A board game for interdisciplinary training and dialogue

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The paper reports on the design and educational use of a board game on climate change which covers central bio-physical, economic and political aspects of the issue. By using a board game as common language between students and scientists from different scientific cultures, knowledge of different disciplines can be integrated and different views can be discussed. Familiarity with a particular jargon is not needed, but can develop through playing and debriefing the game. Already in the game design phase scientists from climatology, economy, political science and modelling as well as integration experts were involved. It includes (i) a simple climate module accounting for greenhouse gases, global mean temperature and climate impacts, (ii) an economic growth and innovation module which allows switching between energy technologies, and (iii) a political network with international coalitions and trans-national actors. Thus, even complex issues as the free rider problem, trade-offs between adaptation and mitigation of climate change and path-dependencies can be studied. The game is called KEEP COOL and is readily available for educational use from a publisher. The experience with the game indicates that it can be effectively used in training seminars with students. This contribution also shows some pitfalls and essential instruments for its adequate use.

Introduction

Climate Change is an interdisciplinary challenge for society. Solving adaptation and mitigation issues requires adequate knowledge from climatology and other natural sciences, as well as new technologies and new social organisation. Instruments and institutions for coping with climate change can be situated on local up to global scales. Both international relations and economic structures matter when climate impacts, vulnerabilities and mitigation strategies are assessed. These different facets of the challenge, addressed in different disciplines across scientific cultures and residing on different scales in time, space and organisation are additionally complicated by ubiquitous uncertainties and complexities. To link interdisciplinary research with actual instruments for approaching the problem there is an increasing need for improved communication processes at the science-policy interface, such that some scholars call for transdisciplinary or postnormal science (e.g. Funtowicz and Ravetz 1993). In this contribution I want to point at two concerns related to the transdisciplinary communication and teaching of climate change (and other issues of global change):

1. Differences in language hinder communication between scientific cultures and between scientists and the public. On the surface, this relates to specific scientific jargon and to unnoticed equivocations by using identical signifiers for different disciplinary technical terms. More deeply, language use is related to particular problem frames, making it difficult to get a deeper understanding of the knowledge others have on climate change.
2. This increases the obstacles if one wants to get an overview about the complex problem. However, having an overview is central for guiding policy-relevant research and for developing a common understanding for action.

The design of the simulation game KEEP COOL was motivated to provide an instrument for dialogue between scientists, students and the general public. It is expected that a board game can address the above concerns since (i) a game creates a new but easy to understand language for its players which is rooted in common gaming experience and can serve as a starting point to introduce particular jargon (Reckien and Eisenack 2006), (ii) a simulation game only works if the subject matter is simplified to some central issues, and (iii) simulation games are known as excellent learning tools (e.g. Torres & Macedo 2000), in particular in interdisciplinary settings (e.g. Diehl 1991).

In a game of KEEP COOL, three to six players aged twelve and above represent groups of countries such as Europe, OPEC, or the Developing Countries. For one to two hours they can choose between "black" and "green" growth, but also adapt to inevitable climate impacts like droughts or floods, which become increasingly sever when global mean temperature rises. Lobby groups like the oil industry or environmental groups have to be taken into account. The winner is the player who most effectively reconciles climate protection with particular interests. If some players are too ruthless, everybody loses. The game thus sets up a fun way of communicating the complexities of a sustainability issue, integrating economic, environmental and political goals, to students and the public at large. Based on these basic ideas, the game simulates an international arena of groups of nation states where negotiations and transfers of knowledge and money play a central role. It is complemented by an economic module, where high or low emitting "factories" can be built (representing economic growth). Also investments in R&D and in adaptation measures can be made (taking account for learning-by-doing and knowledge spill-over). Based on the emissions of the factories, the game keeps track of the global mean temperature, which influences the probabilities and strength of climate impacts. The games links results from diverse scientific activities (in particular from climatology, economics and political science). Via its basic mechanisms, a free rider problem is set up, where different strategic options (e.g. ignore / mitigate / adapt) and institutions (e.g. insurances, emissions trading, technology transfer) can be tested, discussed or even invented. Although the gaming options provided by KEEP COOL are complex, it is easy to start a session since all options build on the same basic core rules. A facilitated game can start after 10-20 minutes of instruction. More time is needed for debriefing a game session or for playing the game multiple times for exploring its possibilities.

Up to now, the game is used for various purposes from awareness rising and public relations via science communication and interdisciplinary team building to education and stakeholder dialogues. In particular, the resonance from media after the release of the game was very positive. Potential target audiences are families, students and pupils, journalists and politicians, consultants and environmentally concerned, NGOs and game freaks. In this paper I focus on its use as a teaching device for students.

Games are claimed to have several advantages in learning environments, relating not only to cognitive and affective learning, but also to motivation, interest and changes in the character of later course work (Greenblat 1981). Although compared to standard teaching methods, empirical evidence for improved learning of declarative knowledge is ambivalent and depends on other factors (e.g. facilitation skills), games are known to be effective in enhancing motivation and increasing students' interest (Garris et al. 2002, Druckman 1995). Simulation games seem extremely helpful in decision processes where the circumstances to decide and the actual decision are taken by different entities. Furthermore, simulation games have ice-braking capacity and open up dynamic participation, making them a good starting point for course work. They are known to lessen resistance to accept novel ideas and stimulate interest in the new issue by supporting group discussion

(Petranek 1994). Games are in particular claimed to be effective in the area of interdisciplinary teaching (e.g. Diehl 1991, Crookall 1995, Clark et al. 2003). Empirical studies show that different disciplinary backgrounds of students participating in a gaming exercise have only limited influence on the perceived learning results (Diehl 1991). This indicates that games are a good common ground for a mixed group of students from different subjects. The literature on simulation games emphasizes that the effect of gaming exercises crucially depends on a subsequent debriefing, since processing of experience is necessary to provide insight (e.g. Lederman 1992).

Climate change and sustainability are subject of many simulation games. There are also established games to teach and analyze international relations (e.g. CRISIS, Diehl 1991). An overview about such games is given by Starkey and Blake (2001). Games as FISH BANKS (Meadows et al. 1989) are well-known. The recent games SURFING GLOBAL CHANGE (Ahamer 2006) or DEMOCS (Walker and Higginson 2003) initiate a discourse dynamic, while others rely on computer simulations. Basic chances in addressing climate change through gaming are discussed by Klabbers et al. (1994) and Toth (1994). There are relatively simple card games which can be used to teach the issue (e.g. Holt and Laury 1997), and more complex ones (e.g. SUCLIME, considering the economic structure and demographic change, de Vries 1998). There are also computer games available (CLIMATE CHALLENGE, Red Redemption 2006; CLIMATE COMPUTER GAME, ECF 2002). Another board game is WINDS OF CHANGE (ECF 2005), which also includes aspects of mitigation, adaptation and insurance. While KEEP COOL focuses on international negotiations, WINDS OF CHANGE puts emphasis on economic development within an emissions trading regime. The board game ENERGIE 21 takes a regional view and raises awareness on a broad set of renewable energy options (Meyer and Stiehl 2004).

The paper begins with a description of the game design and its objectives. After describing a typical seminar set-up for teaching with KEEP COOL, including game session and debriefing, I report on the evaluation of the game and present insights that help using it efficiently. Conclusions elaborate on the role of the game as a communication instrument.

Game design

The design objectives of KEEP COOL are diverse, since the game is made to serve multiple purposes. Besides learning, which is elaborated here, it was also meant as a tool for awareness rising on the issue of climate change, for public understanding of science and as an interdisciplinary communication project within science. I state the learning objectives from the simple to the more ambitious:

- Providing a broad overview of the problems, challenges and chances related to climate change.
- Teaching basic declarative knowledge on climate change (e.g. natural climate variations or the greenhouse effect, see Appendix for a non-exclusive list).
- Illustrating the interdisciplinary nature of the issue, involved scientific disciplines and important interfaces. The focus was put on (i) basic climate dynamics and climate change impacts, (ii) economic investment decisions relating to mitigation, adaptation and business-as-usual, and (iii) international relations and lobby pressure.
- Introducing basic relevant terminology in two ways: (i) disciplinary and commonly established terms (as “learning-by-doing”, “mitigation”, or “adaptation”), and (ii)

virtual game terminology as common ground for students with different background (as „protection token“, „green factory“ or „target card“).

- Experiencing and reflecting central challenges as the free rider problem, power relations and agenda setting.

It is obvious that some of these objectives cannot be incorporated directly in a game (i.e. by introducing particular cards, tokens or rules etc.) without making it overcomplex. This is in particular the case for the last learning objective. It was therefore necessary to plan from the onset that the game experience is used as a device for reflection after playing. This points at the role of the debriefing process.

The chosen key element are international negotiations with the potential of bilateral and multilateral agreements. Therefore, each player represents a group of states with similar interests in the Kyoto process, but no international regime is prescribed at the beginning of the game. The negotiations are fuelled by a common problem – climate change – and its tension with individual interests, represented by playing cards representing lobby pressure. Thus, during the game a free rider problem emerges, were players have to chose between egoism and co-operation and different coalitions may emerge. This reflects typical problems of real-world climate negotiations and introduces a dramatic element into the game. Around this key element, different secondary features were included. For mitigation, players can transform their energy systems by investing in technologies with low emissions. Additionally, R&D activities are possible and learning-by-doing effects are incorporated. Adaptation measures are possible to reduce damages, which non-linearly increase with the global mean temperature. Different types of damages illustrate various impacts on economy and society. These are not evenly distributed between industrialized and developing countries, such that also development issues are touched. Finally, natural causes for climate change as solar activity and volcano eruptions are part of the game. For the design of KEEP COOL some basic decisions were made:

- It should be a board and not a computer game, since face-to-face communication is a more appropriate form to simulate real-world climate negotiations. Moreover, a face-to-face game encourages discussing and questioning experiences from the game directly, offering a natural starting point for debriefing.
- The scientific background has to be simplified as far as possible. Some key features of climate change were chosen, and emphasis was put on the appearance of important processes and not on quantitative details. It was the target that as much game elements as possible refer to real-world processes selected as relevant, but not to represent them in detail. Players shall learn what climate change is about and not become experts about particular issues.
- Also players without interest in the topic should have fun; therefore dramatic decisions and competitive elements have to be included. This increases the chance to raise interest, motivates for repeated game sessions, and makes the game a stronger experience. Therefore, the game rules are strictly separated from scientific background information.

The game comes as a typical board game box, which can be ordered by a publisher (Eisenack and Petschel-Held, 2004). The game board is a map of the world, where countries are coloured according to six typical alliances in climate negotiations. Each one is represented by a player, who also gets a country panel providing game relevant economic information of his alliance (basically economic targets and investment costs, which decrease if a player specializes in one particular technology and introduce path-

dependencies into the game). Three types of tokens can be placed on the board: “black factories” for greenhouse gas emitting energy production, and “green factories” for low emission technologies (nuclear power is excluded for simplification). A player can decarbonize her economy by voluntarily removing black tokens and buying new green ones. “Protection tokens” represent an aggregate for various adaptation measures. Global mean temperature is indicated by a so called “carbometer”, a stick where chips are piled up to a certain level. During the game, chips are removed or added to the carbometer, depending on greenhouse gas emissions made by the players and natural processes, simulated by a “climate recovery” game move and greenhouse cards. The latter are drawn randomly and produce climate impacts, depending on the global mean temperature and a rolled dice. Most impacts incur costs on a particular player, but some also produce benefits. These are paid in game currency, called carbon chips, which are earned by operating green and black factories. Finally, every player draws a target card at the game start, making it necessary to satisfy certain lobby interests (e.g. the oil industry, insurance companies or development aid), which are portrayed as trans-national actors.

The game is played in clockwise order, where every player can decide in which types of factories she invests, if she buys protection tokens, undertakes R&D or removes factories, all paid in game currency. It is a central game rule that players are allowed to negotiate about everything, for example to compensate mitigation efforts of other players by side-payments or to invest in new factories in other countries (allowing for the simulation of clean development and joint implementation instruments, but also a technology protocol). However, such negotiations are not mandatory, and the game starts from a situation where no international agreement is in force. It is completely up to the players whether they develop bi- or multilateral climate protection strategies or not. Depending on the target cards there are also incentives for international agreements which counteract climate protection. Therefore different „scenarios“ emerge in each game, e.g. depending on whether the umbrella group let by the US chooses to promote renewable energies or not. The game is won by the player who attains her targets first. However, to underline the free rider nature of the problem, the game is lost by all if the global mean temperature increases above a certain level.

Educational use

The game is played with five to 25 students in one to two hours, including the game instructions by a facilitator. Learning follows an experiential approach where participants make affectual and cognitive experience during the game. They are faced with the consequences of their decisions, they are inside of the simulation (Torres and Macedo 2000). To turn this into knowledge, a reflection on the experience is central. The importance of the debriefing process is based on two assumptions. First that the experience has affected the participants in some way, and second that a processing of that experience is necessary to provide insights (Lederman, 1992). An in-depth facilitated debriefing of KEEP COOL takes at least another one or two hours.

Thus, in a standard seminar setting, at least two sessions are needed, although it is preferable to choose a four hours block such that experience is still present during debriefing. It can be valuable to start a course with the game, since seminar participants will know each other better afterwards. It can also be played repeatedly in later sessions to wrap up knowledge from other teaching instruments. The game can also be used in seminars on broader topics, where climate change is just an example. Then, providing an overview is the basic objective.

The only resources needed are one game kit per six participants. Facultatively, there is a short reader which provides basic information on the issue and relates various game elements to reality (Wirsing and Eisenack 2004). A detailed facilitation and debriefing guide is currently in preparation.

In the beginning of a typical session, the facilitator explains the basic game elements, while the players put the appropriate tokens on the table. This needs about ten minutes, and although the complete rules are not known to participants yet, it is enough to let the first player make her move, improving efficiency of the introduction. During this first move, the player is guided step by step, such that all players learn the rules simultaniously. At later game moves, the facilitator is ready to answer game questions in the case of unclarities. It is also recommended for efficiency and enjoyment not to explain particular rules for uncommon situations at this stage – such rules are only introduced if they become relevant. Explaining the rules is not related to the climate change issue, which does not need to be introduced before the game. However, as players get more and more used to rules, they usually begin asking questions why some rules are as they are. Some game elements are especially designed to provoke such questions. Those questions that can shortly be answered are directly explained by the facilitator. More complicated questions are collected and postponed to the debriefing phase. The sessions goes on until every group has finished the game, be it with winners or with all participants loosing. Groups that finish earlier are allowed to observe games of other groups or to start a second game. When the last group finalizes its first game, debriefing starts.

Generally, the debriefing process can be decomposed into the three phases: (i) introduction, (ii) self-reflection, and (iii) intensification of the analysis and generalization (cf. Lederman 1992). Debriefing is also important to exclude potential misconceptions. The game is designed such that every player has approximately even chances to win, although the initial conditions are quite different, e.g. between Europe and the Developing Countries. The facilitator has to explain such game artefacts to avoid mistakes in transfer from game experience to reality. Since first questions about climate change are provoked by game elements explicitly designed for this purpose, a part of reflection already occurs during the games. However, a formal debriefing has to be introduced for the whole group. In a short start up phase, every participant gets the opportunity to shortly express her feelings about the game. Some players are strongly affected such that this is necessary before reflective work. In many cases, the groups discuss about the winner, why some or all players lost and why the global change scenario emerged during the game in the observed way.

Further reflection is based on these first comments and on the questions and observations collected during the game. Other issues are avoided, except when essential questions where not asked by participants or problematic artefacts have to be discussed. By artefacts, such game elements or game dynamics are meant which do not correspond to the intended subject matter. Every simulation game has such artefacts, since it abstracts from its content and introduces new mechanisms due to the requirement of being a game and not reality. This is analogue to formal or computer models (Stachowiak 1973). Examples for artefacts in KEEP COOL are:

- The game focuses on important inter-dependencies, but quantities (e.g. damages from climate impacts or the relation between greenhouse gas emissions and global mean temperature) are not based on scientific findings. They represent a compromise between simplification and game dramatics.
- The Developing Countries have a particular bonus, reflecting land use changes. However, this bonus makes their negotiation power much stronger than in real

climate negotiations. This is a compromise to avoid frustration for the player representing that role.

- The situation that all players loose when a certain threshold is passed may suggest that something like a „climate collapse“ occurs. To avoid catastrophism, it is important to communicate that this has not to be expected in real life.

It is valuable to start the reflection phase with discussing various game elements and their relation to reality. This serves the purpose of providing overview, provoking further questions and addressing declarative knowledge. It is not always obvious which game elements are easily „decoded“ by the participants, so it is worth to ask questions as a facilitator. The exercise is also fundamental to achieve the advanced learning objectives, since they relate on the ability to transfer basic game experience to more complex reflections. For the introduction phase and subsequent clarification of questions and game elements, about one hour is needed.

A second hour is used for a detailed discussion of a more advanced theme. If the seminar is large enough, it can be split into several groups for teamwork, each group focussing on one advanced theme and reporting to the plenum in the end. Examples for advanced themes are:

- The free rider problem
- Basic strategies: ignore, mitigate, adapt
- Interdisciplinarity: which interfaces between disciplines are important?

In this group work, participants are encouraged to draw on their game experience as well as their previous knowledge. They can thus learn from each other and those players which have not thought about climate change before can contribute to the discussion by their observations from the game. The facilitator can intervene by pointing at arguments in this discussion which correspond to real-world issues of climate change or can ask questions related to the observed game dynamics. He can ask for

- reasons for building black/green factories or adaptation tokens during the game
- decisions and processes which probably stabilized or eroded the climate.
- the distribution of costs and benefits between players
- explanations for the game outcome
- the coalitions of actors which emerged during the game
- causes for regime changes during the game

Depending on previous knowledge, also more complex issues can be discussed, e.g. if adaptation imposes negative externalities on other players; if an overshooting strategy, where expansion of conventional energies is used to finance the subsequent transformation of energy systems, makes sense; or how strong the influence of agenda setting is (e.g. by the first move the player of the US and their partners makes).

Evaluation

Experience with the game was made with different players, under different conditions and on different levels. Game sessions were played with families, students, pupils, scientists, journalists, consultants, game experts and on public events. The games in the developing phase started with very volatile rules and workshop setups and ended with a unguided test,

where testing persons received a prototype game kit with instructions and an evaluation sheet. With the final game there is intensive experience with documented, facilitated games, in particular with NGOs, schools and at university seminars. In this paper I concentrate on the latter.

Evaluation is mainly by participant observation. Based on this, I will conclude this section with some hypotheses about the effective use of KEEP COOL. They are additionally justified by preliminary results from a qualitative study which is currently undertaken to explore learning success of students. It focuses on the effect of the game in the initial phase of seminars related to climate change or global change in general. Students receive an email questionnaire before and after the first seminar sessions, which contains open questions about their basic knowledge, problem framing and interdisciplinary perspective. Three groups will be compared: (i) a seminar with traditional teaching and without the game, (ii) a game session with intensive debriefing, and (iii) a game session without subsequent debriefing.

Most students grasp the rules of the game very fast, but it usually takes one or two moves until an intense communication and negotiation phase starts. It seems that differences in getting into the game mainly relate to players' experience with board games in general. Moreover, some participants seem sceptic about the use of a game in serious teaching. On the other hand experience suggests that the disciplinary background and previous knowledge have little influence.

After the rules are clarified, substantial questions are increasingly asked. They take the form of openly asking why a certain rule is as it is (e.g. "*Why do protection tokens become more expensive?*"), or of proposing corrections/modifications (e.g. "*I would like to reduce emissions for one round by sacrificing my income*"), which may be justified or not, but can be used to correct misconceptions or discuss further issues. In many cases, the facilitator can also observe knowledge deficits from the communication between players (e.g. "*We should remove factories, otherwise the* weather *will become worse*"). This provides valuable hooks for short explanations during the game or for debriefing. Typical short questions are related to:

- the combination of countries each player represents (international coalitions),
- reasons for the regeneration of the climate after each move (ocean sink)
- the meaning of various climate impact cards,
- the effects of volcano eruptions on the climate,
- the meaning of protection tokens and their increasing costs (various adaptation measures),
- indolences of mitigation strategies, e.g. that building green factories has no direct effect on emissions if black factories are not removed.

All this indicates that learning is initialized already during game. In most cases it is easy to explain these questions within the game context – without making extensive reference to the work or jargon of related scientific disciplines. This indicates that the game creates a simple terminology which can be used as a starting point for students' research in different scientific directions.

Students with more experience in the issue often enjoy inventing new international agreements. Others try hard to realize their personal political attitudes within the game to change the real-world conditions they observe, e.g. by giving the US the global lead role in

greenhouse gas emissions mitigation, or to test out being a “bad guy” by not caring about climate change at all. If the participants know each other well, also role play elements are voluntarily been introduced, e.g. by speaking with an accent. It can be observed that tension increases when multiple player are close to their targets. First discussions after the game usually concentrate on the strategic aspects of winning the game. All together, in most sessions players are in some way affected by the game. This is often confirmed when they are asked directly after the game if they had fun.

However, if they are asked if they had learned something new, they express little surprise about what they experienced during the game, although they typically like to draw the relation of the game to their claimed previous knowledge. This confirms the objective that the game at least provides an overview of knowledge which is already available to some degree, but scattered. On the other hand, such critical remarks of students in many cases contradict the facilitator’s observation during game when many substantial questions are asked or misconceptions appear. This underpins the need for a debriefing phase to make learning conscious. Students seem to have an intuition for that, since in sessions where a debriefing is refused, critical comments are likely to be made. During debriefing is becomes clear in many cases that not all game elements are decoded correctly.

Comments of students during the game and in the end of debriefing also indicate a shift in the relevance assigned to different scientific issues related to climate change. For example, some students of physics or geo-ecology start reasoning about how to analyze bargaining situations and wonder what social sciences may contribute to that.

Shifts in problem framing can be sometimes observed. Many students which have previous knowledge start thinking about adaptation strategies, while before the game focussing mainly on greenhouse gas reduction. After some sessions, players saw strong actors like the US in a more important role to solve the problems of climate change, while before the game more players had the opinion that an effort of all actors is necessary. Players estimate the costs of climate change to be higher after the game, but at the same time some say that particular actors can profit from climate change. Sometimes, the probability of climate change was estimated higher after the session. Of course, these changes in perception have to be discussed carefully.

Finally, discussion of artefacts often leads to suggestions for game improvement, which opens up very interesting channels of communication. Such proposals typically reflect personal experiences or interests of the participants, and would, if implemented, lead to a substantial more complex game. This indicates several effects of the game: (i) through the game students become familiar enough with the issue to discuss such suggestions, (ii) the game provides a terminology and mental map to communicate complex issues in a simple way, without the need to go deeply into, e.g., theories of international relations, economic analyses or computer models. In subsequent seminar sessions the common jargon provided by the game can be used as a reference for detailed presentations and discussions.

Feedback after debriefing mostly showed satisfying results. Most groups enjoy playing the game and agree that they would like to play the game again. However, a detailed assessment of learning effects of the game on longer time scales, compared to standard teaching methods, is ongoing work. It was often recognised that there was much information hidden in the game that was not completely revealed. In order to explore these options, it is often suggested to play the game repeatedly and with different co-players. This should allow for deeper insights, since learning of rules it not needed any more and previous game experiences can be utilized to improve gaming performance, thereby revealing additional or more sophisticated strategies to cope with climate change.

Alternative climate regimes and instruments for climate protection can be explored by experimental game sessions with improvised extra rules, or where some players have a prescribed strategy or target card. There is little observed experience with this idea yet, but those groups which play the game multiple times tend to create increasingly complex institutional arrangements.

The current experience with using the board game KEEP COOL as a device for teaching and discussing climate change with students suggests the following hypotheses:

1. Game sessions only facilitate learning if they are carefully debriefed.
2. Learning effects from KEEP COOL are partially non-conscious and mainly relate to obtaining a holistic picture of otherwise scattered knowledge. A broad set of declarative knowledge is touched, but not deeply understood after the seminar session.
3. KEEP COOL provides students with a joint interdisciplinary jargon and a common reference for further seminar work.
4. This can be used effectively for discussing complex matters as the free rider problem or interdisciplinarity already in the debriefing phase.
5. Playing the game repeatedly could contribute to a deeper understanding.

Discussion and Conclusions

A considerable part of the subtleties of climate change lies in the entangled structure of the problem, involving experts from various backgrounds and cultures. It is an open debate whether current forms of science are appropriate for such kind of hybrid problems, or are even at their root (Latour 1993). This also results in a challenge for teaching climate change, since mental frames, languages and communication patterns across different disciplines have to be learned. Providing an integrated overview together with in-depth knowledge is beyond the capacities of a single scientist. At the same time an integrated perspective is essential to adequately discuss climate change in the public. In this paper I presented a board game which hopefully contributes to this effort.

KEEP COOL is designed to cover central aspects of the issue, in particular basic climate dynamics, greenhouse gas emissions and impacts, economic mitigation options, adaptation measures, international relations and climate negotiations. It does so in an abstracted and simplified way without relying on particular previous knowledge. It shows interfaces and interactions between different sectors and communicates climate change in a fun way to enable learning.

In a facilitated seminar setting, the game is introduced, played and debriefed within three to four hours within groups of up to 25 students divided into groups. Integral part is a team work phase which reflects on selected advanced topics drawing on the game experience. The assessment of the game indicates that it can be effectively used in training seminars. The well-known fact that debriefing is essential for experiential learning from a simulation game is confirmed by the experience with KEEP COOL. To really explore its possibilities, it should serve as a starting point for further teaching. Since it successfully provides a broad picture of climate change and touches some basic declarative knowledge, this would take the advantage of referring to common experience and game terminology in the later coursework. Already in the debriefing phase, central challenges as the free rider problem, power relations and agenda setting can be more deeply reflected than before the game. It may be helpful to use the game for wrap-up in the end of a seminar alternatively, but that

would miss the chance of team-building and initializing group dynamics from the onset, an effect that is also commonly known for simulation games in teaching environments. Finally, the evaluation of the game shows that the participants shift their perceptions about the interaction of different scientific cultures in analyzing climate change. All this indicates that most of the design objectives of the game are attained at least to some degree. This makes a more detailed evaluation, where facilitation guides, workshop setups and more specific teaching objectives are assessed, a promising task.

The observation that advanced students tend to discuss extensions and modifications after the game demonstrates an interesting potential for games, which was also confirmed in the development phase where scientists from climatology, economy, political science and modelling as well as integration experts were involved. The same is true for game sessions with scientists from different backgrounds and with members of environmental NGOs. By using a board game as common language, knowledge can be integrated and different views can be discussed. In this regard I suggest that games may serve a similar purpose as formal or computer modelling. Although models allow for much more complicated representations, games have the advantage that no mathematical training is needed. Since parts of the game relate to established models, they offer the possibility to validate and improve the use of models without the need to explain them in detail. Through talking about a game, scientists and stakeholders can obtain feedback about their theories without the risk to get lost in technical matters. Similar observations can be made for other model-related games (Reckien and Eisenack 2006). By playing a game with non-scientific experts, where the game is a medium to communicate a formal model, the teaching situation is shifted towards a dialogue where both sides learn from each other without the need to introduce the model itself in detail.

For the future, besides improving the facilitation handbook and evaluating learning effectiveness more thoroughly, the request for two further versions of KEEP COOL is currently discussed. Since the board game addresses people aged twelve and above, there is the demand of a further simplified game made for children. This, of course, needs to be rooted more thoroughly in pedagogical practice and requires different learning objectives. Another idea is to convert KEEP COOL into a computer game. As discussed above, this is problematic since the open face-to-face negotiations, which make up a central part of the gaming experience, may be lost. Moreover, the role of the facilitator has to be „simulated“ effectively such that learning processes are not sacrificed. On the other hand, a network game, where people meet in the internet for a gaming session, may reduce these problems and offers the possibility of a detailed recording of game sessions to assess learning effectiveness.

The current ready-to-play version, however, already contributed to teaching and communicating climate change. The game initialized productive dialogues with the media, stakeholders and students. This shows that although climate change is a complex and broad issue, and although different experts frame it in various ways, innovative instruments can contribute to closing the gap between scientific research, education and public action.

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Appendix: Game content

This appendix provides a non-exclusive list of disciplinary game content that is referenced in the game:

- The difference between weather and climate
- Natural climate change, in particular solar activity and volcanos
- Reduction of athmospheric carbon by solution in the oceans
- Natural versus society-made causes of climate change
- Climate effects of land-use changes
- Diverse potential climate change impacts
- The existence of some benefits due to climate change
- Adaptation strategies
- Carbon intensity: relation between greenhouse gas emissions and economic income
- Mitigation strategies
- The role of technological change
- Important international coalitions in climate negotiations
- The role of NGOs and lobby pressure
- The free rider problem

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