About Dinosaurs in Laboratories - Evaluation of the Serious Game Cards for Biosafety

Freese, Maria; Bekebrede, Geertje

About Dinosaurs in Laboratories - Evaluation of the Serious Game Cards for Biosafety

Maria Freese[1,2(✉)] [ID] and Geertje Bekebrede[1] [ID]

[1] Faculty of Technology, Policy and Management, Delft University of Technology, Jaffalaan 5, 2628 BX Delft, The Netherlands
`maria.freese@ovgu.de`
[2] Faculty of Mechanical Engineering, Otto von Guericke University, Universitaetsplatz 2, 39106 Magdeburg, Germany

Abstract. Cards for Biosafety is a serious game, which was developed as part of a national research project. The aim of this game is to let young biotechnology researchers learn about risks and mitigation measures in different biotechnology environments. To evaluate the game and its learning objective, an online questionnaire was developed and distributed to national and international biosafety experts who had received a print version of the game. In total, 17 participants completed the questionnaire. The results show that Cards for Biosafety supports learning on different cognitive levels of the revised version of Bloom's taxonomy. Especially the influence of fun and humor on the game play and the learning process was emphasized by the respondents. In addition, the creativity of the participants plays a major role in learning. Future research is needed to draw valid conclusions about the effectiveness of learning after playing Cards for Biosafety in comparison to traditional tools.

Keywords: Biosafety · Biotechnology · Cards for Biosafety · Evaluation · Fun · Learning · Serious Games

1 Introduction

Within the T-TRIPP project (Tools for Translation of Risk research into Policies & Practices), which is part of part a National Biotechnology and Safety research programme, different research activities were conducted. One of these research activities focused on the development of a serious game. In order to identify a concrete problem to be addressed by such a serious game, the analyses of the project team were based on the IDEAS approach [1]. The IDEAS approach basically consists of four main steps and defines the participation of the actual target group as a central component. The results of this participatory approach with experts from the field of biotechnology have clearly shown that a) a serious game for education is needed b) to be able to let young biotechnology researchers c) think more deeply about biosafety in an interactive way.

a) The need for a serious game is mainly grounded in the need for an interactive method that makes it possible to discuss topics, such as biosafety and biosecurity and associated risks, with each other in an open and safe environment. The expectation is that

the cognitive exchange about these topics in the context of a serious game can contribute significantly to the learning success compared to conventional methods, which have a less strong focus on interaction, engagement, and innovation. The advantage of the latter aspect has already been discussed by Orhan and Sahin [2] for training approaches in biotechnology. Franklin, Peat and Lewis [3] have already addressed the extent to which biology students and teachers find card game discussions useful. The students considered such a method as an added value and the teachers rated the card game discussions as a possibility for active learning.

b) The project analyses have shown that especially junior researchers (Master students, PhD students or Postdocs) should make use of the serious game to give them more active knowledge around biosafety topics.

c) The focus on biosafety has arisen from the content-related discussions with the researchers, who talk about the fact that it is sometimes difficult to explain the rules to researchers, that safety is not always the top priority or that there is a lack of awareness for safety issues. Further results are described in detail in Freese, Tiemersma and Verbraeck [4].

During last year's (online) International Simulation and Gaming Associations conference, we played a prototype of the serious game Cards for Biosafety with workshop attendees in addition to a more content-oriented presentation of the development of this game. Based on the feedback from workshop and conference attendees as well as from subject-matter experts, the game has been further developed to the final version and sent to biosafety experts around the world. The main question for any educational game is if and to what extent the game influences learning and achieves the goal of the game. From a development perspective, the game was designed with 'serious fun' elements. Therefore, the game experience is also examined. The aim of this publication is to discuss the evaluation of this serious game with regard to the achievement of its intended learning objectives and game experiences.

2 Cards for Biosafety

Cards for Biosafety, which was inspired by the entertainment game Cards against Humanity [5], is an analogue card game that can be played with 3 to 8 players. The aim of the game is to let junior researchers think more deeply about safety aspects and thus, create a better understanding of related risks and measures to mitigate these risks in different biotechnology environments. The game is round-based and each round takes about 10 min to play depending on the number of players and the depth and length of the discussions as part of the debriefing. Only the first round takes a bit more time as the players are still busy learning the rules of the game.

2.1 Game Play

The detailed description of the game play can be found in Freese, Tiemersma and Verbraeck [4]. The most important game mechanics that are relevant for a better understanding of this publication are described here. The game is based on different rounds that are independent of each other, making it possible to play as many rounds as possible.

There are three main phases per round: 1) Choosing a scenario, 2) choosing a risk card, and 3) choosing a measure card.

In the first step, the game facilitator selects a scenario (e.g., "fundamental lab research on mutations in the SARS-CoV-2 virus"). This can be done by choosing a scenario consciously or picking it randomly.

In the second step, the facilitator distributes five risk cards (e.g., "non-labelled containers on workbench") to every player. Each of them chooses one of these cards that represents the best, funniest or most realistic risk for the scenario selected in the first phase. The players should not only choose an appropriate risk card, but also think about an argumentation for their choice. Every player pitches their arguments and after the pitches, the players vote for the risk card that symbolizes the most appropriate risk for the scenario. The selected risk card is used as a starting point for the next phase.

In the third step, the facilitator distributes five measure cards (e.g., "make instructions in several languages") to every player. Similar to the previous phase, the players have to choose a measure card that represents the best way to mitigate the previously chosen risk and give a pitch with regard to their choice. This is followed by another voting round, and the players must identify the best measure card.

Cards for Biosafety is seen as a discussion starter. To guarantee this and thus, focus on the serious part of this game, it is important to provide enough space for debriefing moments. During the game play, several debriefing moments exist, meaning that after every phase (risk, measure) or round a debriefing can be initiated. If necessary, the facilitator gives more background information about the selected scenario. The facilitator booklet contains information about the scenarios which can be shared in advance or with participants after a round has finished. To guarantee the achievement of the intended learning goal, a final debriefing can be conducted at the end of the game play to discuss the results from a meta perspective. There are different ways to intensify the debriefing process, because part of the game is of course also the direct exchange process between the players without the facilitator's support. Within the debriefing, different topics are addressed. Besides the players' emotions, concrete experiences related to specific events are analyzed, but above all the connection to everyday life is built up. Here, it is interesting to know why different cards were chosen and how this information (or similar information) on the cards is related to the working world of the players. More concrete debriefing questions can be found in Freese, Tiemersma and Verbraeck [4]. The learning effect increases when the game is played with a diverse group in terms of level of experience [4], which is why we recommend playing this game with both junior (e.g., Master students, PhD students or Postdocs) and senior researchers (e.g., biosafety officers or project leaders). The added value of the debriefing can be supported by the attendance of a senior researcher who can put the element of fun in a serious context making it possible to learn "why a dumb answer could be right".

2.2 Developing an Engaging Prototype

The game was designed with 'serious fun' elements, which means engagement is an important design criterion. To reach the objectives, discussion and creativity is relevant as well. Based on the feedback from gaming and biotechnology experts in numerous

iterations, the following aspects were prioritized and implemented in the final Cards for Biosafety prototype.

To encourage and challenge the players as much as possible, the formulations on all cards needs to be neutral. Phrases such as "Due to …" were removed, as these already provide an argumentation aid. In various playtests, we recognized that pitching for a card should be given greater importance. Therefore, each player gets a short moment to argue their card. To further increase creativity, we have added a number of blank scenario, risk and measure cards with the idea that the players themselves can write down their projects, risks or measures on these cards and thus consider their own projects as part of the game.

Another way to improve discussion and creativity was to work with a competitive element. After the players have presented their pitches, each player will be given the opportunity to vote for the pitch they think is the best (funniest, most realistic, …). It is not possible to vote for yourself. The player with the most votes wins the phase and round and gets one point. When there is a tie after voting, the players with the same number of votes must defend their cards again. Afterwards, the other players have time to adjust their scoring. A secret voting system is given as option, when the game is played with people with different levels of experience. The players are asked to vote with the corresponding cards upside down and turn over the cards at the same time and thus make the scoring open. In this way, junior researchers are not influenced by the scoring of the more experienced researchers. Our experience from play-testing showed that players considered the competitive element - pitching creative ideas against each other - to be very valuable.

Finally, it was important to check the risk and measure cards with regards to an appropriate balance between fun and seriousness. As already described in Freese, Tiemersma and Verbraeck [4], the cards were validated by experts, but a conscious decision was made to also include funny cards in the game and to work with fun throughout the course of the game play and serious discussions. All this has been incorporated into the final version of Cards for Biosafety (see Fig. 1).

2.3 Learning Objective

As mentioned earlier, we want to let junior researchers think more deeply about biosafety aspects. This learning objective can be classified using the taxonomy of Bloom [6] or the revised taxonomy of Bloom by Anderson and Krathwohl [7]. Generally speaking, these taxonomies assume that there are different levels of cognitive learning goals and that one first needs to acquire knowledge before one can apply it to different situations and thus, create new input. By using Cards for Biosafety, we want players to go through these different phases. After playing Cards for Biosafety, players should have learned something new about specific biotechnology projects, associated risks, and measures to mitigate the risks, and should be able to adapt this to other situations they might or will encounter as well. Based on this, the following research question can be formulated: Does playing Cards for Biosafety support learning on the different cognitive levels of the revised version of Bloom's taxonomy?

Fig. 1. Impression of the serious game Cards for Biosafety (TU Delft Gamelab, 2021)

3   Experimental Set up

To evaluate the Cards for Biosafety game, we developed and distributed an online questionnaire.

3.1   Online Questionnaire

The online questionnaire consisted of five main parts. First, we asked participants for their consent. Second, we focused on demographical data, such as gender, age, and nationality. Third, we used the Game Experience Questionnaire (GEQ) to measure the game experience of the participants [8]. The GEQ is a well-known and often cited instrument to measure the game experiences based on seven components: competence, immersion, flow, tension/annoyance, challenge, and (positive and negative) affect. Due to the fact that the GEQ was originally developed to measure the players' experience of digital games, we added a 'not applicable' category to the 5-point answer scale of the GEQ in case participants have the impression that an item is less suitable for the evaluation of a card game. The use of the GEQ in order to measure the participants' experience with an analogue game is supported by a study from Johnson, Cuijpers, Pollmann and van de Ven [9]. Fourth, we included several questions regarding the achievement of the intended learning results, the different levels of learning according to the revised Bloom's taxonomy and the participants' chosen strategies in order to try to win the game. Regarding the questions related to the revised Bloom's taxonomy, we chose open-ended questions per level and associated verbs [10] related to that level and let participants self-select what they experienced through the game by selecting the verbs themselves and giving

corresponding descriptions. Lastly, the participants could share their general feedback with us.

Within the last quarter of 2021, the Cards for Biosafety game was sent to various people worldwide who expressed interest in receiving the game. After that, in the period from March to April 2022, a standardized email was sent to the contact persons to whom the project team sent the game with a request to forward this link to those who played the game.

Since the game was sent to different organizations, the facilitation was the responsibility of the respective organizers of the gaming session. To allow for comparability between the sessions, the instruction manual provides specific information, such as the recommended number of players. The game developers did not participate in the sessions and do not have specific information about the gameplay itself. The data are based on self-assessments of the participants. This study was approved by the author's university human research ethics committee.

3.2 Participants

In total, 19 people participated. Two participants did not complete the questionnaire and were excluded from further analysis, which means that a total of 17 participants (female = 7, male = 10) will be considered for further analysis. Their age ranged from 21 to 63 years ($M = 34.00$ years, $SD = 14.87$ years). Seven nationalities were represented with a majority of Dutch participants ($N = 11$).

The current position of the participants is diverse. Seven Bachelor students, two Master's students, one PhD student, three Senior researchers and three Biosafety officers completed the questionnaire. In addition, one participant mentioned that he or she works as a Biomedical Laboratory scientist and as a PhD student at the same time.

As Cards for Biosafety got inspired by the entertainment game Cards against Humanity [5], we asked the participants if they knew Cards against Humanity and thus, are familiar with the game play. Ten (58.8%) participants answered "Yes" and seven (41,2%) did not know this game.

In order to understand the setting in which the participants played Cards for Biosafety a bit better, we asked them about the timing and the number of players. One participant (5.9%) mentioned that he or she played the game last week, seven participants (41.2%) answered that they played it last month and nine participants (52.9%) said that they played Cards for Biosafety more than a month ago. This is probably also explained by the fact that the game was distributed at the end of 2021.

With regard to the number of players during such a Cards for Biosafety session, thirteen participants played the game in a session with four, five or six players in total and four participants played the game with either less than three or more than six other players.

4   Results

4.1   Game-Experience Questionnaire

A detailed overview of the descriptive results of the GEQ can be found in Table 1. Considering the description of the results in this section, our attention is mainly focused on the (extreme) mean values of the outer values of the scale (between 1 and 2 as well 4 and 5).

The participants were fairly interested in the story of the game ($M = 4.06$). They found it an aesthetically pleasing game ($M = 4.00$) and felt imaginative ($M = 4.13$). In addition, the participants scored high on positive affect, they felt content ($M = 4.00$), were fully occupied with the game ($M = 4.00$), had fun ($M = 4.41$), were happy ($M = 4.35$), felt good ($M = 4.12$), and enjoyed it ($M = 4.41$). Considering the opposite side of the scale (negative affect), the participants indicated that they were not put in a bad mood ($M = 1.41$), that they just thought a little bit about other things ($M = 1.88$), that the game did not make them tired ($M = 1.41$), and that they were not bored ($M = 1.29$). The scores of the questions whether participants felt annoyed ($M = 1.29$), irritable ($M = 1.24$) or frustrated ($M = 1.24$) ranged from not at all to slightly. Furthermore, they did not feel pressured ($M = 1.88$), while other scores related to the factor challenge where neutral. In contrast to this, they have not forgotten to keep track of the time ($M = 1.87$) and the connection with the outside world ($M = 1.75$).

In order to understand the participants' strategy behind choosing appropriate cards, we asked them about their approach for choosing their risk or measure card. The participants answers can be divided into four categories: 1) Creativity (e.g., "if i didn't have the right cards in my hands I had to be creative to get the right card myself"), 2) experience (e.g., "No strategy at all, rather than just thinking about what I had learned previously"), 3) choice of the funniest cards (e.g., "I chose the funniest or the most accurate ones", and 4) others (e.g., "Pushing the limit a bit what was just acceptable").

4.2   Learning Results

With regard to the statement that Cards for Biosafety gave the participants an opportunity to learn more about biosafety aspects, one participant disagreed (5.9%), one participant chose the neutral category (5.9%), six participants agreed (35.3%) and five participants totally agreed (29.4%) with the statement. In addition, three of them totally agreed (17.6%) and seven participants agreed (41.2%), one was neutral, and two participants disagreed [one of them works as a Biosafety officer]) that the Cards for Biosafety game provided new knowledge on biosafety aspects.

In order to understand what the participants learned, we asked them if they had gained new insights during the Cards for Biosafety game play. Fourteen participants (82.4%) agreed on that. Furthermore, we asked what the insights were:

Table 1. Results of Game Experience Questionnaire.

Factor	Items	Min	Max	M	SD	N
Competence	I felt skillful	2	5	3.76	.97	17
	I felt competent	3	5	3.82	.81	17
	I was good at it	3	5	3.81	.54	16
	I felt successful	2	5	3.62	.81	16
	I was fast at reaching the game's targets	2	5	3.60	.83	15
Sensory and Imaginative Immersion	I was interested in the game's story	3	5	4.06	.83	17
	It was aesthetically pleasing	2	5	4.00	.82	16
	I felt imaginative	2	5	4.13	.72	17
	I felt that I could explore things	2	5	3.82	1.07	17
	I found it impressive	1	5	3.71	1.11	17
	It felt like a rich experience	1	5	3.47	1.07	17
Flow	I was fully occupied with the game	2	5	4.00	.87	17
	I forgot everything around me	1	5	2.59	1.18	17
	I lost track of time	1	4	1.87	.89	16
	I was deeply concentrated in the game	1	5	3.35	1.17	17
	I lost connection with the outside world	1	4	1.75	.86	16
Tension/Annoyance	I felt annoyed	1	4	1.29	.77	17
	I felt irritable	1	5	1.24	.97	17
	I felt frustrated	1	4	1.24	.75	17
Challenge	I thought it was hard	1	5	2.24	1.20	17
	I felt pressured	1	5	1.88	1.32	17
	I felt challenged	1	5	3.53	1.01	17
	I felt time pressure	1	5	2.13	1.41	16
	I had to put a lot of effort into it	1	5	2.65	1.22	17
Negative affect	It gave me a bad mood	1	5	1.41	1.18	17
	I thought about other things	1	4	1.88	.99	17
	I found it tiresome	1	4	1.41	.87	17

(continued)

Table 1. (*continued*)

Factor	Items	Min	Max	M	SD	N
	I felt bored	1	3	1.29	.69	17
Positive affect	I felt content	2	5	4.00	.79	17
	I thought it was fun	3	5	4.41	.71	17
	I felt happy	3	5	4.35	.30	17
	I felt good	3	5	4.12	.60	17
	I enjoyed it	3	5	4.41	.62	17

Note. The participants scored on a 5-point scale ranging from 1 = not at all, 2 = slightly, 3 = moderately, 4 = fairly to 5 = extremely.

- "Provided the participants with insights in each others organizations and the challenges they encounter"
- "Negotiation and persuasion is part of achieving a goal and that is a great addition to practice and get acquainted…"
- "To think about possibilities I never thought of before."
- "Refreshing ideas how to solve problems, that this can also be a way to get a better notion of biosafety issues"
- "As a newbie to biotech topics, all the information I gained was basically new territory for me."
- "Critical Thinking Skills Work within a network of professionals. Discover new things"
- "This game provided a significant insight into how to complete risk assessment whilst also emphasizing how to implement risk assessment in a formal setting. it is a good game."
- "Thinking outside the box"
- "That there is more to biosafety than you'd think!"

These quotes already indicate that the insights are at different levels of cognitive learning objectives which is why the focus in the next section is on the different levels of Bloom's taxonomy.

4.3   Applying Bloom's Revised Taxonomy

The first level 'Remembering (Knowledge)' of Bloom's Revised Taxonomy [7] is mainly about recognizing and recalling information that has been acquired previously [10]. According to quotes formulated by the participants, the Cards for Biosafety game gave them the opportunity to recognize "the challenges of biosafety professionals", that "In everyday life there are always different interests", "That there are multiple forms of biological risk both inside and outside the lab", "Possible solutions", "important aspects of biosafety", and "biosafety aspects in the workplace more easily". These are some of the responses that clearly illustrate the variety of content taught by the play of Cards for Biosafety.

The second level 'Understanding (Comprehension)' basically describes that one is able to understand the meaning based on the used materials [7, 10]. According to the participants, "The game ensures that people listen to each other about certain considerations of different stakeholders and what is behind them. This helps to understand each other". In addition, Cards for Biosafety gave them the chance to understand "how useful is to work together", "The core tenants of risk assessment […]", "How things can go wrong", "the complexity of biosafety", and "possible dangers outside of the obvious". Furthermore, the game made it possible to explain "what biosafety culture is", "Solutions to these situations", "the concept of biosafety in a very simple way", and "cause and repercussion". It becomes clear that the participants not only perceived information, but were also able to comprehend it.

The third level 'Apply (Application)' means the use of learned input in new situations [7, 10]. With regard to the participants' experiences with Cards for Biosafety, they indicated that the game showed them "the need of a Biosafety officer" and "Where future problems might occur". Furthermore, the participants highlighted that the game gave them the chance to incorporate "safety education in the labs", "Sophisticated ideas", and "biosafety in my daily practices in the lab". These statements of the participants show that a connection and thus a link can be drawn to a new situation.

The fourth level 'Analyze (Analysis)' deals with dividing the 'system' into parts and understanding the relation between the different elements of the system [7, 10]. In a first step, the participants explored "solutions and problems in biosafety", "new mitigation strategies", "The possibilities in biosafety", "an out-of-the-box kind of idea to learn rather strict rules", and "creativity". In addition, they discussed "specific situations […]", "checks of risk bearing packages", "very different opinions and ideas such as new ideas in dealing with biosafety problems, Key factors and fundamental problems of Biotech, connections and interrelationships between variables", "the need of biosafety in biomedical and research laboratories", "How measures taken to resolve these risks can be beneficial and not beneficial – there is no one-size-fits-all solution", "Extreme situations", "the concept of biosafety in a very simple way", and "strategies for solving the issues". In order to create the basis for discussion, it is necessary to break down information into its components in order to use it appropriately. This also seems to be possible during and after the game play.

The fifth level 'Evaluate (Evaluation)' covers the ability to assess facts and give reasons for certain decisions or opinions [7, 10]. The participants highlighted that the Cards for Biosafety game gave them the chance to argue (= give reasons for) "about biosafety issues", "About possible solutions", and "which danger would be the greatest". In addition, the participants had the chance to evaluate the "Difficult situations" and "[…] knowledge on biosafety". Before one can evaluate information, he or she has to form an opinion to be able to give reasons for it.

The last level 'Create (Synthesis)' means bringing all the information together and creating something new [7, 10]. With regard to this level, the participants said that Cards for Biosafety gave them the chance to learn "about biosafety problems and challenges such as data security", "more about Biosafety", "and revise the various aspects of biological risk management […]", "Where future problems might be introduced", and "a better way to put biosafety in context". As argumentative decision-making and defending one's

own chosen card is also a central mechanic in the game, we also asked the participants whether it was possible for them to defend something. They answered that Cards for Biosafety made it possible to defend "the need of a Biorisk management system.", "The solutions you come up with", "my stands [views]", and "why biosafety exists.

4.4   In-Game Discussions

As the discussions within Cards for Biosafety are expected to make a significant contribution to learning, we asked the participants to what extent they considered the discussions valuable (through an open question). The participants found the discussions:

– "Very interesting"
– "Good"
– "interesting, curious about solutions"
– "multifaceted, exciting, diverse"
– "stimulating, broadening knowledge and career perspectives"
– "Insightful, Helpful, and Useful"
– "Funny"
– "A lot of cards on the table makes it less organized"
– "Fun and interesting"
– "Fun and insightful"
– "hilarious".

5   Discussion and Conclusions

This paper focused on the evaluation of the Cards for Biosafety game which aims to let young biotechnology researchers think more deeply about biosafety. Therefore, an online questionnaire was distributed to different national and international (future) biosafety experts. In total, 17 participants formed the basis of our descriptive analysis. Even though the sample size certainly still has potential to increase, it can be stated at this point that based on the feedback of the sample described in this publication, but also after the use of Cards for Biosafety in several workshops and conferences, it is a well-developed, fun and creative way to learn more about biosafety on different cognitive learning levels.

With regards to the results of the GEQ, we see that players had the competence to play this game. The players were challenged and the game was not too easy to play. They were generally immersed (except for the rich experience) and were in a flow related to the play intention. They were less in a flow if we look at the environment-related items. The players did not feel annoyed. We see low-scored values in the immersion and flow factors in comparison to other components of the GEQ. Cards for Biosafety was deliberately designed as a simple card game to stimulate discussion. Most likely, a simple cards game is not expected to be associated with a high degree of immersion. This can also be seen in the publication of Johnson, Cuijpers, Pollmann and van de Ven [9], who removed 3-immersion related questions from the GEQ with the argumentation that not all items of the GEQ can be used for analogue games. The question that arises is what one wants to achieve with a high degree of immersion implemented in such a serious game. In our case, we wanted to give the players enough space to explore their

own creativity and therefore decided on such a game. This is reflected not only in the GEQ questions in the area of immersion, but also with regard to the flow, which has conceptual overlaps with immersion [11].

The developers of the GEQ recommend using this questionnaire immediately after finishing the game play. Due to different reasons, this was not realized in the setting described in this publication, however, this should be done in future sessions to be able to compare the results of the two different data sets with each other.

If we take a look at the results of the open-ended questions related to the learning objectives, we see that playing Cards for Biosafety supports cognitive learning on different levels. Comparable to Freese, Tiemersma and Verbraeck [4], the feedback of the players highlighted the role of fun and humor and their influence on the game play, which can be seen, among other things, in the responses related to the in-game discussions. During the game, the players may be forced to choose a card that may sound a bit funny, and not too realistic to them. This is an indicator that Cards for Biosafety has successfully made use of the concept of 'serious fun'. Think about the title of this publication which addresses dinosaurs in laboratories. Of course, the chance of meeting dinosaurs in laboratories is quite low, however, exactly this example shows the added value of the debriefing. During the discussions as part of the debriefing, the focus can be on the translation of dinosaurs in the laboratory - used as a metaphor - to visitors who do not have permission to visit a laboratory in a higher safety category. In addition, one of the added values of Cards for Biosafety is its stimulating effect on the creativity of the players. As every player gets random cards, the chance is quite high that they need to come up with creative ideas. The question to what extent creativity (e.g., creative thinking skills) can positively influence cognitive learning has already been discussed by Siburian, Corebima and Saptasari [12]. Learning was in this case primarily supported by the fun and interactive medium of the game. Even though we have received less input regarding the frequency and description of responses in the higher levels of Bloom's taxonomy, we hope that Cards for Biosafety will add value to traditional tools, such as presentations, for both the trainer and the learner. In addition, it must be critically noted that the classification of cognitive learning goals was based purely on the participants' self-assessment. Self-assessments are subjective instruments and what is learned can be both overestimated [e.g., 13] and underestimated [e.g., 14]. Furthermore, the selection of the verbs chosen as well as the interpretation of the corresponding verbs associated with the revised version of Bloom's taxonomy must be critically questioned. With regard to this, Stanny [15] has already described the extent to which the selection of verbs within Bloom's Taxonomy can tell something about learning of students.

6 Future Use and Research

The game has experienced growing interest by national and international biosafety experts. Possible areas of application are wide ranging. In discussions with experts, the use of this game as part of educational and team-building activities and as part of training activities conducted by a Biosafety officer were mentioned. Moreover, they highlighted the use as biosafety awareness tool on the work floor with the aim of designing future learning in such a way that it is more attractive, interesting, and fun. This

paper focused mainly on cognitive learning skills. Future research should focus also on the effect Cards for Biosafety might have on the behavior of people.

In addition to the interest in the game, the game concept also received a lot of attention. In discussions with gaming experts, it became clear that Cards for Biosafety is an ideal frame game, which means that the game concept, i.e., the game mechanics, can also be transferred to other areas of application.

References

1. Freese, M., Lukosch, H.K.: The funnel of game design - proposing a new way to address a problem definition using the IDEAS approach. In: Wardaszko, M., Meijer, S., Lukosch, H., Kanegae, H., Kriz, W.C., Grzybowska-Brzezińska, M. (eds.) ISAGA 2019. LNCS, vol. 11988, pp. 170–180. Springer, Cham (2021). https://doi.org/10.1007/978-3-030-72132-9_16
2. Orhan, T.Y., Sahin, N.: The impact of innovative teaching approaches on biotechnology knowledge and laboratory experiences of science teachers. Educ. Sci. **8**(4), 213 (2018). https://doi.org/10.3390/educsci8040213
3. Franklin, S., Peat, M., Lewis, A.: Non-traditional interventions to stimulate discussion: the use of games and puzzles. J. Biol. Educ. **37**(2), 79–84 (2003). https://doi.org/10.1080/00219266.2003.9655856
4. Freese, M., Tiemersma, S., Verbraeck, A.: Risk management can actually be fun – using the serious cards for biosafety game to stimulate proper discussions about biosafety. In: Proceedings of the 52nd International Simulation and Gaming Association's Conference, Indore, India, 06 September–10 September 2021
5. Cards against Humanity LLC, 18 April 2022. https://www.cardsagainsthumanity.com
6. Bloom, B.S.: Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain. David McKay Co Inc, New York (1956)
7. Anderson, L.W., Krathwohl, D.R.: A taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives. Longman, New York (2001)
8. IJsselsteijn, W.A., de Kort, Y.A.W., Poels, K.: The game experience questionnaire. Technische Universiteit Eindhoven (2013)
9. Johnson, D.O., Cuijpers, R.H., Pollmann, K., van de Ven, A.A.J.: Exploring the entertainment value of playing games with a humanoid robot. Int. J. Soc. Robot. **8**(2), 247–269 (2015). https://doi.org/10.1007/s12369-015-0331-x
10. Wilson, L.O.: Anderson and Krathwohl Bloom's Taxonomy Revised. Anderson-and-Krathwohl_Revised-Blooms-Taxonomy.pdf, 18 April 2022
11. Procci, K., Bowers, C.: An examination of flow and immersion in games. Proc. Hum. Factors Ergon. Soc. Ann. Meet. **55**(1), 2183–2187 (2011). https://doi.org/10.1177/1071181311551455
12. Siburian, J., Corebima, A.D., Ibrohim, S.M.: The correlation between critical and creative thinking skills on cognitive learning results. Eurasian J. Educ. Res. **81**, 99–114 (2019)

13. Kajander-Unkuri, S., et al.: Congruence between graduating nursing students' self-assessments and mentors' assessments of students' nurse competence. Collegian **23**(3), 303–312 (2016). https://doi.org/10.1016/j.colegn.2015.06.002
14. Elimelech, E., Ert, E., Ayalon, O.: Bridging the gap between self-assessments and measured household food waste: a hybrid valuation approach. Waste Manag. **95**, 259–270 (2019). https://doi.org/10.1016/j.wasman.2019.06.015
15. Stanny, C.J.: Reevaluating bloom's taxonomy: what measurable verbs can and cannot say about student learning. Educ. Sci. **6**(4), 37 (2016). https://doi.org/10.3390/educsci6040037