“Reflectories” for the Promotion of Competences in Education for Sustainable Development Using the Example of Climate Change

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Abstract. In order to meet the challenges in a globalised world, appropriate competencies should be initiated among pupils in the sense of education for sustainable development. In Germany, the focus in this context is on systems thinking and evaluation competence. At the same time, the importance of digital media in the everyday lives of children and at school is increasing more and more. Both the promotion of ESD skills and the use of digital media in teaching are based on a constructivist approach to learning.
The question therefore arose, how can ESD competences be promoted with digital media? With the help of a design-based-research approach online learning arrangements (so-called reflectories) were developed. The word “reflectory” is composed of the terms “reflect” and “(s)tory”. In concrete terms, the learners are integrated into a “story” within which they are invited to make reflective decisions. Then they are immediately confronted with possible consequences of their decisions, which in turn are starting points for further necessary decisions. On the basis of audio contributions, images and text materials, learners have to weigh up and finally make and reflect on complex and uncertain decisions. The content of the reflectories is based on the Sustainable Development Goals (SDGs). In a first step, content-related aspects and interactions were worked up on selected SDGs and reviewed by expert scientists. Subsequently, reflectories were developed with the involvement of teachers. The reflectories are beeing tested with teachers and students. In the paper, the criteria for the promotion of competences will be discussed based on the corresponding research results. Students were very motivated by the fact that they could make their own decisions on the basis of which they could continue to work. It was particularly emphasized that they learned that decisions can often not be right or wrong, but that these decisions can also have many consequences.
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Climate change is one of the greatest challenges facing humanity worldwide. Like other global challenges, climate change is characterized by very complex interdependencies. The dynamics of these interdependencies are partly unknown or at least uncertain. There are no simple possible solutions and, above all, no options for action with which all people are satisfied. The challenges are not new. As early as 1992, 178 countries agreed at the UN Conference on Environment and Development in Rio de Janeiro to set the course for global sustainable development. Sustainability is defined as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs and choose their own lifestyles" [World Commission on Environment and Development 1987: 27]. "There are four dimensions to sustainable development—society, environment, culture and economy—which are intertwined, not separate. Sustainability is a paradigm for thinking about the future in which environmental, societal and economic considerations are balanced in the pursuit of an improved quality of life" [UNESCO, 2019].

In the 21st century, however, it still appears to be a great challenge to make the idea of sustainable development a reality for people. A reorientation of education on the issue has become crucial and serves as an important function in making pupils aware of the present and future challenges. Pupils need competences that are anchored in the German language literature of geographical education in the concepts of «global learning» and «education for sustainable development». In addition to initiating a global perspective, the focus is on leading people to judge themselves personally and for them to take action. In the analysis and evaluation of problems, both a networked consideration of ecological, economic, socio-cultural and political factors and interactions between the local, regional and global levels are considered necessary [Schrüfer 2013]. Pupils should recognize and understand global connections; they must be able to develop and apply standards of value and have the ability to intervene in the development of complex systems in order to steer them towards sustainability [Lauströer, Rost 2008: 90].

1. Competences for education for sustainable development

In recent decades, education on sustainable development has increasingly gained recognition worldwide, yet the understanding of how this should be imparted and the corresponding competences and goals not only differ within one's own country but also among different countries around the world [Nguyen 2017; Martens, Roorda, Cörvers 2010; Thomas, Barth, Day 2013]. The OECD states that «it needs to equip students with the skills they need to become active, responsi-

ble and engaged citizens» [OECD2018: 4]. Among other competencies, the OECD Education 2030 project identified three main transformative competences: creating new value, reconciling tensions and dilemmas, taking responsibility [OECD2018: 5]. After more than two decades of intensive discussion on the understanding of education on sustainable development, an international consensus seems to have finally been reached on competences. UNESCO published the following eight competencies in 2017 [UNESCO 2017]:

- *Systems thinking competency:* the abilities to recognize and understand relationships; to analyse complex systems; to think of how systems are embedded within different domains and different scales; and to deal with uncertainty.
- *Anticipatory competency:* the abilities to understand and evaluate multiple futures—possible, probable and desirable; to create one's own visions for the future; to apply the precautionary principle; to assess the consequences of actions; and to deal with risks and changes.
- *Normative competency:* the abilities to understand and reflect on the norms and values that underlie one's actions; and to negotiate sustainability values, principles, goals, and targets, in a context of conflicts of interests and trade-offs, uncertain knowledge and contradictions.
- *Strategic competency:* the abilities to collectively develop and implement innovative actions that further sustainability at the local level and further afield.
- *Collaboration competency:* the abilities to learn from others; to understand and respect the needs, perspectives and actions of others (empathy); to understand, relate to and be sensitive to others (empathic leadership); to deal with conflicts in a group; and to facilitate collaborative and participatory problem solving.
- *Critical thinking competency:* the ability to question norms, practices and opinions; to reflect on own one's values, perceptions and actions; and to take a position in the sustainability discourse.
- *Self-awareness competency:* the ability to reflect on one's own role in the local community and (global) society; to continually evaluate and further motivate one's actions; and to deal with one's feelings and desires.
- *Integrated problem-solving competency:* the overarching ability to apply different problem-solving frameworks to complex sustainability problems and develop viable, inclusive and equitable solution options that promote sustainable development, integrating the above- mentioned competences.

2. Systems thinking competence, evaluation competence and competence for action as central goals

In the German-speaking world, the central focus of competences in connection with education on sustainable development is on systems

thinking and assessment competences which then lead to action competence. When examining the underlying models and concepts, one may see that some of the competences broken down by UNESCO can be found in the models. In the following, therefore, these two competences will be discussed in particular.

2.1 Systems thinking competence

As previously mentioned, the global challenges are characterized by a very high degree of complexity and networking. These are systems in which many variables are related to each other and can thus be seen as connected parts that work as a whole. Hence, intervention in one system can damage the entire system. In addition, due to the large number of interconnected parts, it is difficult to predict behavior and changes. This means that, due to the complexity of systems, it is almost impossible to know all the bases for decisions and their effects or consequences before certain decisions are made. This requires a certain risk awareness and the ability to deal with uncertainties. The ability to think systemically or to be competent in systems is therefore seen as an essential approach to solving complex dynamic problems [Frischknecht-Tobler et al. 2008: 12; Mehren et al. 2014: 4–5]. This includes describing, reconstructing and modelling complex areas of reality as systems and giving explanations on the basis of the modelling, making forecasts—taking into account the probability of occurrence and the model limits—and designing and assessing possibilities for action [Frischknecht-Tobler et al. 2008: 20]. Frischknecht-Tobler et al. show in their model the phases of competence development. In a first step, learners can describe systems with their elements, relationships, feedback and interactions. Different effects (balancing, amplifying) of feedback are discussed. In the next step, it is important to generate an understanding for future changes and to learn to grasp the dynamics of systems. The third step is to enable learners to make predictions based on the models of how systems could develop in the future. Finally, possible action plans can be assessed (What happens if one intervenes in systems and changes them? How does this affect other elements of the system and possibly other systems?).

2.2. Evaluation competence

The complexity of global challenges refers not only to the so-called factual complexity (complex issues) but also to ethical complexity. This results from different standards of value and comes to bear, above all, the question of «correct action» [Bögeholz, Barkmann 2005: 211–214; Ohl 2013: 6]. This ethical complexity requires that processes, facts and problems be evaluated not only from one's own perspective, but also from multi-perspectives. In order to understand different perspectives and to be able to use them as a basis for decision-making, the underlying value standards must be recognized [Ohl 2013: 6]. Values provide orientation aids and can have an action-guiding function. They are initially acquired through socialization and are often regarded without reflection as the only correct values. Therefore,

one's own points of view, previously regarded as immutable, should be relativized, and it should be recognized that one's own value system and thus one's own view of the world represent a culturally determined construct [Thomas 2006, Sahakian, Seyfang 2018]. A change of perspective can then be carried out by incorporating other points of view. By accepting different scales of value in connection with systemic thinking, a simple classification into «right» or «wrong», «good» or «bad» is hardly possible anymore. Ambiguity tolerance is another central competence in this context. Hence, dealing with ambiguity and ignorance must also be learned.

2.3 Competence for action

Based on a constructivist learning concept, the student is responsible for his/her own learning process. Learning is understood as an active process in which pupils create order and links in available information. It is important to note that it is not a matter of showing pupils normatively prescribed courses of action. Rather, they should be enabled to develop attitudes that are as self-determined as possible and to act on the basis of these attitudes, despite any uncertainties they may have [Kyburz-Graber, Nagel, Odermatt 2010: 22]. Students should be challenge the existing ways of doing things [Lotz-Sisitka et al. 2015]. Uncertainties about the consequences of one's own decisions and actions often cannot be adequately assessed, coupled with the fact that decisions in complex systems are usually neither right nor wrong, thereby frequently leading to a feeling of powerlessness or excessive demands. The promotion of action competence should help learners to be able to make decisions, despite these difficulties.

3. Reflectories[1] as an instrument for promoting system thinking competence, evaluation competence and competence to act

Various methods are proposed to promote these competences. In principle, the focus is on constructivist-oriented lesson planning. Constructivist learning environments emphasize the active formation of one's own knowledge by the learner. Learning is cooperative, collaborative and self-regulated [Loyens, Gijbels 2008]. Learning situations should be authentic, complex and multi-layered. The teacher changes her/his role from a facilitator of knowledge to a learning companion [Schulz-Zander 2005, Rosa 2012; 2017]. The use of digital media can help to promote constructive learning processes. Digital media facilitate self-directed, innovative learning processes in which complex interrelationships can be brought into new forms of presentation and contexts. They enable location-independent cooperative working methods and offer varied opportunities for participation in social processes at different scales.

In order to promote *system competence* in teaching, it is important that the topics and situations being dealt with are sufficiently complex, that they address the different dimensions of sustainability (eco-

[1] Reflectories can be found at www.reflectories.de

logical, economic, social and political) and that they are prescribed at different scales. Interactions between elements and dimensions and between personal actions and global processes should become visible. Complex issues are characterized by both factual and ethical uncertainties. This should be reflected in the teaching materials. To promote *evaluation competence*, various positions should be considered, especially with regard to different values and norms. In addition, it should be noted that a life-world reference promotes reflection. Reflection, in turn, is a prerequisite for evaluation competence. In the sense of promoting *competence to act*, it is important that learners are given the opportunity to cooperate, communicate and negotiate. They need options for action that also show them possibilities for co-responsibility.

So-called *reflectories* were developed on the basis of these criteria. The word «reflectory» is composed of the terms «reflect» and «(s) tory». The learners are integrated into a «story», within which they are to make decisions in a reflected way and experience possible consequences of their decisions, which in turn can be starting points for further actions or decisions. Reflectories are online learning arrangements that make complex interrelationships understandable for pupils, linking them to their environment and encouraging critical reflection, also with regard to a multi-perspective approach. In addition, they serve to practise with how one may deal with uncertainty. On the basis of audio contributions, videos, images and text materials, options for action must be reflected upon and assessed, in order to ultimately make decisions. As in reality, these decisions are usually complex, contain controversial information and are frequently characterized by ignorance and uncertainty (*competence to act*). Furthermore, interactions and feedback effects of individual action as well as regional, national and global processes become clear (*system competence*). Often the options are also based on different perspectives, values and norms, against the background of which they are to be evaluated (*evaluation competence*). Depending on the decision, the action will take a different course. In addition, learners are asked to reflect on the consequences of their decisions. In this way, the complex interactions of the processes should be clearly reflected. Decisions that have to be made by learners in a reflectory should therefore refer to as many scales as possible (from individual to global) and include as many development dimensions of sustainability as possible with their conflicting goals. The aim is for learners to recognize the complexity of global challenges, to reflect on ways of dealing with complexity, controversy, multi-perceptivity and ignorance and to derive consequences for their own actions in their own personal environments. In concrete terms, learners are to be encouraged to develop skills in systemic and assessment competence, which will ultimately lead to expanded action competences and their own commitments.

4. Example: Reflectory «Climate Change»

This reflectory starts with a short introduction to the effects of climate change. Learners will then have the opportunity to travel to countries that are already feeling different effects of climate change. In the first step they will be asked to decide where they would like to go. They can choose between a train trip to Amsterdam in the Netherlands, a cruise to Spain or a flight to Vietnam. Depending on the decision, they can, for example, learn about the consequences of climate change in Ho Chi Minh City. The theme is a typhoon that mainly hit the coastal town of Da Nhang, where it damaged the coast, destroyed houses and beaches and caused enormous damage to property. It will be explained to students how to (possibly) adapt to climate change, and they can listen to different opinions and then choose what type of adaptation they would recommend for Da Nhang. In the following step students learn the consequences of their recommendation and that climate *adaptation* alone are not sufficient enough to face climate change. Various climate *protection* options are presented subsequently, such as reforestation, the introduction of e-scooters, a sustainable mobility concept or the construction of climate-friendly hotels. Possible consequences of such measures will also be pointed out in order to promote systemic thinking. Once a particular decision has been made, learners will then experience the corresponding effects. The decisions have both positive and negative effects. In the next decision, the issue of climate change will be raised to a more global level, and the responsibility of all countries around the world will be addressed. Learners receive information on the grandfathering principle, the polluter pays principle and the principle of per capita emissions. Here, too, a decision must be made and the consequences of the decision for various countries are shown. In the last step, the reference to one's particular choice of journey is re-established by addressing the responsibility of the individual.

The information and decisions presented here are only one of several possibilities. The learners can decide individually, they can discuss in groups, include different perspectives, obtain further information with the help of additional material and deepen contents with the help of additional tasks.

5. Research design and results

5.1 Creating the reflectory

The reflectory was developed on the basis of the presented criteria for the promotion of systems thinking competence, evaluation competence and competence to act. A further basis was an evaluation of already existing reflectories on other topics (e. g. "No Hunger" or "Sustainable Cities"). Since these are very complex topics which should be prepared for pupils, a reduction of the system was already made during the creation of the reflectories. For example, certain locations and consequences of climate change were selected, which led to a reduction in complexity. Four experts in geography education and four teachers from different types of schools were involved in the de-

velopment. This should ensure, on the one hand, that the theories for the promotion of competences are considered extensively (experts in geography education) and, on the other hand, the levels of different types of schools are adequately considered (teachers). The reflectories should be suitable for pupils aged 14 and over. The texts of the reflectory were sent to two specialist scientists for review. The comments of these reviews were included in the texts and tasks of the reflectory.

5.2 Evaluation research

With regard to the central research questions (To what extent are reflectories suitable for the promotion of systems thinking and reflection competence in the context of Global Learning? How do pupils rate the use of reflectories?), the reflectory has been tested at different schools throughout Germany. The tests were carried out using questionnaires, interviews and concept maps. Furthermore, online questionnaires for pupils and for teachers were developed. The questionnaire for pupils aims at determining their motivation, interest and comprehensibility. Moreover, interviews were conducted with four students in order to analyse their assessment competence and action competence. In addition, pupils created concept maps before and after using the reflectory, which were also used to measure a possible change in systems thinking competence. In the following, the survey instruments are presented in more detail together with the respective results.

5.3 Questionnaire

The first part of the questionnaire for pupils focused on general information on the use of the reflectory, such as the methods used in class or previous experiences. In the main part, the extent to which selected competences were promoted by the reflectory from the students' point of view was recorded. Sixteen statements were formulated for this purpose, to which the degree of agreement could be indicated using a four-level response scale (not applicable, less applicable, more applicable, applicable), as well as the option of "no answer" for each statement. In addition to this, open-ended questions provided information about what learners took with them from working with the reflectory and what wishes they may have for further reflectories. Finally, demographic data were collected (gender, grade, type of school, federal state).

The Reflectory "Climate Change" was tested in the period from May to July 2019 by 77 students from different German federal states, each with a different curriculum. Subsequently, the corresponding evaluation questionnaire was completed. Learners in the eighth to thirteenth grades (ages 14 to 19) from different school types participated, with more than half of the pupils attending grammar school/ high school.

In terms of interest and motivation, more than half of the learners stated that they were interested in the subject (85.7%) and would like

to continue working on it (60%). The data also show that most of them enjoyed working with the reflectory (79%). This corresponds to listening to audio tracks (74%) and especially to working with digital media (90%). Accordingly, 83% of those surveyed stated that they would like to work more frequently with reflectories in geography lessons.

Looking at the statements aimed at information on the promotion of evaluation competence, similar results can be seen. For example, the majority of learners considered it good that they had to make their own decisions in the reflectory (84%) and confirmed that they have a clear picture of the effects of their decisions (79%). Far less, but still a considerable proportion (42%), stated that they felt insecure when making decisions. The statement that many different opinions led to confusion, however, was confirmed by only 18%. With regard to the promotion of systems thinking, the majority of learners agreed with the statement that through the reflectory they have become more aware of how everything is connected (75%) and indicated that they have understood what the reflectory is about (90%) and that they want to think about the effects of their own actions (71%).

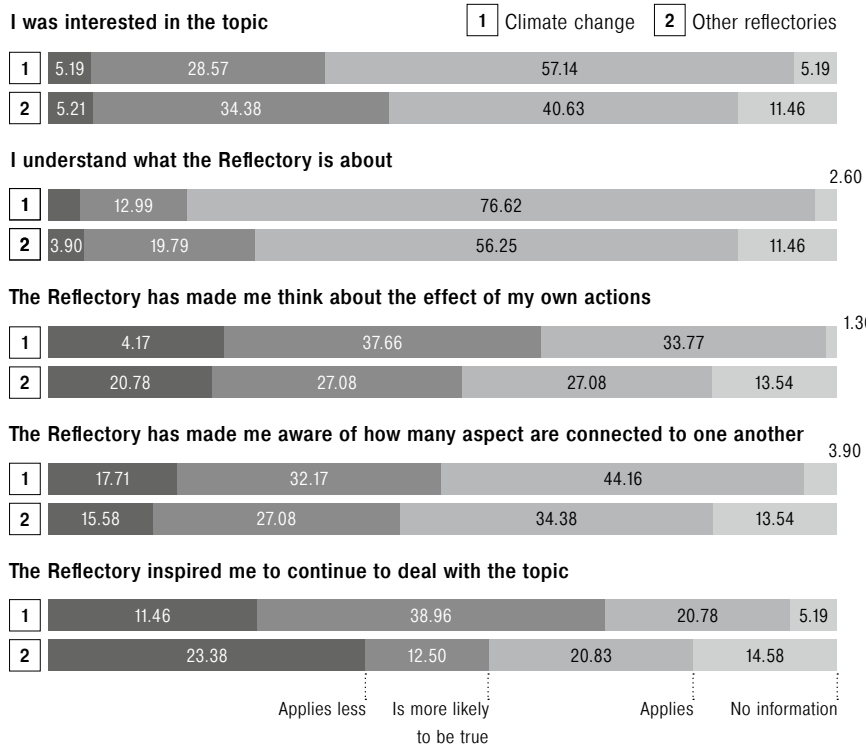
Within the section of open questions, a considerable proportion of the respondents stated that they would like to deal more intensively with climate change from now on and make a contribution to fighting it through their own actions. Several interviewees also indicated a higher awareness of the complexity of the issue and the pros and cons of individual decisions. In this context, a considerable number of respondents would like to receive help in finding decisions in the future, e. g. preliminary information on the effects of certain decisions and information on the decision-making paths of other users. With regard to teaching, reflectories should be used more frequently in the classroom, preferably with somewhat shorter audio tracks as opposed to other materials (illustrations, videos, text).

With regard to the three other reflectories that have been created so far ("No Hunger", "Sustainable Cities", "Sustainable Production and Consumption"), the survey described above was carried out in the same period with 96 other learners of the same grades and school types. In comparison, it is noticeable that significantly more learners stated that they were more interested in the topic «Climate Change» and that they have understood what the reflectory is about. This could possibly be due to the current relevance of the topic as well as the prior knowledge of the students. In addition, a significantly larger proportion of respondents also stated, as mentioned above, that they had become aware of the connections between individual aspects and that the reflectory had encouraged them to continue to deal with the topic and to reflect on the effects of their own actions.

5.4 Concept Mapping

Within the framework of a geography didactic course for master students in the summer semester 2019, the question to what extent the climate reflectory can increase the systems thinking competence of

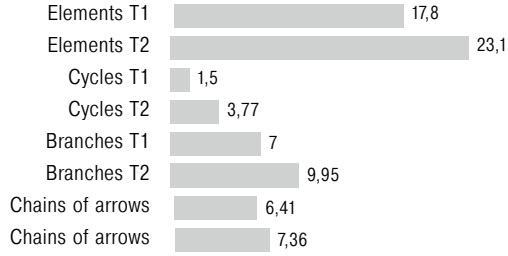
Figure 1: **Selected items compared between the reflectory "Climate Change" and the other reflectories (*N* = 173)**



pupils was investigated. To this end, a "pre-post" design was developed in which the systems thinking competence of a total of 22 pupils in higher grades (9 to 11) was recorded using concept maps, both before and after the reflectory was tested. The concept mapping method, which is used worldwide to record and analyse (system-relevant) knowledge, was chosen to make visible the embedding of individual terms in a network of relationships (cf. [Jahn et al. 2015: 343–344]). In addition, the concept maps make it possible to assign pupils a competence level to systemic thinking [Mehren et al. 2015: 29–30].

In concrete terms, learners were familiarised with the method using an example concept map and were then asked to draw up an individual concept map on the subject of «climate change» using paper and pencil within a maximum of twenty minutes. No terms were specified. After the employment of the reflectories, the learners received the same task again. For each knowledge network, the structural index [Mehren et al. 2015: 31; 33] was then calculated, a kind of degree of linkage that provides information on how strongly elements of a system are networked with each other.

Figure 2: **Average number of terms, cycles, branches and arrow chains before and after the use of the reflectory (T1, T2) (*N* = 22)**



For evaluation, individual elements and relations were first counted. Elements are terms that consist of one or more words. Relations, on the other hand, refer not only to the links between certain terms, which were subdivided into branches starting from particular terms, but also to the chains of arrows and cycles that connect several terms to one another. Type and number of relations were then compared to the number of terms mentioned. The structure index is calculated according to the following formula: SX = (cycles + branches + chain of arrows): number of elements, where cycles correspond to a closed chain of arrows running in the same direction, branches correspond to an element that leads to or away from at least two arrows, and a chain of arrows corresponds to a sequence of at least three arrows running in the same direction.

After examining the results of the overall sample before and after the use of the reflectories, on average, a slight increase in the structural index could be observed (T1: 0.896; T2: 1.011; Mean = + 0.115). There are strong fluctuations between the values of individual subjects (Min =—1.48; Max = + 1.22). When looking at individual components, there is a corresponding absolute increase for all elements and relations. The average difference is highest for the elements (+5.27), followed by branches (+2.95), cycles (+2.27) and chains of arrows (+0.95). In this context, it can be observed that some concept maps have only a few cycles but many chains of arrows, while others contain only a small number of both elements.

Considering the widely varying differences in the structural index, the question arises as to what extent these can actually be attributed to the implementation of the reflectory. For example, the individual prior knowledge and motivation of learners, which are regarded as factors that influence concept mapping, were not recorded ([Kinchin, 2000] in [Jahn et al. 2015: 345]). It must also be taken into account that system competence and specialist knowledge cannot

be distinguished from one another within the framework of the applied study design. As a result, a pupil with little prior knowledge of climate change cannot model a complex impact diagram (cf. [Mehren et al. 2015: 31]). The reflectory may have led to an increase in specialist knowledge, which subsequently made more complex modelling possible. It is also noticeable that some concept maps were designed similarly to a mind map. Although some of these maps contain meaningful terms and complex links, they lack directional information and labels, so that no statement can be made about the type of individual relations. Others, on the other hand, are less complex but completely labelled and thus achieve higher values.

Since the structural index only allows statements to be made on the quantity of the linkages and not on their quality in terms of content (cf. [Mehren et al. 2015: 31]), a qualitative evaluation was also carried out (N = 22). For this purpose, different categories were created on the basis of the elements (terms) listed.

In order to capture the interviewees' perspectives on the climate change system, i. e. whether causes or consequences are more likely to be taken into account or to what extent possible solutions are considered, an analysis of the elements according to their function was first carried out. The following categories were created for this purpose: actors, influencing factors, consequences, causes and possible solutions. The data show that at time T1 a large proportion of the elements can be attributed to the consequences of climate change, although this percentage is slightly lower after the implementation of the reflectory, in favour of the possible solutions mentioned. This could possibly be due to the fact that consequences of climate change have already been identified (e. g. from the media or from school), while possible solutions have increased or become more cognisant through the reflectory (consequences: T1 = 40%, T2 = 37%; possible solutions: T1 = 10%; T2 = 14%). Actors and causes are cited somewhat more frequently in T1 than in T2, while influencing factors are constantly represented with 14 percent (actors: T1 = 10%, T2 = 8.5%; causes: T1 = 18%, T2 = 14%). When looking at individual pupils, it is noticeable that T1 focuses more on terms in the category of consequences and actors, while T2 has a greater variety of term categories, indicating a more complex understanding of the system.

In order to obtain information about the significance of the four intertwined dimensions of sustainability from the students' points of view on the climate change system, the terms were sorted according to the ecological, economical, social, and political dimensions. Different possible combinations were also taken into account and individual terms were assigned to several dimensions when necessary. It is striking that most terms refer to the category of ecology or at least take up partial aspects of ecology. Both before and after the use of the reflectory, a large proportion of terms in the ecology/economy category were cited (e. g. "agriculture", "electric cars"), which indicates that the

pupils are aware of corresponding aspects (T1 = 79%, T2 = 81%). In general, an increase in more complex terms can be observed, which can be assigned to several dimensions at the same time. These are terms that refer to causes, consequences or possible solutions, such as "throwaway society", "high flood risk" and "more regional trade".

In order to find out which topics are relevant for the pupils with regard to climate change and which topics have possibly been taken up specifically from the reflectory, thematic categories were formed on the basis of the elements used in the concept maps (humans, animals, politics and economy, nature and environment, climate, water, CO2, possible solutions). It becomes clear that concepts of the categories human, possible solutions and nature and environment increase from T1 to T2 (human: T1 = 15%, T2 = 19%; solutions: T1 = 4%, T2 = 8%; nature and environment: T1 = 11%, T2 = 13%), while the categories animals and politics and economy are less represented (animals: T1 = 8%, T2 = 6%; politics and economy: T1 = 14%, T2 = 10%). The results can partly be explained by the fact that the reflectory addresses various possible solutions for combating climate change, focusing on people, nature and the environment. While political and economic aspects are also addressed, these seem to play a subordinate role for the students.

5.5 Qualitative Interviews

In order to obtain additional and more comprehensive information with regard to a possible acquisition of competence in systems thinking and assessment, qualitative, guideline-based interviews with four pupils were conducted in addition to the online survey. The complexity of the information, through both the diversity of the subject matter and the diversity of opinions, can cause uncertainty among learners [Ohl 2013]. Dealing with uncertainty in decision-making is another aspect that was to be analysed in the interviews. The interviews started with a very open question about how the pupils experienced the implementation of the reflectory. They were then asked to first comment on the content (including new findings, aspects that were particularly memorable), then on the decision-making process, and finally on the relevance to everyday life.

Even though the pupils were already familiar with the topic of «climate change» from class, the respondents felt that they had «learned something in a playful way» (Red[2]) and that new information had also been gained. When asked about new findings, details were highlighted as follows (our translation): «For example, with living. Whether they want to switch to houseboats or that they want to condense [the land] with houses. And the problems that arise. I didn't know, for example, that the air wouldn't be able to circulate well. I found that very interesting» (Green) or: «I thought the water desalination system was cool be-

[2] The colors refer to the interviewed persons.

cause I didn't know it existed before» (Purple). In addition to new details, however, it was also emphasized that they had become more aware of connections and interactions: «It was good to see that there were measures or also different measures against climate change, and that it was then also communicated how large the influence of the respective things is, both on climate change, and on the people in the region» (Blue). This interviewee even sums this up more clearly by commenting on the reflectories to the effect that they give a «very balanced overview of consequences and interrelationships, that one does not only refer to a topic or a measure, but also that alternatives are shown, so I thought it was really good» (Blue). New insights also resulted from the fact that the consequences of the decisions were presented: «And then suddenly there were things that I hadn't even thought about before, …». (Green).

The fact that they were able to make their own decisions was particularly positively emphasized by all interview partners. «It was only then that you could decide which countries to travel to. Whether you travel by train, plane or ferry. I thought that was actually quite cool, because you could then decide for yourself which city or country you would like to travel to" (Purple). The diversity of opinions was largely positively evaluated: «I found this actually very interesting, because there were always many different opinions. That's why I liked it» (Green). However, the dilemma situations led to uncertainties: «in between I was not sure, because I could understand both and found something good and bad with both … There I found it hard to decide» (Green).

By taking the time for reflection, the awareness grew that one has to contemplate the advantages and disadvantages and that there is no perfect solution. («It was mainly a weighing between what is good for the ecological part, what is good for the economic part, what is bad or good for the social part and then I tried to weigh which decisions have the most positive influence on these three categories» (Blue)). There was also a growing awareness that the consequences of the decisions had to be taken into account: «there are still many side issues that have not been taken into account before. So that one must always think about exactly which decision one makes now» (Green). In addition to weighing the advantages and disadvantages, possible consequences for the future were also considered («I have always thought about the future, what could result from it» (Green); «but you just have to think about what makes sense for a long time» (Red)).

Since action competence cannot be measured within this framework, pupils were asked to what extent they consider the content of the reflectory to be relevant to everyday life and to what extent their willingness to take action had increased as a result of the reflectory. By dealing with the topic themselves, with the help of their own decisions, they became more sensitised to different aspects of climate change: «I think one rather thinks about which means of transport one

uses» (Blue), «I think one has become more sensitive about the information that is then said in the news that one can understand more easily, ... what they tell you (Blue), «but it has simply made it clear again that climate change really must be stopped or reduced» (Purple).

6. Interpretation of results and Conclusion

The results of the study show that the majority of learners have a positive view of the reflectory and would like to work with it more frequently in class. It is found to be particularly useful in that one has to make his/her own decisions and that the consequences of these can be seen immediately afterwards. The pupils are not only able to participate actively but feel that their opinions are important and relevant, which in turn has a positive effect on learning success. Uncertainties in decision-making are less attributed to the diversity of different opinions than to the dilemma situations repeatedly anchored in the reflectory, in which, similar to real situations, every decision has its advantages and disadvantages. In this context, learners ask for additional information on individual measures and their consequences. With regard to the promotion of assessment competence, the results point to an increased awareness that decision-making must take into account as many possible consequences as possible, that careful consideration must be given to different advantages and disadvantages, and that there is no perfect solution. With that in mind, it can be assumed that different points of view are included in the processing of the reflectory and that a change of perspective is carried out as a result, and that the handling of non-knowledge is practised in the sense of ambiguity tolerance. Ambiguity tolerance is another important competence in the context of education for sustainable development. Due to the diversity of information and the content-related complexity of the topics, it must be assumed that decisions must be made on ESD topics, even if not all aspects can be taken into account, as they are not known [Vogt et al. 2018]. Ambiguity tolerance is particularly important with regard to future impacts, which can usually only be estimated.

While there is an increase in subject-specific knowledge, knowledge is particularly gained in certain contexts and interactions. This refers, among other things, to a higher awareness of the complexity of the topic and the pros and cons of individual decisions. In this respect, the different opinions of actors as well as the measures and corresponding consequences described are regarded as particularly profitable. The data collected on the basis of concept maps correspondingly point to a more complex understanding of the «Climate Change» system after the use of the reflectory (e. g. due to the increase in the abovementioned possible solutions or the increasing consideration of the different dimensions of sustainability), even if the average increase in the calculated structural index is small and there are strong fluctuations at the level of individual learners. In the sense of system competence, it can be assumed that pupils work with the reflectory to

deal with different modes of action, assess alternative courses of action and consider how individual actions affect other elements of the system. The aspects mentioned can be assigned to subsection 4 (Assessment of drafts of action) of the System Competence Model according to Frischknecht-Tobler [2008: 30].

Last but not least, the results indicate an increased willingness to act. This includes both the willingness to deal with the topic more intensively from now on and to rethink what effects one's own actions have, as well as the willingness to make an active contribution through one's own actions. In this context, it can be assumed that the reflectory has stimulated people to actively make decisions and act accordingly despite the difficulties mentioned above (e. g. ignorance, uncertainty).

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