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07 **On your marks, get set, go:** Research on an educational escape game

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ABSTRACT

The central question guiding this study is whether knowledge can be effectively imparted through the medium of an escape game. This question formed the basis for the development of a digital educational escape game designed for an informal learning environment. The objective of "Project Pollination: A Buzzing Rescue" aims to enhance understanding of biodiversity, its significance, and how players can contribute to its conservation, particularly regarding pollinators in their local environment. This paper provides insights into the game and the research foundations upon which it was built. Finally, the in-game data and evaluation findings are discussed in relation to future research directions.

KEYWORDS

escape game, serious game, evaluation, research

PERMALINK

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1. Introduction

1 This paper is based on a presentation delivered at the Summer School "Beyond the Lock: Innovative Approaches to Escape Rooms in Education, Culture, and Organizational Development" (July 3-5, 2024, University for Continuing Education, Krems).

2 First, I will introduce the online game "Project Pollination: A Buzzing Rescue," which was developed in 2022/2023 at the Leibniz Institute for the Analysis of Biodiversity Change, Museum Koenig Bonn (Germany). Subsequently, I will describe the conditions set within the game to facilitate evaluation and educational research. Finally, I will present and discuss game and evaluation data in relation to a planned research project.

3 The escape game genre has been increasingly adopted in informal learning environments such as museums. At an international conference in 2021, for example, I participated in a serious escape game about the Sustainable Development Goals (SDGs) in a science center. However, I later wondered: Do players of educational or serious escape games actually retain any knowledge? Museums and science centers employ a variety of methods to transfer knowledge, engage visitors, and promote 'learning for fun.'[1] Game-based learning and serious games are two such approaches.[2]

4 At the Museum Koenig Bonn, we secured funding to develop an online educational escape game in collaboration with the game consulting company Pfeffermind (Berlin, Germany). We define an educational escape game as ""an interactive game set in the real or virtual world, in which a group solves various puzzles and challenges while

1 Packer, Jan (2006). Learning for Fun: The Unique Contribution of Educational Leisure Experiences. Curator: The Museum Journal, 49(3), 329–344. https://doi.org/10.1111/j.2151-6952.2006.tb00227.x; Lewalter, Doris & Schwan, Stephan (2017). Wissenschaftskommunikation in naturwissenschaftlich-technischen Museen aus psychologischer Sicht. Psychologische Rundschau, 68(3), 182–187. https://doi.org/10.1026/0033-3042/a000362

2 Game-based learning e.g., Ćosović, Marijana & Brkić, Belma Ramić (2020). Game-Based Learning in Museums—Cultural Heritage Applications. Information, 11(1), 22. https://doi.org/10.3390/info11010022; Rowe, Jonathan P., Lobene, Eleni V., Mott, Bradford W., & Lester, James C. (2017). Play in the Museum: Design and Development of a Game-Based Learning Exhibit for Informal Science Education. International Journal of Gaming and Computer-Mediated Simulations (IJGCMS), 9(3), 96–113. http://doi.org/10.4018/IJGCMS.2017070104; Serious games e.g., Back, Jon, Back, Svante, Bexell, Emma, Stanisic, Stefan, & Rosqvist, Daniel (2019). the Quest: An Escape Room Inspired Interactive Museum Exhibition. In Extended Abstracts of the Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts (CHI PLAY '19 Extended Abstracts, 81–86). Association for Computing Machinery, New York, NY, USA. https://doi.org/10.1145/3341215.3356987; Wouters, Pieter, van Nimwegen, Christof, van Oostendorp, Herre, & van der Spek, Erik D. (2013). A Meta-Analysis of the Cognitive and Motivational Effects of Serious Games. Journal of Educational Psychology, 105(2), 249–265; Approaches used e.g., Beale, Katy (2011). Museums at play: games, interaction and learning. Edinburgh: MuseumsEtc; Kelly, Lynda & Bowan, Amelia (2014). Gamifying the museum: Educational games for learning. In Nancy Proctor & Rich Cherry (Eds.), Museums and the Web Asia 2014. Silver Spring, MD: Museums and the Web. https://mwa2014.museumsandtheweb.com/paper/gamifying-the-museum-educational-games-for-learning/

experiencing a scenario with a clear objective"" [translation][3]. Another term for this type of game is 'serious escape game,' derived from 'serious games,' which are designed to be both entertaining and educational.[4]

5 Our aim was to convey what biodiversity is, why it is important, and how individuals can contribute to its conservation, with a particular focus on pollinators in Germany. Additionally, we aimed to develop a game that is accessible on demand, playable within a maximum of 60 minutes by individuals or groups aged 13 and above, available in both German and English, and grounded in research-based/evidence-based design principles.[5] These principles include insights from previous studies on escape games, serious games, and game-based learning in informal settings. Furthermore, the game was designed to enable educational research. The iterative development process was influenced by the constraints of the funding period and a fixed budget, and it included multiple rounds of user testing.

2. The Game

6 Following the work of Connolly et al. and Lamaarti et al. the game "Project Pollination: A Buzzing Rescue" can be categorized as follows:[6]

- Game type: Digital game
- Primary purpose: Serious game (learning and fun)
- Subject: Biology, general knowledge (biodiversity, pollination)
- Platform: Online (browser-based)
- Intended impact/outcomes: Knowledge acquisition, content understanding and motivational engagement (fun and interest)
- Interaction style: Traditional interface (mouse, keyboard)
- Environment: Virtual, not mobile, online, 2D, no location awareness
- Player modes: Single-player and group player (for groups, an additional web-based video conferencing tool is required)

3 Neubig, Céline (2024). Unlocking knowledge. Was educative Escape Rooms von den weltbesten Räumen lernen können (p. 7, [translation]). Master Thesis ZHdK Zürcher Hochschule der Künste.

4 Neubig, 2024, p. 133 [translation].

5 Gerjets, Peter & Schwan, Stephan (2021). Evidenzbasierte Entwicklung innovativer Vermittlungsformate zur Unterstützung des Wissenserwerbs. In Henning Mohr and Diana Modarressi-Tehrani (Eds.), Museen der Zukunft: Trends und Herausforderungen eines innovationsorientierten Kulturmanagements (429–454). Bielefeld: transcript Verlag. https://doi.org/10.1515/9783839448960-019

6 Connolly, Thomas M., Boyle, Elizabeth A., MacArthur, Ewan, Hainey, Thomas, &, Boyle, James M. (2012). A systematic literature review of empirical evidence on computer games and serious games, Computers & Education, 59(2), 661–686. https://doi.org/10.1016/j.compedu.2012.03.004; Laamarti, Fedwa, Eid, Mohamad, &, El Saddik, Abdulmotaleb (2014). An Overview of Serious Games, International Journal of Computer Games Technology, 1, 1687–7047. https://doi.org/10.1155/2014/358152

7 The objective of the game is to help a city win the competition "BiodiverCITY - The city with the highest biodiversity in Germany". Players have one year (60 minutes) or four seasons to enhance biodiversity by making the city more pollinator-friendly. Throughout the game, which begins in autumn, players can complete fourteen quests. Each quest allows three attempts, with penalties for incorrect answers and hint usage. Once a season ends, players cannot return to unfinished quests. It is possible to complete the game without solving all quests or playing all seasons, as skipping is allowed. The game interface includes a city map that changes dynamically based on player progress. Information is accessed through a 360° museum environment and a simulated laptop, embedded in the map. Some content is only unlocked by solving mini-games and puzzles. A hint system is available, and at the end of the game, players receive a final score indicating their city's ranking in the competition (maximum score: 750 points). Players are also given the option to complete a survey and download a summary PDF of the game's content.

3. Research Conditions

8 A game's outcomes depend, among other factors, on the way it is played. For instance, if a player skips the summer quest on helping insects, we cannot expect them to acquire that knowledge unless they already possessed prior information. To gain insight into player behavior, we implemented an unobtrusive ""in-game data collection""[7]. This system records gameplay duration, final scores, completed quests, hint usage, survey participation, and language preferences.

9 To enable further research, we integrated an online survey tool (LimeSurvey) at the end of the game. For privacy reasons, the game does not store any personal data. Instead, an anonymized random player ID is generated and linked to the survey, allowing in-game data to be correlated with survey responses.

10 We also developed a second version of the game featuring an alternative feedback system (elaborated feedback instead of correctness-based feedback).[8] This version is not yet publicly available.

7 Steiner, Christina, Hollins, Paul, Kluijfhout, Eric, Dascalu, Mihai, Nussbaumer, Alexander, Albert, Dietrich, & Westera, Wim (2015). Evaluation of Serious Games. An Holistic Approach (p. 4338). Proceedings of ICERI2015 Conference, 16th-18th November 2015, Seville, Spain.

8 e.g., Van der Kleij, Fabienne M., Feskens, Remo C. W., & Eggen, Theo J. H. M. (2015). Effects of Feedback in a Computer-Based Learning Environment on Students' Learning Outcomes: A Meta-Analysis. Review of Educational Research, 85(4), 475–511. https://doi.org/10.3102/0034654314564881

4.1. In-game Data

11 The game link was accessed 3,197 times between 26 October 2023 and 15 July 2024. But, approximately 1,846 times (58.6%) at least one quest was played. In the ensuing discussion, the focus shall pertain to the 1,846 individuals who engaged in the playing of at least one quest.

12 The analysis revealed that, on average, five (median=5) quests were completed per game. However, it is noteworthy that less than a quarter of players managed to complete all seasons (**see Tab. 1**).

Tab. 1: Number of quests solved per game (*n*=1.846)

Number of solved quests	n	%
1	328	17.8
2	271	14.7
3	206	11.2
4	89	4.8
5	86	4.7
6	93	5.0
7	82	4.4
8	62	3.4
9	83	4.5
10	91	4.9
11	81	4.4
12	102	5.5
13	125	6.8
14	147	8.0
	1,846	**100.0**

13 Furthermore, 193 individuals (10.5%) utilised hints during the course of the game. The specific quests for which these hints were used, and the number of hints employed, are outlined in Tab. 2. Additionally, 41 individuals (2.2%) participated in the English version of the game.

14 As illustrated in Table 2, the in-game data for each quest is presented. For instance, the quest entitled "Malik-Biodiversity", which is among the earliest quests, demonstrates the highest number of clues utilised (6.9%, *n*=98). Conversely, the quest "Otto - Pesticides", which occurred in the spring, was the most frequently unresolved (33.7%, *n*=251).

15 The average duration of play was 8:29 minutes (*SD*=11:17 (mm:ss), Min=0, Max=58 minutes, *n*=1848). The mean score achieved by players was 297 points (*SD*=223, Min=35, Max=730). It is noteworthy that no game attained the highest score.

16 A mere 3.3% of participants (*n*=61) proceeded to access the PDF file containing the game's content. A slightly higher percentage of participants, 4.1% (*n*=75), voluntarily accessed the survey link. The survey data are presented below.

4.2. Evaluation Data

17 During the period spanning from 26 October 2023 to 15 July 2024, a total of 75 players (representing 4.1% of the total sample) initiated the survey link in response to the voluntary invitation. Reliable data is available for 56 players (74.7%). Of these, 69.6% (*n*=39) played alone, 26.8% (*n*=15) in pairs, and 1.8% (*n*=1) played with three or more people.

18 The data indicates that more than half of the participants were aged 25 years or older (62.5%, *n*=35), five players were between 22 and 24 years old, another five were between 16 and 18 years, seven (*n*=12.5%) were between 13 and 15 years old, and the rest were under 12 years old or younger (*n*=4, 7.2%). Those who played with someone were mostly under 25 years old.

19 The mean number of quests completed per game was thirteen (median value). Furthermore, it was observed that 13 (23.2%) participants utilised hints during the course of the game. The specific quests for which hints were utilised, as well as the number of hints employed, exhibited variability (see Tab. 3). It is noteworthy that a game was played in the English version (1.8%), while the remainder were played in the German version.

Tab. 2: In-game data for each quest of the four seasons from all who have played at least one quest (*n*=1846)

					***n* and (%) of players that solved the quest directly correct (S0) or with one (S1) or two (S2) wrong solutions before**			**Number of players per quest that used hints**
Season	**Quest**	**Played by**	**Solved by**	**Not solved by**				
		n	***n*** (%)	***n*** (%)	**S0** (%)	**S1** (%)	**S2** (%)	***n*** (%)
Autumn	Rika - Kitchen herbs	1,608	1,434 (89.2)	174 (10.8)	1,187 (82.8)	153 (10.7)	94 (6.6)	25 (1.6)
	Malik - Biodiversity	1,429	1,241 (86.8)	188 (13.2)	1,036 (83.5)	128 (10.3)	77 (6.2)	98 (6.9)
	Otto - Cultivated plants	1,622	1,498 (92.4)	124 (7.6)	1,165 (77.8)	246 (16.4)	87 (5.8)	27 (1.7)
Winter	Rika - Insect hotel	989	866 (87.6)	123 (12.4)	647 (74.7)	139 (16.1)	80 (9.2)	18 (1.8)
	Kim - Bats	1,030	921 (89.4)	109 (10.6)	735 (79.8)	110 (11.9)	76 (8.3)	18 (1.7)
	Esha - Winter help	976	925 (94.8)	51 (5.2)	827 (89.4)	69 (7.5)	29 (3.1)	11 (1.1)
Spring	Malik - Flies	804	659 (82.8)	145 (18.0)	458 (69.5)	115 (17.5)	86 (13.1)	31 (3.9)
	Otto - Pesticides	744	493 (66.3)	251 (33.7)	304 (61.7)	92 (18.7)	97 (19.7)	18 (2.4)
	Kim - Chocolate	784	649 (82.8)	135 (17.2)	431 (66.4)	125 (19.3)	93 (14.3)	9 (1.1)
	Esha - Benefit Food	746	713 (95.6)	33 (4.4)	650 (91.2)	46 (6.5)	17 (2.4)	7 (0.9)
Summer	Rika - Summer help	549	492 (89.6)	57 (10.4)	371 (75.4)	77 (15.7)	44 (8.9)	12 (2.2)
	Malik - Nature city	606	458 (75.6)	148 (24.4)	270 (59.0)	114 (24.9)	74 (16.2)	28 (4.6)
	Kim - Lifecycle	579	450 (77.7)	129 (22.3)	243 (54.0)	121 (26.9)	86 (19.1)	22 (3.8)
	Esha - Every season	600	558 (93.0)	42 (7.0)	483 (86.6)	49 (8.8)	26 (4.7)	6 (1.0)

Tab. 3: In-game data for each quest of the four seasons from all players that filled in the questionnaire (*n*=56)

					***n* and (%) of players that solved the quest directly correct (S0) or with one (S1) or two (S2) wrong solutions before**			**Number of players per quest that used hints**
Season	**Quest**	**Played by**	**Solved by**	**Not solved by**				
		n	***n* (%)**	***n* (%)**	**S0 (%)**	**S1 (%)**	**S2 (%)**	***n* (%)**
Autumn	Rika - Kitchen herbs	55 (98.2)	54 (98.2)	1 (1.8)	47 (87.0)	6 (11.1)	1 (1.9)	/
	Malik - Biodiversity	52 (92.9)	47 (90.4)	5 (9.6)	38 (80.9)	5 (10.6)	4 (8.5)	7 (12.5)
	Otto - Cultivated plants	53 (94.6)	52 (98.1)	1 (1.9)	39 (75.0)	10 (19.2)	3 (5.8)	1 (1.8)
Winter	Rika - Insect hotel	55 (98.2)	51 (92.7)	4 (7.3)	42 (82.4)	6 (11.8)	3 (5.9)	1 (1.8)
	Kim - Bats	55 (98.2)	53 (96.4)	2 (3.6)	47 (88.7)	3 (5.7)	3 (5.7)	/
	Esha - Winter help	54 (96.4)	53 (98.1)	1 (1.9)	52 (98.1)	/	1 (1.9)	1 (1.8)
Spring	Malik - Flies	53 (94.6)	50 (94.3)	3 (5.7)	33 (66.0)	10 (20.0)	7 (14.0)	4 (7.1)
	Otto - Pesticides	47 (83.9)	33 (70.2)	14 (29.8)	18 (54.5)	5 (15.2)	10 (30.3)	2 (3.6)
	Kim - Chocolate	50 (89.3)	47 (94.0)	3 (6.0)	34 (77.3)	6 (13.6)	4 (9.1)	1 (1.8)
	Esha - Benefit Food	52 (92.9)	51 (98.1)	1 (1.9)	35 (94.6)	2 (5.4)	/	1 (1.8)
Summer	Rika - Summer help	52 (92.9)	52 (100.0)	/	45 (86.5)	7 (13.5)	/	1 (1.8)
	Malik - Nature city	55 (98.2)	46 (83.6)	9 (16.4)	22 (47.8)	16 (34.8)	8 (17.4)	5 (8.9)
	Kim - Lifecycle	53 (94.6)	51 (96.2)	2 (3.8)	30 (58.8)	16 (31.4)	5 (9.8)	1 (1.8)
	Esha - Every season	54 (96.4)	54 (100.0)	/	51 (94.4)	3 (5.6)	/	1 (1.8)

20 As illustrated in Table 3, the in-game data for each quest is presented. For instance, the quest entitled "Malik-Biodiversity", which was among the earliest quests, exhibited the highest number of clues utilised (12.5%, *n*=7). In contrast, the quest entitled "Otto - Pesticides" was the least frequently solved (29.8%, *n*=14) and played (*n*=47, 83.9%) compared to the other quests. In addition to the quest "Malik - Nature City" (*n*=24, 52.2%), "Otto - Pesticides" was a quest where the majority of players who solved it used hints (*n*=15, 45.5%). A comparison of the in-game data and subgroup data reveals a similar pattern (see Tab. 2 and Tab. 3).

21 The average duration of the 56 games was 26 minutes and 31 seconds (SD=14:18 (mm:ss), Min=1 minute, Max=56 minutes, *n*=56). Furthermore, 610 points were accumulated (SD=67, Min=435, Max=700). The minimum time indicates that individual players have skipped almost all quests.

22 The 56 players who completed the questionnaire assigned an average grade of 2 (MW=2.05, SD=.840, Min=1, Max=4) on a six-point scale ranging from "very good (1)" to "unsatisfactory (6)". The players' assessment of the game's difficulty was categorised as "partly easy, partly difficult (3)". (Median=3, Min=2, Max=5) on a scale from "very easy (1)" to "very difficult (5)" with a tendency towards "easy (2)" (see Fig. 1). However, it was observed that those who assigned the most negative rating (i.e., "sufficient" = 4) did not consider the game to be particularly challenging (Fig. 1).

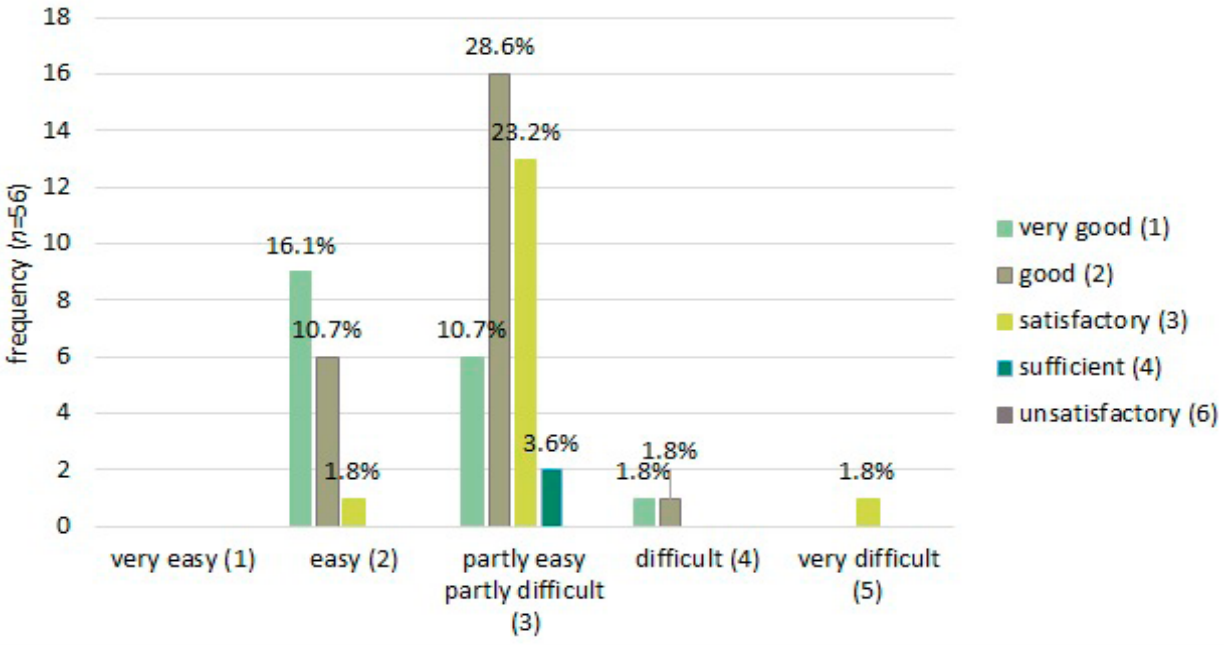

Fig. 1: Frequencies and percentages of scores in relation to individual perceptions of game difficulty (*n*=56)

23 Six statements were provided concerning the usability of the game, which were to be evaluated using a 5-point Likert scale ranging from "strongly disagree (1)" to "fully agree (5)". The results of this evaluation are illustrated in Figure 2.

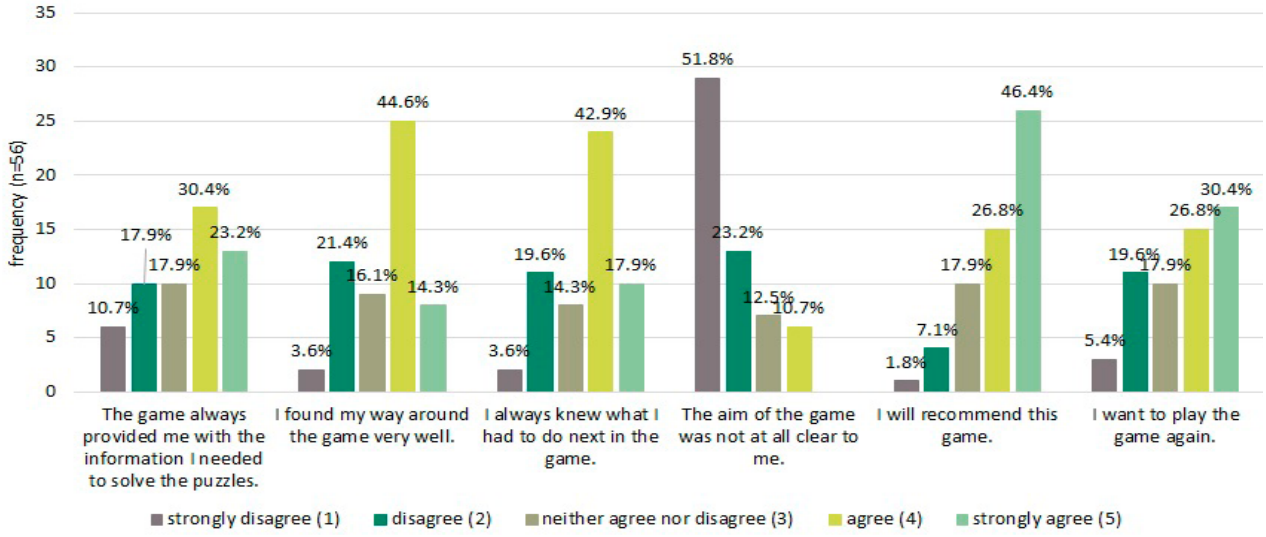

Fig. 2: Frequencies and percentages of ratings of usability statements (*n*=56)

24 The objective of the game was evidently clear to approximately 75% of the players, as evidenced by these ratings. However, a proportion of players (approximately 41%) encountered difficulties navigating the game and/or felt disoriented about subsequent steps (approximately 46%). Notwithstanding these challenges, the game's overall usability is reported to be satisfactory on average.

25 The objective of the exercise is to facilitate the transfer of knowledge or to stimulate interest in the subject matter. However, the prerequisite for effective learning is the presence of three fundamental factors: attentiveness, motivation, and interest. The evaluation questionnaire was designed to assess three facets of situational interest. Each statement for the subscales emotion (E), value (V) and cognition (C) has to be rated on a 5-point Likert scale from "strongly disagree (1)" to "strongly agree (5)". The subscales thus characterised were found to be highly rated (see Tab. 4). Consequently, the content was perceived as significant and valuable by the players themselves and by society at large (MW=4.82, SD=.593), the game was also enjoyable (MW=4.19, SD=.841), and it captured the players' attention (MW=4.12, SD=.736).

Tab. 4: Descriptive statistics and Cronbach's Alpha for the situational interest subscales

Aspects of Situational Interest	*n*	Min	Max	MW	SD	Number of items	Cronbach's Alpha
Emotion (E)	56	1	5	4.19	.841	3	.819
Value (V)	56	1	5	4.82	.593	3	.885
Cognition (C)	55	1	5	4.12	.736	7	.853

Note. Min = Minimum, Max = Maximum, M = mean and SD = standard deviation.

5. Discussion

26 This paper has introduced "Project Pollination: A Buzzing Rescue," outlined its research foundations, and presented some initial in-game and evaluation data.

27 The in-game data demonstrate an absence of a predetermined sequence. Players are at liberty to select the season and quests of their choosing, as well as the sequence in which they wish to undertake them. The game's linearity is limited to the sequence of the four seasons. Consequently, the number of players who have completed a quest will vary. It is evident that the number of quests played decreases from season to season. This phenomenon can be interpreted in two distinct ways: Firstly, some players may opt to skip seasons and quests. It is evident that their participation is limited to the most recent season or a select number of quests. Secondly, players may choose to discontinue playing. This suggests that the game has not effectively sustained players' engagement. The game's appeal is therefore questionable, as a high percentage of those who initiated the game but never participated in a single quest abandoned it. This phenomenon may also be attributed to the novelty value of the game. Further research is needed here, as the subsample of players who completed the questionnaire showed high situational interest. This suggests that the game has the potential to generate situational interest, which could serve as a prerequisite for learning, at least among a subset of players.

28 An analysis of in-game data reveals that, during the inaugural season, players sought the most assistance from hints for the quest entitled "Malik - Biodiversity". One potential explanation for this phenomenon is that players were unable to locate the necessary information to complete the quest. Post-game discussions with players indicated that the terms "your laptop" and "InstaPic" were not clear to them, and that they required more time to acclimatise to the game's mechanics. Consequently, a revised in-game onboarding process, incorporating enhanced guidance at the outset, could serve

as a potential solution. In-game data also provides insight into other issues related to quests, such as which quest was the most difficult in terms of completion rates. This information can be utilised to formulate potential revisions or to conduct further qualitative studies that offer a more profound understanding of the challenges encountered.

29 A small number of players voluntarily completed the evaluation questionnaire. Contrary to the target group mentioned at the outset, the minority comprised players between the ages of 13 and 15. The reasons for the under-representation of this age group are unclear; it is not evident whether the game did not appeal to this group, or whether the subjects simply did not complete the questionnaire. The data gathered from the questionnaire indicates that the game is of an acceptable level of difficulty. However, the quests could benefit from enhanced clarity in wayfinding and information search to facilitate player progress. A number of further inferences might be drawn from the data, but the author will limit themselves to those mentioned in this text, and discuss the limitations instead.

30 It is imperative to consider the voluntary nature of participation when analysing the phenomenon. The impact of self-selection cannot be discounted. Consequently, the interpretation of evaluation outcomes should be approached with a degree of caution. Moreover, the general in-game data indicates that the game may not be successfully engaging players or that players are bypassing seasons and quests. However, it is not possible to draw any conclusions as to the reasons why players might be doing so. Consequently, further research employing an alternative sampling strategy is required to gain a more profound understanding of players' in-game decisions.

31 In the context of research and evaluation, the non-linear nature of the game poses a significant challenge. The presence of a free sequence within a season, coupled with the capacity to bypass quests and seasons, complicates the interpretation of in-game data. Consequently, it is recommended that future games adopt a linear approach to enhance the interpretability of in-game data.

32 The development of the game commenced with the question of whether players of an educational or serious escape game take anything away. At this juncture, a definitive conclusion remains elusive. Further research is required, including a comparison of the two versions of the game. Nevertheless, it is imperative to establish

the foundations for research studies, in order to triangulate different sources of data.[9] In order to ""derive more conclusive evidence on the […] effect of the evaluated serious game""[10], it is necessary to consider both data from the game itself and that provided by the users.

Acknowledgement

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Note on the use of AI
Both the free versions of ChatGPT and DeeplWrite were used in the manuscript for proofreading and language revision.

Link to the German-speaking trailer
https://youtu.be/ExXNvzLcoE8
Link to the game
https://projectpollination-lib.de/en/

9 Steiner et al., 2015.
10 Steiner et al., 2015, p. 4338.

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About the author

Since April 2021, **Dr. Inga Specht** is the head of the department of visitor and educational research at the Leibniz Institute for the Analysis of Biodiversity Change (LIB), Museum Koenig Bonn (Germany). She did her Ph.D. on conflicting information in museums and she likes playing board and escape games.
ORCID-ID: https://orcid.org/0000-0002-1518-6827