoros (1992) have compared these two models and found significant results when classifying into equivalent styles. The classification of the learning preferences of Honey and Mumford (2000) can therefore be allocated to the four learning styles of Kolb (1984) and is described with the following characteristics:

Kolb: The accommodating style – Honey and Mumford: Activists.

Activists have a preference for concrete experience in the perception continuum and prefer active experimentation on the processing continuum. The accommodating style emphasises action and getting involved in new experiences. People with this learning preference are good at adapting to changing environments and tend to solve problems using in a trial-and-error manner.

Kolb: The diverging style – Honey and Mumford: Reflectors.

The diverging style emphasises concrete experience and reflective observation. Reflectors prefer to reflect on expert interpretation provided by trainers. People with this learning preference have a good imaginative ability and are good at learning from observation.

Kolb: The converging style – Honey and Mumford: Pragmatists.

Pragmatists have a preference for abstract conceptualisation and active experimentation. This converging style emphasises practical applications of ideas, problem solving and decision-making. Convergers prefer learning through peer feedback and activities that apply skills.

Kolb: The assimilating style – Honey and Mumford: Theorists.

This assimilating style consists of abstract conceptualisation and reflective observation. Theorists rely on thinking alone and reason inductively. They are good at creating theoretical models and prefer to learn from theory readings and case studies.

Most studies define learning preferences with a 'dominant' learning style, meaning that the learning style with the highest preference score is the dominant learning style of an individual. However, within this research learning styles are not defined as 'dominant learning styles', but instead as 'learning preferences'. This is because an individual could have multiple strong learning preferences, instead of one dominant learning style. When these learning preferences of a random population are researched, an equal distribution among the four learning styles is expected (Kolb, 1993). Pilots, however, significantly deviate from this equal distribution ((1) convergers (44.2%), (2) assimilators (23.6%), (3) divergers (16.3%), and (4) accommodators (15.9%)), with a tendency towards abstract conceptualization (Kanske, 2001). The same ranking of preferences was shown by a study that identified the learning preferences among Australian aviation students (Gao, Au, Kwon & Leong, 2013). This study therefore expects to find the same distribution of learning preferences and will answer the first sub-question: *what are the learning preferences of pilots?*

1.4 This study

The goal of this study is to examine whether learning styles can be used to enhance the performance of pilots, answering the research question: can the learning style of pilots be used as a tool to enhance the training effect of type recurrent training? One specific application of learning styles, researched in this study, is described in the matching hypothesis (Coffield et al., 2004; Ford & Chen 2001; Reynolds 1997; Smith, Sekar & Townsend, 2002). This hypothesis states that training effectivity, and thus performance, is enhanced when the instructional strategy of training is *matched* to an individual's preferred learning style.

A second application of learning styles is to *mismatch* the instruction strategy with the learning preferences of an individual (Grasha 1984, 51; Gregorc 1984; Gregorc, 2002). The deliberate mismatching hypothesis states that learning is enhanced when underutilised learning preferences are strengthened. These two applications of learning style theories are usually researched in classroom settings (Coffield et al., 2004), while this study is examined in the current training design of KLM currency training, a typical setting that has not been researched yet. Within this training, pilots had to perform tasks in a simulator. Some of these tasks were related to developing a new skill called 'critical thinking' (CT). Studies show that individuals with the capacity to think critically about understanding the problem at hand, and their solutions to it, succeed in making higher-quality decisions (Cohen, Freeman & Thompson, 1998; Klein 1993; Hess et al., 2008; Duron, Limbach & Waugh, 2006), leading to enhanced performance. Instruction strategies within the training of this study could either match, or mismatch with the learning preferences of a pilot. To identify the effects of these applications, an observation list was designed to assess the performance of pilots during the KLM currency training. In the exploration of other sub-variables, other applications of learning preferences are briefly discussed to identify any other possible effects besides (mis)matching.

1.5 Hypotheses

Matching hypothesis

Kolb (2000) aims to balance learners, and provide them with all sorts of capacities to learn. Honey and Mumford (2000) also suggest that underutilised learning styles should be strengthened to enhance learning. Nevertheless, they claim that teaching methods should be designed in a manner that learning activities can be matched with learning style preferences (as researched by Ford & Chen 2001; Reynolds 1997; Smith, Sekar & Townsend, 2002). This means that learners experience and process the learning activities on their preferred ends of the two continuums (Kolb, 1984). This cognitive fit between a learning preference and instruction method should result in a learner that is enhanced to concentrate on, absorb and process new information. It is also argued that individuals learn better when they are allowed to use their 'own' strategies during training, as they are provided by procedures and structures that they are familiar with (Canino & Cicchelli, 1988; Hayes & Allinson, 1996). Within this study, it is therefore expected that the performance of a pilot will be better when the dependent variable 'match' is higher in the positive domain during a scenario. In sum, the first hypothesis of this study states that matching the instruction strategy to the learning preferences of pilots result in enhanced training effects.

Deliberate mismatch hypothesis

In contrast to this matching hypothesis, there is a second application to enhance learning using learning styles: the deliberate mismatch hypothesis (Gregorc, 1984). This is a variation of the theory of Kolb (1984), and states that learners will be more challenged to learn when faced with unfamiliar styles, resulting in enhanced motivation and concentration to absorb the new information. Furthermore, people will train their underutilised learning styles using these unfamiliar learning instructions, resulting in more balanced learners with more capacities to learn (Gregorc, 1984; Kolb, 1984; Kolb, 2000). Within this study, it is therefore expected that the performance of a pilot is enhanced when the dependent variable 'match' is higher in the negative domain (mismatch). This forms the second hypothesis: deliberately mismatching the instruction strategy with the learning style of a pilot results in enhanced training effects.

2. METHOD

The aim of this study was to identify the relationship between training effects and learning preferences. The identification of learning preferences is achieved in the first phase of the study. In the second phase - the experiment - the training effects are measured by an observation list based on several models. The effects of learning preferences on individual tasks of the training were compared between the participants, a so-called 'between-subjects design'. Additionally, the tasks were combined into one training, where the resulting training effects were compared between all the pilots that participated in all of the conditions of the experiment. This results in the use of a second design of this study, a repeated-measures (within-subject) design. Within this experiment, the second (CRM) recurrent training of 2017, 'Type Recurrent-2 2017' (TR2), of KLM is examined. KLM's recurrent training was designed as a result of a process called 'alternative training and checking program' (ATQP) to provide more effective and more operator-specific training. During the ATQP-process, the AF447 accident was analysed and it was concluded that the confirmation bias of the pilots played a significant part during this crash (Malmquist, 2014). In order to prevent similar accidents and to improve the decision-making process, 'teaching' the critical thinking skill was added to the TR2 training program, in addition to training other (NON-) technical skills. The tasks of this training program were therefore prefixed by KLM and fit to use in the experiment phase. Three introduction strategies were composed to match three different learning styles in simulation-based training. These instruction strategies were counterbalanced, as the instructor and researcher, in consultation with the crew, randomly distributed the instruction strategies of the scenarios during the briefing.

Within this design, the following 3 independent variables were manipulated and measured: First, (A) the specified learning preference of a pilot: activist, reflector, theorist, and pragmatist. Each learning preference has an ordinal scale: (0) very low preference, (1) low preference, (2) moderate preference, (3) strong preference, and (4) very strong preference. Second, (B) the specific instruction strategy of a scenario (nominal): (1) demo and feedback (matched with reflector), (2) coaching and feedback (matched with pragmatist), and (3) trial-and-error, expressed as feedback only (matched with activist). NOTE: Due to practical limitations, there was no fourth explicit instruction strategy that matched the theorist-learning style. The third independent variable describes the match between the (A) learning preference and the (B) instruction strategy. This (C) matching variable (ordinal) has a scale from (-10) very strong mismatch, (-1) strong mismatch, (0) neutral, (1) strong match, and (10) very strong match. These 5 scales express 5 conditions, aiming to answer the research question. A fictive pilot (Figure 2), with fictive learning preferences, is created to illustrate the relationship between the 3 variables. Within this example, the instruction strategy 'feedback only' is very strongly matched to the learning preferences of the pilot, whereas the instruction strategy 'demo and feedback' is very strongly mismatched to the learning preferences of the pilot. Lastly, the 'coaching and feedback' instruction strategy is neutral to the learning preference of the pilot.

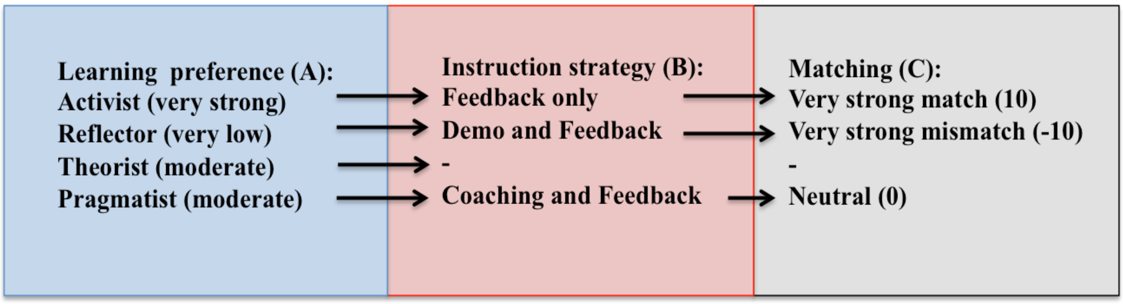

Figure 2. The relationship between the independent variables as illustrated with a fictive pilot.

In addition, a few other variables were taken into account to identify the number of responses and demographics of the participants. These covariates consist of the (a) gender, (b) age in years (ordinal), (c) experience in years (ordinal), and (d) the position (instructor, captain, first officer, and second officer).

The (training) effects of manipulating the independent variables are measured by the dependent variable: performance. The performance score (interval) has a minimum score of 0 and a maximum score of 1 and is rated by an observation list based on the SHAPE-model of KLM (Appendix A). This model emphasises the desired behaviour and performance of KLM pilots.

2.3 Participants

The type recurrent training is mandatory for all pilots from the B777-B787 division, which consists of 1038 pilots. For this reason, participants did not need to be specifically recruited, but were invited to voluntarily participate in this study alongside their training. The process of participation is divided into the (1) learning preference phase, and (2) experiment phase. If a participant completed phase 1, he became part of the 'total group', if a participant completed both phases, he also became part of the 'experiment group'. The process of participation, with all 7 steps, can be found in Appendix B.

All pilots received a unique email with a participant number (in order to secure the ethical guidelines) with an invitation (Appendix C) to define their learning preferences. In this email, pilots were asked to complete this survey voluntarily in order to contribute to the improvement of their training and that of their colleagues, eventually becoming part of the first phase of this study. The participants received a feedback-email with a summary of the outcome of this study, and tips & tricks for their learning preferences that can be used to improve their learning capacities. Moreover, by participating in this first phase, respondents had a chance to win one of the five 'bol.com' gift cards (€20 each). In this first phase, the identification of the learning preferences of 395 pilots were identified, forming the total group.

In the second (experiment) phase of the study, the researcher had to select suitable training sessions for observations. A training session, consisting of a crew of 2 pilots, was suitable to be observed when: (1) both crew members had completed the LSQ, meaning that their learning preferences had been identified. (2) Both pilots had NOT yet carried out the TR-2 2017 training. Training sessions with 'uithelpers', which are substitutes for a training session, were excluded from the experiment. (3) Both pilots, and instructor, agreed to participate in the study and were properly informed beforehand. If one or more of the criteria above was not met, the training was not suitable to be observed and thus excluded from the experiment. When pilots matched the necessary criteria, they were observed and automatically included, resulting in 0 dropouts during the experiment phase. Finally, a total of 42 pilots were observed and included in the experiment group.

The mean ages of the total and experiment groups are respectively 43.14 (SD 9.89) and 41.12 (SD 10.26). Other demographic statistics of the total and experiment groups are shown in Table 1. Table 1 shows a significantly larger presence of males (95.2%) than females (4.8%) in both groups. These percentages are obviously not generalizable to a random real-world population. However, the results are definitely generalizable for the aviation industry since the proportions of both groups are in line with the B777-B787 division, and pilots in general (Kaske 2001; Gao et al., 2013; Skyviews 2003).

Table 1. *Sample characteristics.*

	Total		**Experiment**	
	N	**%**	**N**	**%**
Total	395	100	42	100
Female	19	4.8	2	4.8
Male	376	95.2	40	95.2
Age	$\bar{x}$ 43.1	SD 9.89	$\bar{x}$ 41.1	SD 10.26
Position				
Captain	155	39.2	14	33.3
First Officer	147	37.2	14	33.3
Second Officer	93	23.5	14	33.3
Experience	$\bar{x}$ 20.9	SD 19.90	$\bar{x}$ 17.6	SD 9.81

The total group (left) included 395 pilots, the experiment group (right) included 42 observed pilots.

This study extensively strived to secure the privacy and anonymity of all participants. Participation in this study was always voluntary and pilots were always able to quit their participation. Moreover, to meet the ethical guidelines of the Psychology Research Ethics Committee (CEP, 2015), compensation, debriefing and an informed consent were included.

2.5 Procedure

All potential participants, the whole B777-B787 division of KLM, were individually invited to respond to the Learning Style Questionnaire by email. Participants were informed that the experiment was part of a learning style study conducted by KLM crew training, NLR and Leiden University, aimed at personalising and optimising the KLM training program. As this training is mandatory, and pilots are frequently observed, most of them saw their participation as an opportunity to improve. The KLM crew-training department prefixed the grouping of crews, which could not be altered. These crews were randomly put together, although a crew always consisted of: (a) a captain and a first officer, or (b) two second officers. When a training session of a crew was fit to observe (both crew members had completed the questionnaire, and had NOT yet carried out the TR-2 training), the researcher contacted the instructor. The researcher informed and briefed the instructor of this training (Appendix D) and asked both participants permission to observe their training. Participants were told that this observation would have no impact on their training, and they were asked to act as if the researcher was not present (Appendix E; informed consent).

A training session (Figure 3) always lasted 6.5 hours in total, consisting of 2.5 hours of briefing, 3.5 hours of training in a simulator, and 0.5 hours of debriefing. The researcher, when permission was granted, was only present in the simulator part to score the performance of the participants in this part of the training. During these 3.5 hours, the crew had to complete 3 tasks (3 inflight-scenarios). In every condition, two participants (a crew) carried out all scenarios. The learning preferences of the crew were not yet known during the training sessions. Also, in each scenario the dependent variables were randomly assigned to measure their effects on performance. It was therefore unknown whether the instruction strategy during a task was a match or a mismatch, with the learning preferences of the crew. After completion of the experiment, feedback was sent to the participant that included information about their learning styles and the matching of instruction strategies.

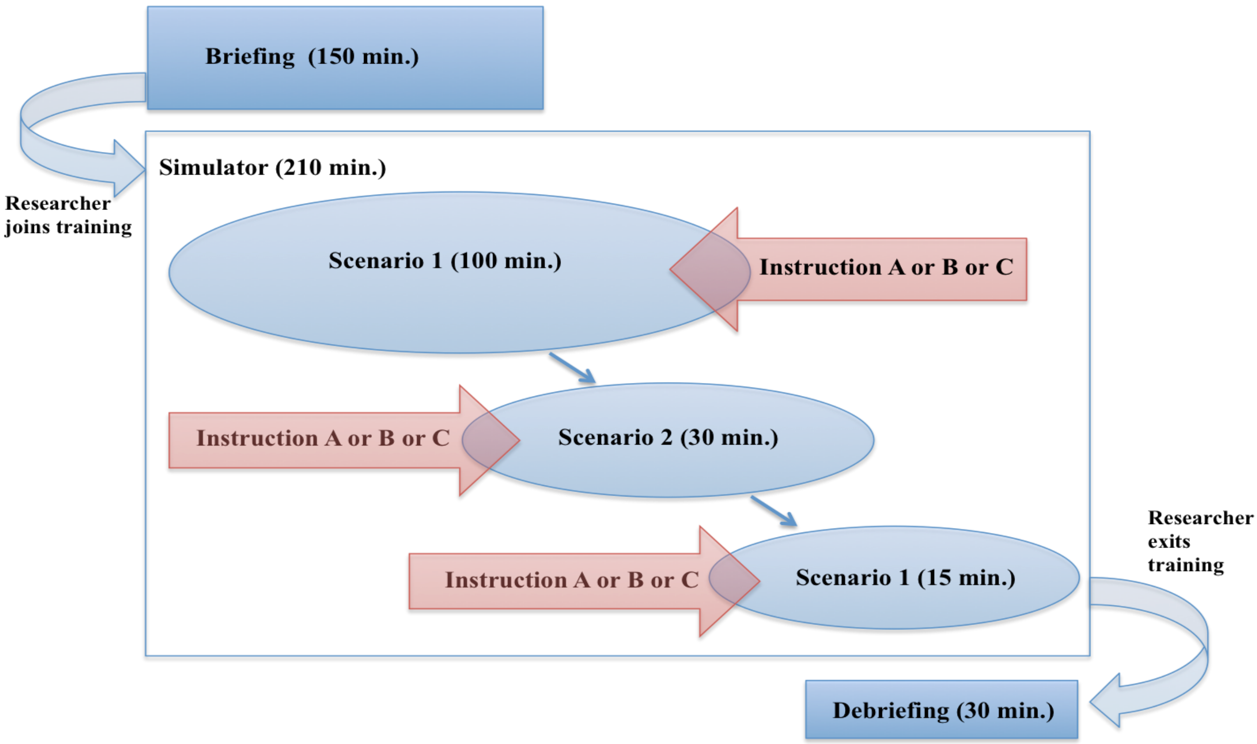

Figure 3. Training design of the type recurrent 2.

The TR2-2017 training period lasted from May 2017 to December 2017 during which a total of 1,200 pilots were trained. The training conditions for every session were very similar. Observed training sessions always took place indoors in a KLM training area at Schiphol-Oost during daytime. This training area consists of a coffee room, (de)briefing room, and a B777 or B787 simulator.

2.6 Apparatus

The survey was developed and collected on a website called 'SurveyMonkey'. Participants accessed a specific link to: https://nl.surveymonkey.com/r/learningstyle questionnaire. The observation list was filled in during training on a laptop using Microsoft Word to facilitate the speed of answering questions and adding notes. Results of these programs were transformed into data in Microsoft Excel and later analysed using IBM SPSS Statistics 23.0.

Replicas of the cockpit of a Boeing-777-200ER, Boeing777-300ER and Boeing-787 were used as full flight simulators during training. They are manufactured by THALES and have been used for simulation-based training at KLM since 2000. The tasks of the experiment were programmed in these simulators and reflected real-flight scenarios.

2.7 Questionnaires

There are multiple questionnaires available to determine learning preferences (Coffield et al, 2004). The learning styles inventory (Kolb, 2000) is among these options. However, because of its accessibility and popularity, the Learning Style Questionnaire (Honey & Mumford, 1989; Honey & Mumford 2000), 'LSQ', was used within this study to identify the learning preferences of the pilots. The LSQ consists of (a) the survey, (b) a scorings table, and (c) a norming table. All extended forms can be found in appendices F & G.

The survey has 80 dichotomous questions to measure the learning preferences towards 4 different variables; learning styles. Per learning style, 20 questions can be answered with either 'agree' or 'disagree'. A quantitative score on a variable, as activist, is the sum of the total of 'agree' answers on related questions. The sum of scores are qualitatively normed to label variables as (0) very low preference, (1) low preference, (2) moderate preference, (3) strong preference, and (4) very strong preference. A study with 1302 participants (Honey & Mumford, 1992) validated these norms. Moreover, before the survey was distributed to the pilots, a test panel (consisting of 12 volunteers) tested the questionnaire in order to look for ambiguity and abnormalities. As a result, one small change was made to the original learning style questionnaire. This related to question 30, where the Dutch translation of the word 'flippant' ('onbezonnen') was added due to a commonly reported indistinctness. Furthermore, the introduction started with 5 questions to identify the participant number and relevant demographics. Lastly, 4 questions were added as final questions to measure the participant's self-identification in his or her learning preferences. The self-identification of participants was rated as 'good' when their chosen learning style was in line with the result of the learning style questionnaire; further effects of self-identification were not examined within this study and can be part of future research. The average completion time of the survey was 12 minutes.

One of the participants is used as an example to explain the interpretation of the results and questions. This participant X answered question 1 (related to theorist) with 'agree', the 2nd question (related to activist) with 'disagree' … the 80th question (related to pragmatist) with 'disagree'. All 'agree' answers were added up, which resulted in sums of: activist (13), reflector (5), theorist (10), and pragmatist (14). A first impression is that pragmatist is his 'dominant' learning style, followed by activist. However, using the norming table (found in Appendix G) the following learning preferences can be identified. Participant X has a very strong preference for the activist learning style, followed by a moderate learning preference for 'pragmatist'. This reflects his strong preference for active experimentation on the processing continuum (Kolb, 1984; Honey and Mumford 2000). His scores are reflected in a model (Figure 4) that has been created to visualise learning style preferences.

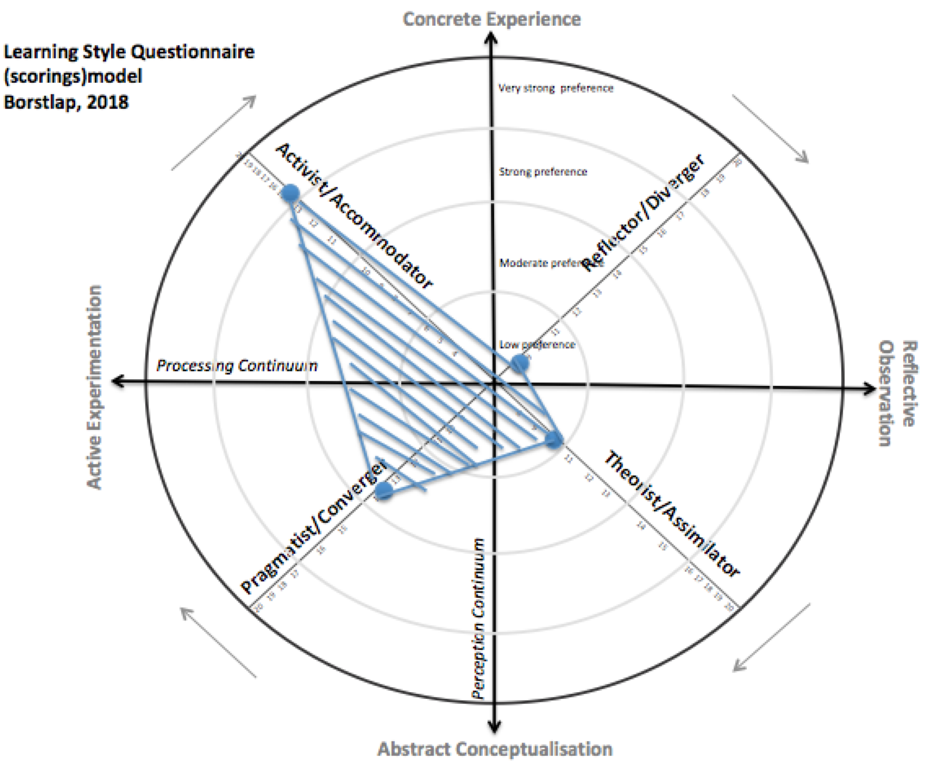

Figure 4. LSQ model: Learning preferences of participant X.

The learning preference of participant X is neutral to the instruction strategy ‘coaching and feedback’, no enhanced performance is therefore expected when this instruction is given. Referring to the matching hypothesis: his learning preferences (very strongly) match with an instruction strategy of feedback only. At the same time, an instruction that incorporates demo and feedback (very strongly) mismatches with his learning style, because of his very low preference for ‘reflector’. The matching hypothesis can therefore be accepted when he scores significantly higher on a scenario instructed with feedback only, whereas the mismatching hypothesis can be accepted when he scores significantly higher with a demo and feedback instructed scenario. The practical applications of these hypotheses for participant X are visualised in Figure 5.

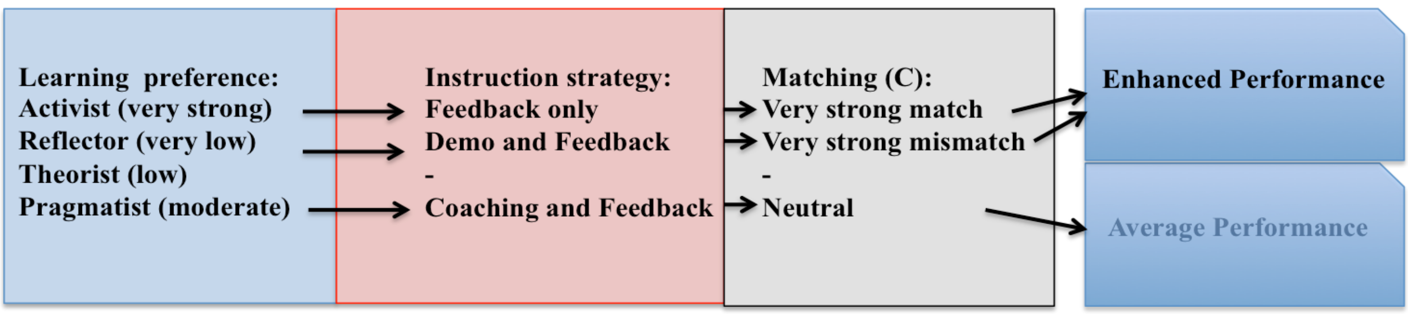

Figure 5. Applying the matching and mismatching hypothesis to participant X.

2.8 Tasks

The TR2 training consisted of 3 scenarios that reflected problems that could occur during a flight, training specific aspects of the pilots. During these scenarios, multiple tasks had to be performed by a crew to ‘solve’ the problem. A full description of these scenarios can be found in Appendix H. A specific observation list had to be created to measure the performance of tasks during the scenarios. This observation list aimed to rate the performance of desired behaviour during the training. The process of making this observation list was as follows. Firstly, the researcher attended multiple training sessions to become familiar with the set-up of the training, cockpit and flight simulator. Secondly, a task analysis of the scenarios was made with 2 expert instructors to describe a ‘perfect’ performance of each scenario. (1) Observable reflections of the desired behaviour of pilots during test scenarios that were collected together with an expert instructor, and an (2) observation-tool by KLM to measure performance called ‘MINT’ were used. Thirdly, each ‘perfect’ scenario consisted of multiple desired aspects of behaviour. These aspects needed to be divided, and grouped, into variables that assess specific parts of desired behaviour. Usually, the desired behaviour of teams can be divided into technical, and non-technical aspects (Flin & Martin, 2001; Flin et al., 2017; Gontar & Hoermann, 2014; O’Connor et al., 2002). KLM incorporated these aspects to create their SHAPE-model, to evaluate and assess the desired behaviour of their pilots. In this model (S) Self, (H) Human Interaction, and (E), Environment and Situation embrace the non-technical aspect, whereas (A) Aircraft, and (P) Procedures incorporate the technical aspects. An extended overview of this model with examples of desired behaviour can be found in Appendix A.

Fourthly, observable expressions and reflections of these aspects during a scenario were used to measure these aspects. These observable reflections were transformed into questions that the researcher could answer during scenarios to measure the desired behaviour. These questions were normed together with an expert instructor and a pilot by either a 0-1, or a 0-2. After bundling all the questions, the observation list was created and ready for testing. Lastly, two training sessions were observed to test the first version of the observation list. After some small changes and additions, a definitive version was ready for usage. The full definitive observation list can be found in Appendix I.

2.9 Observations

The same researcher carried out each observation in order to enhance the reliability of the results. Moreover, to improve the reliability and validity of the observation list, questions were often discussed and checked by instructors. No disagreements were found during these discussions and check-ups. The learning preferences of the participants were not yet known during the training sessions, establishing a ‘double-blind’ procedure to minimise the confirmation bias. Lastly, the researcher was only present during the simulation part of the training in order to minimise the halo bias.

Despite the effort to minimise biases and mirror each experiment, the presence of different instructors between training sessions could not be prevented. This could have had a negative effect on the reliability between observations, but instructors are experienced and trained to follow the same training manual (Appendix H). Moreover, the tasks were identical in each training session and the usage of the instructors’ instruction strategies were always briefed and discussed with the researcher. One instructor was more than cooperative with the research and instructed 7 of the 21 observations. This instructor instructed significantly more training sessions than other instructors, making him an expert on this training. To identify possible differences between this instructor and others, the performance of pilots between these groups was compared in the exploratory results.

2.10 Analysis

During the process of analysing data, many steps were taken before conclusions could be drawn from the collected raw data. The following events worth mentioning were executed during this process. (1) Raw data from observations collected in Microsoft Word was transformed into more quantitative data in Microsoft Excel. (2) The transformed data was checked on all criteria: correct norming of scores, no missing data and no exorbitant outliers. If inconsistencies were found, data was either removed, or adjusted using the references of the extended Word files of all observations. (3) The sum of scores of events was added up, which led to rates of performance of a scenario. For example, if a participant scored 40 points on event 2, he scored 40 out of 55 points, resulting in a score of 72.7%. When a question was removed due to missing data it was subtracted from the total score. (4) The match between the instruction strategy and the learning preference of a participant was identified. (5) The scores were entered in SPSS in order to reject or accept hypotheses using several statistic test methods.

The matching hypothesis is accepted when the two matching conditions result in significant higher performance than the mean performance. The mismatching hypothesis will be accepted when the two mismatching conditions result in significant higher performances than the mean performance. To test these criteria, a univariate analysis of variance (ANOVA) was performed. This test method analyses the means per condition of matching, and mismatching. A significant F score ($p<.05$) indicates significant effects of matching, and mismatching. The hypothesis of matching, or mismatching, can be accepted when the related conditions are significantly higher then the mean performance ($p<.05$). The two conditions per matching, and mismatching (strong and very strong) were deliberately not combined to one condition. Combining these two preference scales would have violated the norms of the LSQ (Honey & Mumford, 1992), causing the absolute 0-20 scores of a learning preference be even further reduced from relative 5 to 3 variables. The 5 conditions also give better insights into the distinctions between learning styles of individuals. The assumptions of this statistical method were then tested by manipulation checks that indicate the randomization of participants across the conditions, non-normally distribution of variables and equal variances.

3. RESULTS

The first part of the results was evaluated against the question: *what are the learning preferences of pilots?* A total of 495 completed questionnaires were collected; 100 of these surveys were removed from the data as they were either incomplete or the second or third answer of a single participant. This resulted in the identification of the learning preferences of 395 pilots, representing the total group. In the second part of the results, the main research question was evaluated. In this phase, 42 pilots were observed and used in further analyses.

3.1 Learning preferences

The learning preference of a participant consists of 4 different learning styles (activist, reflector, theorist, pragmatist). The combination of 4 preferences (very low – very strong) for each learning style represents the total learning preference of an individual. Instead of calculating the total learning preferences, the results of Table 2 show the mean preferences for each learning style and learning continuum. The normed variable (Table 2) indicates the following order of learning style preferences of pilots (from strong to lower): (1) Theorist *M*= 2.65, (2) Pragmatist *M*= 2.55, (3) Reflector *M*= 2.38, and (4) Activist *M*= 1.93, with a significant preference for Theorist ($t(394)= 2.866$, $p= .004$) and a significant tendency towards abstract-conceptualization ($t(394)= .319$, $p= 0.019$).

Table 2. *Results of the Learning Style Questionnaire.*

		Absolute		**Normed**	
	N	**Mean**	**SD**	**Mean**	**SD**
Activist	395	8.20	3.11	1.93	0.98
Reflector	395	14.11	3.00	2.38	1.01
Theorist	395	13.58	2.75	2.65	1.04
Pragmatist	395	14.32	2.51	2.55	0.99
Conc. Experience	395	11.15	1.78	2.15	0.59
Refl. Observation	395	13.85	2.46	2.51	0.87
Abs. Conceptualis.	395	13.95	2.21	2.60	0.84
Act. Experiment.	395	11.26	2.06	2.24	0.72
Total	395	12.55	1.54	2.38	0.57

The absolute variable shows the means of the mean of agree answers (0 – 20) per learning style. The normed variable (0 – 5) is made up after applying the norming table of the LSQ (Honey & Mumford, 1992).

To determine the effects of mismatching and matching in further analyses, the preference scale of each learning style of a participant is used. Instead of showing the mean preferences, Figure 6 therefore shows the ratio per preference scale of each learning style. For each learning style, the 'very low' and 'low' bars form the conditions in the mismatching group, the 'strong' and 'very strong' bars represent participants of the two matching groups of the experiment.

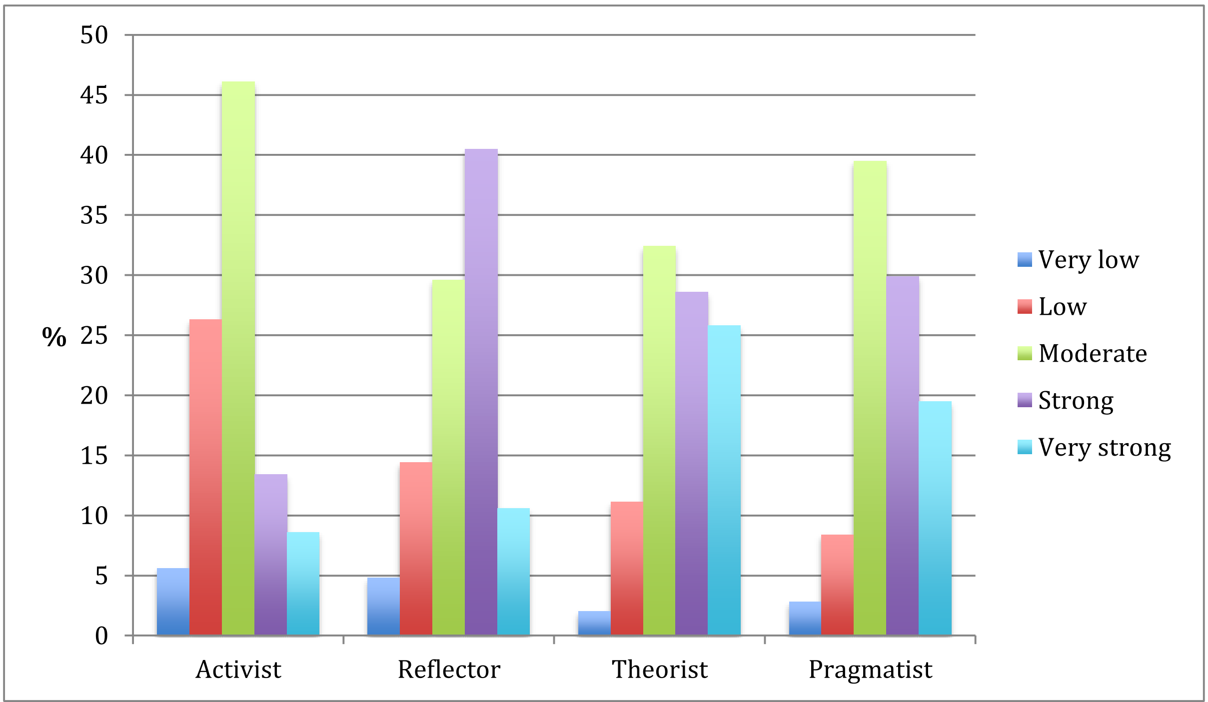

Figure 6. Ratio of learning preferences per learning style.

Finally, these outcomes were tested for deviating results, despite the large variation of learning preferences. Each learning style was therefore plotted against each other; these 6 scatter plots showed no outliers.

3.2 Matching

The main research question focused on matching, or mismatching, instruction strategies with learning styles to enhance training effectivity. The scores of a scenario were labelled from 'very strong mismatch' to 'very strong match' after the pilot completed all the tasks. The mean of all scores per condition, describing the effects of matching or mismatching in a scenario, are given in Table 3.

Table 3 *Performance scores per rate of matching and mismatching.*

	N	Mean	SD
Match	43	.719	.206
Strong	29	.674	.207
Very strong	14	**.812**	.173
Neutral	49	.692	.226
Mismatch	26	.721	.187
Very strong	9	**.733**	.236
Strong	17	**.714**	.164
Total	118	.708	.210

The scores vary from 0 to 1, scores in bold are higher than average.

The scores of a very strong mismatch and a very strong match are notably higher. However, there are no significant differences between the conditions (F(4, 113)= 1.167, p= 0.329, η_p^2.= .040) and an observed power of 35.7%. A boxplot (Figure 7) was used to illustrate the mean performance scores per condition and to find possible outliers. As a result, one outlier was identified (observation 119). The score of the participant in this scenario was .308; this score is within the range of two standard deviations of the overall mean score (*N*= 112, *M*= .708, *SD*= .210). This score was also achieved in the third scenario, which has the largest range of scores of the three scenarios. This score was therefore also within the range of two standard deviations of the third scenario (*N*= 36, *M*= .692, *SD*= .269). This outlier was therefore not excluded from the results.

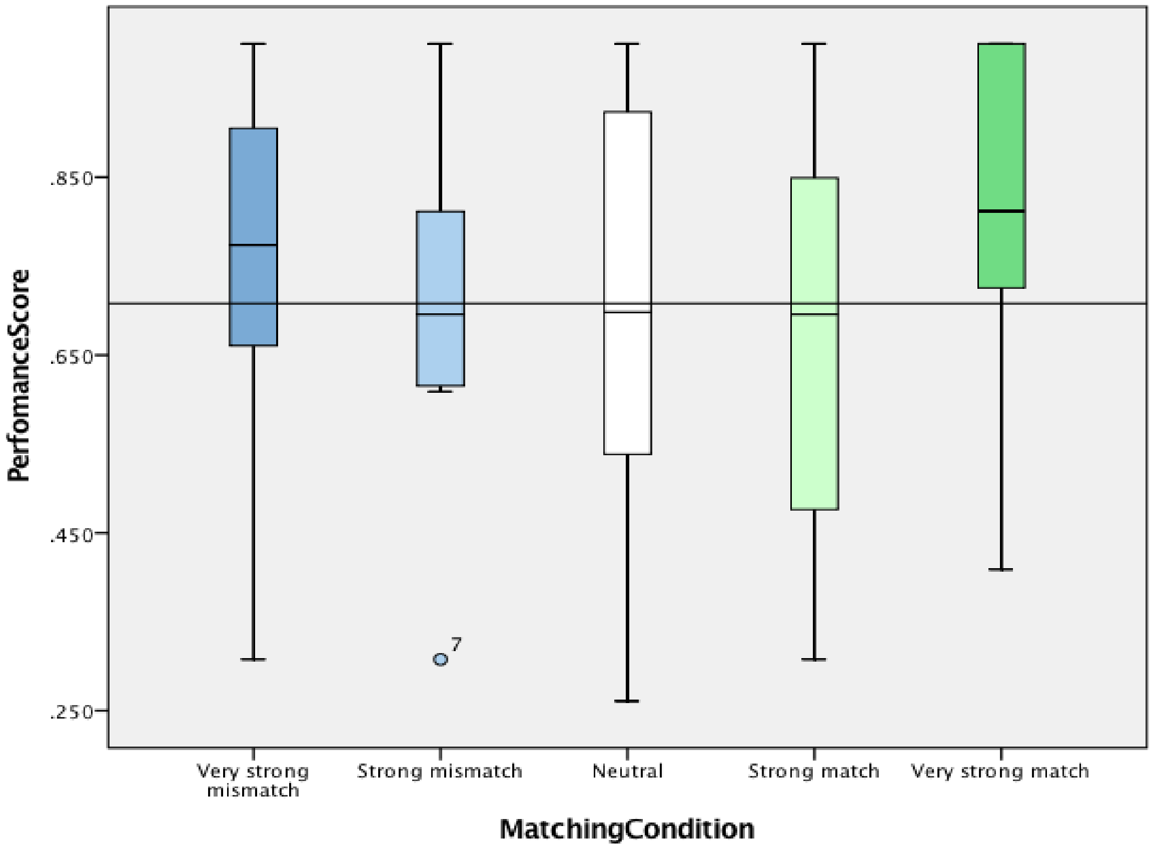

Figure 7. Boxplot of the mean performance (Y-axis) per matching condition (X-axis). Outlier 7 is mentioned as number 119.

3.3 Manipulation checks

Manipulation checks were performed to examine the randomization of participants across the 5 conditions. The following tests examined whether or not the independent variables within the conditions significantly differed, as non-normally distributed variables may have harmed the internal validity of the results.

The five different scales of the activist learning style (χ^2(16)= 142.585, *p*= <.001), the reflector learning style (χ^2(16)= 42.871, *p*= <.001), and pragmatist learning style (χ^2(16)= 25.214, *p*= .014) are not normally distributed across the conditions. The theorist learning style does meet the assumption of a normal distribution (χ^2(16)= 24.152, *p*= .086). Levene's test indicates equal variances (*F*= 1.046, *p*= .387). Besides, the mean learning preference of reflector and pragmatist do not significantly differ (reflector: *F*(4, 113)= 2.030, *p*= .095; pragmatist: *F*(4, 113)= 2.367, *p*= .057) between the conditions.

As the assumption of normally distributed variables had partly been violated, confirmatory tests were performed to research the impact on the validity and reliability of this study. Within all three non-normally distributed learning styles, no significant differences in scores were found (Activist: $F(4, 113) = 1.230$, $p = .302$, Reflector: $F(4, 113) = .760$, $p = .554$, Pragmatist: $F(4, 113) = 2.441$, $p = .068$). As most previous researchers (Cuevas, 2015; Coffield et al., 2004; Newton, 2015; Pashler, McDaniel, Rohrer & Bjork, 2008) define learning preferences by one or two dominant learning styles, participants were also compared by their dominant learning style. This analysis shows that by using this approach no significant effects between learning styles were found ($F(9,108) = .538$, $p = .844$), the performance score per dominant learning style can be found in Appendix J.

In the experiment phase, 21 training sessions, consisting of 3 scenarios each, were observed. However, due to the lack of time in 4 sessions, a total of 59 (instead of 63) scenarios were observed, which resulted in 8 missing scenario scores. Due to time restrictions, some scenarios were also too short to imply a demo or use coaching. The instructions (Feedback only ($N = 68$ (57.6%), $M = 0.717$, $SD = 0.226$), Coaching and feedback ($N = 18$ (15.3%), $M = 0.643$, $SD = 0.222$), and Demo and feedback ($N = 32$ (27.1%), $M = 0.725$, $SD = 0.160$)) were therefore not normally distributed ($\chi^2(8) = 18.471$, $p = 0.018$ (<0.05). This harms the internal validity of this study; hence it was decided not to modify the conditions because no significant differences in scores between the instructions ($F(2, 115) = 1.057$, $p = 0.351$ (>0.05)) were found. In addition, Levene's test showed equal variances ($F = 1.466$, $p = .143$).

The covariate gender is normally distributed across the conditions ($\chi^2(4) = 2.704$, $p = .608$), with equal variances (Levene's test resulted in $F = 1.450$, $p = .202$). It has been noted that female pilots ($N = 5$, $M = .902$, $SD = .121$) score significantly higher ($F(1, 116) = 4.620$, $p = .034$) than male pilots ($N = 113$, $M = .70$, $SD = .209$). The covariate age also meets this assumption ($F(4, 113) = 2.330$, $p = .060$); Levene's test also showed equal variances for age ($F = 1.270$, $p = .286$). In addition, no significant correlation was found between age and performance ($r = .063$, $N = 118$, $p = .497$). Experience also does not violate the assumption of a normal distribution ($F(4, 113) = .989$, $p = .417$) and has equal variances (Levene's test indicated $F = 1.394$, $p = .241$). It is notable that more experience predicts better performance, as there is a significant positive correlation between experience and performance (*r*= .211, *N*= 118, *p*= .022). This correlation is illustrated in the scatterplot of Figure 8.

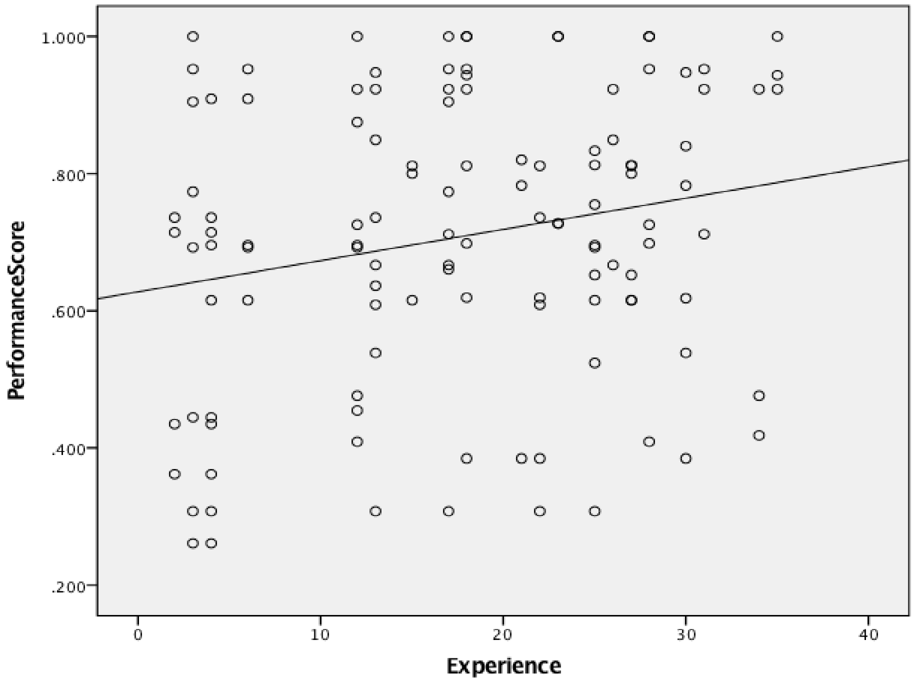

Figure 8. Scatterplot of experience (X-axis) and performance scores (Y-axis).

Lastly, the distribution of the covariate position was tested. The position of the pilots was not normally distributed across the conditions (χ^2(8)= 18.774, *p*= .016). However, no significant difference in scores between the positions (*F*(2, 115)= .013, *p*= .987) was found.

The external validity of this study pertains to the generalizability of the experiment group towards the whole pilot division, and the real-world population. Possible differences between the groups were therefore compared and analysed. As a result, no significant differences between the learning preferences of the participants in the total and experiment group (for Activist; χ^2(4)= 1.919, *p*= .751, for Reflector: χ^2 (4)= 2.459, *p*= .652, for Theorist: χ^2(4)= 5.984, *p*= .200, for Pragmatist: χ^2(4)= 1.643, *p*= .801) were found. Also, no significant differences were found for gender (χ^2(1)= 0, *p*= 0.988), position (χ^2(2)= 2.521, *p*= .284), age (*M*= 43.14, *SD*= 9.89, (*F*(1, 392)= 2.365, *p*= .125) and experience (*M*= 20.94, *SD*= 19.90, (*F*(1, 393)= 1.762 *p*= .185) between the experiment and total group, indicating a strong external validity of this experiment.

The external validity, equal variances and confirmatory tests do not fully compensate for the non-normal distribution of specific variables. However, these results show that the effects on the performance scores of these variables are small. To meet the assumption of a normal distribution of the learning preferences, a much larger group of participants is required, as it is nearly impossible to meet the assumption of having 5 participants for each 'kind' of learning preference in each condition, with a normal distribution of the participants. The learning preferences of participants also need to be known before the tasks are performed in order to meet this requirement. However, the tasks were deliberately performed double-blind to minimalize the observer bias. Another option is to reduce the conditions from five to three (matching, neutral and mismatching). This option would have led to a normal distribution of the variables across the conditions. As this was an orientating study on how to research the effects of matching and mismatching, the decision not to decrease the (insights in) effects of different levels of matching and mismatching was more important than not violating some of the assumptions. It was therefore decided not to modify the design of the conditions.

3.5 Exploratory tests

Four questions have been examined to explore other statistics that can be of use in increasing the training effectivity of pilots. Exploratory data analysis was used for these statistics and they are not part of the main results; each result is therefore followed by a brief conclusion.

I. Which pilots' learning preferences show enhanced training effectivity?

There was no significant correlation found between performance scores and learning styles (Activist: r= .102, p= .274, Reflector: r= -.146, p= .113, Theorist: r= .014, p= .879, Pragmatist: r= .127, p= .172). Furthermore, specific scales of preferences per learning style did not significantly lead to increased performance scores (Activist F(4, 113)= 1.230, p= .302, Reflector F(4, 113)= .760, p= .554, Theorist F(4, 113)= 1.784, p= .137, Pragmatist F(4, 113)= 2.441, p= .068).

II. What instruction strategy is the most effective strategy in simulation-based training?

To answer this question, Table 4 shows the mean scores per instruction strategy.

Table 4. *Mean performance scores per instruction.*

	N	Mean	SD
Instruction			
Trial&Error	68	.717	.226
Coaching	18	.643	.222
Demo	32	.725	.160
Total	118	.708	.210

No significant (p >0.05) differences in scores between the instruction strategies were found.

There was not one particular instruction method that led to a significantly increased training effectivity ($F(2, 115)= 1.057$, $p= 0.351$). However, the coaching instruction strategy resulted in notably lower scores. The distraction caused by coaching during a training session, affecting the workload management of a crew and resulting in less attention towards other tasks during a scenario (Flin & Martin, 2001; Flin et al., 2017) could explain this effect. This reasoning could also explain why instruction strategies consisting of a demo, and a trial-and-error approach - which did not distract the crew during a scenario - scored slightly higher. Future research should design instruction strategies that do not have a negative impact on the pilots and should aim to maximize the opportunities of instruction strategies.

III. What are the effects of the instructor's experience on training effectivity?

The performance scores of the expert instructor and the other instructors were compared to address this question. The performance scores of participants with an expert instructor (N= 42, M= .793, SD= .170) were significantly higher ($F(1, 116)$= 11.538, p= .001 (< 0.05)) than the results of those with other instructors (N= 76, M= .661, SD= .216). As no instruction related variables have shown significant effects, it is imaginable that instruction methods have little influence on training effectivity. With an effect size of $\eta^2= 0.090$, the instructor's experience has a medium to large effect (Cohen, 1988) on the performance of pilots. This result shows that an expert instructor, compared to other instructors with less experience, leads to higher performance scores. Training sessions given by an instructor with more knowledge and experience is thus required to teach effectively.

IV. Do pilots with better CT-skills deliver a better overall performance?

Regarding the second sub-hypothesis that higher CT-performances indicate higher overall performance scores, the correlation of the total scores was analysed. This resulted in a significant correlation (r= .894, p < 0.01). The relationship between CT-performance and overall performance is visualised in Figure 9.

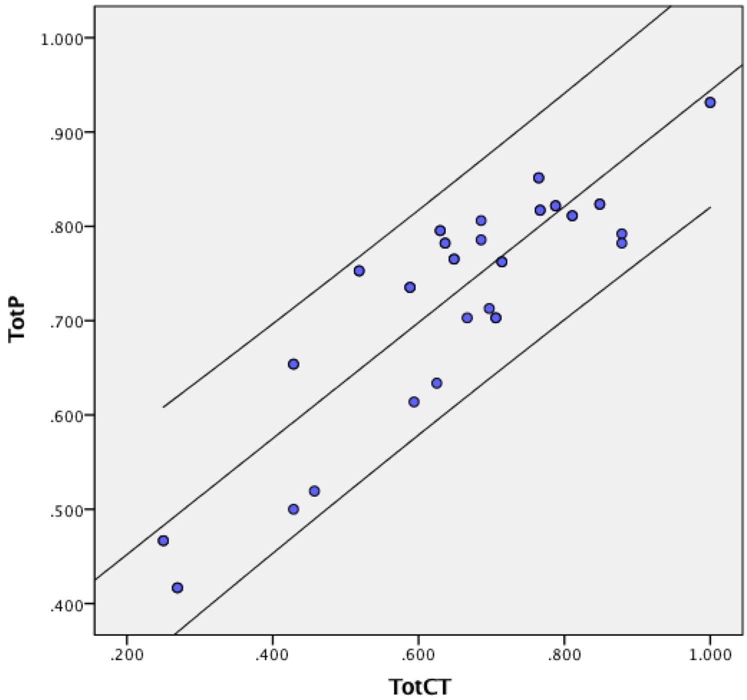

Figure 9. Scatter plot of the critical thinking scores and mean performance scores. A significant correlation is found, without outliers.

These results showed that pilots with better CT-skills were also better overall performers. This could signify that pilots' CT-skills have a predictive validity to other skills that are required for making better decisions, and making fewer errors in the cockpit. For example, better CT-skills are correlated with better decision-making and workload management (Flin & Martin, 2001; Flin et al., 2017). Training these skills may therefore result in improved air safety (Salas et al., 1999).

4. DISCUSSION

The aim of this study was to research whether learning styles could be used in aviation and in simulation-based training to enhance training effectivity. In the first phase of this study, the learning preferences of KLM pilots were captured.

4.1 Learning preferences

The results showed that the order of prevalence of pilots' learning preferences is as follows: (1) Theorist, (2) Pragmatist, (3) Reflector, and (4) Activist, with a tendency towards abstract conceptualization. This sequence and tendency is, apart from the exchanged order of Theorist and Pragmatist, in line with the expected distribution (Kanske, 2001; Gao et al., 2013). The deviations are possibly due to a different approach in ranking the learning preferences, as this research uses mean preferences instead of dominant learning styles. The differences could also be a result of the limitations of this study (further explained in limitations). A fictive average KLM pilot is made up by averaging all results per learning preference. These results are interpreted by visualisation in Figure 10.

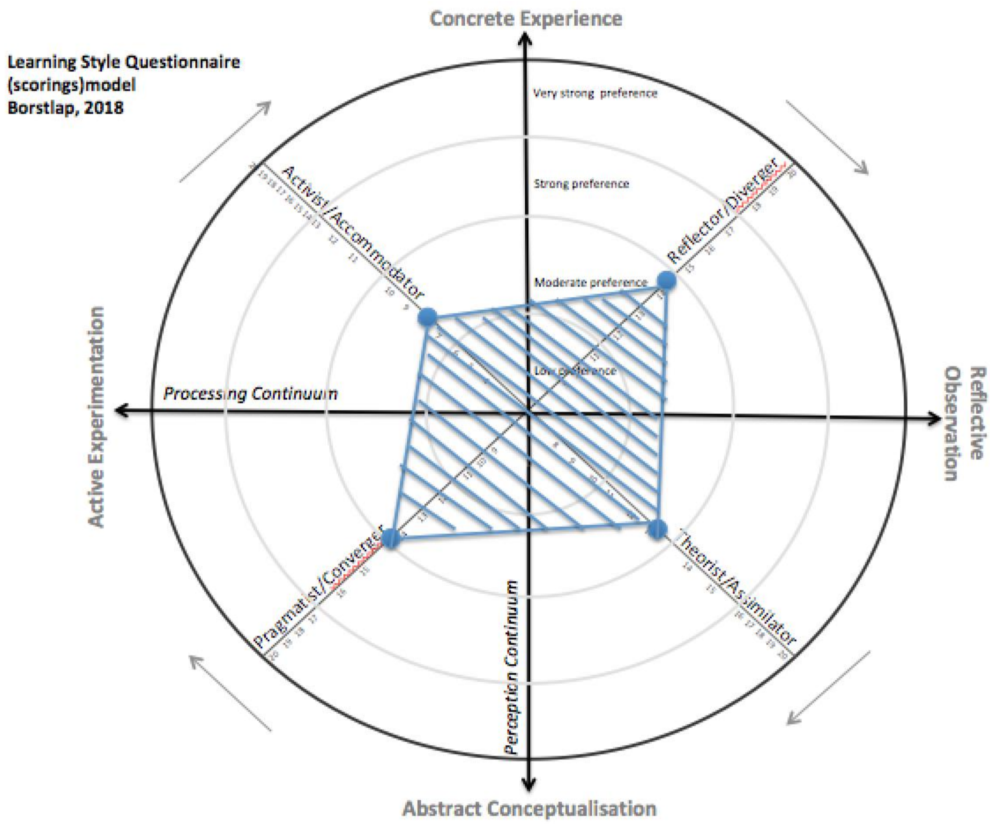

Figure 10. Model of the mean learning preferences of a fictive average KLM pilot.

This model comes close to an equal distribution of learning preferences, like a real-world population described by Kolb (1984). The results also resemble a normal distribution for each learning style: it shows a symmetric distribution for the learning preference scales, with a peak in the middle (for the moderate preference). Thus, these results confirm the norms that were created by the study of 1302 participants by

Honey & Mumford (1992). This indicates that the results of this research can, apart from other pilots, be generalizable towards other work fields with team performances and a real-world population, increasing the significance of this study for other fields of research.

4.2 Enhancing training effectivity

In the experiment phase, the effect of matching and mismatching the learning preferences on training effectivity was examined and evaluated against the following hypotheses.

Matching hypothesis

Matching the events instruction strategy with a pilot's learning preferences did not result in significantly enhanced training effectivity; the matching hypothesis of this research can therefore not be accepted. This means that a (strong and very strong) match did not result in significantly higher performance scores. This result is in line with most studies that researched the effects of matching learning styles (Cuevas 2015; Coffield et al., 2004; Newton 2015). However, the outcomes showed that a very strong match between learning preferences and instruction strategies resulted in notably higher training effects. This could indicate actual effects of matching. Future research should try to revise the definition of dominant learning styles and make them more adaptable to rates of learning preferences. Applying these revised research designs in future studies may eventually lead to different conclusions towards learning styles.

Deliberate mismatch hypothesis

Deliberately mismatching the instruction with a pilot's learning preferences did not lead to significantly enhanced training effectivity, meaning that the mismatching hypothesis of this research is rejected. However, as a very strong match resulted in higher performance scores, a very strong mismatch had the enhanced training effects. This confirms the ideas to revise the definition of learning styles once again and emphasizes the importance of not reducing learning preferences to simply matching and mismatching.

4.4 Significance

The results of this study show many opportunities for science when individuals are rated by learning preferences, instead of being labelled by a dominant learning style. The theoretical significance of this study may therefore eventually lead to different views and definitions on learning styles. This study is also of practical significance for companies with training departments, such as KLM and NLR. As a result of this, the following recommendations should be considered:

(I) Identification of very strong preferences for learning styles, OR very low preferences for learning styles can possibly be used to design instruction strategies. It is recommended that the learning styles of the remaining KLM pilots be captured, to identify individuals with very strong (dis-) preferences to adapt their instruction methods. This is because matching very strong preferences and mismatching very low preferences show promising results.

(II) The performance of female pilots seems better than that of their male colleagues. Airlines should look into the opportunity to research whether this result is due their stronger selection towards females, possible effects of the presence of a female in a crew, or significant better overall performance of female pilots.

(III) It is recommended that experienced instructors be employed to effectively train newly introduced and trained skills (such as Critical Thinking). When allocating inexperienced instructors to a training session, it should be borne in mind that the training effects of the session could be significantly lower.

4.5 Limitations

One of the limitations of this research is the possible low validity of the LSQ as the construct validity is often criticised (Coffield et al., 2004; Zwanenberg, Wilkinson & Anderson, 2000). This questionnaire was deliberately chosen over the LSI (Kolb, 1984), as it defines learning preferences (I) more constructively (and in more preferences, instead of one dominant learning style), and (II) as it is more reliable than the LSQ (Ciantis & Kurton, 1996; Coffield et al., 2004). Besides the criticised validity, participants of this research were confused by the content of some questions and reported some displeasure in completing the questionnaire, as certain questions had to be answered in a specific way to comply with the regulations of KLM. This underlines discussions about the predictive validity of the LSQ (Coffield et al., 2004; Skyviews, 2003). These studies question the restrictions of the questionnaire and state that work patterns, exposure, and experiences result in adaptations of one's learning preferences. For example, the learning preferences of pilots could adapt to activist and pragmatist due to the recurrent exposure to active experimentation in simulation-based training. Future research could use different methods to define the learning preferences in other ways, for example translating the LSQ or using the LSI of Kolb instead. Combining the outcomes of learning preferences of these results may provide for a higher validity and reliability, and possibly have effects on the matching and mismatching hypotheses.

The following limitations derive from the distinctions between instruction strategies and instructors. As multiple instructors were part of this research, it could violate the inter-method reliability. This means that the instruction methods between the training sessions may vary, for example, a demo of instructor X may differ from the demo of instructor Y. Besides this, another limitation could be the distinctions between instruction methods. Sometimes, an instructor's demo or coaching was so brief, that the impact of this instruction method was uncertain. It is also arguable that learning CT-skills always started in the theorist part of the learning cycle, as pilots were briefly informed of the theoretical models prior to the simulation phase. Although this was a minimal explanation of critical thinking, future designs should aim to exclude this part in order to make stronger distinctions between the instruction methods. This research aimed to minimise the previous limitations by an extensive briefing towards the instructor. However, future research should aim to include only one instructor to increase the reliability and validity.

Another limitation of this research is the unqualified observer, which could possibly lead to less reliable observations (Flin et al., 2017). Although many steps were taken to make the observer more experienced, and observations were always discussed with the training instructor, observing NOTECH-Skills are difficult and observers should be qualified (Flin et al., 2017). To examine the possible learning effects of the observer's observation skills, the training effects of the first half of the training sessions were compared to the second half of the training sessions. The performance showed no significant differences, indicating that the unqualified observer negligible affected the main hypotheses. The CT-performance of pilots was however significantly higher in the second half. This could be due to the increased skills of perceiving CT-performance by the observer, but it is also strongly imaginable that this is the effect of the more highly experienced instructors, as the experience of instructors showed a significant impact on (CT-) performance.

This study was designed with the best available options; however, some limitations were due to the imperfections of the method. The violation of the non-normal distribution was also a limitation of this study. The design of this research used five different conditions with a large variety of learning style variables, which resulted in the violation of the assumption of a normal distribution of the variables. Although this had little effects on the validity, future research should ensure that enough participants are recruited to meet this assumption. Another revision of this study design could involve knowing the learning preferences of participants beforehand in order to divide them across the conditions more satisfactorily. Finally, future research should consider reducing the conditions from five to three conditions (matching, neutral and mismatching).

4.8 Conclusion

This study aimed to research whether learning styles, and other related aspects, can be used to enhance training effectivity in crew training settings. The results of the matching and mismatching hypotheses showed no significant effects, but indicate simple solutions to enhance the training methods in societal settings. Future research should attempt to use recommended different approaches when formulating learning preferences in order to retest these hypotheses.

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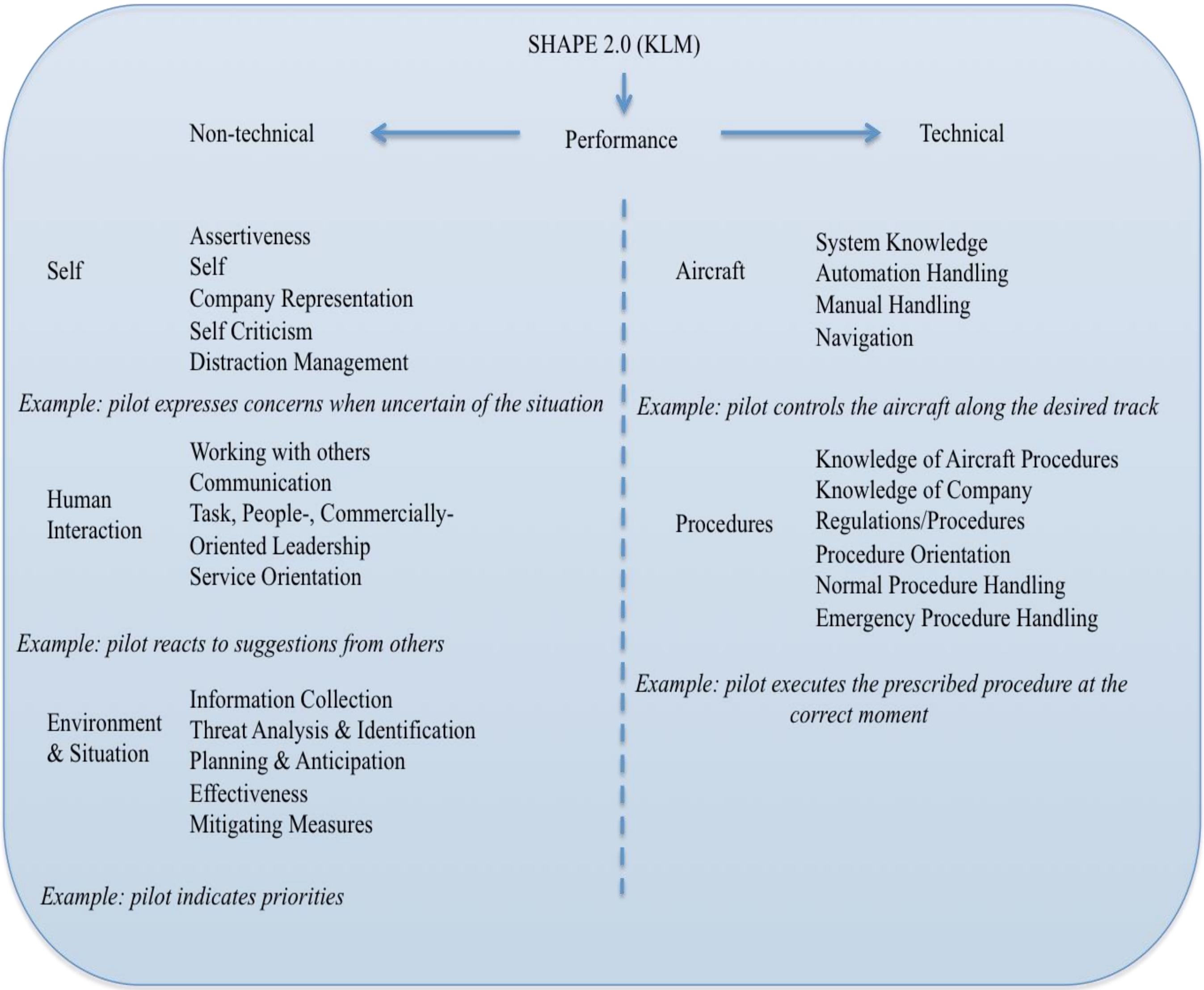
6. APPENDIX

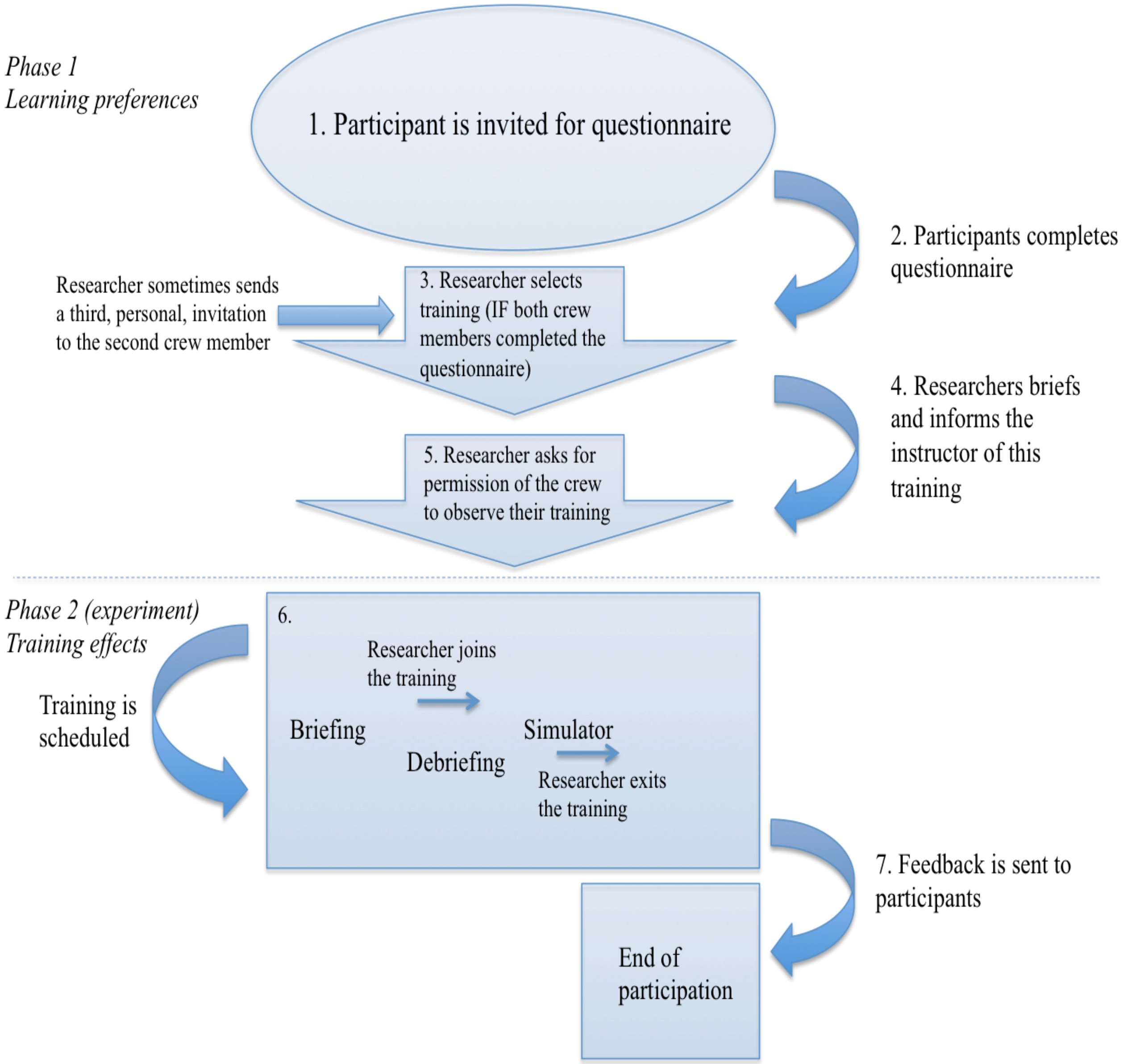
Appendix A

SHAPE 2.0 (KLM) with examples of desired behaviour



Appendix B

Participation process



Appendix C
Invitations

For English see below

Beste XX,

U ontvangt deze mail omdat u bent geselecteerd om mee te doen aan een onderzoek naar leerstijlen (van piloten van KLM) dat wordt uitgevoerd in samenwerking met NLR en de Universiteit Leiden. Het onderzoek wordt uitgevoerd onder piloten van de B777 en de B787 in de Type Recurrent 2.

Voor dit onderzoek zal worden gekeken of voor u, en uw collega's, de trainingen kunnen worden gepersonaliseerd en geoptimaliseerd. Hiervoor ontvangt u in deze mail een vragenlijst om uw persoonlijke leerstijl te bepalen. Het invullen van deze vragenlijst gaat snel en duurt ongeveer **10 minuten**, het is hierbij belangrijk dat u bij het antwoorden hiervan vertrouwt op **uw eerste ingeving.** Aan het eind van de vragenlijst kunt u aangeven of u de resultaten van uw leerstijl wilt ontvangen, in deze resultaten zal ik een uitleg geven over uw leerstijl en bijpassende tips & mogelijkheden.

Om de anonimiteit voor het onderzoek te waarborgen heeft u een participantnummer gekregen. Dit nummer vult u in het begin van de vragenlijst in. **Uw participantnummer is: XX**

U kunt via deze link beginnen met het invullen van de vragenlijst:https://nl.surveymonkey.com/r/learningstylequestionnaire
Mocht u onverhoopt tussentijds worden gehinderd, kunt u de vragenlijst op een later moment afronden.

Tevens wordt onder de deelnemers 5 bol.com cadeaubonnen van €20 **verloot**, de winnaars worden 17 augustus bekend gemaakt.

Ik dank u alvast voor uw medewerking.

Met hartelijke groet,

Thomas Borstlap
0657379166
thomasborstlap@gmail.com

ENGLISH

Dear XX,

You receive this mail because you are selected to participate in a study of learning styles (of KLM pilots) which is carried out in cooperation with NLR and Leiden University. This study is conducted by pilots of the B777 and B787 in the Type Recurrent 2.

This research will examine whether trainings can be personalised and optimised for you, and your colleagues. Therefore, you hereby receive a questionnaire to determine your specific learning style. The completion of this questionnaire will only take about **10 minutes**, it is important that you trust your **first intuition**. At the end of the questionnaire you can select whether you want to receive the results containing your learning style, in these results I will explain your learning style and give associated tips & opportunities.

To ensure anonymity for this research, you have been granted a participant number. You enter this number at the first question of the questionnaire. **Your participant number is: XX**

You can start the questionnaire by following this link:
https://nl.surveymonkey.com/r/learningstylequestionnaire
If you are suddenly interrupted while filling in the survey, you may complete the survey at a later stage.

Moreover, by participating, you have a chance to **win** a bol.com gift card (5x €20). The winners will be announced on the 17th of August.

I thank you in advance for your cooperation.

With kind regards,

Thomas Borstlap
0657379166
thomasborstlap@gmail.com

Appendix D

Written briefing towards instructors

Beste *XX,*

Binnenkort staat u ingedeeld als instructeur op een TR2-2017. De sessie waar u op staat ingedeeld is namelijk geselecteerd om onderdeel van een leerstijlen onderzoek uit te maken. Dit onderzoek is bedoeld om de trainingen voor u en uw collega's nog beter te personaliseren en optimaliseren. Ik zou dan ook graag uw type recurrent 2 van –***datum-*** willen bijwonen om te observeren. Door middel van deze mail stuur ik u wat meer informatie over dit onderzoek.

Voor mijn onderzoek zijn niet veel trainingen geschikt, beide piloten moeten namelijk de leerstijlen vragenlijst hebben ingevuld en een bepaalde leerstijl hebben. In de training van *XX* is dit het geval, waardoor de training geschikt is om te onderzoeken.

Tijdens mijn onderzoek kijk ik of bepaalde instructie strategieën in combinatie met bepaalde leerstijlen van crews voor een verhoogde performance kan zorgen. Voor deze performance, ofwel trainingseffectiviteit, heb ik een observatielijst gemaakt (per scenario) die voor een groot deel is gebaseerd op SHAPE 2.0 en het Recognition-Metacognition model om Critical Thinking te scoren. U zou mij enorm helpen als u deze observatielijst zou willen invullen tijdens, of na afloop, van de **eerste drie scenario's** (waarin de instructie strategieën m.b.t. Critical Thinking in terug komen).

Daarnaast is het ook belangrijk dat de drie instructie strategieën (demo+feedback, coaching+feedback en alleen feedback) strikt worden toegepast per scenario, d.w.z. **niet meerdere strategieën door elkaar in één scenario**. **Dus alle 3 de strategieën worden eenmaal gebruikt in de eerste drie scenario's**. Het meest praktisch is om deze volgorde van strategieën per scenario vooraf vast te stellen, het is de bedoeling dat de crew hier niet over ingelicht is. Deze opzet is besproken met de Chief Flight Instructors, vanuit hun is er toestemming deze trainingsopzet te onderzoeken.

Tot slot is mijn rol in de training puur het observeren en het scoren van de crew, ik zal daarom alleen aanwezig zijn bij de sim-sessie (ik zal een kwartier van tevoren in de koffiecorner staan). Hierbij wil ik nog benadrukken dat de anonimiteit van de observatie zeer zorgvuldig gewaarborgd is. Mocht u nog vragen hebben kunt u mij mailen of bellen op onderstaand nummer.

Alvast bedankt namens KLM Crew Training, NLR en de Universiteit Leiden voor uw medewerking.

Tot *(dag)!*

Met vriendelijke groet,
Thomas Borstlap
0657379166

Appendix E

Informed consent

Beste XX,

Ik wil u op de hoogte stellen dat ik contact heb gehad met de instructeur van uw Type Recurrent 2 training van XX. Ik zou namelijk graag deze training willen observeren voor mijn onderzoek naar leerstijlen dat ik uitvoer als stagiair bij KLM (voor dit onderzoek heeft u eerder een vragenlijst ingevuld).

Mocht u op deze observatie bezwaar hebben, of als u meer informatie wilt, kunt u mij bellen op: 06-57379166. Anders zie ik u graag morgen om XX bij de koffiecorner om het een en ander kort toe te lichten (ik zal alleen bij de sim-sessie aanwezig zijn).

Met vriendelijke groet,
Thomas Borstlap

Appendix F

Learning Style Questionnaire as in SurveyMonkey

Learning Style Questionnaire

Hartelijk dank voor het deelnemen aan mijn onderzoek.
Deze vragenlijst is opgedeeld in drie onderdelen. In de eerste sectie worden algemene vragen gesteld, de tweede sectie bestaat uit de leerstijlvragenlijst en in de laatste sectie zijn er vier slotvragen. In totaal zal het ongeveer 10 minuten duren om in te vullen. Uw antwoorden zullen uitsluitend voor dit onderzoek worden gebruikt en worden tevens geanonimiseerd. Mocht u opmerkingen hebben kunt u die kwijt in de laatste sectie, voor andere vragen of opmerkingen kunt u met mij contact opnemen.

1. What is your participant number? (5-digit number in the mail)
2. What is your gender? Male Female
3. What is your age?
4. What is your position? (multiple answers possible)
Instructor Captain First Officer Second Officer
5. For how many years are you a professional pilot? (number of years after completion of the professional training)

De vragenlijst bestaat uit 80 verschillende uitspraken. De accuraatheid van de uitslag wordt bepaald door de eerlijkheid van uw reacties. Er bestaan geen goede en ook geen slechte antwoorden. Als u het meer eens dan oneens bent met de stelling, antwoord dan met 'Agree'. Bent u het meer oneens dan eens met de stelling, antwoord dan met 'Disagree'.

Het invullen van uw eerste ingeving is meestal beter dan te veel nadenken over uw reactie. Heeft u moeite met het bedenken van een situatie om antwoord te geven op een stelling, denk dan aan situaties waarin u samenwerkt met andere mensen (let op: dit hoeft niet per se in de cockpit te zijn, het gaat om uw algehele voorkeur).

1. I have strong beliefs about what is right and wrong, good and bad. Agree Disagree
2. I often act without considering the possible consequences. Agree Disagree
3. I tend to solve problems using a step-by-step approach. Agree Disagree
4. I believe that formal procedures and policies restrict people. Agree Disagree
5. I have a reputation for saying what I think, simply and directly. Agree Disagree
6. I often find that actions based on feelings are as sound as those based on careful thought and analysis. Agree Disagree
7. I like the sort of work where I have time for thorough preparation and implementation. Agree Disagree
8. I regularly question people about their basic assumptions. Agree Disagree
9. What matters most is whether something works in practice. Agree Disagree
10. I actively seek out new experiences. Agree Disagree
11. When I hear about a new idea or approach, I immediately start working out how to apply it in practice. Agree Disagree
12. I am keen on self discipline such as watching my diet, taking regular exercise, sticking to a fixed routine, etc. Agree Disagree
13. I take pride in doing a thorough job. Agree Disagree
14. I get on best with logical, analytical people and less well with spontaneous, 'irrational' people. Agree Disagree
15. I take care over how I interpret data and avoid jumping to conclusions. Agree Disagree
16. I like to reach a decision carefully after weighing up many alternatives. Agree Disagree
17. I am attracted more to novel, unusual ideas than to practical ones. Agree Disagree
18. I don't like disorganised things and prefer to fit things into a coherent pattern. Agree Disagree
19. I accept and stick to laid down procedures and policies as long as I regard them as an efficient way of getting the job done. Agree Disagree
20. I like to relate my actions to a general principle, standard or belief. Agree Disagree
21. In discussions, I like to get straight to the point. Agree Disagree
22. I tend to have distant, rather than formal relationships with people at work. Agree Disagree
23. I thrive on the challenge of tackling something new and different. Agree Disagree
24. I enjoy fun-loving spontaneous people. Agree Disagree
25. I pay careful attention to detail before coming to a conclusion. Agree Disagree
26. I find it difficult to produce ideas on impulse. Agree Disagree
27. I believe in coming to the point immediately. Agree Disagree
28. I am careful not to jump to conclusions too quickly. Agree Disagree
29. I prefer to have as many sources of information as possible - the more information to think over the better. Agree Disagree
30. Flippant (onbezonnen), superficial people who don't take things seriously enough usually irritate me. Agree Disagree
31. I listen to other people's points of view before putting my own view forward. Agree Disagree
32. I tend to be open about my feelings. Agree Disagree
33. In discussions, I enjoy watching the plotting and scheming of the other participants. Agree Disagree
34. I prefer to respond to events in a spontaneous, flexible way rather than plan things out in advance. Agree Disagree
35. I tend to be attracted to techniques such as flow charts, contingency plans etc. Agree Disagree
36. It worries me if I have to rush work to meet a tight deadline. Agree Disagree

37. I tend to judge people's ideas on their practical merits. Agree Disagree
38. Quiet, thoughtful people tend to make me feel uneasy. Agree Disagree
39. I often get irritated by people who want to rush things. Agree Disagree
40. It is more important to enjoy the present moment than to think about the past or future. Agree Disagree
41. I think that decisions based on a careful analysis of all the information are better than those based on intuition. Agree Disagree
42. I tend to be a perfectionist. Agree Disagree
43. In discussions, I usually produce lots of spontaneous ideas. Agree Disagree
44. In meetings, I put forward practical, realistic ideas. Agree Disagree
45. More often than not, rules are there to be broken. Agree Disagree
46. I prefer to stand back from a situation and consider all the perspectives. Agree Disagree
47. I can often see inconsistencies and weaknesses in other people's arguments.
Agree Disagree
48. On balance I talk more than I listen. Agree Disagree
49. I can often see better, more practical ways to get things done. Agree Disagree
50. I think written reports should be short and to the point. Agree Disagree
51. I believe that rational, logical thinking should win the day. Agree Disagree
52. I tend to discuss specific things with people rather than engaging in social discussion. Agree Disagree
53. I like people who approach things realistically rather than theoretically. Agree Disagree
54. In discussions, I get impatient with irrelevant issues and digressions. Agree Disagree
55. If I have a report to write, I tend to produce lots of drafts before settling on the final version. Agree Disagree
56. I am keen to try things out to see if they work in practice. Agree Disagree
57. I am keen to reach answers via a logical approach. Agree Disagree
58. I enjoy being the one that talks a lot. Agree Disagree
59. In discussions, I often find I am a realist, keeping people to the point and avoiding wild speculations. Agree Disagree
60. I like to ponder many alternatives before making up my mind. Agree Disagree
61. In discussions with people I often find I am the most dispassionate and objective.
Agree Disagree
62. In discussions I'm more likely to adopt a 'low profile' than to take the lead and do most of the talking. Agree Disagree
63. I like to be able to relate current actions to the longer-term bigger picture. Agree Disagree
64. When things go wrong, I am happy to shrug it off and 'put it down to experience'.
Agree Disagree
65. I tend to reject wild, spontaneous ideas as being impractical. Agree Disagree
66. It's best to think carefully before taking action. Agree Disagree
67. On balance, I do the listening rather than the talking. Agree Disagree
68. I tend to be tough on people who find it difficult to adopt a logical approach. Agree Disagree
69. Most times I believe the end justifies the means. Agree Disagree
70. I don't mind hurting people's feelings so long as the job gets done. Agree Disagree
71. I find the formality of having specific objectives and plans stifling. Agree Disagree
72. I'm usually one of the people who puts life into a party. Agree Disagree
73. I do whatever is practical to get the job done. Agree Disagree
74. I quickly get bored with methodical, detailed work. Agree Disagree
75. I am keen on exploring the basic assumptions, principles and theories underpinning things and events. Agree Disagree

76. I'm always interested to find out what people think. Agree Disagre
77. I like meetings to be run on methodical lines, sticking to laid down agenda. Agree Disagree
78. I steer clear of subjective (biased) or ambiguous (unclear) topics. Agree Disagree
79. I enjoy the drama and excitement of a crisis situation. Agree Disagree
80. People often find me insensitive to their feelings. Agree Disagree

Na het invullen van de vragenlijst wordt uw leerstijl bepaald. Deze komt niet altijd overeen met het beeld wat u over uzelf heeft. Met de volgende vier stellingen wordt er gevraagd wat u denkt voor een leerstijl u zelf heeft.

Imagine you are going to learn to ride a one wheel bike (een éénwieler). How would you learn to ride it?
You would think about riding it, and watch others ride it.
You first want to understand the concept of riding a one wheel bike before riding it.
You would seek practical tips from an expert in one wheel bikes.
You would leap on the bike and give it a try

I am
a do-er (een doener; 'feel and do') / a decision maker (een beslisser; 'think and do')
a creator (een dromer; 'feel and watch') / a planner (een denker; 'think and watch')

I am
an activist (you want practical tasks, little theory) / a theorist (you want handouts, something to take away and study) / a reflector (you want breaks to go off and read and discuss) /
a pragmatist (you want shortcuts and tips)

I prefer
auditory learning (listening, lectures, discussions) / kinaesthetic learning (physical activities, doing) / visual learning (using charts and diagrams over words)

U bent aangekomen bij het einde van het onderzoek. Hartelijk dank voor het invullen van de vragen, mocht u geïnteresseerd zijn welke leerstijl(svoorkeur) er bij u is uitgekomen kunt u dit aangeven in de volgende vraag. Deze leerstijlen zullen pas na afloop van het onderzoek bekend worden gemaakt. Als u nog opmerkingen heeft kunt u die hieronder kwijt.

Ik wil graag een mail ontvangen met de uitslag van het onderzoek. Ja Nee

Opmerkingen

Appendix G

The norming tables of the learning style questionnaire (Honey & Mumford, 1992)

Learning Styles Questionnaire Profile Based on General Norms for 1302 People

Activist	Reflector	Theorist	Pragmatist	
20	20	20	20	Very strong preference
19				
18		19	19	
17				
16		18		
15		17	18	
14				
13	18	16	17	
12	17	15	16	Strong preference
	16			
11	15	14	15	
10	14	13	14	Moderate
9	13	12	13	
8				
7	12	11	12	
6	11	10	11	Low preference
5	10	9	10	
4	9	8	9	
3	8	7	8	Very low preference
	7	6	7	
	6	5	6	
2	5	4	4	
	4	3	3	
	3			
1	2	2	2	
	1	1	1	
0	0	0	0	

Your preferred learning styles

Now circle your **total** scores for each learning style on the table below to determine the strength of your preference.

ACTIVIST	REFLECTOR	THEORIST	PRAGMATIST	
20 19 18 17 16 15 14 13	20 19 18	20 19 18 17 16	20 19 18 17	Very strong preference
12 11	17 16 15	15 14	16 15	Strong preference
10 9 8 7	14 13 12	13 12 11	14 13 12	Moderate preference
6 5 4	11 10 9	10 9 8	11 10 9	Low preference
3 2 1 0	8 7 6 5 4 3 2 1 0	7 6 5 4 3 2 1 0	8 7 6 5 4 3 2 1 0	Very low preference

Appendix H

Type Recurrent

5. INSTRUCTEURS INFO

5.1. FLIGHT 1 LOFT SCL-EZE AIRSPEED UNRELIABLE (01:40) CPT=PF

Focuspunt: Airspeed unreliable during climbout met terugkeer naar SCL. Het herkennen van de Airspeed unreliable situatie, het correct uitvoeren van de memory-items en de follow up.

Scenario: Crew zit aan boord in SCL. Machine staat geparkeerd aan gate 16 met draaiende APU. ATL is afgetekend, zonder bijzondere klachten. Pushback facing west, uittaxieen via Q, H en Z. Take-off 17 vanaf V voor een ALBAL 2C RNAV departure. Tijdens het uitklimmen door FL080 in IMC ontstaat er een AIRSPEED UNRELIABLE situatie. Dit treedt onaangekondigd op, daarom zit het ook niet in de briefing of het huiswerk.

De airspeed unreliable wordt geinitieerd door de Left en Center pitot te blocken, deze zullen gaan werken als een 'hoogtemeter'. *(Een enkele failure of blocking van een pitot tube levert geen foutieve indicatie op.)* Hoe hoger je vliegt, hoe groter de snelheid afwijkt van wat hij zou moeten zijn. LH en RH PFD hebben een foutieve indicatie. Op de ISFD zie je een flag bij de speedtape op de B777. Op de B787 zal de ISFD een foutieve indicatie geven. Op de B787 zal er een "AIRSPEED UNRELIABLE" alert gegenereerd worden.

Afhankelijk van de hoogte waarop de failure gezien en behandeld wordt kunnen allerlei warnings afgaan. Eerst zullen de memory items worden gedaan, daarna vliegend met 4 graden pitch en 70 pct N1 de QRH. Afhankelijk of de machine te trimmen is zullen de PFC's wel of niet afgezet worden. Als het vliegtuig te trimmen is worden de PFC's niet afgezet. Dit kan in een later stadium problemen geven als de speedindicatie tijdens approach te laag is. Het vliegtuig wordt dan moeilijk bestuurbaar doordat het niet te trimmen is. Wellicht worden nu alsnog de PFC's afgezet zoals in de QRH staat.

De bedoeling is een terugkeer naar SCL, ook gezien de hoogte waarop de failure zich voordoet en de weerscondities van de velden enroute is de verwachting dat men niet verder wil richting de Andes maar aan de westkant zal blijven. Het weer aan de oostkant van de Andes is matig, Mendoza is net boven limieten en SCL is verder prima vliegweer.
Indien de echte snelheid (CAS) te hoog is voor flap extension, kan de simulator een "crash" genereren (ongeveer 270 kts).
Terugkeer zal tijd kosten. Afhankelijk van de hoogte waarop besloten wordt terug te keren, zul je de route aan moeten passen. Wellicht willen de kandidaten (zo snel mogelijk) richting zee, wellicht zitten ze hoog en willen ze de arrival via UMKAL oppikken, graag jullie flexibiliteit in deze. Holdings liggen eventueel bij LESTA (FL100) of aan het begin van de approach bij SEDPA (5000ft).
Tijdens de descent, voordat transition level wordt gepasseerd volgt de EFIS CONTROL PANEL failure. Vanwege de hoeveelheid workload geven we deze failure niet te vroeg.
Tijdens de approach zou ook een windshear warning kunnen ontstaan ivm de foutieve wind indicatie. (QRH Airspeed Unreliable procedure heeft een referentie naar Windshear System.)

op de B777-simulator moet je de CB trekken en de 90sec startup afwachten om de ISFD weer terug te krijgen na het scenario.

5.2. FLIGHT 2 LOFT EZE-SCL (00:30) N-1 DRIFTDOWN AND DECOMPRESSION FO=PF IN LH SEAT

Focuspunt: Engine failure met driftdown en een slow decompressie gevolgd door een emergency descent. De motorstoring komt nadat het vliegtuig in een turbulent gebied komt. Waarschuw de mensen daar eventueel voor. Waarschijnlijk is het speedwindow geopend op .82/.84, en seatbelts on. Voor een correcte driftdown zal de speedwindow gesloten moeten worden.

Scenario: Speelt zich af net voor ToD richting SCL. Repos is boven positie PAPIR op de UA306 richting Mendoza Niet geheel realistisch omdat de FO daar in principe niet in de LH seat zit, maar de situatie kan zo zijn dat de gezagvoerder de laatste rust had of nog een rondje door de cabine loopt.
Vraag de mensen of ze de volgende route in het FMS willen zetten:

PAPIR-DOZ-UA306-UMKAL-UMKAL2B-ILS17R
(B787, vraag of ze cost index 200 willen selecteren)

De verkeersleider kan hier een waarschuwing geven dat een previous aircraft turbulentie heeft gemeld. Waarschijnlijk wordt nu het speedwindow geopend en op .82/.84(B787) gezet. Allereerst volgt een engine failure. Doe dit net na Mendoza zodat het terrain een interessante factor is. Bedoeling is een driftdown waarbij het speedwindow nog open staat. Die zal gesloten moeten worden voor een correcte driftdown.

Vervolgens ontstaat er een slow decompression (B777). Deze stap kan snel na de engine failure geselecteerd worden, het duurt een paar minuten voordat deze zichtbaar wordt op de EICAS. Op de B787 moet de decompressie stap pas geselecteerd worden als de driftdown is ingezet en de instructeur het een mooi moment vindt. Een slow decompression is op de B787 niet mogelijk, de failure komt direct.
Er zijn geen guidelines voor decompressie, wel voor N-1. DP1 ligt 11 NM voor UMKAL. Er zal een keuze gemaakt moeten worden tussen terugkeren naar Mendoza, Cordoba of Buenos Aires (niet haalbaar qua fuel), of N-1 een emergency descent maken naar veilige hoogte om door te vliegen naar Santiago. Er zijn geen procedures qua O2, N-1 is de route vliegbaar. Gezien het feit dat Mendoza open is, is de verwachting dat de crews na de descent uitwijken naar het nearest suitable airport, Mendoza. Op FL 100 stopt het scenario.
Na het stoppen van het scenario willen we de mensen met het masker op nog even laten voelen aan de 100%/normal en de emergency knop. We weten allemaal hoe die eruit zien maar weten we die ook te vinden als we het masker op hebben?

5.3. FLIGHT 3 SKILL (00:15) ILS APPROACH 17R SCL MET GEAR FAILURE FO=PF

Tijdens deze approach ontstaat en een gearprobleem, "MAIN GEAR BRACE LEFT"(777), "GEAR SIDE BRACE L" (787).
Deze failure wordt voorafgegaan door een status message "GEAR INDICATION SYSTEM", misschien wordt dit al gezien.
Er is niet veel tijd om de QRH af te handelen, waarschijnlijk wordt er een go-around gemaakt. Indien wordt besloten de cabine in te lichten en een noodlanding voor te bereiden, houd er rekening mee dat dit in werkelijkheid zo'n 15 minuten vergt. Dit scenario hoeft niet afgemaakt te worden, flight freeze na het beslismoment is voldoende. Is het duidelijk dat er tijd over is, dan kunnen ze alsnog deze landing maken.
Tijdens de debriefing willen we verder ingaan op deze failure en de eventuele gevolgen.

Appendix I

Observation list

Flight Preperation

P	E3	**1.** Did the crew identify threats?	
P	E5	**2.** Did the crew discuss mitigating measures?	
P	E2	**3.** Did the crew proactively anticipate to the environment?	
P	E5	**4.** Did the crew use the special Engine-Out SID? (engine failure before the first turn)	
P	E5	**5.** Did the crew discuss actions in case of an Engine Failure in the SID?	
P	E1	**6.** Did the crew notice that the weight of the aircraft is lower than the maximum landing weight?	
P	H2	**7.** Did the PF confirm the understanding of the mitigating measures with the PM?	
P	H1	**8.** Did the PF ask the PM if (s)he had questions remaining?	
P/CT	E1/ Cr	**9.** Did the crew **explicitly** check the flight instruments for inconsistencies in this flight phase (or conflicts)?	
P	E1	**10.** Did the PF actively monitor the aircraft if it stood still after pushback?	
P	P4	**11.** Did the crew NOT deviate from the procedure in this flight phase (before taking off)?	
P/CT	E1/ QT	**12.** Did the crew perform a recap before taking off? AND mention (1) engine failure threat and the following mitigating measures	
		Time in minutes	
		Fuel in tons	

Airspeed Unreliable Situation

P/CT	E1/ Cr	**13.** Did the crew detect a difference/conflict in the airspeed indicators before the warning of an unreliable airspeed occurs?	
P	E2	**14.** Did the crew explicitly identify and state the failure as “Airspeed Unreliable”?	
P	P5	**15.** Did the crew perform the memory items as per QRH?	
P	H3	**16.** Did the crew give explicit instructions to each other after identifying the airspeed unreliable?	
P	A3/ P5	**17.** Did the crew trim the aircraft AND turn right after noticing the airspeed unreliable?	
P	H2	**18.** Did the crew communicate effectively with each other during the recognition, and beginning of handling the unreliable airspeed situation?	
P/CT	E1/ E3/ QT	**19.** Did the crew mention the available fuel during this event, and interpreted it as more than enough?	
P	H5	**20.** Did the crew proactively communicated with the cabin crew/purser/passengers during the first half of this event? OR did the crew discuss or switch off/on the seat belts sign?	
P	E2/ S1	**21.** Did the crew have a good awareness of the height, position and terrain of the aircraft? AND therefore mention a possible uncertainty in the height of the aircraft.	
P	E5	**22.** Did the crew mention measures to handle the height uncertainty?	

P/CT	E1/ E2/ Cor	**23.** Did the crew actively look for alternative solutions or indicators to determine a reliable airspeed?	
P/CT	E1/ Cr	**24.** Did the crew proactively search for inconsistencies, gaps or changes in information?	
P	A1/ E1	**25.** Did the crew notice that the ATC receives the same airspeed as the crew (due the transponder) and therefore concludes that theirs (ATC) is NOT reliable as well.	
P	H1	**26.** Did the crew proactively communicated with the air traffic control?	
P	P5	**27.** Did the crew correctly use the Airspeed Unreliable table to identify flaps 20, power and pitch setting?	
P/CT	E1/ QT	**28.** Did the crew perform a recap (or summed up the situation) AND hereby (in)directly concludes that a reliable airspeed cannot be determined.	
P/CT	E1/ E2/ E3/ Cr	**29.** Did the crew discuss the alternatives for returning to Santiago, OR applied Critical Thinking AFTER their decision to weigh their considerations?	
P	S5/ H2	**30.** Did the communication of the crew NOT severely decreased when the over speed stall warning occurred?	
P	P5	**31.** Did the crew perform the Airspeed Unreliable NNC?	
P	E1	**32.** Did the crew recognize the EFIS Control panel failure?	
P	H1	**33.** Did the crew react to suggestions from each other to handle the EFIS Control panel failure?	
P	P5	**34.** Did the crew inhibit the concerned EFIS Control panel and use the alternate EFI control panel OR FMS	
P	H5	**35.** Did the crew proactively communicate with the purser/cabin crew during the second half of this event, AND informed them about the expected landing?	
P/CT	E1/ QT	**36.** Did the crew discuss time (OR performed) for a recap after finishing the EFIS CONTROL PNL checklist?	
P/CT	E1/ Cr	**37.** Did the crew actively check or discuss the weather of their desired destination that could have changed during the scenario?	
P/CT	E1/ E3/ Cr	**38.** Did the crew discuss the length of the runway during the scenario?	
P/CT	E1/ Cr/ Cor	**39. B777** Is the crew aware of the conflict (due the AU) in the drawn route of the holding (AND/OR approach) in the EFIS? AND suggests the right measures to fix it. OR be critical in the interpretation of the drawing.	
P/CT	E1/ P3/ Cr/ Cor	**40.** Did the crew discuss the re-use of the autopilot during the scenario?	
P	H3	**41.** Was there a good/distinct distribution of tasks between the PM and PF during the scenario?	
P	P5/ E4	**42.** Did the PM walk effectively through the checklists OR shows (s)he embraces the concerning procedure?	
P/CT	E1/ E2/ Cr	**43.** Did the crew make use of Critical Thinking shortly before the landing AND either (1) identified a wrong assumption, or (2) gap in information, or (3) a conflict.	

P/CT	E1/ QT	**44.** Did the crew discuss the current plan AND landing configurations before landing (flaps, power, pitch)?	
P/CT	E2/ E2/ Cr	**45.** Did the crew make an estimation of their landing?	
P	A3	**46.** Did the PF make a smooth landing according FCTM techniques within the touchdown zone?	
		Time in minutes	
		Fuel in tons	

Engine failure & slow decompression

P	P4/ E1	**1.** Did the crew anticipate on the turbulence?	
P	S2/ S5/ H2	**2.** Is the crew able to respond to each other when the engine fails?	
P/CT	A1/ P5/ Cor	**3.** Did the crew turn off the speed windows after the engine failure?	
P	A1/ A2/ A3	**4.** Did the FO bring the aircraft in a descent? By using (1) using drift down or (2) other automatic mode.	
P	E2/ E5	**5.** Did the FO mention the terrain ahead AND did (s)he formulate a plan for a safe route?	
P	H5	**6.** Did the crew inform the cabin crew/passengers about the turbulence? AND/OR did the crew turn on the seat belts sign	
P	H1	**7.** Did the crew proactively communicated with the air traffic control?	
P/CT	E1/ Cr/ Cor	**8.** If the crew did NOT turn off the speed windows after the engine failure, did the crew recognize that the aircraft is NOT in VNAV descent?	
P	P5	**9.** Were the memory items performed correctly by the crew?	
P	P5	**10.** Was the CABIN ALT non-normal procedure accomplished?	
P/CT	E1/ Cr	**11.** Did the crew actively check uncertainties OR assumptions after the engine failure?	
P	E5	**12.** Did the crew use the corresponding correct minimum safe altitude during the event?	
P	H3/ E3	**13.** Did the FO make a diversion plan with actions to do and priorities?	
P/CT	E1/ QT	**14.** Did the crew discuss the time for a quick test/recap?	
P	S5/ A3	**15.** Did the crew maintain the desired flight path with interruptions and distractions from the 2 failures?	
P	E2	**16.** Did the crew discuss the threats of terrain, possibly sustained use of oxygen and N-1 CRZ altitude near mountains?	
P/CT	E1/ QT/ Cr/ Cor	**17.** Did the crew use Critical Thinking to search for information about correctness and completeness of their plan and did they adjust the plan if required?	
		Time in minutes	
		Fuel in tons	

Main Gear Brace L Failure

P	S5	**1.** Did the crew identify the threat of continued approach and rushing actions?	
P	H2	**2.** Did the crew ask effective questions during the approach?	
P	H1	**3.** Does the PF discuss his decision with the PM before he makes a continued/missed approach?	
P/CT	S1/ E1/ QT	**4.** Did the crew identify an uncertainty and consider a quick test or verbalise the uncertainty with each other?	
P/CT	E2/ QT	**5.** Did the crew check the amount of fuel and interpret the available time?	
P	H1/ H5	**6.** Did the crew inform the air traffic control of possible problems with the landing? OR did the crew make/discuss a brace call towards the passengers?	
P	P5	**7.** Did the crew perform the non-normal checklist during approach before 1000ft RA?	
P/CT	E3/ E4/ QT/ Cr/ Cor	**8.** Was the crew able to use Critical Thinking during the event, searching for gaps, conflicting issues or assumptions? AND therefore did not make a decision with a lack of information.	
P/CT	P2/ E2/ Cr	**9.** Did the crew discuss the conflict of switching off the fuel pumps in the checklist?	
P/CT	E1/ E2/ E3/ Cr/ Cor	**10.** Did the crew discuss the consequences of making a go-around or making the approach with uncertainties?	
		Time in minutes	
		Fuel in tons	

Appendix J

Performance scores per dominant learning style

	N	Mean	SD
Dominant learning style			
None	20	.661	.242
Activist	12	.733	.235
Reflector	17	.672	.171
Theorist	17	.772	.222
Pragmatist	26	.717	.218
Activist + Theorist	3	.742	.110
Activist+ Pragmatist	6	.659	.262
Reflector + Theorist	9	.666	.160
Reflector + Pragmatist	3	.813	.132
Theorist + Pragmatist	5	.750	.191
Total	118	.708	.210

In the case of three or more dominant learning styles, a participant is labelled as ‘none’.