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## **Cleared for take-off: Game-based learning to prepare airline pilots for critical situations**

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# Summary

Over the last decades, there has been a strong improvement in aviation safety. The downside of these improvements is that airline pilots less frequently experience difficult situations. Hence they do not have as many opportunities to develop through experience the competencies that they need in critical situations. However, competencies can also be learned and developed through training. In aviation, this is being done through simulator training.

The thesis investigates whether competencies can be developed through training with the use of serious games. Assuming that the high level competencies needed to act adequately in critical situations can be trained in games, the relatively scarce flight simulators can then be fully dedicated to the training of technical skills. Thus, we formulate the following problem statement.

**Problem statement:** *To what extent can a serious game be used to train airline pilots to act adequately in critical situations?*

We address the problem statement from two different perspectives. On the one hand, we investigate whether games are a suitable training method to develop competencies. On the other hand, we examine whether airline pilots will accept to be trained through games.

To answer the problem statement, we formulate three research questions. They focus on (1) the design of serious games for competency development, (2) the effect of voluntary gameplay in a serious game, and (3) the airline pilots' acceptance of game-based learning as a training method.

In **Chapter 1**, we briefly describe the background of the problem, before we introduce the problem statement and the three research questions. Also, we discuss the research methods used, and provide a short description of the following chapters.

**Chapter 2** gives an overview of relevant literature. We discuss the five main elements of the problem statement, viz. (1) airline pilots, (2) airline pilot training, (3) critical situations, (4) competencies, and (5) game-based learning.

In **Chapter 3**, we address the first research question.

**RQ 1:** *How should a serious game be designed to support competency development effectively?*

To answer the research question, we first identify and discuss three requirements that a game needs to fulfil in order to support competency development. Next, we translate the four components of the Four Components for Instructional Design (4C/ID) model into six characteristics that games should have for competency development. We show that the characteristics can be supported by sixteen elements that are commonly present in games, or that can be added to the game or the environment.

We introduce the Serious Games for Competency Development (SG4CD) model, in which we connect the sixteen elements for gameplay and learning with the six characteristics for competency development. The SG4CD model shows which elements are needed to develop competencies using a serious game. Based on the model, games for competency development can be designed in a more structured way.

In **Chapter 4**, we address the second research question.

**RQ 2:** *What is the effect of voluntary play on the outcomes of a serious game?*

Based on the two types of outcomes of serious games, we split RQ 2 into two subquestions.

**RQ 2a:** *To what extent does the voluntary play of a serious game affect the learning effect?*

**RQ 2b:** *To what extent does the voluntary play of a serious game affect the gameplay experience of the player?*

To answer the research question and its subquestions, we conduct an exploratory study consisting of three experiments, in which the participants voluntarily or mandatorily play the *CloudAtlas* game. This game was specially developed for the study. In the first experiment, there was no distinction between voluntary and mandatory participation. In the second and third experiments, the distinction between voluntary and mandatory participation was also a factor.

Here we remark that the game which was used in the experiments did not result in a learning effect. In general, playing or not playing the game does not influence the test results of the participants. Consequently, RQ 2a cannot be answered conclusively.

For RQ 2b, we investigated the enjoyment of the players and how they experienced the game. We did not find indications that voluntary play, which is highly valued by several game-design experts, has an effect on the game experience. On the contrary, our findings show that participants with a stronger sense of obligation play the game as long, and as well as voluntary players, and with as much fun. In all three experiments, participants who played the game mandatorily report an equal amount of enjoyment as the voluntary players. Furthermore, they do not have strong negative feelings about that obligation. They even play the game longer than the voluntary players.

In **Chapter 5**, we discuss the preparations that we have made to be able to answer the third research question.

We describe the design and development of the *Shuttle to Mars* game. The design of the game is based on the SG4CD model and supports the characteristics for competency development. We pay special attention to the design of "meaningful events" in order to be able to provide the player with authentic learning tasks.

We report on the playtest that we have performed with the first version of the *Shuttle to Mars* game. The playtest shows that the game is playable and that the players enjoy playing it. Furthermore, the players are able to see the parallels between game events and aviation situations. The outcomes of the playtest are positive and give confidence that the game can achieve a positive learning effect.

In **Chapter 6**, we answer research question 3.

**RQ 3:** *To what extent do airline pilots accept a game to develop essential competencies for critical situations?*

We discuss the small-scale study that we conduct with the *Shuttle to Mars* game. Five airline pilots and three instructors (who are also captains of an airline) play and assess the game. Based on the outcomes, we may conclude that airline pilots are open to the innovative approach of using games as a training method for essential competencies. However, the pilots do indicate that the version of the game that they have tested is not yet adequate. With improvements to the game and when it is embedded in the airline pilot training, the pilots believe that the game has the potential to provide a positive and effective learning experience.

In **Chapter 7**, we answer the research questions and the problem statement. Moreover, we discuss the limitations of the research and give recommendations.

The research in this thesis shows that using serious games as a training method for competency development has potential. In the first place, we have shown that a game can be used to develop competencies. A serious game can support all the characteristics needed for competency development. Secondly, we have found that airline pilots and instructors are open to using serious games as a training method. They were motivated to play the game. Finally, our research shows that playing a serious game mandatorily does not have negative effects. Therefore, a serious game may also be effective for airline pilots who are less willing to be trained by playing serious games.

Based on our findings and the anticipated results of future research, we expect that game-based learning can become an effective and validated training method for aviation. Moreover, we expect it to become a standardised training method that will be part of initial and recurrent training for airline pilots. We consider game-based learning for aviation to be *cleared for take-off*.

