Voluntary Play in Serious Games

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EXECUTIVE SUMMARY

Voluntary Play in Serious Games

Watch out for coffee spills!
It's barely costing you fuel!

Cumulonimbus

Cumulonimbus

Score: 58   Total time played: 0m 9s   16°c

Problem area

Play is commonly considered to be a voluntary activity. Game designers generally believe that game play is essentially different when play is obligatory. Psychological studies have revealed positive effects of freedom of choice on motivation and participation, making it plausible that voluntary play could have a positive impact on the learning effect of a serious game. However, in practise, voluntary play is not common for serious games, as training is usually mandatory.

Description of work

In this study an experiment was executed in order to determine whether and to what extent gameplay and learning effect of a serious game are affected by the freedom to choose to play or not play the game. Participants were randomly assigned to a voluntary or a mandatory gameplay group. Mandatory players were required to play the serious game *CloudAtlas* for a minimum of ten minutes, while the voluntary players were free to decide if and how long they wanted to play. Both groups also had access to

text-based instruction on the topic of the characteristics of clouds. Duration of gameplay, game scores and test scores were then analysed to determine the impact of voluntary play.

Results and conclusions

The study found no statistically significant differences in test scores and game scores between the voluntary and the mandatory group. However, the length of gameplay did show a wide variance. Contrary to our expectations voluntary players played for a shorter period of time than mandatory players and made less attempts. None of the voluntary players played for more than three minutes, while two participants in the mandatory group played for more than half an hour. This outcome may indicate that a minimum time requirement is beneficiary for gameplay and consequently for the learning effect of serious games.

Although the study focused on voluntary and mandatory players, some other results were found. Women and non-gamers played shorter and achieved lower game scores than men and gamers respectively. This may be indicative of their general gaming skills. However, they did not perform worse on the test.

The findings of this study suggest that, contrary to the opinion of many game designers, being required to play a serious game does not necessarily take the fun out of the game.

Applicability

This study provides further insight in how serious games should be designed and implemented for professional training. While the content of the game is aviation related, the results are expected to be applicable for all game applications for professionals.

Voluntary Play in Serious Games

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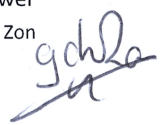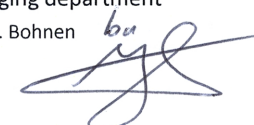A. Plaat[1]

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This report is based on a paper presented at the Games and Learning Alliance Conference, Rome, Italy, December 9-11, 2015.

Customer	National Aerospace Laboratory NLR
Contract number	----------
Owner	NLR
Division NLR	Aerospace Operations
Distribution	Unlimited
Classification of title	Unclassified
Date	June 2016

Approved by:

Author	Reviewer	Managing department
E. Kuindersma	G.D.R. Zon	H.G.M. Bohnen
Date 27-6-2016	Date 27-6-16	Date 27-6-2016

Summary

Voluntariness is an important feature of games. This is pointed out in several definitions of game and play. Serious game designers intend to generate engaging gameplay, which implies that voluntary play should be equally important for serious games as for entertainment games in order to make sure they are in fact engaging.

The impact of freedom of choice in playing or not playing a serious game on the learning effect and gameplay was studied in a controlled experiment using a small game designed specifically for this purpose. In the game *CloudAtlas*, participants have to decide to fly an aircraft under, over or straight through a certain cloud, based on their knowledge about the characteristics of the cloud. Participants, 19 in total, were randomly assigned to a voluntary or a mandatory gameplay group. Mandatory players were required to play the game for a minimum of ten minutes, while the voluntary players were free to decide if and how long they wanted to play. Both groups also had access to text-based instruction on the topic of clouds. Duration of gameplay, game scores and test scores were then analysed to determine the impact of voluntary play.

This report describes the outcome of this study on the impact of voluntariness on learning in a serious game. The findings of this study suggest that, contrary to the opinion of many game designers, being required to play a serious game does not necessarily take the fun out of the game.

Content

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1 Introduction

Serious games are "games that do not have entertainment, enjoyment or fun as their primary purpose" [1]. Over the last two decades they have become a substantial research topic in the educational field [2]. Especially the effectiveness of serious games has been much researched. These studies mainly focused on comparing the effects of serious gaming to those of traditional learning methods [3]. However, traditional learning methods are usually mandatory in nature, whereas serious gaming may be expected have a more voluntary character offering a student freedom of choice. Psychological studies have revealed positive effects of freedom of choice on motivation and participation [4, 5], making it plausible that it will also have a positive impact on the learning effect. Yet, to the best of our knowledge, no studies have taken into account the possible impact of freedom of choice within serious gaming (i.e., voluntary versus mandatory gameplay) on the effectiveness of the games.

The purpose of this study is to determine whether, and to what extent, gameplay (duration and score) and learning effect (test scores) of a serious game are affected by students' freedom of choice to play this game.

2 Background of the study

Games have been used in training for centuries [6]. Although the term 'serious game' had been used in different contexts before [7], Abt [8] introduced the term in relation to instruction. In his view, the instructional aspect did not have to be incorporated into the game itself, but could also be part of the context. In 2002 the term moved toward digital games [9]. Nowadays, serious games are defined as (digital) games with a main purpose other than entertainment, enjoyment or fun [1]. When the main purpose is educational, serious games are also known as instructional games or game based learning.

At the basis of the definition of serious games lies the definition of games in general. Salen and Zimmerman [10] define games as "systems in which players engage in an artificial conflict, defined by rules that result in a quantifiable outcome", and McGonigal [11] defines them as "activities with a goal, rules, a feedback system, and voluntary participation". Other scholars on game and play also include "voluntary" or "free" in their definitions of games [1], [12, 13, 14, 15]. While there is not a particular definition of games that is universally accepted, game designers have reached considerable consensus about the main principles of games, although a game does not necessarily need to satisfy all principles. Games often have rules, goals, a storyline, and outcomes; they offer interaction, feedback, and competition. Furthermore, and critically

important: they are played voluntarily and they are fun, or as they can be frustrating at times – at least they are 'immersive' or 'engaging'. A game should deeply absorb the player.

Most definitions of serious games originate directly from game definitions. Especially on account of the fun characteristic of games the term "serious games" appears to be an oxymoron. If games are fun by definition, they cannot be serious at the same time [16]. Also, games are non-productive and separate from the real world [12], whereas serious games have specific learning objectives related to life or work skills [14]. Callois [13] has even stated that it ceases to be play when this play of a game is forced. Thus, games should be played voluntarily. Yet serious games are meant to be instructional and instruction is typically non-voluntary [14]. This paradox may have an impact on player attitude and as such on the learning effect of the serious game. Players may have a more positive attitude when they are allowed the freedom to choose to play a serious game. In contrast, Huizinga [12] also stated that play is a serious activity, and that fun and serious do not necessarily exclude one another.

Offering learners a choice in their assignments empowers them to take control, which provides them ownership of the learning process and motivates them to be engaged. This increases interest and, with that, it increases time spent on the chosen assignment [17]. The freedom to choose what, when, and how to contribute in the learning process can motivate learners to actively participate and accomplish more [18]. These factors have also been identified as having a positive impact on the effectiveness of serious games.

In a study of forced play, Heeter et al. [4] found that non-gamers, with little or no experience with digital games, are likely to be at a disadvantage in serious gaming, as obtaining the intended effect of a serious game depends on how well the game is played. The negative affect that non-gamers experience in a game are expected to interfere with learning or with the cognitive benefits. Their study also showed that resistant players have less attention for the game they have to play and that they experience less positive and more negative feelings about that game. They would not play the game if they did not have to. Heeter et al. concluded that serious games are least effective for players who dislike a game and most effective for those who like it.

Closely related to freedom of choice is the topic of consent. Mollick and Rothbard [5] examined the role of consent as a psychological response to "mandatory fun" in gamification in the work environment. They found that games which employees consented to significantly increased their positive affect, while resistance resulted in a decrease in positive affect and a marginal decrease in performance. They also identified two sources of consent. Employees who play games outside of work were more likely to consent to them in other settings, and individuals who were allowed to choose which game to play showed higher levels of consent and perceived control. The latter may coincide with the freedom to choose to play a serious game or not, leading us to expect that playing a serious game voluntarily will increase positive affect and possibly performance.

Based on the motivating aspect of choice and the original definition of games we expect that voluntariness or freedom of choice will have a positive impact on the learning effect of serious games.

3   Experiment

The purpose of our experiment is to determine whether using the game voluntarily as a learning tool will result in improved player performance as opposed to mandatory gameplay. The experiment consists of a short training and a test of knowledge and application questions. The independent variables in this research are each participant's gender, age, and interest in gaming. The dependent variables are game score, test score, and time spent playing the game. In this section the recruitment of participants and the experimental design will be discussed, followed by the procedure and the materials.

3.1   Participants and Design

Participants have been recruited through various social media and by personal invitation. They were told the experiment related to aviation, but the focus on gaming was not disclosed. Only persons over the age of 18 were selected to participate. They were asked to give their informed consent before being registered. As an incentive participants were offered a chance to win a € 100 gift certificate. Chances of winning are related to completing all stages of the experiment, not to personal results.
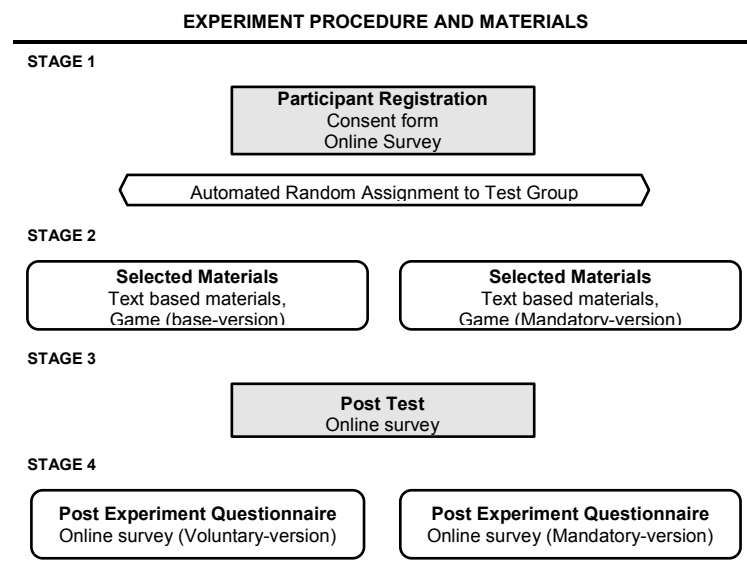
A total of 64 persons registered for the experiment and completed an online survey with demographic information and levels of motivation and prior knowledge. They were randomly assigned to one of two groups, resulting in a voluntary gameplay group of 29 participants and a mandatory gameplay group of 35 participants. The participants will be referred to as 'voluntary players' and 'mandatory players' respectively. In the experiment voluntary players will be free to decide if and how long they want to play the game, while mandatory players will be required to play the game for at least ten minutes. Twenty participants completed the training and its test. Post-experiment surveys show that many participants did not finish their participation due to other priorities. There were 9 completes from mandatory players and 11 from voluntary players. One complete in the voluntary group was disqualified, because the participant indicated to accidentally have finished the test without playing the game. The experiment was completed in a valid way by 10 men and 9 women with a mean age of 39 (SD = 15). The groups did not differ significantly in terms of age, gender and interest in gaming.

The participants' prior knowledge on aviation and meteorology, as reported on the online survey with a possible score of ten, had a mean score of 4.16 (SD = 2.39) and did not differ significantly

between test groups. However, mandatory players were more motivated to participate in the experiment than voluntary players (One-way ANOVA: $F_{(1,17)} = 9.28$, $p < .05$).

3.2   Procedure and Materials

The experiment consisted of four stages, shown in Fig. 1. All materials were available online. Participants could complete all stages online at their own computer and at their own convenience. Registration took place by the participant providing an e-mail address and indicating their valid age and informed consent with a check mark. At the time of registration each participant was randomly assigned to a treatment group and gained access to a webpage with the experiment instructions and materials. After registration each participant provided demographic information, information concerning prior knowledge of aviation and meteorology, and their personal motivation for participating in the experiment in an online questionnaire (Appendix A).

EXPERIMENT PROCEDURE AND MATERIALS

STAGE 1

> **Participant Registration**
> Consent form
> Online Survey

> Automated Random Assignment to Test Group

STAGE 2

> **Selected Materials**
> Text based materials,
> Game (base-version)

> **Selected Materials**
> Text based materials,
> Game (Mandatory-version)

STAGE 3

> **Post Test**
> Online survey

STAGE 4

> **Post Experiment Questionnaire**
> Online survey (Voluntary-version)

> **Post Experiment Questionnaire**
> Online survey (Mandatory-version)

Fig. 1. Schematic Representation of the Procedure Stages and Corresponding Materials

The participants were then asked to study the text based materials and play the game. Voluntary players were free to decide if and how long they played, while mandatory players were told to spend a minimum of ten minutes playing. The text based instruction consisted of 13 webpages, offering information about cloud classification, characteristics of different cloud types, possible hazards, and the impact of clouds on aviation. It showed drawings and photographs of different types of clouds (Appendix B). Both test groups had unlimited access to the same set of text based materials.

3.2.1   The CloudAtlas Game

The game is identical for both test groups, but for the mandatory players the webpage enforced a ten minute minimum of active gameplay before allowing the player to take the test. The game is

played in an internet browser using the keyboard as the input device. The objective is to fly an aircraft as far as possible (Fig. 2). During flight the player encounters the types of clouds that have been addressed in the text based instruction. Applying their knowledge about clouds and possible hazards, the players must decide to fly through a cloud, go over or under it, or land the aircraft to wait for the danger to pass. The impact of cloud hazards (i.e., icing, turbulence or lightning) on the aircraft is visualized on screen and results in increased fuel consumption. Consistent with reality, flying above a certain altitude requires oxygen. A limited supply of oxygen is available at the start of the game. During the game extra amounts of fuel and oxygen can be picked up to prolong the flight. The player may also encounter balloons and flocks of birds. Colliding with these must be avoided, because this will immediately end the game. In all other cases the game will end when the player runs out of fuel or oxygen. The distance travelled by the aircraft translates into a game score. Picking up score boosters during flight adds to the score, while making unnecessary landings leads to a deduction of points.
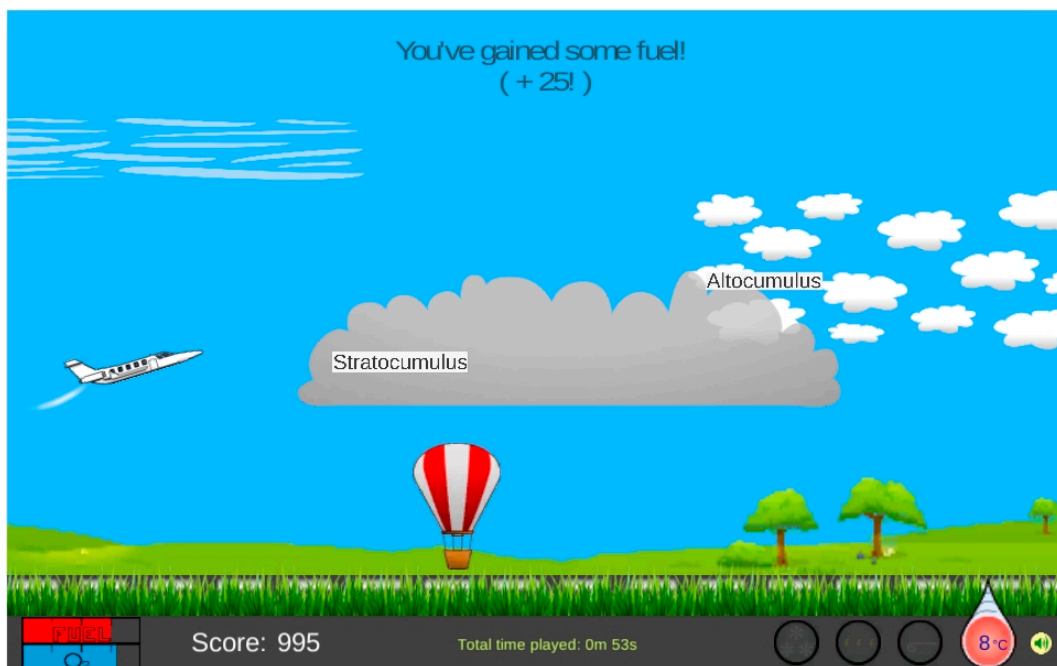

Fig. 2. *Screenshot of the game*

3.2.2 Tests

Participants studied the materials and played the game at their own pace and were free to proceed to the test when ready. Mandatory players had to play at least ten minutes for the test to become available. The test consisted of 11 knowledge questions and 7 application questions (Appendix C). In the knowledge questions participants were asked to reproduce cloud characteristics and recognize clouds from drawings and photographs. In the application questions players had to apply their knowledge to a certain situation. For example, a picture was presented of an aircraft and a certain type of cloud, with a number of possible routes drawn in the picture (Fig. 3). Participants were asked to choose the best route, taking into consideration safety,

comfort and efficiency. They were also asked to explain their reasons for choosing this specific answer. Application questions were assigned higher weights than knowledge questions. Test scores were calculated as the percentage of points earned of a maximum of 49 points.
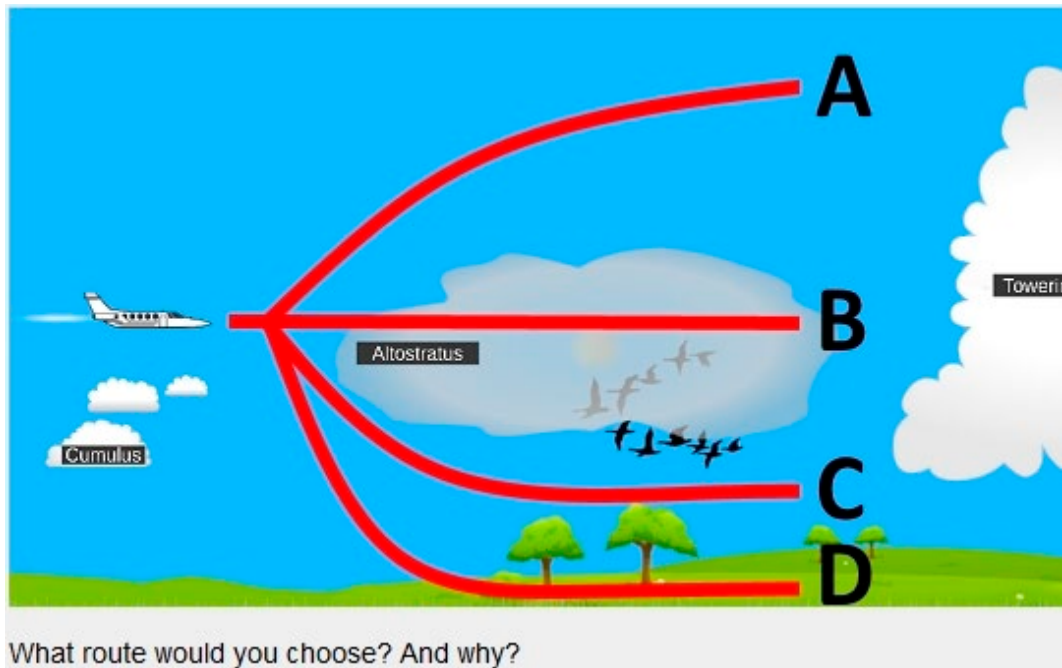
Fig. 3. *Test Item: Application Question*

After the test participants were presented with the post experiment questionnaire (Appendix D). This questionnaire solicited more information on prior knowledge and gaming preferences. The voluntary players were asked about the extent of the freedom of choice they experienced in choosing to play or not to play the game. The mandatory players were asked whether they would have played the game when given a choice. Upon completion of the test and the questionnaire, participants were informed about the follow-up and about their chance of winning the gift certificate.

The questionnaires used in the experiment have been constructed specifically for this study. No validated survey questions pertaining to voluntariness or game enjoyment were found in literature. Several questionnaire items use a ten point scale. Such a scale is easily understood [19] across age groups and education levels, and provides better data for analysis [20]. The use of an even scale avoids the neutral midpoint, forcing the participants to make a distinct choice for each item. Furthermore, the use of a ten point scale is common in both customer satisfaction surveys and game reviews.

4 Results

A total of 19 participants completed the experiment by taking the final test, 16 of them played the game. Game scores ranged from 721 to 4770, and test scores from 25 to 77. Table 1 shows the means and standard deviations on game and test scores. One-way analysis of variance controlled for motivation (ANCOVA) was used to control for the possible effects of the group difference that was found on motivation to participate prior to the experiment. This analysis showed no statistically significant differences for test scores and game scores between the groups.

Table 1. *Means and Standard Deviations for Voluntary and Mandatory Gameplay Groups*

| | Test Group | | | |
| | Mandatory (n=9) | | Voluntary (n=10) | |
Measure	M	SD	M	SD
Gameplay (min)	16.8	8.2	3.4	2.9
Test score (%)	48.7	18.3	44.9	11.3
Game score	2723	1332	1092	1085

T-tests revealed that there were no significant differences in test score and game score between male and female participants. Nor was there a difference between gamers and non-gamers for test score. However, gamers did achieve a higher game score than non-gamers ($F(1,17) = 8.35$, $p < .01$). Participants aged 40 and below scored significantly higher in the game ($F(1,17) = 15.58$, $p < .01$) and on the test ($F(1,17) = 4.90$, $p < .05$) than participants over the age of 40.

The length of gameplay varied widely, as three participants chose not to play at all, while two participants played for more than half an hour. The number of tries varied from zero to 22. Table 1 reveals that mandatory players played an average of 13.4 minutes longer than voluntary players (One-way ANOVA: $F(1,17) = 23.50$, $p < .001$). There was a significant effect of gameplay type on the amount of time played using prior motivation as covariate, $F(1, 16) = 10.98$, $p < 0.01$.

A t-test revealed that there was no significant difference in length of gameplay between male and female players. Nor was there a difference between gamers and non-gamers. Females did however have a lower average time per game attempt ($F(1,14) = 5.90$, $p < .05$). Participants over the age of 40 also had a lower average time per attempt than younger participants ($F(1,14) = 4.64$, $p < .05$).

We expected to see two subsets of players in both test groups: those who played only as long as required (up to 12 minutes) and those who continued playing (more than 12 minutes). Table 2 shows counts and percentages for these subsets. Within the voluntary group we also expected to find players who did not play at all and players that only played to get an idea of the game by playing three tries or less (Table 3).

After the test, participants were asked how much they had enjoyed playing the game on a scale from 1 to 10 (M = 6.56, SD = 1.55). There was no significant difference between the test groups or between male and female participants. Younger participants however enjoyed the game more than older participants ($F_{(1,17)}$ = 8.96, p < .01), and gamers enjoyed it more than non-gamers ($F_{(1,17)}$ = 5.49, p < .05).

Table 2. *Subsets in Mandatory and Voluntary Gameplay Groups*

		Gender		Gaming Interest	
		Male (n = 10)	Female (n = 9)	Non-Gamer (n = 11)	Gamer (n = 8)
Mandatory (n = 9)	Less than 12 minutes	1	2	2	1
	More than 12 minutes	5	1	2	4
Voluntary (n = 10)	Less than 12 minutes	4	6	7	3
	More than 12 minutes	0	0	0	0

Table 3. *Subsets in Voluntary Gameplay Group*

		Gender		Gaming Interest	
		Male (n = 10)	Female (n = 9)	Non-Gamer (n = 11)	Gamer (n = 8)
Less than 12 minutes (n = 10)	No play	2	1	3	0
	3 tries or less	2	2	2	2

Mandatory players were asked how they felt about being obligated to play the game for a minimum amount of time. In general participants were neutral about this (M = 2.11, SD = .78). They were also asked if they would play the game if they were given a choice. Almost 78% indicated they would. A correlation for the data revealed that the feeling about being obligated to play and the decision to play the game if not mandatory, were not significantly related, r = .44, n = 9, *p* = .23. A positive decision to play the game if it was not mandatory was not associated with a neutral or positive feeling about being obligated to play the game. Voluntary players were asked about the amount of freedom they experienced in choosing to play or not play the game on a scale from 1 to 10. The experienced levels of freedom ranged from 6 to 10, with a mean of 8.20 (SD = 1.69) and did not differ between gamers and non-gamers, male and female players or younger and older participants.

5 Discussion

Test scores

This study sought to investigate the impact of freedom to choose to play or not play a serious game on the learning effect of this game. The learning effect of the serious game was measured by a test taken shortly after the training. We expected voluntary players to play the game longer and then perform better on the test than mandatory players. In effect, the data showed that mandatory players spent more time playing the game. The time spend on training does not appear to be a factor. Performance does not differ statistically between the two groups. There are several candidate causes for this. The group of voluntary players may have been able to extract knowledge from the game more efficiently than the mandatory players. It is also possible they were more successful in studying the written materials. Finally, there may be design issues with the game or the test. The game may not be as effective as expected or the test may not be valid.

Gameplay

The second aspect of interest was gameplay, measured in game score and duration. Contrary to our expectations voluntary players played for a shorter period of time than mandatory players and made less attempts. All voluntary players decided to quit playing the game within ten minutes. This raises the question why. Apparently voluntary players did not become fully engaged in the game, even though they rate the game about the same for enjoyment as the mandatory players do. Two thirds of the mandatory players play more than two minutes beyond the ten minute minimum, showing that the game in fact can be engaging. This outcome may indicate that a minimum time requirement is beneficiary for gameplay, as it forces the participant not to give up at the first setback.

Motivation

Players may have been extrinsically motivated to participate in the experiment by the chance of winning a € 100 gift card. This extra motivation can be expected to have been equal between the voluntary and mandatory players.

In line with the findings of Fulton et al. [17] we expected freedom of choice to motivate voluntary players and encourage them to accomplish better results. Additionally it would be understandable for a mandatory player to have a negative feeling about the obligation to play. However, voluntary players did not do better on the test, nor did they score higher on the level of enjoyment than mandatory players. Mandatory players reported a neutral feeling about having to play the game for a minimum amount of time, not a negative one. Possibly the fact that one participates voluntarily in the experiment changes the way one feels about an obligation to play the game. Alternatively these outcomes may possibly be caused by the limited number of participants or the game design. Further research is needed to clarify this.

Mandatory players even indicated that they would play the game if it was not mandatory. Although the following results were not significant with the number of participants in the current study, they do indicate an interesting trend. The percentage of mandatory players, who said they would play the game without the obligation, was higher than the percentage of voluntary players who actually did. The gameplay duration estimated by the mandatory players was also higher than the time played by the voluntary players.

Non-gamers

While the study focused on the differences between voluntary and mandatory players, some other results were found. Women and non-gamers played shorter and achieved lower scores than men and gamers respectively. This may be indicative of the general gaming skills of these groups. However, they did not perform worse on the test. These outcomes do not support the findings of Heeter et al. [4], who concluded that non-gamers are likely to be at a disadvantage in serious gaming. Also, the negative affect Heeter et al. found has not been established in the current study, despite the fact that non-gamers enjoyed the game less than gamers.

6   Limitations and future research

This study had a limited number of participants. By recruiting through social media we aimed to reach a large number of participants, but in fact the number of participants was limited. The group difference on prior motivation would probably not have occurred with a larger sample size or a different assignment strategy (pair matching). From the 64 initial registrations, only 19 persons completed the experiment. This dropout rate may also have influenced the results. Also mandatory participation to the study (as part of a regular course) would be of interest as this would provide a normal motivation setting for students in which the effects of voluntary gameplay can be observed without self-selection issues. It is intended to repeat the CloudAtlas experiment taking the above recommendations into account.

Another interesting angle for future research is the effect of different mandatory minimum amounts of gameplay on the total duration of gameplay to establish a recommended minimum.

7 Conclusion

This study aimed to determine whether and to what extent gameplay and learning effect of a serious game are affected by the freedom to choose to play or not to play the game. We expected that using the game voluntarily as a learning tool would result in improved player performance in a test, in comparison to the results after mandatory gameplay. This result was not found. However, it was found that mandatory gameplay in the CloudAtlas game does not ruin the enjoyment and engagement in the game, which contradicts the assumption of many game design theorists and practitioners that games need to be played voluntarily in order to be engaging, fun, and effective.

8 References

1. Michael, D., Chen, S.: Serious Games: Games That Educate, Train and Inform. Thomson, Boston (2006)

2. Wu, W., Hsiao, H., Wu, P., Lin, C., Huang, S.: Investigating the Learning-Theory Foundations of Game-Based Learning: a Meta-Analysis. Journal of Computer Assisted Learning 28(3), 265-279 (2011)

3. Wouters, P., Van Nimwegen, C., Van Oostendorp, H., Van Der Spek, E.: Meta-Analysis of the Cognitive and Motivational Effects of Serious Games. Journal of Educational Psychology 105(2), 249-265 (2013)

4. Heeter, C., Lee, Y., Magerko, B., Medler, B.: Impacts of Forced Serious Game Play on Vulnerable Subgroups. International Journal of Gaming and Computer-Mediated Simulations 3(3), 34-53 (2011)

5. Mollick, E., Rothbard, N.: Mandatory Fun: Consent, Gamification and the Impact of Games at Work. The Wharton School Research Paper Series (2014)

6. Susi, T., Johanneson, M., Backlund, P.: Serious Games - An overview. Technical Paper, University of Skövde, Skövde (2007)

7. Djaouti, D., Alvarez, J., Jessel, J., Rampnoux, O.: Origins of Serious Games. In Ma, M., Oikonomou, A., Jain, L. (eds.): Serious Games and Edutainment Applications. Springer-Verlag, London (2011) 25-44

8. Abt, C.: Serious Games. Viking Press, New York (1970)

9. Sawyer, B., Rajeski, D.: Serious Games: Improving Public Policy Through Game-Based Learning and Simulation. Woodrow Wilson International Center for Scholars, Washington D.C. (2002)

10. Salen, K., Zimmerman, E.: Rules of Play: Game Design Fundamentals. MIT Press, Cambridge (2004)

11. McGonigal, J.: Reality Is Broken. Penguin Press, New York (2011)

12. Huizinga, J.: Homo Ludens: A Study of the Play Element in Culture. Beacon Press, Boston (1955)

13. Callois, R.: Man, Play and Games. University of Illinois Press, Champaign (1961)

14. Garris, R., Ahlers, R., Driskell, J.: Games, Motivation, and Learning: a Research and Practice Model. Simulation & Gaming 33(4), 441-467 (2002)

15. Prensky, M.: Computer Games and Learning: Digital Game-Based Learning. In Raessens, J., Goldstein, J. (eds.): Handbook of Computer Game Studies. MIT Press, Cambridge (2005) 97-122

16. Breuer, J., Bente, G.: Why So Serious? On the Relation of Serious Games and Learning. Eludamos, Journal for Computer Game Culture 4(1), 7-24 (2010)

17. Fulton, S., Schweitzer, D.: Impact of Giving Students a Choice of Homework Assignments in an Introductory Computer Science Class. International Journal of the Scholarship of Teaching and Learning 5(1), Article 20 (2011)

18. Becker, K.: How Much Choice is Too Much? Inroads 38(4), 78-82 (2006)

19. Hernon, P., John Whitman, R.: Delivering Satisfaction and Service Quality: a Customer-Based Approach for Libraries. American Library Association, Chicago, IL (2001)

20. Coelho, P., Esteves, S.: The Choice Between a Five-Point and a Ten-Point Scale in the Framework of Customer Satisfaction Measurement. International Journal of Market Research 49(3), 313-339 (2007)

Appendix A   Registration survey

Thank you for participating in the NLR CloudAtlas Project.

With this questionnaire we will collect some general information about you, in order to analyse our data later on. Only the researchers will have access to any personal information. Before the research data will be analysed, all results will be anonymised.

There are 6 questions in this survey.

What is your gender? *
○Female ○Male

What is your age? *
Please write your answer here:

What is the highest level of education you have completed?
Please choose **only one** of the following:
○ Primary education
○ Lower secondary education
○ Upper secondary education, or vocational
○ Bachelor, Master, Doctoral, or equivalent

What pastimes/hobbies are you interested in? *
Please select between 1 and 3 answers:

☐ Cooking/eating out	☐ Reading	☐ Theatre
☐ Computer games	☐ Shopping	☐ Watching TV
☐ Gardening	☐ Social Media	☐ Walking
☐ Movies	☐ Sports	☐ Other:

On a scale from 1 to 10, how motivated are you to participate in this experiment? *

          1 2 3 4 5 6 7 8 9 10
Motivation ○ ○ ○ ○ ○ ○ ○ ○ ○ ○
1 = not motivated at all, 10 = extremely motivated

Please indicate your level of agreement with each of the following statements. *

	1	2	3	4	5
I am personally connected to one of the researchers involved	○	○	○	○	○
I am connected to the NLR, the research institute involved	○	○	○	○	○
I am participating because I would like to win a prize	○	○	○	○	○
I am participating because I am interested in NLR and aviation	○	○	○	○	○
I am participating because I am interested in training and education	○	○	○	○	○
I am participating because I am interested in clouds and meteorology	○	○	○	○	○

1 = strongly disagree, 5 = strongly agree

Appendix B Written materials

Content

Introduction

Clouds are formed when humid air cools down around small particles in the air (like smoke or dust). When the saturation point is reached, the invisible water vapour changes into a visible state. They are the visible indicators of current weather and they are often indicative of future weather.

The importance of meteorology for the safety of civil aviation has been acknowledged since the early days of aviation. Clouds are part of the meteorological conditions that impact aviation.

A pilot needs to be able to recognize and classify clouds, assess the risks and decide what to do.

Cloud classification

While clouds appear in infinite shapes and sizes, they all fall into some basic forms. The cloud naming system was introduced by Luke Howard in 1803. Clouds are classified according to the height of their base in the sky and they are named for their height, shape and behaviour.

The system is based on the Latin language.

- **Cirro-form**: cirrus = tuft or curling lock of hair. Composed of ice crystals, cirro-form clouds are whitish and hair-like.
- **Cumulo-form**: cumulus = heap or pile. Generally detached clouds, they look like white fluffy cotton balls.
- **Strato-form**: stratus = layer, these clouds are usually broad and fairly widespread appearing like a blanket.

Howard noticed that clouds often have features of two or more categories. He also designated a special category for rainy clouds.

- **Nimbo-form**: nimbus = rain.

Clouds are vertically divided into three levels:

- **High-level, 5 to 13 km**: Cirrus, Cirrostratus, Cirrocumulus
- **Medium-level, 2 to 7 km**: Altostratus, Altocumulus, Nimbostratus
- **Low-level, 0 to 2 km**: Stratus, Stratocumulus
  - **Low-level with vertical development**: Cumulus (and Towering Cumulus), Cumulonimbus

Source: http://www.srh.weather.gov/jetstream/clouds/cloudposter.htm
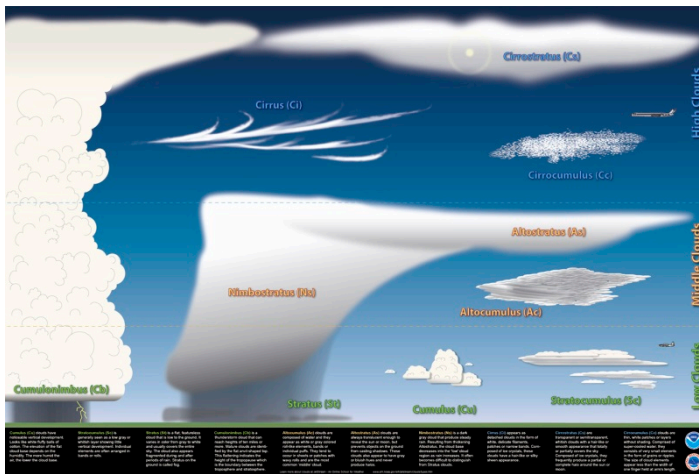
Cloud type: Cirrus

Cirrus appears as detached clouds in the form of white, delicate filaments, patches or narrow bands. Composed of ice crystals, these clouds have a hair-like or silky sheen appearance.

Main characteristics
- High-level cloud
- Isolated patches or a layer covering a wide area
- White streaks in many shapes and sizes
- Consist of ice crystals
- Generally occur in fair weather
- May produce fall streaks: falling ice crystals that evaporate before they touch the ground
- May produce optical phenomena such as halos and cloud iridescence
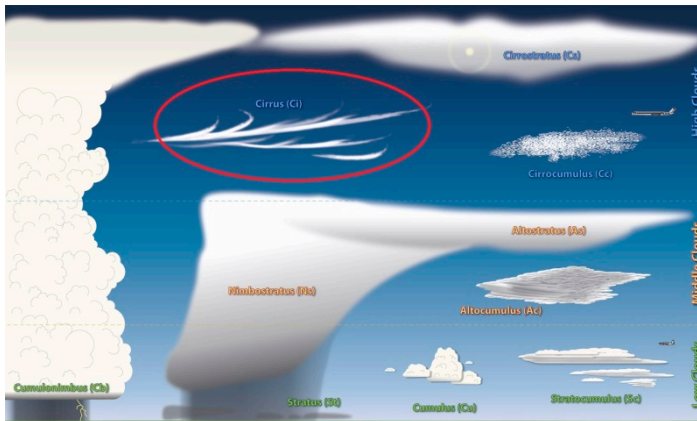
Hazards
- Some turbulence
- Small chance of icing

Flying advice

Isolated patches rarely have any great significance, but an extensive deck, increasing from one direction, may indicate an approaching front. Cirrus is often associated with turbulence, but it will generally cause little discomfort to pilots or passengers.

Photographs
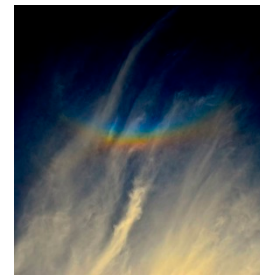
Source: <u>The Cloud Appreciation Society</u>

Cloud type: Cirrocumulus
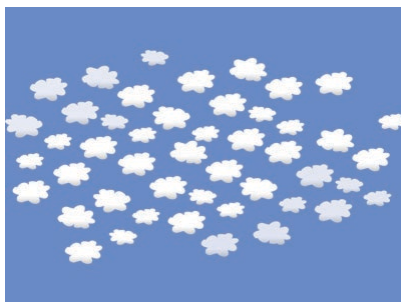
Cirrocumulus clouds are thin, white patches or layers without shading. Comprised of super-cooled water, they consist of very small elements in the form of grains or ripples.

Main characteristics
- High-level cloud
- Brilliant white with a spotty appearance, no shadows
- Appears in wide, patchy sheets
- Consist of a combination of water droplets and ice crystals
- Do not produce precipitation and are normally associated with fine weather
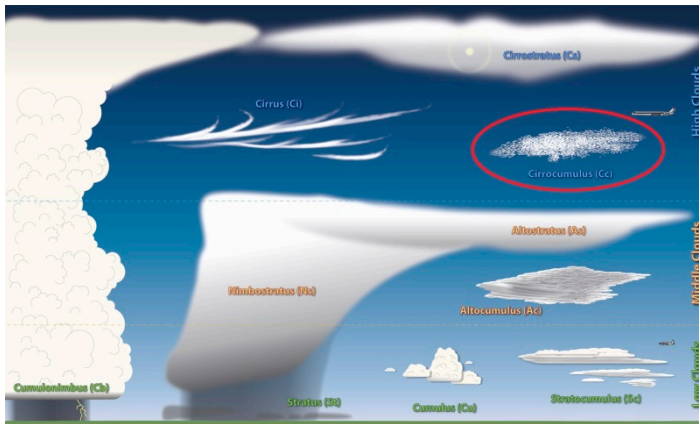
Hazards

- Chance of some turbulence
- Chance of icing

Flying advice

No special advice needed.

Photographs

Source: The Cloud Appreciation Society

Cloud type: Cirrostratus

Cirrostratus are transparent or semi-transparent, whitish clouds with a hair-like or smooth appearance that totally or partially covers the sky. Composed of ice crystals, they frequently produce a partial or complete halo around the sun or moon.

Main characteristics

- High-level cloud
- An even layer of Cirrus covering a wide area
- In a very thin layer of in strands
- Will often produce optical phenomena such as halos and iridescence
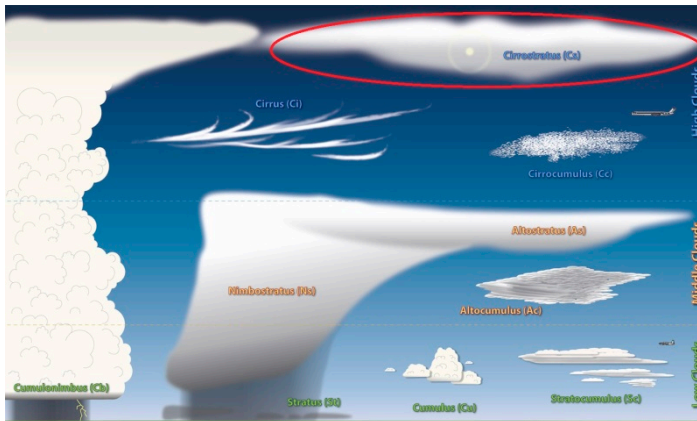
Hazards
- Small change of turbulence
- Very small chance of icing

Flying advice
Cirrostratus formations may cause slight turbulence at cloud level, but this is unlikely to affect aircraft operations or discomfort passengers.

Photographs

Source: The Cloud Appreciation Society

Cloud type: Altocumulus

Altocumulus clouds are composed of water and they appear as white or grey coloured roll-like elements, bands or individual puffs. They tend to occur in sheets or patches with wavy rolls and are the most common 'middle' cloud.

Main characteristics
- Mid-level cloud
- Layer or patches of mostly separated clouds
- Parallel bands or rounded masses
- A portion of altocumulus is shaded
- Altocumulus clouds do not produce rain, but may indicate a forthcoming weather change
- May easily be confused with Cirrocumulus, which is a high-level cloud without any shading
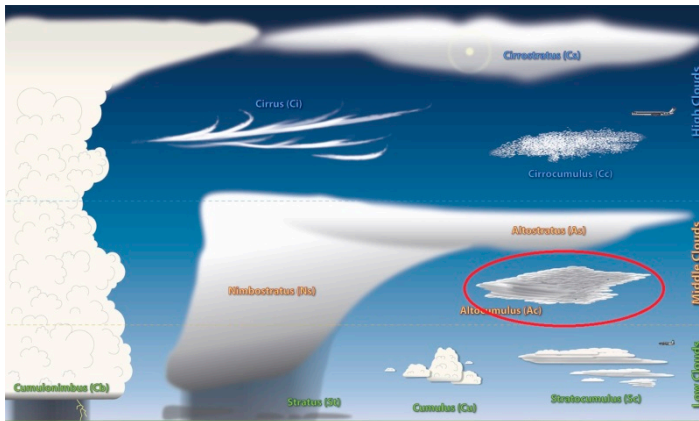
Hazards
- Some turbulence, and small chance of severe turbulence
- Very small chance of icing

Flying advice
No reason to fly around these clouds, unless a warning for turbulence has been issued. Do keep an eye on the thermometer as icing may occur at below freezing temperatures.

Photographs
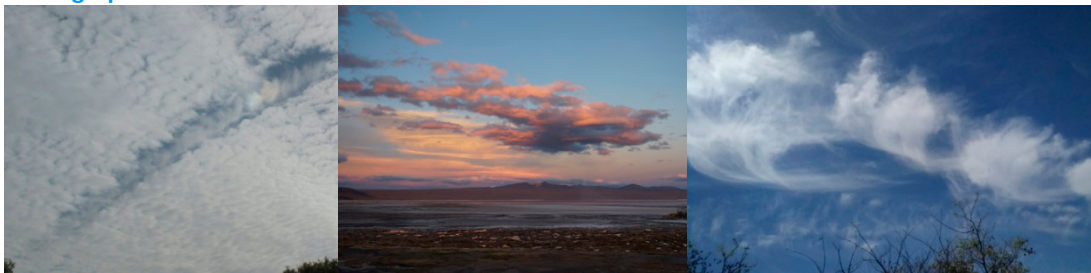
Source: The Cloud Appreciation Society

Cloud type: Altostratus

Altostratus clouds are always translucent enough to reveal the sun or moon, but prevent objects on the ground from casting shadows. These clouds also appear to have grey or bluish hues and never produce halos.

Main characteristics
- Mid-level cloud
- Usually covers the whole sky
- Grey or bluish-grey color, never white
- The sun (or moon) may shine through, but will appear watery and will not cast shadows
- May easily be confused with Cirrostratus, but Altostratus does not show a halo around the sun or moon
- Altostratus clouds may produce some rain, and they usually form ahead of storms with continuous rain or snow
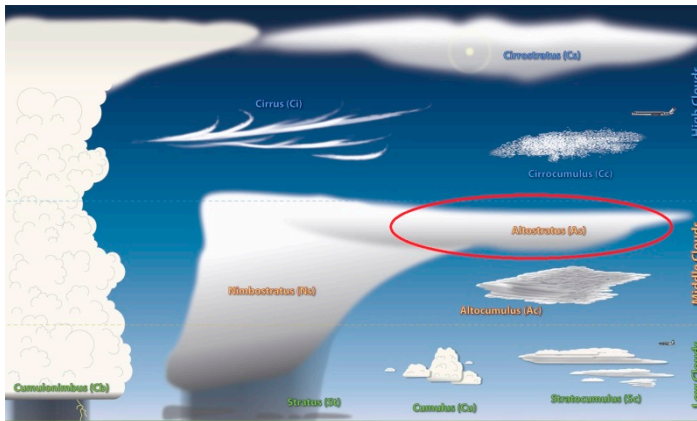
Hazards

- Small chance of some turbulence
- Chance of serious icing

Flying advice

A thick deck of Altostratus may be a cause for concern if temperatures within the cloud are below freezing. So keep an eye on the thermometer.

Photographs

Source: The Cloud Appreciation Society

Cloud type: Nimbostratus
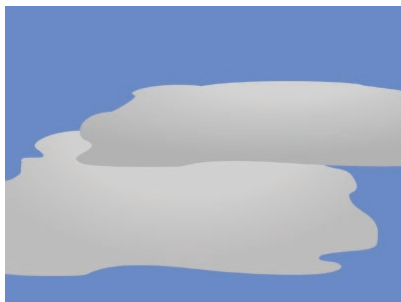
Nimbostratus is a dark grey cloud that produces steady rain. Resulting from thickening Altostratus, the cloud base decreases into the 'low' cloud region as rain increases. It often becomes difficult to distinguish from Stratus clouds.

Main characteristics

- Mid-level cloud, with a base height as low as 0.5 km
- Often called rain clouds
- Thick layer with uniform grey appearance
- May have some vertical development
- Bottoms can be blurred due to falling rain or snow
- Produces steady rain or snow
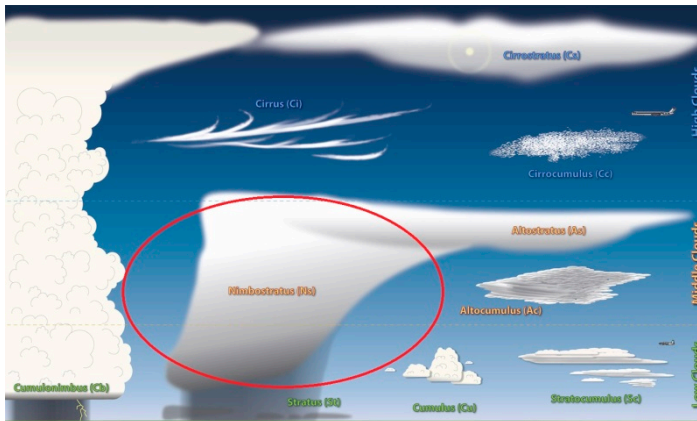
Hazards

- Some chance of turbulence
- Chance of icing
- Some chance of lightning

Flying advice

Keep an eye on the temperature to know of icing may occur. There may be some turbulence, but nothing too severe.

Photographs
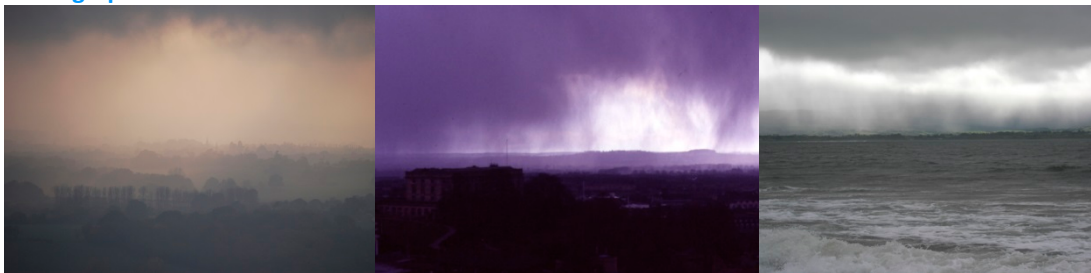
Source: The Cloud Appreciation Society

Cloud type: Stratus
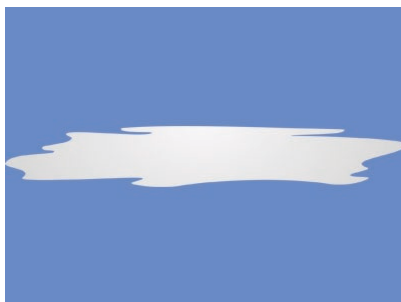
Stratus is a flat, featureless cloud that is low to the ground. It varies in colour from grey to white and usually covers the entire sky. The cloud also appears fragmented during and after periods of rain.
Fog is a Stratus cloud on ground level.

Main characteristics

- Low-level cloud, with a base height as low as 0 km
- Combination of water droplets, super cooled water and ice crystals
- Wide sheets with ragged, grey appearance
- May produce light precipitation from a thick layer
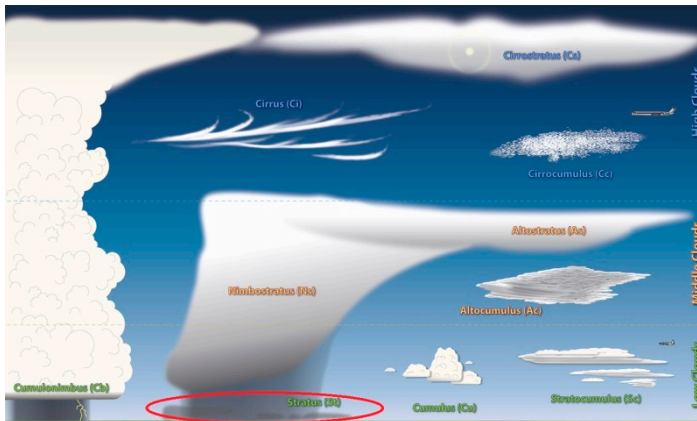
Hazards

- No turbulence
- Some chance of serious icing

Flying advice

Low to the ground it can mask the surrounding terrain. Landing through fog should be avoided.

**Photographs**
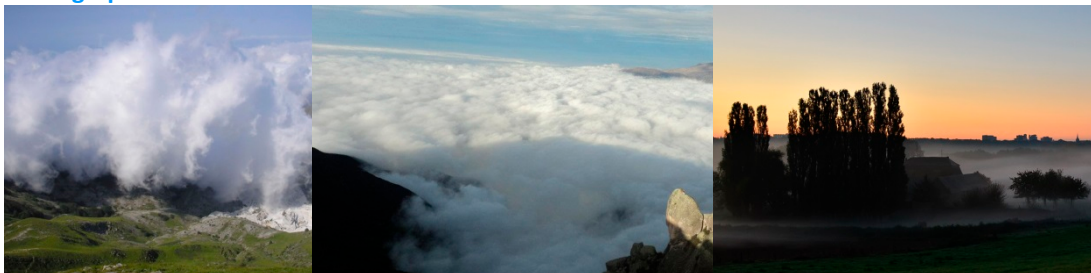
Source: The Cloud Appreciation Society

Cloud type: Cumulus
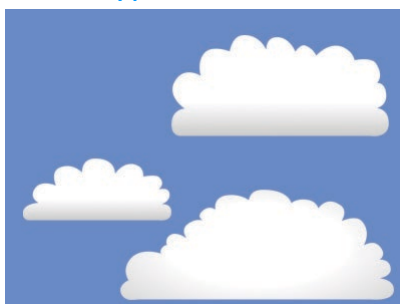
Detached, generally dense clouds and with sharp outlines that develop vertically in the form of rising mounds, domes or towers with bulging upper parts often resembling a cauliflower. The sunlit parts of these clouds are mostly brilliant white while their bases are relatively dark and horizontal.

Main characteristics

- Low-level cloud with vertical development: the top of a cumulus may reach into the mid and high levels.
- Puffy clouds with flat bases
- Can be white or light grey, with shading
- Appear by themselves or in clusters
- Come in various forms and sizes
- May show a high vertical development: Towering Cumulus
- Produce no precipitation, but can grow into Cumulonimbus
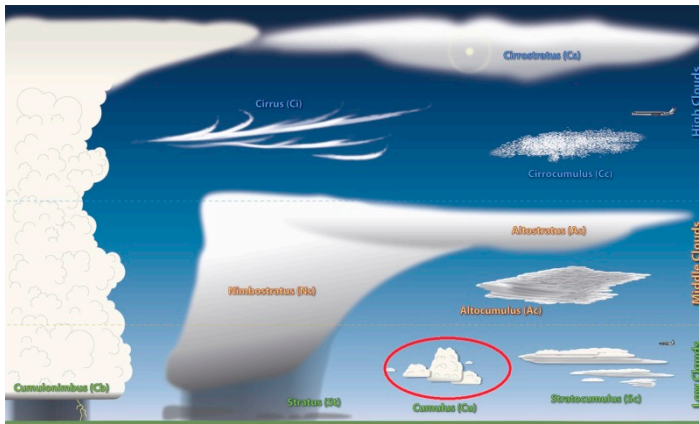
Hazards

- Chance of turbulence
- Chance of icing
- Small chance of lightning

Flying advice

Regular Cumulus may give a little bit of a bumpy ride. Towering Cumulus isn't Cumulonimbus yet, but it still may give some lightning and bad turbulence.

**Photographs**

Source: The Cloud Appreciation Society

Cloud type: Cumulonimbus

The thunderstorm cloud, this is a heavy and dense cloud in the form of a mountain or huge tower. The upper portion is usually smoothed, fibrous or striated and nearly always flattened in the shape of an anvil or vast plume. Under the base of this cloud which is often very dark, there are often low ragged clouds that may or may not merge with the base. They produce precipitation.

Main characteristics

- Low-level cloud with vertical development: the top of a cumulonimbus may reach into the mid and high levels.
- Has a grey to almost black color
- Top shaped like a mushroom or anvil
- Can reach a height of several kilometers
- Produces moderate to heavy showers
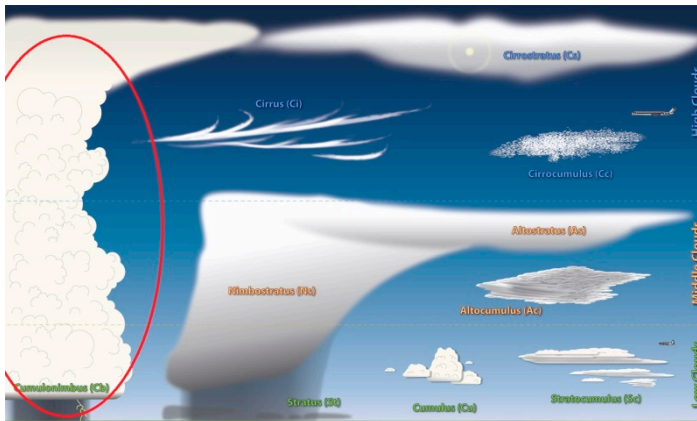
Hazards
- Chance of severe turbulence
- Chance of icing
- Big chance of lightning

Flying advice
Do not fly through or under a Cumulonimbus cloud, because there is a great risk of lightning within and under. Land your plane and wait for the storm to pass, or fly over it.

Photographs

Source: The Cloud Appreciation Society

Hazards

Pilots may encounter some hazards, in and around clouds, which influence aviation safety and passenger comfort.
The most common are:

- Turbulence
- Icing
- Lightning

Turbulence
In almost all types of clouds turbulence may occur. Turbulence is any irregular or disturbed airflow in the atmosphere. Its origin may be thermal or mechanical and it may come about either within a cloud or in clear air. Occurrences of turbulence are local in extent and transient in character. Although general forecasts of turbulence are quite good, forecasting precise locations is difficult.

Turbulence hardly ever causes damage to the aircraft, therefore most pilots do not worry and

just ride it out. Passengers, however, often experience turbulence as far more severe than it actually is.

Icing

The most hazardous aspect of structural icing is its aerodynamic effects. The presence of ice on an aircraft decreases lift, thrust, and range, and increases drag, weight, fuel consumption, and stall speed. For icing to form the atmosphere must have super-cooled visible water droplets and the temperature of the free air and the aircraft's surface need to be below freezing.

Clouds are the most common form of visible liquid water and super-cooled water is liquid water found at air temperatures below freezing. Water droplets in the free air do not freeze at 0°C, instead their freezing temperature varies from −10 to −40 °C, forming super-cooled droplets. When these strike an exposed object, such as a wing, the impact induces instant freezing and results in aircraft icing. When flying through a cloud at sub-zero temperatures, icing should be expected.

As a general rule, serious icing is rare in clouds with temperatures below −20°C since these clouds are almost completely composed of ice crystals. However, icing is possible in any cloud when the temperature is 0°C or below.

Lightning

Lightning is a sudden electrostatic discharge during a thunderstorm between electrically charged regions of a cloud, between two clouds, or between a cloud and the ground. Lightning occurs as a result of a build-up of static charges within a Cumulonimbus cloud. An aircraft passing close to an area of charge can initiate a discharge and this may occur even at some distance from a thunderstorm.

A lightning strike can damage electronic equipment and in rare events it can puncture the skin of an aircraft. Nearby lightning can blind the pilot leaving him momentarily unable to fly the aircraft. Lightning can also induce permanent errors in the magnetic compass when it is nearby or, even at a distance, it can disrupt radio communications.

A lightning strike can be very distressing to passengers and crew, but damage to an aircraft in flight which is sufficient to compromise the safety of the aircraft is rare. The safety of an aircraft in flight is usually not affected.

Appendix C Post Test

This is the test to finish the first part of the NLR CloudAtlas Project. You will answer some questions about clouds to see how much you have learned from your selection of learning materials. Next we will ask you some survey questions.

If you are not yet ready to take the test, you can return to your CloudAtlas Dashboard and spend some more time on the learning materials.
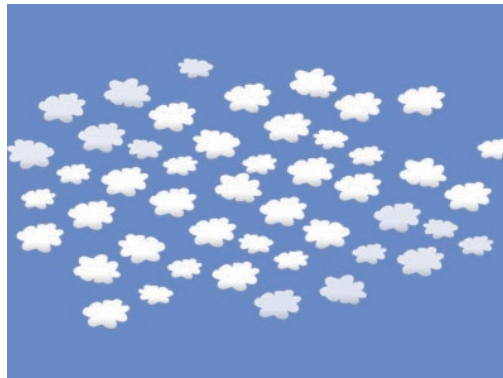
What are the ten main types of clouds? *
Please select 10 answers:

☐ Altocumulus	☐ Cirrus	☐ Nimbocumulus
☐ Altostratus	☐ Cumulocirrus	☐ Nimbostratus
☐ Altus	☐ Cumulonimbus	☐ Nimbus
☐ Cirrocumulus	☐ Cumulostratus	☐ Stratocirrus
☐ Cirronimbus	☐ Cumulus	☐ Stratocumulus
☐ Cirrostratus	☐ Nimboaltus	☐ Stratus

What cloud type is pictured here? *
Please choose **only one** of the following:
○ Altocumulus
○ Altostratus
○ Cirrocumulus
○ Cirrostratus
○ Cirrus
○ Cumulonimbus
○ Cumulus
○ Nimbostratus
○ Stratocumulus
○ Stratus

What cloud type is pictured here? *
Please choose **only one** of the following:
○ Altocumulus
○ Altostratus
○ Cirrocumulus
○ Cirrostratus
○ Cirrus
○ Cumulonimbus
○ Cumulus
○ Nimbostratus
○ Stratocumulus
○ Stratus

What cloud type is pictured here? *
Please choose **only one** of the following:
- ○ Altocumulus
- ○ Altostratus
- ○ Cirrocumulus
- ○ Cirrostratus
- ○ Cirrus
- ○ Cumulonimbus
- ○ Cumulus
- ○ Nimbostratus
- ○ Stratocumulus
- ○ Stratus

What cloud type is pictured here? *
Please choose **only one** of the following:
- ○ Altocumulus
- ○ Altostratus
- ○ Cirrocumulus
- ○ Cirrostratus
- ○ Cirrus
- ○ Cumulonimbus
- ○ Cumulus
- ○ Nimbostratus
- ○ Stratocumulus
- ○ Stratus

What cloud type is pictured here? *
Please choose **only one** of the following:
- ○ Altocumulus
- ○ Altostratus
- ○ Cirrocumulus
- ○ Cirrostratus
- ○ Cirrus
- ○ Cumulonimbus
- ○ Cumulus
- ○ Nimbostratus
- ○ Stratocumulus
- ○ Stratus

What cloud types can be seen in this photograph? *

Please choose **all** that apply:

☐ Altocumulus
☐ Altostratus
☐ Cirrocumulus
☐ Cirrostratus
☐ Cirrus
☐ Cumulonimbus
☐ Cumulus
☐ Nimbostratus
☐ Stratocumulus
☐ Stratus

What cloud types can be seen in this photograph? *

Please choose **all** that apply:

☐ Altocumulus
☐ Altostratus
☐ Cirrocumulus
☐ Cirrostratus
☐ Cirrus
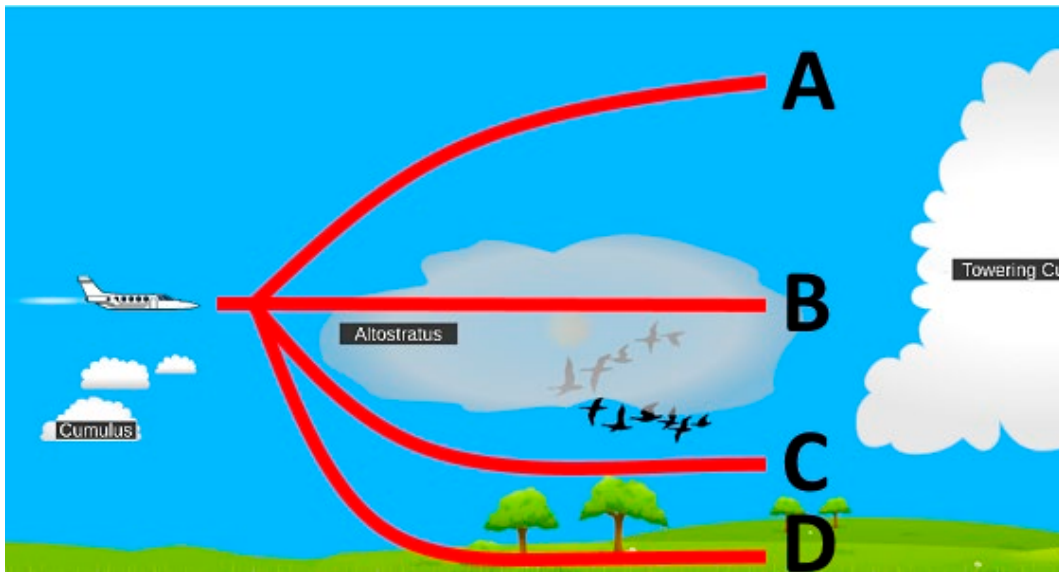☐ Cumulonimbus
☐ Cumulus
☐ Nimbostratus
☐ Stratocumulus
☐ Stratus

What are the chances of icing, turbulence and lightning for Cumulonimbus? *

Please choose the appropriate response for each item:

	No chance	Very small chance	Chance	Good chance	Certain
Icing	○	○	○	○	○
Turbulence	○	○	○	○	○
Lightning	○	○	○	○	○

What are the chances of icing, turbulence and lightning for Altostratus? *
Please choose the appropriate response for each item:

	No chance	Very small chance	Chance	Good chance	Certain
Icing	○	○	○	○	○
Turbulence	○	○	○	○	○
Lightning	○	○	○	○	○

What cloud(s) should you absolutely try not to fly through? *
Please choose **all** that apply:
☐ Altocumulus
☐ Altostratus
☐ Cirrocumulus
☐ Cirrostratus
☐ Cirrus
☐ Cumulonimbus
☐ Cumulus
☐ Nimbostratus
☐ Stratocumulus
☐ Stratus

Clouds are generally divided into groups, based on their étage (level). There are high-level, mid-level and low-level clouds, and low-level clouds with vertical development. *
Please indicate what level each cloud type is on.

	High	Mid	Low	Low + vertical
Altocumulus	○	○	○	○
Altostratus	○	○	○	○
Cirrocumulus	○	○	○	○
Cirrostratus	○	○	○	○
Cirrus	○	○	○	○
Cumulonimbus	○	○	○	○
Cumulus	○	○	○	○
Nimbostratus	○	○	○	○
Stratocumulus	○	○	○	○
Stratus	○	○	○	○

In the following section of the test you will be shown a picture of the sky with clouds. In the picture several routes are drawn. What route would you choose for this specific situation?
Look and read quickly, because each picture and description will only be shown for 15 seconds.
Select the route you would take and also the main reason why you chose this.
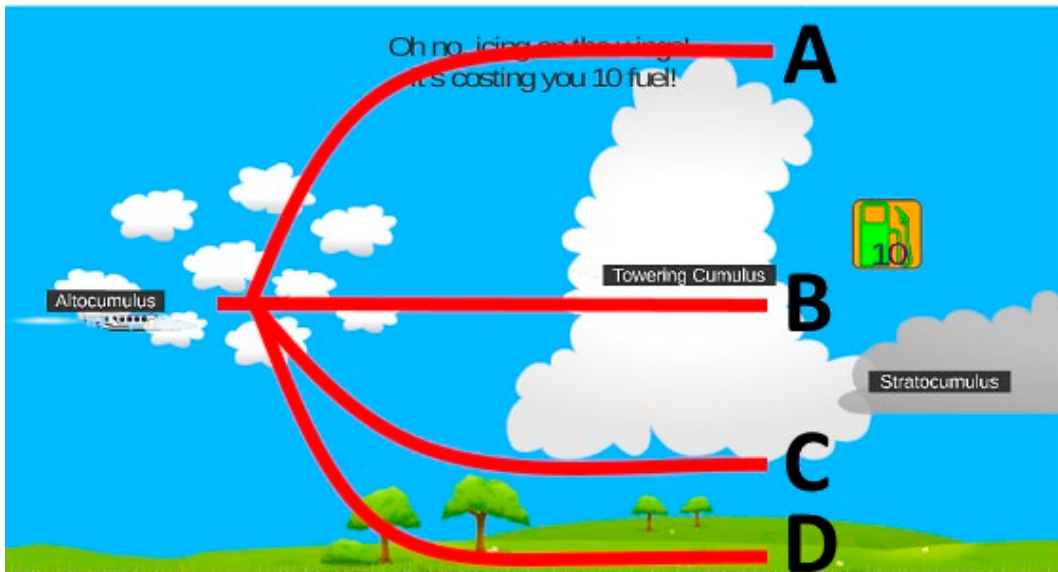
What route would you choose? *
Please choose **only one** of the following:
○ Route A
○ Route B
○ Route C
○ Route D

What are the main reasons for you to select this route? *
Please select at most 3 answers:
☐ This route is the fastest
☐ This route is the shortest
☐ This route is most fuel efficient
☐ To avoid the risk of icing
☐ To avoid the risk of turbulence
☐ To avoid the risk of lightning
☐ To avoid a collision
☐ To save oxygen
☐ To receive a bonus
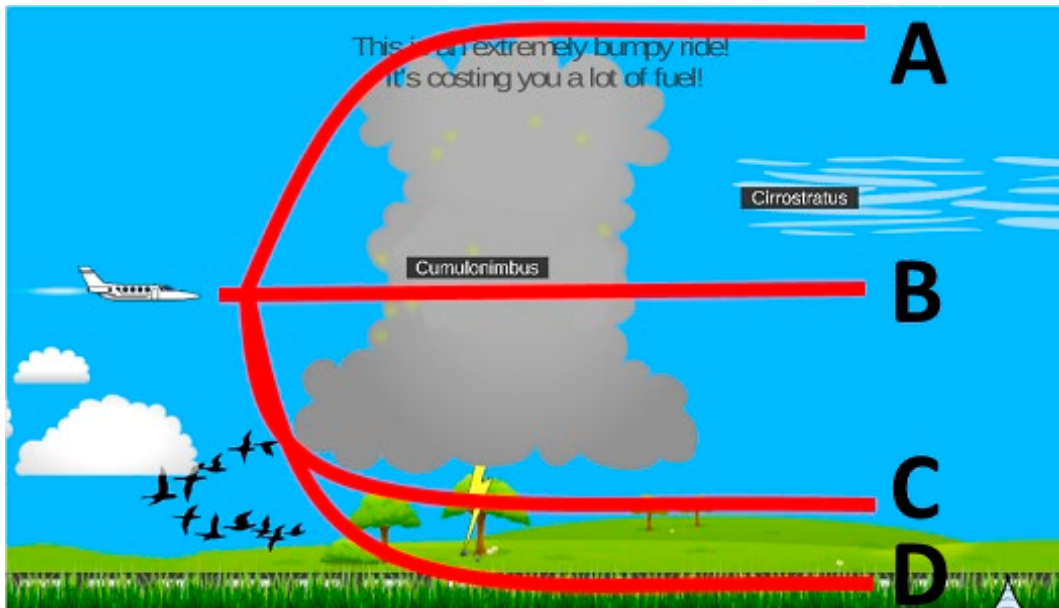☐ Random guess

What route would you choose? *
Please choose **only one** of the following:
○ Route A
○ Route B
○ Route C
○ Route D

What are the main reasons for you to select this route? *
Please select at most 3 answers:
☐ This route is the fastest
☐ This route is the shortest
☐ This route is most fuel efficient
☐ To avoid the risk of icing
☐ To avoid the risk of turbulence
☐ To avoid the risk of lightning
☐ To avoid a collision
☐ To save oxygen
☐ To receive a bonus
☐ Random guess

What route would you choose? *
Please choose **only one** of the following:
○ Route A
○ Route B
○ Route C
○ Route D

What are the main reasons for you to select this route? *
Please select at most 3 answers:
☐ This route is the fastest
☐ This route is the shortest
☐ This route is most fuel efficient
☐ To avoid the risk of icing
☐ To avoid the risk of turbulence
☐ To avoid the risk of lightning
☐ To avoid a collision
☐ To save oxygen
☐ To receive a bonus
☐ Random guess

You have now finished the NLR CloudAtlas test. Unfortunately our testing tool does not allow us to show you your results. Your answers have been stored in our database and will be used to generate test scores later on.

Please continue to answer a short survey to finish up this part of the experiment.

Appendix D Post Experiment survey

Please answer the following questions on a scale of 1 to 10.
Score 10 for the extreme positive answer, and 1 for the extreme negative. *

	1 2 3 4 5 6 7 8 9 10
How interesting do you find the topic of clouds and meteorology?	○ ○ ○ ○ ○ ○ ○ ○ ○ ○
How familiar were you with clouds and meteorology before this experiment?	○ ○ ○ ○ ○ ○ ○ ○ ○ ○
How much did you learn from the experiment?	○ ○ ○ ○ ○ ○ ○ ○ ○ ○

How often do play (computer) games in everyday life? *
Please choose **only one** of the following:
○ Absolutely never
○ Very rarely, only a few time per year
○ A few times per month
○ A few times per week
○ Every day
○ Multiple times per day

What type of games do you play? * [conditional question]
Please choose **all** that apply:
☐ Card games (non-computer)
☐ Board games (non-computer)
☐ Puzzles (non-computer)
☐ Action and adventure games (computer)
☐ Shooter games (computer)
☐ Role playing games (computer)
☐ Strategy and puzzle games (computer)
☐ Card and board games (computer)

How did it make you feel that you were obligated to play the game for a given minimum amount of time? *
Please choose **only one** of the following:
○ Annoyed: I wanted to quit before the time was up
○ Neutral: I did not really notice the time
○ Good: I liked knowing when I could move on

What do you think about the game controls? *
Please choose **only one** of the following:
○ The game was very easy to control
○ The game was easy to control
○ The game was hard to control
○ The game was very hard to control

Please answer the following questions on a scale of 1 to 10. Score 10 for the extreme positive answer, and 1 for the extreme negative. *

	1 2 3 4 5 6 7 8 9 10
Did you enjoy the game?	○○○○○○○○○○
Did you learn anything from the game?	○○○○○○○○○○

Would you have played the game if it wasn't mandatory? *
Please choose **only one** of the following:
○ No
○ Probably not
○ Probably yes
○ Yes

Why would you choose to play the game? * [conditional question]
Please choose **all** that apply:
☐ Because it is part of the selected materials
☐ Because I would hope it adds to the learning materials
☐ Because I am curious and would want to see what it looks like
☐ Because I like games
☐ Other:

How much time would you spend on the game? * [conditional question]
Please choose **only one** of the following:
○ No more than 2 minutes
○ Less than 8 minutes
○ About 8 to 12 minutes
○ More than 12 minutes

Why would you choose not to play the game? * [conditional question]
Please choose **all** that apply:
☐ Because I don't need any extra material beside the learning materials
☐ Because I think it would not add anything to the learning materials
☐ Because I don't like games
☐ Other:

If you have any comments or remarks for us, feel free to post them here.
Please write your answer here:

Thank you for completing this survey.

Appendix E   After care survey

Thank you for taking the time to answer a few questions. We appreciate your cooperation. Your answers will be useful in setting up future research projects.

How did you find out about the NLR CloudAtlas project? *
Please choose **only one** of the following:
○ I was asked in person (verbally or by email)
○ Through a link on Facebook
○ Through a link on Twitter
○ Other

Who has asked you to participate in the project? * [conditional question]
Please write your answer here:

Through whose Facebook account did you find the project? * [conditional question]
Please write your answer here:

Through whose Twitter account did you find the project? * [conditional question]
Please write your answer here:

What was/were the most important reason(s) for you to register to participate?*
Please select at most 2 answers:
☐ I was asked to
☐ I was curious to see the content of the project
☐ I liked participating
☐ I wanted to win the €100 gift card
☐ Other:

Which of these statements applied to you?*
Please choose **all** that apply:
☐ I had difficulties with the English language
☐ It took too long/cost me too much time
☐ I think the project was uninteresting
☐ I think the learning content was boring
☐ I think the learning content was too easy

☐ I think the learning content was difficult
☐ I did not like playing the game
☐ I think the game was too easy
☐ I think the game was too difficult
☐ Other:

We would appreciate some explanatory comments on your answers.
If you have any other comments you can write them here as well.
Please write your answer here:

Thank you for your cooperation.
Would you like to be informed about the results of this project? Let us know by sending us an email.

WHAT IS NLR?

The NLR is a Dutch organisation that identifies, develops and applies high-tech knowledge in the aerospace sector. The NLR's activities are socially relevant, market-orientated, and conducted not-for-profit. In this, the NLR serves to bolster the government's innovative capabilities, while also promoting the innovative and competitive capacities of its partner companies.

The NLR, renowned for its leading expertise, professional approach and independent consultancy, is staffed by client-orientated personnel who are not only highly skilled and educated, but also continuously strive to develop and improve their competencies. The NLR moreover possesses an impressive array of high quality research facilities.

NLR – Dedicated to innovation in aerospace

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