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# The Mammoth prophecies: a role-playing game on controversies around a socio-technical innovation and its effects on students' capacities to think about the future

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**Abstract**

This article reports on a political game played between November 2021 and February 2022 at a European university in the frame of an elective course open to students from all disciplines. It started from a scenario that combined a real and ongoing innovation process—the use of CRISPR/Cas9 technology to introduce specific genes from unfrozen mammoths onto an elephant species to make it more resistant to cold—with a fictive joint project between a US-based company and the Russian government to release those mammoths on an island in the North-West of Russia. Almost no rules were given, and the students were distributed in nine groups to represent different actors deemed relevant to the scenario. These groups were the national governments of (1) Russia, (2) close neighboring states, (3) European countries farther away from the project location; (4) the company working on the innovation, dubbed HELIOS; (5) other market actors; civil society organizations concerned with (6) animal rights and (7) the environment; (8) the European Commission and the EU Parliament; and (9) media. The game was led by the course teacher and two student volunteers. Based on the results of both qualitative and quantitative forms of ex-post evaluation, we assess whether the Mammoth game meets the expectations that guided the game design process. Furthermore, we discuss whether the Mammoth game had a positive effect on students' abilities to think about the future.

## Introduction

Political games are simulations of political processes that have as their primary purpose "not merely to entertain but to educate, train, and steer decision-making processes" ([32], p. 181). The basic idea of political gaming is that the players represent stakeholders in a controversial or conflictual situation and simulate their decisions and actions. As political games provide a place for the mutual definition, subsequent confrontation, and, to some extent, for the negotiation of differing values, cultural objectives, and historical narratives, they allow for a realistic simulation of social/political complexities [25, 39]. For this reason, political games also are an interesting didactic method. In teaching or training settings, political games have been used with audiences ranging from schoolchildren to professionals [1, 2, 9, 14, 16, 18–20, 22, 33, 37, 41]. Political games allow the participants to "feel through" the social/political complexities involved in political situations where the outcome, as in any multiplayer game, depends not on one's actions alone, but to a large degree on the actions of others, their definitions of the situations, and their open and tacit interests. As Susskind and Corburn [36] showed, the underlying pedagogy of "learning by doing" mainly draws from theoretical sources ranging from John Dewey's and Kurt Lewin's

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theories of experiential learning to more recent contributions in cognitive psychology.

Against this backdrop, the article has two objectives. Firstly, it reports on a game played in the frame of an elective course on futures studies at a European university of technology and discusses whether the expectations guiding the game's design were met. The game, dubbed the Mammoth game, was intended to simulate controversies around a socio-technical innovation. The objective of the course was to provide students with an idea of how futures studies proceed in methodological terms, while increasing their sensibilities for potential conflicts surrounding a "well-intended" innovation. As described below in Sect. Design principles, the game was designed to achieve a good balance between the principles of reality, meaning, and play [17], and the first question guiding the ex-post evaluation of the game was whether such a balance was achieved.

The second objective of the article moves the focus of attention away from the evaluation of the game to the evaluation of its impact. Put simply, in the field of futures studies, games have been of interest due to two kinds of learning effects. On the one hand, by offering experiential futures (XF; see in particular [8, 10–12]), games allow participants to explore a topic of concern through a broad array of information channels, not just by reading and thinking. They are "spaces of possibility" ([31], p. 138), dedicated spatial and temporal arrangements that allow people to collectively move through hypothetical tomorrows [7, 31, 37].

This experience, on the other hand, can trigger in the learner the development of a capacity to imagine alternative futures. This capacity extends beyond the specific situation defined by the game and forms one essential element of an individual's futures literacy [26–28]. It has been shown that interactive forms of teaching about socio-scientific issues help students to develop or improve such generic futures thinking capacities [21]. Among the competencies required for futures thinking, self-efficacy has a particularly important function [24, 30]. Thus, the second question informing the ex-post evaluation concerned potential positive effects on students' abilities to think about the future via their perceived self-efficacy.

This ex-post evaluation is based on two sources of data. Towards the end of the game, the game leaders carried out qualitative, semi-structured interviews with each of the player groups. Further, participants were asked to complete a survey addressing their experiences with the game and inviting them to provide feedback in a way that allowed for a quantitative assessment.

Since teaching in the winter term 2021/2022 was still shaped by the COVID-19 regulations, the game was mostly played online—the only exception being a meeting early in the semester during which the scenario was presented. Game communication was facilitated via email, a Moodle-based online learning platform hosted by the university, and via the online conference provider BigBlueButton. Partly due to this virtual setting, apart from the materials provided in Appendices A, B, C, D, and F, none of the materials often used in political games (e.g., boards, role cards, dictionaries of important concepts) was distributed in the game. Despite this lack of materials, and despite the fact that the winter term 2021/22 was the fourth semester of distance learning in a row, student engagement was very high. The game evidently provided a teaching alternative that stood out profitably compared to other, more conventional online teaching formats [23].

A few introductory course meetings were dedicated to lectures on the history of futures studies and the methodological and philosophical difficulties this field faces: the lack of empirical data about the future, its internal epistemological heterogeneity, the impossibility of a value-neutral discourse about the future, and the at times confrontational juxtaposition of values like democracy, ecological sustainability, cultural diversity, and existential urgency in times of crisis. The lectures provided the background against which the game was positioned as a way to tackle some, yet certainly not all, of these difficulties. The idea was that students gain a sense of the nature of the knowledge that can be achieved by a serious use of futures studies methods.

In the following two sections, we introduce the game (Sect. Game design) and describe the game moves (Sect. The game moves). The subsequent section (Sect. Ex-post evaluation) then details the activities carried out in the ex-post evaluation. Thereafter (Sect. Results), we address the two research questions mentioned above, i.e., whether the game achieved a good balance between reality, meaning, and play and whether we have any indications of a positive effect of our game on futures thinking capacities amongst the participants. The conclusion finally discusses some lessons that can be drawn from the Mammoth game in terms of how to use games in university education.

## Game design

### Design principles

The Mammoth game was created as a role-playing game (RPG). Students formed groups to represent a set of actors provided by the course teacher (see Sect. The groups). The groups had to decide on a strategy and, in the course of time, to reassess repeatedly how it was impacted by the respective state of play. Based on this assessment, the groups submitted written moves together with an explanation of how they expected this to contribute to the

realization of their strategic goals. The game leaders then synthesized these moves into a new state of play.

Building on the approach of triadic game design developed by Harteveld [17], the Mammoth game was designed to achieve a balance between reality, meaning, and play. *Reality* means that the game should incorporate as many aspects as possible of how the problem under scrutiny presents itself in the real world. This, of course, is important if the purpose of the game is policy advice, but it is also essential in education and training. In the Mammoth game, reality was achieved by introducing an actual, envisioned innovation (i.e., an element from the real world) as well as using arguments and stories from the actual media coverage of this innovation. Further, the selection of game groups was grounded in an exploratory stakeholder analysis, and although this analysis was based on a partly fictitious scenario, it also included a considerable slice of reality.

*Meaning*, the second pillar of triadic game design, requires that the game has a specific purpose, that this purpose is clear at the outset and that this purpose is relevant to the participants. In the design of the Mammoth game, meaning arose from the confrontation of several conflicting environmental values. As described below, the technological innovation was to use genome editing technology—perceived by some as an enormous interference in the "natural" character of a genetic code—to preserve permafrost—an important challenge in times of global warming and climate change—through the creation of a mammoth-like elephant which could live in the cold areas concerned—perceived by some as unethical, instrumental use of a living species. Other value conflicts concerned the impact of the innovation project described in the scenario on the local and regional economy and the rather strict regulation—and in fact, prohibition—of the release of genome-edited organisms within the EU.

The final pillar, *play*, requires the game designer to create an engaging, immersive experience for the players. As will become apparent in the sections describing the evaluation of the game, this was achieved by having both reality and meaning conveyed through the scenario, but also by offering students an alternative and unknown didactical format.

The following rules governed the Mammoth game:

1. Groups could make whatever move they wanted, as long as it was based on a sound argument emerging from their strategies as well as the various background documents and sources they had identified during the first phase of research.
2. Moves were submitted to the game leaders prior to deadlines. The game leaders then checked the move for plausibility and, if necessary, conferred with the groups about possible changes.
3. Further, the participants were advised to avoid communication outside class on game-relevant topics with members of other groups. If communication of this kind did occur, they were asked to document it and report it to the game leaders (not to receive sanctions, but to inform about information flows).
4. Group media was given the option to organize interviews, if they wanted.
5. The internal discussion process was to be documented in some detail.

### The groups

The game started with a course session in mid-October 2021 and proceeded in almost weekly steps until late January 2022 (see Appendix F for a timetable of the course). Thirty-seven students started the game—two dropped out early. Of the remaining 35 student participants, eight were enrolled in BA programs and 27 in MA programs. Although the university offers a broad range of disciplines in engineering and natural sciences, the majority of students were enrolled in computer science, information and computer engineering, and software engineering. The most likely reason for this is that while all university students can select the course as an elective, it is explicitly mentioned only in the curricula of these three disciplines. Two of the students were pursuing an interdisciplinary degree with a considerable share of social science courses, held jointly with another European university. It should be emphasized that the scenario, with its focus on a biotechnology project, did not overlap with any of the participants' fields of study.

The first step for the students was to choose which group they wanted to join. Based on an exploratory stakeholder analysis of the scenario, the teacher proposed eleven groups. It is important to emphasize that when selecting their group, the students did not yet know the scenario. Table 1 shows the names of the eleven proposed groups, their short name, and the final distribution of game participants (= 35 students + 1 teacher).

As noted in Table 1, one of the proposed groups—civil society organizations: research ethics—was canceled, because it was not selected by a sufficient number of students.

Apart from the exploratory stakeholder analysis, the list of proposed game groups was also informed by the conceptualization of social acceptance of technological innovation proposed by Wüstenhagen et al. [40]. This conceptualization has three dimensions:

**Table 1** Game groups

| Group name | Short name | Final number of students | Comment |
|---|---|---|---|
| **1. National governments in Europe: Russia** | Russia | 5 | |
| **2. National governments in Europe: close neighbors** | Neighboring Countries | 2 | Initially 3 students, 1 dropout in Nov 2021 |
| **3. National governments in Europe: Countries farther away from North-West Russia** | Countries Farther Away | 3 | |
| **4. The European Commission and the EU Parliament** | EC and EU Parliament | 3 | |
| **5. Companies: HELIOS** | HELIOS | 3 | |
| **6. Companies: other market actors** | Other Market Actors | 2 | |
| **7. Civil society organizations: animal rights** | CSOs Animal Rights | 6 | |
| **8. Civil society organizations: the environment** | CSOs Environment | 4 | Initially 5 students, 1 dropout in Nov 2021 |
| **9. Civil society organizations: research ethics** | | 0 | Canceled; initially 1 student, relocated to EC and EU Parliament |
| **10. Media, both high-quality outlets, incl. investigative journalism and yellow-press outlets** | Media | 5 | |
| **11. Umpires**[a] | Game leaders | 3 | 2 students plus 1 teacher |
| | **Total participants** | 36 | (incl. 1 teacher) |

[a] The name of group #11, Umpires, was taken from writings on the use of political gaming at the RAND Corporation in the late 1950s (Goldhamer, 1955; Davison, 1958; Goldhamer and Speier, 1959; see Dayé, 2020, pp. 77–128 for a summary of these efforts). Apparently, this label was chosen back then to emphasize the non-steering role of the umpires, whose task was mainly to check the plausibility of the moves submitted by the game groups. Also, the RAND games usually established a Committee on Nature, a subgroup of the umpires whose members had the possibility to introduce events that in contrast to all other elements of a new game state, did not follow from the groups' moves. Since no such separate committee was created in the Mammoth game, the more generic term game leaders came to be used over the course of the game. The game leader group consisted of the teacher and two students

I. Socio-political acceptance
II. Community acceptance
III. Market acceptance

These dimensions cover different subject-object relations of acceptance [34]. Socio-political acceptance is concerned with how a technology (e.g., genome editing) and the associated policy are perceived by the general public, stakeholders, and politicians. Community acceptance refers to the acceptance of a specific technological project (e.g., releasing genome-edited mammoths on an island) by the local population, including farmers, politicians, and other stakeholders. Finally, market acceptance is understood as the reception of a technological product (e.g., genome-edited animals as a means of fighting the environmental consequences of climate change) by market participants across the relevant value chain(s), including, if applicable, retailers and consumers. The list of game groups proposed by the teacher was assumed to cover all three dimensions.

### The scenario

In the next session, the scenario was presented to the students. Set in the near future (8 months ahead), it combined a realistic innovation with a fictitious collaboration between the market actor working on the innovation and the Russian government (see Table 2). The aim of this hypothetical collaboration was to test the innovation outside of the laboratory to further explore its scientific implications, potential benefits, and possible risks.

The project of applying genome editing techniques to create a new kind of mammoth-elephant described in the scenario is an ongoing project run by the US-based company Colossal Laboratories & Biosciences (see https://colossal.com/mammoth/, accessed 10 Feb 2023). The innovation was chosen for its surprising touch and supposed ease on behalf of the students to relate to the story. Furthermore, the teacher had recently been involved in research projects on the social acceptability of genome editing and felt reasonably well-informed about the current status of technical, public, and regulatory debates on these matters [13, 35].

Russia was selected to bring the innovation close to the European Union and thus close to the home of (most) students. Genetic modification is a highly contested issue in the European Union, and the possibility of genome edited animals entering EU territory was accordingly deemed to be a trigger of debate and, perhaps, controversy. It is important to note that the scenario was written several months before Russia began its ongoing invasion of Ukraine on 24 February 2022. Clearly, the choice of this country was informed by decades of political (and military) tensions between Russia and other European countries that at the time of writing, had culminated in the seizure of power of pro-Russian separatists in the Donbas region in 2014—yet, this further escalation had not been foreseen.

**Table 2** The scenario

| |
|---|
| On June 1, 2022, the US-based company HELIOS announces that it has created what they call a "living mammoth." Using genome-editing techniques, the company succeeded in transfering a series of crucial genes found in unfrozen remains of ice-age mammoths into the genome of a closely related elephant species. The animal is now 9 months old and developing well. The researchers expect it to reach an age of 60 to 70 years, just like an elephant. However, the mammoth genes transferred into its genome will allow it to endure much lower temperatures than current elephant species |
| At the same conference, the company declares that it has signed a contract with government of Russia to release a herd of twelve mammoths on Kolguyev Island near the Russian Arctic National Park, with more to be delivered at a later point in time. The objective of this collaboration, a spokesperson of HELIOS explains, is to gain insight both into the animals' adaptation to the arctic climate but also to explore their impact on the local environment. Specifically, the researchers hope the mammoths to have a positive impact on permafrost, which has dramatically decreased in the area in the recent decades. |

## The game moves

### First move: Press releases

Based on the scenario, the groups had a couple of weeks to work out their strategies. During this period, the meetings of the course were dedicated to a more general introduction to origins and techniques of futures studies. To support their preparations, the groups were provided with guidelines for strategy development (see Appendix A). These guidelines spelled out a series of questions on the nature and interests of the entities represented by the group, their definition of the problem(s) arising from the scenario, and their means to make their concerns heard. Based on these points, the groups were asked to formulate their first move.

In this preparation phase, the groups were repeatedly encouraged to ask for meetings with the game leaders to clarify open issues. Four of the nine groups asked for such a meeting. These meetings were used in particular to cope with the structural differences between the groups. While for some of them, it was more or less clear where to begin their research on the entities they had to represent in the game (e.g., EC and EU Parliament, HELIOS, CSOs Animal Rights), other groups first had to decide which (kind of) entities they would like to play. This applied first and foremost to the group Other Market Actors, which had to choose its entity from an extensive range of possibilities. Interestingly, and in contrast to what the game leaders had expected, this group decided not to cover branch competitors of HELIOS, i.e., biotechnology companies, but rather focused on another company located on Kolguyev Island, a fictive oil company that is a major employer for the island's inhabitants. Other groups which had to decide on what entities to represent included neighboring countries (students settled for Finland and Norway) and countries further away (students decided for Germany, Poland, and Romania).

To kickstart the game, it was decided by the game leaders that the first move of the groups had to take the form of published statements, or press releases, by the represented entities that documented their reactions to the press conference described in the scenario. In addition to this move, the groups had to submit to the game leaders the first version of the background materials, which consisted of their answers to the strategy questions from the guidelines (see Appendix A), a list of resources and references used to shape their answers, as well as some documentation of the group meetings and work process.

The public statements (1st move) were then read by representatives of the group in a plenary meeting at the beginning of December 2021 and published on the online teaching platform.

### Second move: invitations to bilateral talks

For their next moves, groups had to submit ranked lists of those groups they wanted to conduct bilateral talks with. The game leaders collected those invitations and distributed them. If the invitations were accepted, the game leaders tried to fit the talk into the schedule (see Appendix B for an overview of the invitations). However, since the talks were facilitated via breakout rooms in BigBlueButton and thus needed technical supervision by the game leaders, the maximum number of bilateral talks was limited to three per group. In addition to the talk invitations, groups had to update their background file to include their reasoning behind the invitations, their expectations for the bilateral talks, and their reactions to the published statements of the other groups.

The talks were finally held in a 3-h session in the first half of December 2021. A timeline of the bilateral talks is reproduced in Appendix C.

### Third move: covert actions

After the bilateral talks, and based on their outcomes, groups had to prepare their third move. This time it was decided to have the moves covert by default, although groups still had the option to publish statements as part of their moves. The Media group was excepted from this rule, since its task was to create several newspaper articles, which were used to re-start the game after the winter break. As always, the game leaders ran plausibility checks across all submitted moves and requested changes in cases where there were reasoned doubts about the plausibility of some aspects of the move.

The newspaper articles submitted by the group Media were cautiously enriched by the game leaders with aspects emerging from the game and from the overview of all background files.

In the first session after the winter break, the media articles were presented in the plenary and published on the course's online teaching platform. The groups then had a few days to reconsider their third moves and submit revisions, if deemed appropriate. The game leaders used these revised versions to write the new state of play, which was eventually published in mid-January 2022 (see Table 3). Parts or aspects of the moves that groups had decided to make public were integrated into the new state of play. Further, three public statements, by HELIOS, Russia, and EC & EU Parliament, were attached to the document which was distributed to all groups by mid-January 2022.

#### Fourth move: EU Working Group meeting, and all-party summit

In the second half of January, a final game meeting was held during which both the EU working group meeting described in the new state of play and a large summit of all game groups took place. The summit was hosted by the EC & EU Parliament group; Russia was invited to join as a co-host, but decided against doing so. Nonetheless, Russia was represented by a high-level government official. The meeting itself was moderated by representatives of the group EC & EU Parliament according to rules that they distributed in advance. After an opening statement by the hosts, each participant could put her:his name on a shared list of speakers which was then followed in chronological order.

#### De-briefing session

The last session of the semester was dedicated to a de-briefing in which the participants discussed the lessons, insights, and surprises that had emerged from the game, the mutual perception, and (mis-) interpretation of positions by other players, as well as the loose ends the game still had at the time of its termination.

### Ex-post evaluation

To assess how the participants had perceived the game, what conclusions they drew from their experience and also whether and where they saw room for improvements in the implementation of the game, an ex-post evaluation was carried out in the second half of January 2022. This evaluation comprised both a series of qualitative group interviews (Sect. Qualitative group interviews) and an online survey to be completed individually (Sect. Online survey).

#### Qualitative group interviews

Semi-structured interviews were carried out by the student game leaders with nine of the ten game-playing groups; the remaining group did not respond to our invitation. The interviews took place on two separate dates in mid-January 2022, set around scheduled common game appointments, with three interviews taking place after the closing summit. Due to the pandemic-related contact

**Table 3** The new state of play

| |
|---|
| We are in mid-July 2022. HELIOS and Russia are proceeding as planned. First animals have grown, and transport is being arranged. The schedule plans for setting free a group of eight animals in mid-September. Reacting to concerns about the mammoths leaving the island, the responsible company HELIOS has issued a statement confirming that the animals will be carrying GPS senders to ensure that they can be tracked in the unlikely event of a complete freezing of the sea between Kolguyev and the mainland |
| Meanwhile, the EC has set up a working group with representatives of various European governments, among them Finland, Germany, Norway, Poland, and Romania. In a joint statement, spokespersons of Finland and Norway expressed the expectation that "a more constant, direct way of communication" would make it "easier to coordinate opinions." Representatives of environmental CSOs are also expected to participate. The first meeting of the working group is scheduled to take place next week (real time 21 Jan 22) |
| In parallel, the EC has also launched an internal working group to re-assess the current genome editing legislation. César Luena López, vice-chair of the social democrat Committee on the Environment, Public Health and Food Safety, commented that in revising the regulations, the safety of consumers and the environment would be the guiding principles. He added: "Now is the moment to have an open dialogue with citizens, Member States and the European Parliament to jointly decide the way forward for the use of these technologies in the EU." |
| The protection of the wildlife on Kolguyev is also an important issue for Russia, as a recent statement by government officials emphasized, and they will make sure that all companies doing business in this area follow high standards in this regard |
| Meanwhile, protests against the project intensify. What was at first a movement apparently focused on social media, as covered by recent media news, with several memes and short video clips going globally viral, has meanwhile grown into a strategic coalition of various actors. Activities of protest are organized both on Kolguyev Island as well as in cities around the world. Relating to the Fridays for Future movement, animal rights activists proclaimed the "Mondays for Mammoths" and used their international connections to organize protest marches in several major cities around the globe, among them in Berlin, Boston, Brussels, Oslo, and St Petersburg. According to the organizers, these protests should raise awareness of the animal risks caused by the planned resurrection of mammoths. Polls carried out in several European countries show a large public support for these protests, with percentages ranging from 59 to 71% |
| On the island itself, a small group of citizens moved into a protest camp. In their view, by endangering local oil production, the project is putting their existence on the island at risk. Images from the camp go around the world, as a highly functional website had quickly been established which includes a live-stream from the camp. |

restrictions that were still in effect at that time, the interviews had to be held via the university's online conferencing service. Each interview was scheduled for 30 min and addressed the following four questions which were adapted flexibly to fit with the conversation:

- How was the game for you?
- How was the group work? (organization, communication, technical issues, opinions)
- How would you assess the realism of the game? Why was it realistic? Why not?
- What would you say are take home messages from the course? (regarding technological innovations, social reactions towards new ideas, political dynamics)

Obviously, it has to be kept in mind that some answers regarding the organization of, experience with, or implications of the game might have been formulated in a more positive manner, as the interviews were conducted by the two student game leaders who were in close exchange with the teacher.

#### Online survey

In addition to the group interviews and to allow for cross-validation, the ex-post evaluation also featured an online questionnaire. This was deemed important to allow students to provide feedback individually, without their group members listening. The questionnaire was designed to address three objectives: (*i*) the students' satisfaction with the game, (*ii*) their perception of the principles of triadic game design, and (*iii*) their perceived self-efficacy.

When creating the questionnaire, we used items developed by Tafner et al. [38] to address objective (*i*) the students' satisfaction with the game. This allowed us to compare our results with those of a recent game played in an educational context in the same region as our university. In our translation, the six items read:

1. I would like to play the game again with the same scenario.
2. I did not enjoy my participation in the game.
3. One can learn to be a good strategist.
4. I did learn nothing new during the political game.
5. Political games should be a more frequent element of university courses, even in such that focus on technology like ours.
6. The time needed for the game could have been used better.

Further items were created to provide indications of (*ii*) how the principles of triadic game design—reality, meaning, and play—were perceived by the students. For instance, as a design principle, reality means that the game model should contain a considerable degree of features that can also be found in reality. The perception by the students of the degree to which *reality* features in the game design informs their assessment of how realistic the game is. This dimension was covered by two questionnaire items: Items no. 13 ("Political games are a very valuable method to learn about the inter-relations between science, technology, and society") and no. 16 ("The game achieved a high level of realism; in reality, things would most likely develop similarly"). Similarly, the students' perception of *meaning* during the game was covered by items no. 3, 4*, 6*, and 12 ("The game helped me to further develop my capacities of strategic thinking.").[1] The dimension of *play* was addressed in items no. 1, 2*, 5, and 17 ("It was easy for me to identify and play the role that my group and I had to represent in the game."). A few additional items concerned the perception of social dynamics during the game (no. 7, 8, 14, 15, 18*, and 19*). The complete questionnaire can be found in Appendix D.

For the items on (*i*) the overall satisfaction of students with the game and (*ii*) their perception of the principles of triadic game design, an answer scale was used that ranged from 1="I strongly disagree" to 6="I strongly agree". The other options (2 to 5) had no labels.

Finally, in order to address (*iii*) the students' perception of self-efficacy, we included the General Self-Efficacy Short Scale-3 [15, 29]. As required by the scale, a fully labeled 5-point rating scale was used that comprised the categories 1="do not agree at all", 2="hardly agree", 3="somewhat agree", 4="mostly agree", and 5="completely agree".

Facilitated via LimeSurvey, the survey was accessible online from 21 January to 2 February 2022. Invitations were sent to all the students except for the two student game leaders ($N=33$). After two reminders had been sent, the questionnaire was closed. Except for three students, all invited participants completed the questionnaire ($n=30$).

For the steps of analysis that involved grouping of items into indices, items no. 2, 4, and 6 were recoded to show the same positive poling as the other items.

## Results

#### Students' satisfaction with the game

In the interviews, all groups universally reported that a game of this kind represented a new and previously unknown experience for them and that they by and large approved of the method and had enjoyed the game. The main challenge, however, had been the flexibility required from the game participants. Initially, some participants felt overwhelmed by the tasks, in particular as

[1] Asterisks * denote questionnaire items with negative wordings.

they were not perfectly sure about the rules, restrictions, and freedoms given to them. They emphasized their lack of prior experience with the game format as the main reason for this feeling. Further, some of the participants stated that they would have wished for more clarification, particularly regarding the pre-game states of the respective actors.

Another issue frequently raised concerning the expected flexibility was the relatively variable time schedule of the game and its changing circumstances, which were perceived as confusing, despite being consequences of the in-game events. The repeated modifications of tasks that occurred during the course of the game were explicitly mentioned as challenging, with some participants wishing for these issues to be determined at the very beginning. Some also suggested that the group forming process might be revised for future games, with either seeking a completely even distribution of participants across all groups or a distribution based on the expected workload for each group. Eventually, most groups expressed their interest in prospectively taking part in a similar game, if given the opportunity.

Two groups suggested shortening the timeframe of the game and organizing it with a denser roster of meetings. Some groups expressed regret that the game was not played in person but via online communication, although they understood the reasons for this.

Regarding the topic, most of the participants reported that they had found it interesting and that they had enjoyed researching on the issue itself and their actors' (potential) attitudes towards it, despite the fact that it was sometimes perceived as challenging.

No major difficulties were reported concerning the intra-group working processes. Some stated that initially they had diverging ideas about their group's goals and strategies, but those issues were typically resolved in the first in-group meetings. It should, however, be noted that the group members were interviewed together and were therefore unlikely to report negative experiences with in-group work in front of their colleagues.

In the online survey, the satisfaction with the game was assessed analogously to the study by Tafner et al. [38], who evaluated a political game focusing on policy-decisions at the EU level used in secondary schools (see Table 4). However, items no. 2, 4, and 6 had been

**Table 4** Items used to assess (i) students' satisfaction with the game

| Descriptives | *N* | Min | Max | Mean (rec) | Std. dev. | Study by Tafner et al. [38] | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | *N* | Mean | Std. dev. |
| 1. I would like to play the game again with the same scenario | 29 | 2 | 6 | 4.21 | 1.15 | 181 | 4.3 | 1.6 |
| 2. I did not enjoy my participation in the game.* | 30 | 1 | 6 | 1.77 (5.23) | 1.33 | 181 | 5.1 | 1.2 |
| 3. One can learn to be a good strategist | 28 | 3 | 6 | 4.75 | 1.11 | 180 | 3.6 | 1.3 |
| 4. I did learn nothing new during the political game.* | 30 | 1 | 5 | 1.90 (5.10) | 1.16 | 180 | 4.4 | 1.5 |
| 5. Political games should be a more frequent element of university courses, even in such that focus on technology like ours | 28 | 1 | 6 | 4.18 | 1,52 | 180 | 3.8 | 1.5 |
| 6. The time needed for the game could have been used better.* | 30 | 1 | 5 | 2.07 (4.93) | 1,048 | 180 | 5.0 | 1.3 |

formulated negatively in the Mammoth game evaluation to increase attention (marked by an asterisk * in Table 4).

Out of the six items, item no. 1 (*"I would like to play the game again with the same scenario."*) was rated the lowest with a mean of 4.2 (4.3 in [38], p. 148). However, due to its wording, this could either mean that students wished for a different scenario or, more likely and based on the general positive feedback, that playing the same scenario twice does not seem desirable. Only three students agreed (rating > 3) with item no. 2 (*"I did not enjoy my participation in the game."*) with scores of 5, 5, and 6. One of those ratings (5) came from a student of a group that due to the development of the game had the feeling of having only little to none influence on the outcome of the game. Prospective game leaders could react to this by giving the group more leverage in negotiations, although such intervention has to be done carefully in order not to diminish the game's realism.

Taking the recoded values for items no. 2, 4, and 6, the sum index calculated with items no. 1 through 6 resulted in a mean of 4.76 (on a scale from 1-strongly disagree to 6 completely agree; see Table 5). This indicates a high level of satisfaction—in the study by Tafner et al. ([38], p. 148), the overall satisfaction was at 4.3 ($N = 181$).

Similar sum indices have been built for items which we assumed to relate to the principles of triadic game design, reality, meaning, and play. However, the index values given in Table 5 are of value only as a first orientation, as in none of the indices, systematic correlations between all grouped items could be found (see Appendix E). Therefore, in the following sections, we focus on the individual items.

Combining the feedback from the qualitative group interviews with the online survey, we can conclude that the Mammoth game was a positive learning experience for the students.

#### Reality, meaning, and play

As with the overall satisfaction with the game, the quantitative evaluation of the three game design principle reality, meaning and play also showed positive results (see Table 5). Across the dimensions, the mean values of the sum indices were higher than 4.6 and thus clearly on the positive half of the scale spectrum (with the centre being at 3.5).

As regards the *reality* of the Mammoth game, the whole idea of using an RPG to simulate the controversies around a socio-technical innovation rests on the premise of disagreements between the actors, among these disagreements about the degree to which the game itself is realistic. Yet, the issue had already come up earlier, when at the very beginning of the game, several groups faced group-internal disagreements on how the actor they had to represent would perceive the situation. In order to develop a plausible strategy, the groups had to integrate the technological innovation—which, to repeat, is an existing innovation project by a US-based company—into their own understanding of reality. They had done this mainly by research on the internet.

However, these initial orientational issues and possible resulting discontents did not lead to a decrease in the perceived reality of the game. As indicated by the mean of the reality index given in Table 5, but also for the relevant item no. 16 ("The game achieved a high level of realism: in reality, things would most likely develop similarly."), the game was perceived as providing a high degree of realism. The mean value for this item was 4.32 (on a scale ranging from 1 to 6), and a standard deviation of 1.07 suggests that the participants' assessments of this item were not overly diverse (Table 6).

Since one of the fundamental ideas of the reality principle is to integrate as many aspects actually surrounding the problem as possible, complexity rises to a level where no single actor holds the power to dominate the game events. This might partly explain the feeling of overload amongst the players that was occasionally described in the group interviews. A careful balancing of complexity, however, is an issue that might need more attention in another run of the game. More support by the game leaders in this initial phase of understanding the scenario, integrating it into one's own view of reality, and coming to an agreement within the group might be required. Although the game leaders had

**Table 5** Mean values for sum indices

| Sum indices | Items | Max | Mean | Std. dev. | *N* |
|---|---|---|---|---|---|
| Satisfaction with game | 1, 2*, 3, 4*, 5, 6* | 6 | 4.75 | 0.79 | 26 |
| Reality | 13, 16 | 6 | 4.62 | 0.89 | 30 |
| Meaning | 3, 4*, 6*, 12 | 6 | 4.84 | 0.85 | 28 |
| Play | 1, 2*, 5, 17 | 6 | 4.70 | 0.76 | 27 |
| General Self-Efficacy Short Scale-3 | 9, 10, 11 | 5 | 4.29 | 0.55 | 30 |

Note: The asterisk * denotes recoded items

**Table 6** Descriptives for items no. 7, 8, and 12 through 19

| Descriptives | *N* | Min | Max | Mean | Std. dev. |
|---|---|---|---|---|---|
| 7. If I were to play the game again, I would select another group. | 29 | 1 | 6 | 2.79 | 1.84 |
| 8. If I were to play the game again, I would stay in the group, but decide for a different strategy. | 29 | 1 | 6 | 2.83 | 1.34 |
| 12. The game helped me to further develop my capacities of strategic thinking. | 30 | 2 | 6 | 4.60 | 1.13 |
| 13. Political games are a very valuable method to learn about the interrelations between science, technology, and society. | 30 | 3 | 6 | 5.00 | 0.98 |
| 14. Collaboration in my group was good in terms of output and efficiency. | 29 | 2 | 6 | 5.66 | 0.81 |
| 15. Collaboration in my group was good in terms of mutual respect. | 30 | 4 | 6 | 5.73 | 0.52 |
| 16. The game achieved a high level of realism: in reality, things would most likely develop similarly. | 30 | 2 | 6 | 4.23 | 1.07 |
| 17. It was easy for me to identify and play the role that my group and I had to represent in the game. | 30 | 3 | 6 | 5.10 | 1.03 |
| 18. It was sometimes hard not to feel personally attacked by criticism within my group. | 29 | 1 | 5 | 1.72 | 1.07 |
| 19. It was sometimes hard not to feel personally attacked by actions of other game groups. | 30 | 1 | 5 | 2.03 | 1.40 |

offered to meet with the groups, this opportunity was not taken by all groups. Further, face-to-face meetings might have made this phase of strategy development easier.

Still, in the group interviews, the dynamics and the unpredictability of the developments within the game were frequently mentioned as interesting aspect and also as something the participants had not expected. After this experience, the groups increasingly understood the game to be very realistic and its progression as likely in a real-life scenario—also, and in particular, when facing an apparently "irrational" behavior of other actors. Thus, the experience of being overwhelmed by the lack of defined possible actions and restrictions that players described in the qualitative interviews can be understood as another factor that contributed to the realism of the game.

With a mean of 4.84 in the sum index (scale ranging from 1 to 6), the players saw the functionality-driven category of *meaning* as being well represented in the Mammoth game. Furthermore, in their high level of agreement with the statement that political gaming is a valuable method for learning about the inter-relationships between science, technology, and society (item no. 13), the players not only indicated that they ascribed a high level of realism to the game but also that they saw it as having meaning, in terms of being a medium for acquiring new knowledge. Hence, that particular question correlated to a great extent with other meaning-related questions (items no. 3 and 4*). Understanding the aspect of meaning as the game serving a specific purpose, the meaning of the Mammoth game was to give students of primarily technical subjects a new perspective on the consequences of innovations and a deeper understanding of the accompanying political dynamics and decision processes. As shown by the quantitative data, most of the students declared that they had learned something from the game. This certainly included some technological knowledge on the one hand, as also confirmed in the statements of some of the respondents in the qualitative interviews, who mentioned that they found it interesting to conduct research and dive deeper into subjects, with which they had not initially been familiar (e.g., CRISPR technology). But on the other hand, the game was much more a lesson in politics. From the very early stages, the attention shifted from technological issues to power relations and tests of strength between the actors (something that arguably also contributes to the realism of the game). In that light the player responses in the quantitative data, rating the game highly as a good means of learning strategic thinking, can be seen as an expression of that dimension. Several responses in the qualitative interviews confirm this.

Finally, the component of *play* as the third principle of triadic game design can be seen as successfully implemented if a game is regarded as engaging or immersive.

Although the Mammoth game did not provide an objective in the narrow sense, meaning a definite goal that could and should be achieved, engagement by students was relatively high during the whole course of the game, even when the semester approached its end, a period of great stress for students as typically many exams are scheduled and submissions are due at this time. In the interviews, many participants also described the fascination they felt upon realising how easily they slipped into their roles and became involved and how very quickly they found themselves representing and fighting for an opinion that was not theirs but which had rather been externally assigned to them. Some participants also mentioned that they had increasing difficulties to understand the perspectives of opposing groups.

Some participants even expressed anger towards some of the moves made by other groups, as they did not match their expectations or reasoning. Frustration of this kind might be an indicator that the participants had become very involved with the game and identified with the role they had taken and the goals they pursued therein. In this context, the plausibility checks conducted by the game leaders were brought into question, since moves that did not fit their own rationale were not only understood as wrong and irrational but as outright implausible. Nonetheless, some participants stated that they found it was precisely this perceived irrationality that gave greater realism to the game (see above).

In the questionnaire, the majority responded that they identified with the roles they had to play (item no. 17), indicating a high degree of immersion. Some players tackled some of the in-game issues and problems they faced with unexpected and creative approaches that still fit the profile of their actors, using back and front stage concepts to push their agenda and thereby showing that they had invested time and thought about the game well beyond mere obligatory requirements. Many of the players expressed quantitatively and qualitatively that they had enjoyed the gaming experience. The reasons given in the qualitative interviews for the satisfaction with the method and the high engagement were often related to the other two principles–realism and meaning. In particular, the abovementioned fascination with the unpredictability of the development and the insight into political dynamics were strongly emphasized. Consequently, the sum index construed for the dimension of *play* resulted in a high mean of 4.70.

While the three principles appeared in general to be well balanced in the Mammoth game, with all of them scoring similar levels for their sum indices, tensions were nevertheless to be observed between them in some cases. Some participants were so immersed in their roles that they found themselves unable to understand the actions of other actors and whilst this is a manifestation of the reality principle, it still led to negative emotions by some participants, thereby reducing the element of play. A similar observation could be made with respect to the development of the game as a whole, where some players were irritated by the seemingly unordered and chaotic turn of events, as these did not match their expectations. (Conversely, some participants stated that it was particularly this element of unpredictability that made them enjoy the game.)

To sum it up, it can be noted that based on the quantitative and the qualitative data at hand, the three principles of triadic gaming—reality, meaning, and play—have been implemented in a relatively well-balanced way into the Mammoth game, with the categories in general mutually enhancing each other.

#### Self-efficacy

The decision to include a scale on self-efficacy in the ex-post evaluation online survey was informed by recent psychological research. It has been shown that a sense of self-efficacy—defined as "our beliefs or expectancies about our ability to do what we believe is necessary to control our futures by achieving desired future outcomes and preventing undesirable ones" ([24], p. 174)—is an integral element of the human capacity to engage in futures thinking. Building on the work of Albert Bandura [3–5] the concept of self-efficacy has been understood as an individual's mental position not towards small or trivial tasks, but rather in the face of challenging and changing situations. Also, it has been shown that people with a high degree of self-efficacy are more likely to engage in futures thinking [30] and do so with a higher feeling of satisfaction.

The Self-Efficacy Short Scale-3 [15, 29] used in the quantitative evaluation resulted in very high values (Table 7). It should be remembered that unlike the other items, where the maximum value was 6, the maximum for this scale is 5. Thus, the mean of 4.29 for the sum index as well as the means of the single items ranging between 4.27 and 4.33 suggest a rather high level of self-efficacy amongst the students after participating in the game. Without exception, they are higher than those from another study, by Beierlein et al. [6], carried out in Germany a decade ago.

However, it is certainly incorrect to interpret this high degree of self-efficacy as being a direct result of the game. As mentioned, no evaluation *lege artis* was carried out that would combine an ex-ante and an ex-post phase of data collection in order to allow for a comparison and determine (or estimate) the effect of the intervention. On

**Table 7** Descriptives for Self-Efficacy Short Scale-3

| Descriptives | *N* | Min | Max | Mean | Std. dev. | Study by Beierlein et al. [6] | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | *N* | Mean | Std. dev. |
| 9. I can rely on my own abilities in difficult situations. | 30 | 3 | 5 | 4.27 | 0.64 | 741 | 4.05 | 0.87 |
| 10. I am able to solve most problems on my own. | 30 | 3 | 5 | 4.33 | 0.71 | 741 | 4.04 | 0.81 |
| 11. I can usually solve even challenging and complex tasks well. | 30 | 3 | 5 | 4.27 | 0.74 | 741 | 3.88 | 0.90 |

the other hand, with the context and thus, the point of reference for the evaluation clearly being the Mammoth Game, the available data from the ex-post evaluation phase allows for the conclusion that at least, the experience of playing the game did not result in a situation where the participants showed low levels of self-efficacy, compared to the study by Beierlein et al. [6]. Thus, even if we cannot say whether the game had a positive effect on their self-efficacy, and while we cannot exclude the possibility of a decrease of self-efficacy amongst our participants, we can at least say that it did not cause them to fully reject the idea that they were able to make an impact on how things are developing in the future.

## Conclusion

This article describes a political game carried out in the context of a course on futures studies held at a European university of technology. The game started from a scenario that combined a factual technological invention effort—the transfer of mammoth genes into the genome of an elephant species with the aim to create a species which can live in cold areas—with a fictitious collaboration project installed to test the capacities of this invention. The invention itself is controversial on various levels, ranging from economic feasibility to clashes of different environment-related values (conservation vs. naturalness, fight against consequences of climate change vs. instrumental use of animals). Thus, the scenario was expected to provide sufficient fuel to ensure lively discussions amongst the students.

The ex-post evaluation of the Mammoth game showed that students were satisfied with the game and that it succeeded in following the three principles of game design described by Harteveld [17], reality, meaning, and play. It also showed that the use of this didactic format in technology-oriented curricula provided a valuable addition by which the students learned to understand and interpret the social implications of technological change, while at the same time developing—through experience—a sense of what kind of knowledge futures studies produce and, thus, improving their futures literacy.

The questionnaire used captured the participants' perception of the three principles and certainly can be used in further, comparable endeavors. However, we would suggest omitting the variable poling of the items, as there are reasons to believe that this decision introduced some bias. Also, while the items themselves provide for interesting results, the attempt to group them into consistent sum indices was not successful.

Games and gamification have been very popular frameworks in society. Yet, as Sweeney [37], p. 27 aptly notes, popularity "does not correlate to efficacy and/or impact, and there is a continued need to analyze critically the constraints of such tools and approaches, their benefits both intended and unexpected, and how they can and might shape objectives and somewhat more serendipitous outcomes." Perhaps against the trend, the Mammoth game is technically a rather low-level endeavour: no cards, no deck, no fancy online portal, and virtually no visual design. Yet, it achieved a high involvement among the students. For us, this leads to the first of two puzzles which might prospectively inform the critical analysis of the impact of games that Sweeney (and others before and after him, e.g. [31]) argued for: How much game material is in fact required to create an engaging environment? This is certainly an aspect where the answer depends heavily on the context. As we are no designers, we were glad that the game worked as it did without us having to create many materials in the hope to engender commitment amongst our participants. And in the face of the ubiquity of gamification in society, and the enormous proliferation of new smartphone apps during the COVID-19 pandemic, we wonder whether in our case, it was specifically the lack of such materials, and the responsibilities that this void put on them, which encouraged engagement amongst our students.

The second puzzle concerns the amount of the game participants' prior knowledge about the game's topic as well as, in the case of a university course, its relation to their own envisaged professional futures. With the majority of the participants studying computer science and related fields, it is hard to perceive of the Mammoth game as an exercise preparing them for their future jobs (unlike, e.g., the Prinz:essin von Homburg game developed by Egger de Campo [16]). Still, even without such immediate training purpose, the Mammoth game was very well received by the students. The

puzzle that remains is that we do not know whether it is *because* or *despite* of this lack of connection to their own plans that the participants showed such high degree of immersion in the game. Anyway, it is encouraging for us to see that our participants showed both openness towards and sensitivity for the generic capacities of futures literacy that the game set out to convey.

Immediately after the game ended, Russian military forces entered Ukrainian territories and began the bombardment of cities and villages across Ukraine. Due to this devastating development, it does not appear feasible at the moment to repeat the game without modifications. Our experience with the game in the winter term 2021/22 was that part of the energy that fuelled student engagement originated in the geopolitical confrontation between the three regions involved, the EU, Russia, and the USA. But this had been a latent political, and not a military conflict at that time, and releasing genome edited mammoths on an island not far from EU borders seemed like an interesting move for Russia in political terms. Today (15 May 2023), this scenario appears to be virtually impossible, and it is to be doubted whether the Mammoth game can be repeated anytime soon without modifying the scenario.

## Supplementary Information

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**Additional file 1:** Appendices

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**Authors' contributions**
For the most part, this article is the result of a joint effort of all the authors. However, Christian Dayé created the game; conceptualized the study, the methodology, and the article; and designed the online survey. As a student game leader, Roman Prunč created the qualitative interview guide and carried out and analyzed the qualitative part of the evaluation. Martin Hofmann-Wellenhof contributed with data curation activities and provided the first exploratory analysis of the quantitative data. All other work steps, ranging from statistical interpretation to writing and editing were done in close exchange of all authors.

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**Availability of data and materials**
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

## Declarations

**Ethics approval and consent to participate**
The study was checked by the Ethics Commission of Graz University of Technology and was approved in a unanimous vote of the Commission (letter dated 9 February 2023). Participation in the study was voluntary; before being able to fill in the online survey, participants were informed about the study's purpose and had to accept to a data policy in line with EU Regulation 2016/679 OF (General Data Protection Regulation).

**Consent for publication**
All three authors consented to publish the article. Further, game participants were asked if they wanted to be thanked by name in the article. The names of those who agreed are provided in the Acknowledgements section.

**Competing interests**
The authors declare that they have no competing interests.

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## Publisher's Note