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Impulses and Dilemma Stories for Values Education in STEM Context in Elementary Schools

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Abstract: Sensitizing children for values is a main aim of education in order to guarantee a justified and peaceful living together. In STEM context, values receive a more specified focus as decisions in natural scientific subjects have not only effects on individuals, but also on society and on earth. To foster the sensitization of values in STEM context, we didactically enriched experimental material for students in the 4th grade of an elementary school with impulses and dilemma stories and evaluated the realization of two experiments in STEM using qualitative observation and interview data. Overall, results indicated an effective integration of impulses and dilemma stories in order to foster values education. In more detail, results showed that a combination of impulses and dilemma stories was effective for students to take the protagonists' perspective in the dilemma story and discuss diverse opinions showing, e.g., self-activity. Furthermore group discussion in contrast to class discussion showed better results in reflecting on problem solutions integrating value issues of, e.g., environmental consciousness. And the students' activity is of importance to stimulate reflection on values. Thus, the study gives first indications that impulses and dilemma stories are adequate didactical methods in order to foster values education in STEM context.

Key words: elementary childhood education, education attainment, values education, STEM, impulses, dilemma stories

1. Theoretical Introduction

Values are relevant in all countries over the world. As Bilsky and Schwartz (1994) showed in their empirical studies on values, they identified universal values which occur everywhere in the world only differing in their importance (Schwartz & Bilsky, 1987). Values are beliefs about desirable end states or behaviors which guide the selection or evaluation of behavior and events (Bilsky & Schwartz, 1994). Based on such a definition, values are the basis for individual behavior which could be explained and described with values (Mischel, 1990). As values include personally and socially desirable end-states (Rokeach, 1973), they are of immense importance for the whole society. The development of values and the education in values is therefore necessary to guarantee a stable and peaceful living together.

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Values education takes place in schools. Not only subjects like religion or ethics, but also in STEM, values education is relevant. This is introduced in the following section. In a second step, we are interested in concrete didactical means for values education, before we present the object of investigation with the main research questions, followed by the field study in which the integration of values in STEM education using impulses and dilemma stories were focused on. After the method section, results, summary and discussion follow. The last issue concerns the implications of the study.

1.1 Values Education in STEM

"Values are the fundament of any social community." (Menzel, 2013, p. 125). As this is the case, the educational mandate of schools includes the transfer of values. This transfer has several names, including, e.g., values education, character education, or moral education, etc. (Berkowitz & Bier, 2014). Particularly, the question "What do people value?" is one key issue in the concept of scientific literacy (Nentwig, Parchmann, Demuth, Gräsel & Ralle, 2005). This competence-based definition of scientific literacy includes not only ethical competence, but also subject competence and process competence (including learning, communicative, social, and procedural competence) (Gräber, Nentwig & Nicolson, 2002). Showing the importance of values in science, it is relevant to teach values in STEM education, as decisions in this context are not only relevant for the individual, but also for society and earth.

Having a closer look to the definition of science and scientific knowledge, we refer to the OECD. This organization defines science in the Pisa Study as following: "The capacity to use scientific knowledge, to identify scientific questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity." (OECD, 2003, p. 133). This means that science requires the "understanding of scientific concepts, an ability to apply a scientific perspective [to a problem] and to think scientifically about evidence" (OECD, 2004, p. 26). In this definition, we find two components of the scientific-technical competence: first a subject-based aspect which refers to the expert knowledge that is taught in science shown in the "understanding of scientific concepts, an ability to apply a scientific perspective"; and second a value-based aspect in the "think scientifically about evidence" which implies the evaluation, decision making, and reflection on questions in STEM context on an individual, but also on a social level.

The engagement in scientific-technical problems makes evaluation, decision making, and reflection necessary to be able to actively participate in a controversial discourse and to represent the own opinion taking subject-related scientific information and knowledge as well as individual and social values into account (KMK, 2004, p. 12). When examining scientific-technical questions, critical reflection and the sensitization for values and norms are fostered — even more than a concrete content-specific argument (Reitschert & Hössle, 2007). In a world that is dominated more and more by technology, a scientific-technical education is a necessary prerequisite in order to understand the modern world and to form it in a responsible way. In this context, the sensitization for values in STEM education gains importance which mainly includes the reflection about values as well as the transfer to daily life.

1.2 Impulses and Dilemma Stories for Values Education in STEM

There are several didactical methods relevant in order to integrate values in education. In school education there are two methods predominant: impulses and dilemma stories.

An impulse is a general didactical medium to stimulate activity respectively a specific behavior (Salzmann, 1969). Impulses could be realized verbally and non-verbally. Verbal impulses are implemented with questions like

"What is your opinion?", prompts like "There may be alternative behaviors possible!", or further demands (e.g., "Further on!") (Bönsch, 1967). Non-verbal impulses could be applied as gestures, silent impulses, or pictures, illustrations and videos (Bönsch, 1967).

In schools, impulses are used very often. Contrary to a simple question, the main objective is to stimulate comprehensive thinking and talking of the students (Spanhel, 1971). This includes expressing an opinion and the justification of this opinion. Furthermore, impulses are helpful in order to regulate the lesson and make didactics more diversified.

Impulses could be used in various scenarios and content areas. They implicitly focus learners on specific aspects they should think about. Therefore, impulses are applicable in any subject area. They could be used in the beginning of a discussion in order to foster the argumentation about content-specific, personal, social and societal aspects of a specific issue. They activate students to state their opinions and start a debate about it.

In STEM education, impulses could be used to quickly integrate values. Unconscious points of view, opinions and attitudes concerning a value-based topic could be laid open using impulses. Statements, demands or questions are well-established realizations, but also pictures, cartoons, video clips, songs, newspaper articles, quotations or gestures could be applied in STEM education. As impulses could be realized very variable and at any point of time during the lesson, they may be a flexible and adequate method to stimulate the reflection about values.

Very similar to impulses, dilemmas could be applied on diverse subject areas, too. A dilemma is a story about a situation in which you have to choose between two unpleasant and morally inconsistent alternatives which both are connected to displeasing consequences (Lind, 2011). Anyhow, persons have to decide on one of these alternatives. In order to make a final decision, a moral judgement is necessary in which diverse competitive values are balanced and some prioritized.

Dilemmas were used in order to classify the moral development of children, youths, and adults (Kohlberg, 1964). Based on Kohlberg's stage model of moral reasoning (Kohlberg, 1971, 1975), diverse approaches were developed which uses dilemma stories in schools to foster values education. One prominent approach is the Values and Knowledge Education (shortly VaKE, Patry, 2007). In VaKE values are integrated into the content-based education using dilemma stories from real-life and linking them to the content which is taught. In such dilemma stories, there is a protagonist who has to decide on two alternatives and to justify the respective decision in order to convince others of the own opinion (Patry, 2007). In this approach, learners have "to imagine themselves as protagonist of the story and take a viewpoint from which they can discuss what they believe and why, so that the students can inclusively come to a conclusion about the best scenario possible" (Lee, 2014, p. 339). VaKE is based on two main mechanisms that foster values education: (1) the confrontation with cognitive conflicts through discussing arguments and counterarguments (Doise & Mugny, 1984) and (2) taking the perspective of the respective protagonist of the story through comparing and evaluating the problem of the story (Weinberger, Kriegseisen, Loch & Wingelmüller, 2005).

While Kohlberg (1971, 1975) focus on the verbal discussion of abstract moral dilemmas and emphasize propositional thinking, the approaches applied in school focus on dilemma stories as narratives presenting "concrete human and interpersonal situations in order to demonstrate their validity" (Vitz, 1990, p. 710). Herein, interpersonal, emotional, imagistic, and story-like phenomenon are stressed which corresponds to the child's understanding of moral issues (Vitz, 1990). As we want to foster values education of elementary students, the dilemma stories used in this study correspond to VaKE.

Looking at STEM education, dilemma stories could be integrated in a flexible manner in experiments in order to reflect on its represented values and its relevance for the individual, society, and the whole world.

Both methods impulses and dilemma stories seem to be suitable for the sensitization for values in STEM education. They both are flexible regarding the content as well as the point of time of their application. Furthermore, they stimulate reflection on specific issues or values. Using dilemma cases can foster collaborative reflection of teachers on science practical work in classrooms (Yoon & Kim, 2010). Reflection on dilemmas with others through group discussion scaffolded, broadened, and pedagogically deepened their understanding and teaching of practical work (Yoon & Kim, 2010, p. 299). Furthermore, “reflection enables us to correct distortions in our beliefs and errors in problem-solving” (Mezirow, 1990). Summarizing these mechanisms, impulses and dilemma stories are able to foster reflective activities in order to sensitize students for values in STEM education.

2. Learning Environment

Being aware that values in STEM context are of great relevance for society, this project focused on the question how it is didactically possible to integrate values in experiments of STEM education in order to sensitize students for values.

To investigate this question, we used experimental material that was part of the international program “Experimento” of the Siemens Foundation. These materials were developed in order to integrate learner-centered designed experiments and realization guidelines addressing self-directed collaboration supported by teachers in a problem-based learning environment of STEM education. This material was didactically enriched with impulses and dilemma stories and their realization was tested and evaluated.

2.1 Values in STEM Education

There are diverse values relevant for STEM education. Thus, we developed a value model differentiating between “learning-process related values” and “subject-specific values”. “Learning-process related values” comprise values directly necessary for cooperatively conducting the experiments, e.g., like team orientation, tolerance, and reliability. These values are independent from the content and could be applied in any lesson. “Subject-specific values” are concretely related to the respective dimension of the experiments, e.g., solidarity, environmental consciousness, and sustainability. These subject-specific values show a relationship to the main topics of the program Experimento. These are energy, environment, and health (see 2.2 Content Areas). Furthermore, there are some values which integrate both aspects, namely learning-process related values and subject-specific values. These values are openness, self-activity, and accountability.

2.2 Content Areas

The experimental material was developed for three diverse content areas, namely for (1) energy, (2) environment, and (3) health. In the subarea (1) energy, learners were confronted with the basic phenomena of the electric circuit, including simple and complex circuits, conductors, isolators, and energy production. In this context, learners should understand the concept of circuits and construct such a circuit themselves in small groups.

In the content area (2) environment, the focus lies on topics like water circulation, water purification, air pollution, recycling, and renewable energies. One main module includes the meaning of waste separation and the development of actions to protect the environment, sensitizing students for own contributions to save the earth.

The third area (3) health mainly includes relevant aspects of the body, like nutrient food, hygiene, breathing,

muscles, bones, and the senses of hearing and seeing. Students get sensitized for their own body, for healthy feeding and its importance for life. E.g., students should understand why nutrients are necessary for living and what they themselves could do for a balanced diet.

2.3 Target Group

The learning material was developed for students in primary schools. Students were from eight to ten years old. The material focused on the integration of experiments in diverse subject areas in order to simplify the identification of connections between scientific phenomena and to foster values education.

2.4 Impulses and Dilemma Stories in STEM Education

The integration of impulses and dilemma stories was carried out according to their fit to the respective content. Overall, twelve modules (four for each content area) were chosen to integrate values. Table 1 presents three examples of the realization of impulses and dilemma stories — one for each content area.

Table 1 Content Area, Module, Impulse, and Dilemma Story in the Experimental Material

Content Area	Module	Impulse	Dilemma Story
Energy	Solar Cells *Content*: Students learn the trans-formation of power. *1. Learning-process related values*: Team Orientation *2. Subject-specific values*: Sustainability; Environmental Consciousness	*Impulse pictures:*  *Impulse question*: What are advantages of solar cells?	*Solar-Story*: Your parents talk about solar cells on the roof of their neighbors during dinner. Your father says that the house does not look good any more. “Who wants to have such plates on his roof? They look ugly!” Your mother answers: “I have a different point of view. I think solar cells are preferable and I wish having them on our roof too.” **Think about:** What’s your opinion?
Environment	Recycling of Organic Waste *Content*: Waste avoidance, waste separation, recycling. *1. Learning-process related values*: Self-activity *2. Subject-specific values*: Accountability Environmental Consciousness	*Impulse*: You know a lot about organic waste. When you look in your bio-waste container you detect paper and plastic. *Impulse question*: Why do different things not belong in the bio-waste container? *Impulse picture*: 	*Paul-Waste-Story*: Today is the birthday of your classmate Paul. His mother gave him gummy bears in small bags for his classmates. He collects each of the single bags in one bigger bag. You watch that Paul throws the whole bag into the bio-waste container. **Think about**: What would you do in place of Paul?
Health	Fat-detectives *Content*: Students learn about fat in diverse food. *1. Learning-process related values*: Reliability *2. Subject-specific values*: Accountability	*Impulse picture:*  *Impulse question*: Why is it important, not to eat a bag of chips every day?	*Chips-Story*: In the afternoon, you go with your friend to the supermarket to buy something to nibble. Your mother told you not to buy unhealthy thinks with your pocket money. Your friend takes some chips and tries to convince you to put the money together to buy them. **Think about**: How would you behave? What do you think about the behavior of your friend?

2.5 Sequencing the Designed Experiments

The work on the designed experiments comprised five steps. The first sequence included the activation of the pre-knowledge. This is necessary in order to focus students on the main issues which are taught afterwards. In a second step, students received teaching aids and experimental material accompanied by explaining their task. In this sequence, teachers should be very much engaged that all students understand what they should do next. In a third step, the experiments were conducted by the students themselves in small groups. Teachers function as support when necessary. In the fourth step, results of the experiment were saved. This is necessary to guarantee the same level of know-how at the end of the lesson. In the fifth step, impulses and dilemma stories are implemented and connected to the content. Integrating didactical methods for values education as last step makes it possible for students to link the knowledge from the experiment to the values in the impulses and dilemma stories in order to think further on this issue.

3. Main Research Questions

In our research, we wanted to know whether and how far it is possible to integrate impulses and dilemma stories for values education in the above mentioned experimental material for STEM education. Therefore the two main research questions were the following:

(1) How are impulses and dilemma stories realized in the conducted designed experiments for fostering values education?

This question comprises four main issues: First, it is of interest, how the teacher sequences the lesson regarding the integration of impulses and dilemma stories, specifically concerning the five-step-procedure. Integrating impulses and dilemma stories in the end of the lesson after conducting the experiments may be meaningful in order to guarantee an elaborated discussion as learners gained content-specific knowledge on the relevant issues beforehand. Second, the instruction regarding impulses and dilemma stories is of interest. Does the teacher present both, impulses and dilemma stories, or only one didactical method or do learners have to read the stories themselves? Such diverse presentation modes may influence the learners' comprehension. Third, the processing of impulses and dilemma stories is examined. Do all learners in the class discuss the value issues or single groups on their own? The last issue concerns the documentation of the results. Again, different ways are possible, e.g., summarizing relevant issues, recording them on the blackboard or writing them on worksheets.

(2) How do students handle impulses and dilemma stories in the designed experiments for fostering values education?

We wanted to know how students handled impulses and dilemma stories including specifically five aspects: First, the expression of statements is relevant. Do students state their opinions and diverse points of view? This issues indicates in a first step, whether the implemented didactical methods are effective. In a second step the justification of the respective opinions are investigated in more detail. Not only the articulation of points of views, but also their confirmation using arguments is of interest. In these statements, it could be examined in a third step, whether students take the perspective of the protagonist of the story taking pros and cons into account. Furthermore, the articulation of problems is looked at. This may give indications of the complexity of the impulses or dilemma stories. The last, fifth issue concerns the interaction with the teacher. Do learners need a lot of help or are they actively dealing with the impulse or dilemma story? These diverse activities are indices whether impulses and dilemma stories are effective for the students' sensitization for values.

4. Method

In this field study, we implemented two STEM experiments in a fourth grade. Thus, we evaluated two lessons on two diverse experiments. The modules were taken from the content area energy with the module “Solar Cells” and from the content area environment with the module “Recycling of organic waste” (see Table 1).

4.1 Data Sample

The sample consisted of one fourth grade class with 24 students (11 boys, 13 girls). The female teacher was very experienced with more than 20 years in their occupation.

4.2 Data Sources and Data Analyses

Data were gathered with three diverse methods, namely observations, interviews, and worksheets.

Observations. Two observers participated in the lessons without actively intervening using pre-structured observation sheets to note relevant issues (Lötscher, 2014). These were pre-structured in relevant sequences, namely in a five step procedure consisting of (1) activating pre-knowledge, (2) work assignment und support, (3) conducting the experiment, (4) saving results, and (5) relating the content to the value aspect using impulses and dilemma stories. Furthermore, time, duration, activities of the teacher and of the learners, as well as the interaction between teacher and learners were listed.

Sequences were further subdivided into specific activities. For the integration of impulses and dilemma stories, there were several activities categorized. Two researchers observed all experiments together each of them using a separate observation sheet. Based on these observation sheets, there were two main analyzing categories identified:

(1) Implementation of the impulses and dilemma stories into the lesson with

- sequencing of the lesson regarding the integration of impulses and dilemma stories,
- instruction regarding impulses and dilemma stories,
- processing of impulses and dilemma stories,
- documentation of the results.

(2) Students’ handling with the impulses and dilemma stories including

- expressing statements,
- justifying opinions,
- taking the perspective of the protagonist of the story,
- articulating problems with handling the dilemma story,
- interacting with the teacher.

Both observation sheets were used, compared, and analyzed according to these categories. Both sheets corresponded to each other.

Interviews. Second, interviews were conducted with the teacher after each lesson, so that we included two interviews in our data set. The interviewee used a pre-structured half-standardized interview guideline in order to integrate the most important dimensions for answering the research questions. The interviews were transcribed and analyzed according to propositions concerning the main categories for answering the research questions. The categories were chosen equivalent to observation data (see Table 2). Interview 1 comprised 2.722 words with 1.626 words from the interviewee, and interview 2 comprised 3554 words with 2931 words from the interviewee.

Table 2 Coding Scheme of the Interviews with Examples

Analyzing category	Example in the Interview
Implementation of impulses and dilemma stories into the lesson with	
Sequencing of the lesson regarding impulses and dilemma stories	This was simply planned in this way. […] You have seen my plan […] and I did it in end-effect in this way. (Interview 1 Lines 18–20)
Instruction of impulses and dilemma stories	I took the dilemma with the picture, because they love having something visual with a story. […] This is always the same schema. (Interview 1, Lines 62–65)
Processing of impulses and dilemma stories	They could follow the story and the impulse; they know gummy bears and also know the problem. (Interview 2, Lines 91–92)
Documentation of results	I use such a worksheet often, also in mathematics […] and then, they solve it in groups. (Interview 2, Line117-119)
Students' handling with impulses and dilemma stories including	
Expressing statements	They had nice ideas, like that we do not need coal-fired power stations any more or that we need alternative energy for solar energy if the weather is bad. (Interview 1, Lines 90–92)
Justifying opinions	They had to be more engaged in groups [with justifying] (Interview 2, Line 212)
Taking the perspective of the protagonist	They understood the dilemma story. (Interview 1, Line 108)
Articulating problems with handling the dilemma story	I was surprised, because it worked better than I suspected. (Interview 1, Line 254–256)
Interaction with the teacher	The support was in end-effect the story and the picture (Interview 1, Line 104)

The unit of analyses was one proposition. A second evaluator was trained in using this coding scheme. This training included a detailed explanation of the coding scheme as well as its application to a part of the contributions. The inter-rater agreement of 10% of the interviews was 0.89 which was satisfactory.

Worksheets. As third data source, we used the worksheets of the students. We counted the ideas which were mentioned and analyzed them according to the above mentioned five categories. Again, two raters evaluated them on basis of the coding scheme. Their ratings matched very well.

5. Results

Question 1: How are impulses and dilemma stories realized in the conducted designed experiments for fostering values education?

According to observation and interview data research question 1 includes four issues, namely the sequencing of the lesson regarding the integration of the value-aspect, the instruction regarding impulses and dilemma stories, the processing of the dilemma story and the documentation of the results.

Observation Data

Sequencing. Here, it was of interest, whether the teacher used the five-step-procedure as intended. Observation data showed that impulses and dilemma stories were integrated in both designed experiments at the end of each lesson in the suggested way following the five-step procedure of (1) activating pre-knowledge, (2) work assignment and support, (3) conducting the experiment, (4) saving results, and (5) relating the content to the value aspect using impulses and dilemma stories. In both lessons, it could be observed that learners gained relevant knowledge on STEM issues during the experiments so that they were able to elaborate on value issues at the end of each lesson. The lesson on "Solar Cells" took 45 minutes, the experiment on "Recycling" 60 minutes.

Instruction. Instructing learners could be realized in diverse ways influencing learners' comprehension. In both experiments, the *instruction* of the value-aspect was realized in a combination of impulse picture and dilemma story. The experiment on "Solar Cells" included the picture of a rooftop with solar cells and the respective dilemma story on solar cells on the neighbor's rooftop. In the module "Recycling" values education was realized with a package of gummy-bears and the Paul-Waste-Story. Interestingly, in both cases students did not read the dilemma story, but listened to the teacher who told them the story, referring to the narratives in values education (Vitz, 1990). Simultaneously, the students could watch the impulse picture respectively the gummy-bears. Therefore, teachers addressed with this format two senses of the students, namely watching and hearing. Such multimodal presentation modus fosters learning according to laboratory research on multimodal information processing (Mayer, 2001).

Processing. Regarding the *processing* of values, two different ways were used: In the module on "Solar Cells", the students mentioned their points of view directly in class. About 80 per cent of the learners discussed diverse opinions verbally and openly in class including values related to environmental consciousness and sustainability. This activity took about 10 minutes. In the module "Recycling of Organic Waste", groups of students had to formulate their ideas on a sheet of paper. These sheets were passed to the next group who could widen the first hints, improve them or add new aspects. There were five groups who each formulated relevant opinions on the dilemma story reflecting on values like environmental consciousness or self-activity. Overall, seven statements were expressed and nine comments added. This activity took longer than the verbal discussion, namely about 15 minutes.

Documentation. Looking at the *documentation* of the results, again two diverse methods were used. In the module "Solar Cells", specific relevant aspects were verbally repeated and saved through the discussion. Students summarized their ideas verbally in class focusing mainly on values related to environmental consciousness and sustainability. In the module "Recycling of Organic Waste", the different opinions of the students were recorded in written format using the above mentioned sheets of paper on the diverse ideas which reflected on environmental consciousness and self-activity. Furthermore, results of the group work were afterwards saved in a verbal exchange of the ideas and questions, and important issues were again summarized.

Interview Data

The teacher evaluated the *sequencing* of the experiment as effective in the realized way. Students got along with the structure very well in order to understand the value issue against the background of the gained knowledge. Impulses and dilemma stories were both used and very well realizable (Interview 1, Line 63). But she also mentioned that for integrating didactical methods to stimulate the sensitization for values, time is a necessary prerequisite: "Values education is always a time issue, very often." (Interview 1, Line 199–200).

Looking at the *instruction*, the teacher gave three reasons why she combined impulses and dilemma stories using two different senses: First, this presentation of information could be realized very shortly, second this kind of presentation is more appealing to the students, and third — the most important one — that combining two senses, the visual with the auditive sense, makes it easier for students to process on the presented information and to think about the story. "With two senses, you catch most." (Interview 2, Lines 90–91). Thus, the teacher was very much interested in learners' comprehending the dilemma story. The students "understood the dilemma and were very creative in finding adequate ideas." (Interview 1, Lines 108–109).

Looking at the *processing* of the realized impulses and dilemma stories, in the first experiment, the teacher

said that the students "had proposed diverse ideas, and I think they also responded to each other" (Interview 1, Lines 70–71). This confirms observation data with a discussion rate of about 80 per cent. In the second experiment, five groups worked together. According to the teacher, she composes groups of five with three normal students, one more advanced student and one less advanced student (Interview 2, Lines 216–218). She also thinks that compared to classroom discussion in group work, students had to be more engaged, even though, there are also some group members who just look stupid while the others do the work (Interview 2, Lines 212–214).

Documenting the problem solutions verbally in classroom using discussion in the module about "Solar Cells" is a very common method all students are familiar with. Furthermore, it is not very much time consuming. The method for saving the results in a worksheet in the "Recycling of Organic Waste" module was justified with an alternation of methods, but also that students stated less questions, that students are familiar with this kind of working sheets ("This division [of groups] I have in class, they get along with it"; Interview 2, Lines 121–122) and that they are more engaged with the topic and debate more in-depth when using a working sheet (see above). Thus, this second method seems to be more effective for learning from the teacher's point of view.

Question 2: How do students handle impulses and dilemma stories in the designed experiments for fostering values education?

Looking at the students' handling of impulses and dilemma stories in the experiment using observation and interview data, five issues were of interest, namely expressing statements, justifying opinions, taking the perspective of the protagonist of the story, articulating problems with handling the dilemma story, and interacting with the teacher.

Observation Data

In the first experiment on "Solar Cells", values education was realized with a discussion in the plenum on the dilemma story. In this debate, about 80 per cent of the students were actively participating in expressing a lot of statements and ideas on solving the dilemma story. Students not only expressed their opinions, but also justified their arguments for or against solar cells. Students mentioned arguments like "Solar cells are causing less impact on the environment, because they have less harmful substances" or "They produce energy without climate changes, but that they are also expensive." (Observation sheet 4, page 4) They also asked interesting questions and applied an argumentation regarding antecedents and consequences of diverse solutions, e.g., anticipating dysfunctional aspects like snow on the rooftop or bad weather conditions without sun. (Observation sheet 3, page 5; observation sheet 4, page 5) These statements express environmental consciousness and sustainability. It also shows that students were able to take the perspective of the protagonists of the story highlighting pros and cons for both positions. Interestingly, students connected their points of view to each other picking up the arguments of the previous speaker and elaborating on it. Overall, the discussion on the dilemma story was very interactive between the students indicating that there were no problems in understanding the important points. Looking at the interaction between teacher and students, the teacher functioned as moderator during the discussion of the dilemma story. She repeated and summarized the statements of the students, and collected the ideas in the plenum. She acted passively in order to stimulate the students' debate without intervening with own ideas or opinions concerning values referring to e.g. environmental consciousness. The teacher redirected the questions from the students to the whole class so that they were answered from the students themselves. Overall, there was no further support necessary, because students were active in dealing with the dilemma story.

In the second experiment on ***"Recycling of Organic Waste"***, learners had to cooperatively write joint ideas

on solving the dilemma as well as questions or further suggestions. Thus, the sheet was subdivided into two columns with one column “ideas” and the other column with “questions/further suggestions”. There were five groups working together in the class so that five work sheets were filled-in with the students’ ideas and questions. Six diverse suggestions were mentioned on these sheets, overall seven statements were expressed and nine comments added. Ideas were about throwing the waste in the correct ton, directly reacting on Paul’s behavior and telling him that it is not correct, or changing the present for the kids reducing the waste. These statements indicate a reflection on values like environmental consciousness (e.g., reducing the waste by changing the present), but also self-activity (e.g., telling Paul that his behavior is not correct). Ideas were much elaborated giving exact advice how to behave in this situation. All students disagreed on Paul’s behavior and justified with their sophisticated ideas, why his behavior is not correct. Noteworthy is the fact that students referred to their classmates’ single ideas with adequate questions or notes on the second column. They were very critical and asked also questions on not understandable or incomplete aspects. For example, one group wrote: “It is not a good idea to throw the waste into the bio-waste container, because in this container only old things are belonging.” (3rd sheet). The comment on this was: “Then, we are allowed to throw all old things into the bio-waste container.” This statement shows the reflection of a group on the statement of another group which is a first necessary activity for values education. Furthermore, students imagined solutions on the questions or problems their classmates stated. Overall, about five different suggestions and questions were written down. On the work sheets every idea was accompanied by a question or suggestion on the other side. This indicates that students took the perspective of the protagonist of the story, but also of their classmates. Furthermore, it shows that there were no problems in working on the dilemma story. The interaction between teacher and students comprised the task assignment of the teacher with reassuring that students understood their task correctly. In a second step, the teacher acted as moderator and went from one group to another and asked them, whether the task is clear, watched their discussion, and answered questions. In order to support and stimulate students’ reflection on the relevant topic, she also prompted students sometimes to further think on single issues they had not considered, yet.

Interview Data

Having a closer look to the interview data, in the experiment on ***“Solar Cells”***, the teacher evaluated the expression of diverse students’ statement as extensive and very creative. “They had nice ideas, like that we do not need coal-fired power stations any more or that we need alternative energy for solar energy if the weather is bad.” (Interview 1, Lines 90–92). She confirmed that students were not only able to state their diverse opinions, but that they also justified their opinions in most cases with adequate arguments using prompts like “I am for it, because… ”, or “I am against it, because… ”. Students were also able to take the perspective of the protagonists of the story, because the narrative was taken from their daily life and was very adequate for students of this age. “The students understood the dilemma story.” (Interview 1, Line 108). The teacher also detected no problems in handling the impulse story. In contrast she stressed a deepening impression of impulse picture and dilemma story for the students. Such methods could serve as control for the content of the lesson as well as for values education, because the dilemma story enables a transfer of the knowledge to their own life. “It is a deepening effect and a control, whether they [the students] understood everything, and of the expert knowledge.” (Interview 1, Lines 138–139). The interaction with the students was unproblematic. The teacher’s support in order to foster values education comprised impulse picture and dilemma story. “The support is in end effect the story and the picture.” (Interview 1, Line 104). Further support includes the teacher’s expert knowledge. “The support is in this respect

[…] the expert knowledge […].” (Interview 1, Lines 109–110).

Regarding the handling of the dilemma story in the “Recycling of Organic Waste” module, the teacher evaluated the expression of statements on the working sheets as numerous, but either as almost very similar. Even though students tried to solve the problem, their approaches and thoughts to do so were influenced by the other groups’ ideas. Students also justified their opinions on the work sheets and in their vivid group discussion. She assumed that the dilemma story was correctly reconstructed from the students who know the story very well from their daily life and that thus they were able to take the perspective of the protagonist of the story. “They could follow the dilemma story in any case.” (Interview 2, Line 101). During the engagement of solving the dilemma story, the teacher thinks that the small group discussion was an adequate mean to deepen the knowledge which was learned in the lesson as they have to reflect on the problem under diverse perspectives of each group member. “I think they had to deal with it much more.” [in the group work] (Interview 2, Lines 219–220). Furthermore, according to the teacher’s opinion the interaction and communication with classmates may foster social values like team-orientation or tolerance. But for sure, such values do not occur in one single group work, but must be developed over time with diverse group works. The interaction with the students included further hints in order to prompt students to relevant issues and specified them. E.g., “Why did you write this?” (Interview 2, Line 120). The teacher said that “it is legitimate that you give one or another impulse, specifically when you know that they are on the right way.” (Interview 2, lines 155–156).

6. Summary and Discussion

This study investigated the integration of impulses and dilemma stories into two experiments of STEM context in order to foster values education. The main question, whether these didactical methods were successful for values sensitization could be answered positively. But for sure, this result must be interpreted carefully as it gives only first indications which must be deepened in further lessons and replicated in further empirical studies.

Regarding the first research question, impulses and dilemma stories were integrated at the end of the experiment after finishing the realization of the designed experiment guaranteeing a more elaborated discussion based on the knowledge that students gained during STEM experiments. Furthermore, the teacher instructed students preferring a combination of two methods, namely of an impulse as picture or object and the dilemma story in order to activate two different senses, namely the sense of vision (picture) and the sense of hearing (narrating the dilemma story). According to the teacher’s point of view combining two methods and senses is more helpful for students to think about values than addressing only one sense. This approach confirms laboratory research on multimodal information processing (Mayer, 2001). In these studies, it is confirmed that multimodal presented information with pictures and words were most effective for learning (Mayer, 2001). As values education includes also learning about diverse opinions and balancing pro and contra reasons, this approach may be effective, too. Furthermore, students processed impulses and dilemma stories very engaged with 80 percent of the students actively discussing in the first experiment and all groups commenting the story on worksheets in the second experiment. Specifically, students were mainly sensitized for the values environmental consciousness, sustainability and self-activity. This is also confirmed by data regarding the documentation of the problem solutions in both experiments.

The second question regarding the handling of the value-aspect indicates successful data, too. Qualitative observation data as well as interview data confirmed that students stated their points of view indicating that

students understood the dilemma story and could take the protagonist's perspective. This issue is of immense importance as it is a relevant mechanism for values education when students compare and evaluate the problem of the story in order to solve it (Weinberger et al., 2005). Furthermore, students elaborated their points of view and also justified their opinions indicating that the dilemma story triggered the reflection on the students' justification structure (Schuster, 2001) taking aspects of environmental consciousness, sustainability, and self-activity into account.

Furthermore the dynamic of the classroom debate provoked the thinking of the students. And the small group work provoked the discussion of diverse perspectives of each group member. Both methods possibly initiated cognitive conflicts as well as a reflection on diverse values (Baldus, 2009). But the teacher evaluated the written ideas as more suitable to deepen knowledge and provoke values education than the discussion in the whole class. She argues that the small group work in which the students had to discuss and formulate their arguments is helpful for them to elaborate more detailed on these issues. This teacher's evaluation is also confirmed by numerous studies on small group work (Cohen, 1994; Slavin, 2010) which state that group work provokes a cognitive conflict through discussing arguments and counterarguments (Piaget, 1928/1986). Elaborating and discussing in small groups of about 4 to 5 students seems to make it necessary to look more detailed into the subject than debating in the whole class.

Regarding the interaction between teacher and students during impulse and dilemma story was in both experiments about the same: The teacher introduced the story by narrating it and showed the impulse picture. Then, students discussed in the whole class or in small groups about problem solutions of the story. The teacher acted as moderator who tried to give adequate prompts to stimulate reflection on values. Thus, students receive an active part in the whole values education, while the teacher functioned as facilitator for learning. This may be also triggered by the active engagement in conducting the STEM experiment. This is in line with a socio-constructivist theory on learning, which stresses learning as a "social-interactive, contextual, constructive, self-regulated and reflective process" (Simons, 1990, p. 1). In this theory perspectives and perspective taking are important processes in learning which is stimulated by the teacher in this lesson (Simons, 1990).

7. Implications

All in all, the research showed that the didactical methods of impulses and dilemma stories give first indications that they may be effective in order to foster values education in STEM context. There are mainly three implications: First, both didactical methods, impulse and dilemma story are combined in order to stimulate two senses, the visual and the auditive sense. This seems adequate to stimulate reflection on dilemma stories and foster values education (Mayer, 2001). Eventually triggered by the active engagement in conducting STEM experiments, students actively discussed with the other classmates expressing their opinions and justifying them adequately. Second, small group discussions may be more adequate to stimulate cognitive conflicts and the reflection on diverse opinions than classroom discussions. In small groups, every child is relevant in order to come to a joint solution (Cohen, 1994; Slavin, 2010), while in the whole classroom some individuals may possibly not actively participate in the discussion. And third, successful values education is dependent on the students' activity. Teachers have to act passively as moderator, while they give the floor to students and their ideas confirming socio-constructivist theories that improve perspective taking and reflection (Simons, 1990).

Further research is necessary in order to confirm the above mentioned first indications with a bigger sample

size and different data sources, like questionnaires for students or video data. But for such data time is necessary – which is also a main antecedent for values education in schools.

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