

COMPUTERIZED USE OF THINKING JOURNEY MODE OF INSTRUCTION AS A MEANS TO ENHANCE CLASSROOM ARGUMENTATION AND LISTEN TO STUDENTS' EGOCENTRICITY AND CHANGE OF STUDENTS' CONCEPTUAL UNDERSTANDING

Yaron Schur, Haim Pensso and Baruch B. Schwarz

ABSTRACT

The combination of the computerized Digalo (Schwarz & de Groot, 2007) as a graphical tool for representing argumentative moves in on-going e-discussions and the Thinking Journey (TJ) mode of instruction (Schur and Galili, 2009, Schur et al. 2009) were used. TJ enables students to get various perspectives on considered scientific concept. The teaching provides cognitive scaffolding for the learner in discussion on the presented visualized situations (pictures, video-clips, models etc). Students' curiosity is encouraged by pondering questions, guiding students' exploration and construction of the target knowledge which emerges from generalization of various perspectives. The Digalo application was used to provide an electronic medium for sustaining collective argumentation. Thirty-two Grade 8 students from two junior-high schools participated in the study, which was conducted as a part of regular lessons in science. All students were requested to participate in small groups synchronous e-discussions on the concept of day/night along the TJ scenario. Results showed conceptual learning of the scientific concept. One could see that TJ interactions in the computerized version allowed students to mediate efficiently to their peers. The visibility of evidence in the TJ interactions used for the discussions lessened the egocentricity level since evidence and collective discussion was made part of the individual's cognitive space. By doing so, students could elaborate superior mental models. And indeed, we found a correlation of $r=6.06$ between egocentricity and mental model. One can consider that this result can be explained from the specific way in which TJ mediated interactions are constructed to enable students to observe phenomena from a variety of perspectives and to connect scientific concepts with observation of specific environments. Integrating between the argumentation idea and the Thinking Journey mode of instruction, enabled to establish focused mediation situations that enabled students to experience meaningful conceptual learning.

KEYWORDS

argumentation, conceptual learning, Thinking Journey, use of multiple perspectives, e-learning, e-discussions, visualized situations

INTRODUCTION

The present study focuses on learning the concept of day/night cycle. It combines two kinds of activities, the first one of an argumentative character, and the second one of an inquiry-based character. Inquiry-based activities are realized through the consideration of multiple perspectives in argumentative moves mediated by the teacher, with the use of the Thinking Journey mode of instruction (Schur et al. 2002; Schur and Galili, 2009, Schur et al. 2009). Students' conceptual learning was measured in three manners:

1. We adopted a pre-treatment-post paradigm with pre and post questionnaires. We checked knowledge construction through: (i) Correctness of knowledge – whether students' answers were more correct after the program; (ii) Elaboration – whether answers were more elaborated after the program; (iii) Mental models – whether the mental models of the students improved; (iv)

Egocentricity – whether students' view became less egocentric; and (v) whether the answers became simpler, less context-bound.

2. We also examined the effects of mediation on learning through the analysis of discussions in class. Some of the groups received mediation from the teacher, some from the experimenter, and some did not receive any human mediation.
3. We undertook a qualitative analysis of argumentative maps – representations of e-discussions, to identify design principles (e.g., mediation principles) for fostering productive collective argumentation.

It appears that concerning comparison of pre and post tests, all measures of knowledge construction (correctness, elaboration, egocentricity, mental models and simplicity) pointed at improvement (for correctness, significance was not attained, though). The mediation patterns of e-discussions were recorded. Two of them are brought in the article to enable to compare between the mediation done by a teacher and that which was done by an experimenter who was a university student. Analyses of the e-discussions show interesting directions concerning specific vs. generic interventions and differences between the mediation of the experimenter and of the teachers. These results suggest the hopes that Thinking Journey instruction raise in science education, but also stress the challenges concerning the role that the teacher should play in such activities.

The rationale for the choice of the concept of day/night cycle

The day/night cycle was chosen for several reasons. The first is its relevance to the students lives – it is a phenomenon they witness every day. Students have explanatory schemes they use to explain themselves or other events linked to the cycle of day and night. Discussing issues on day and night is then not as simple for students as one might think. The second reason is that the development of the day/night cycle concept has been explored in several studies. For example, Vosniadou and Brewer (1994) studied the day/night cycle concept and drew important general lessons on conceptual development in general. First they discerned three stages of conceptual development from naïve models, to synthetic models that integrated naïve and scientific models, to scientific understanding.

Thinking Journey and multiple perspectives

The Thinking Journey method (Schur and Galili, 2009; Schur et al. 2009) is especially designed to overcome problems of egocentricity in science education, by offering multiple perspectives: students are invited to take part in a journey with the help of pedagogical tools such as computerized models or pictures (Schur & Galili, 2008a, Schur and Galili, 2008b). These tools enable students to see different perspectives. Thinking Journey (TJ) approach to teaching suggests a way to improve learning scientific concepts. This method incorporates the features of mediated learning as well as of the constructivist paradigm (conceptual change). The approach suggests variation of learner's perspective on the natural phenomenon learned, instead of unique perspective, common in teaching practice. Changing perspectives allows students to overcome their naïve knowledge usually based on the intuitive egocentric view. A *teacher-students* discussion takes place addressing images of the considered phenomenon, taken from several perspectives, often never seen before by the students. The teacher *mediates* the particular scientific conception to the students who usually hold their own ideas at odds with the scientific knowledge. Mediation, that is to say, bridging between the two types of knowledge, draws on revealing of these ideas, as well as of other possible cognitive difficulties of the learners in real time. Introduction of multiple perspectives prepares conceptual change and construction of certain scientific concepts by the learners. Variation of perspectives presents a central cognitive tool in this process. Students are guided to identify the considered concept in its several manifestations in different environments.

In general, the journey through different perspectives cannot take place, without a tutor that sustains motivation and points out to differences and apparent contradictions between the perspectives. The mediation of the tutor is intensive; it complies with the principles of mediation articulated by Feuerstein and colleagues (Feuerstein, 1990; Feuerstein et al., 2006).

Computerized mediation

The Digalo application was used to provide an electronic medium for sustaining collective argumentation. In a recent study, Asterhan, Schwarz and Gil (submitted) showed that in the case of electronic collective argumentation (in which each student had its own computer, and was participating in a synchronous discussion with the other students and the teacher as a mediator), most students find computer mediation absolutely necessary. The fact that students find that need necessary is perhaps linked to the fact that synchronous e-discussions may become so chaotic that students may rapidly lose control on the processes they are engaged in. According to Asterhan and colleagues, students' specific needs are related in the mediation during the discussion. The mediation should aim at deepening and maintaining focus, supervising and aiding in technical problems, while not imposing ideas. In this study we examine the mediation types (managerial or content, personal or general, wide or focused) on the amount of student's reactions, and their quality (superficial or deep).

RESEARCH

Rationale for choosing the schools for implementing the day/night cycle mediated interaction

The day/night cycle computerized Thinking Journey was conducted in two integrative schools in Jerusalem. Both schools were highly motivated to participate in the study. Four teachers participated in the experiment. Three of them had previous knowledge in mediating using Thinking Journey (TJ) programs. They never had any experience in working with a computerized version of TJ and they needed to get acquainted with the use of the combination of a computerized model and TJ mediation connected to it.

We inquired two research questions, in two different and, to our view, complementary methods:

1. Did the computerized TJ day/night cycle trigger conceptual learning?

This question was tackled according to five aspects:

- a. Correctness of knowledge: Did student's knowledge of the day/night cycle improve?
- b. Elaboration of the answers: Did answers become more elaborate?
- c. Mental model: Did mental models of the day/night cycle progress?
- d. Egocentricity: Did egocentricity in viewing the day/night cycle decrease?
- e. Simplicity: Did answers become simpler and more parsimonious?

2. How does mediation effect students' construction of knowledge through argumentative activities?

This question is being tackled according to two aspects:

- a. What was the role of mediation in the group discussions?
- b. Are there actions or patterns of actions for mediating synchronous discussions of Thinking Journey interactions?

METHOD

Participants

32 8th grade students (ages 14-15) from 3 different classes in two schools in Jerusalem took part in the experiment. All students mastered basic computer tools (Office, internet). The study took place as a part of the regular science classes throughout the school year. Each class (of about 30 students) was divided into two cohorts; each cohort was further divided into groups of 3-4 students. The classroom activities were led by the teachers. As aforementioned, the teachers were all experienced and highly motivated. The four teachers attended the seminar for learning how to work with the computerized version of the Thinking Journey.

Tools

Several types of tools were being used in this study for different purposes. We bring you a description of these tools:

A questionnaire including knowledge items and questions in which students were requested to explain day and night phenomena. An example of knowledge item is:

"Is the day and night phenomenon unique to the earth?"

An example of explanation requested is:

"How would you explain to a friend the phenomenon of day and night?"

The second tool consists of the Digalo graphical tool for representing collective argumentation. The third tool is the preliminary task, an e-discussion on a moral dilemma, the moral right to undertake experiments in animals. Before and during the Digalo-mediated collective argumentation, the teacher articulated rules for good discussions such as obligation to provide reasons for advanced claims or to try to challenge arguments when disagreeing or to be sure that the advanced argument is solid.

The fourth tool consists of the Thinking Journey computerized interactions. It comprised of computerized worksheets and pictures of day and night on the earth and the moon from different perspectives. The computerized version of TJ for teaching the day-night cycle that is used also in this current article is presented in (Schwarz et al. 2009). Other versions of TJ series of interactions for teaching the day-night cycle are presented in the following articles: Schur & Galili, 2008a; Schur & Galili, 2008b; Schur et al., 2009.

Collection and analysis of the data

All questionnaires were collected and argumentative maps were recorded. All lessons were video-taped.

Correctness

The grades for the *correctness* variable ranged from 0-2.

0 – incorrect answer

For example: Q: Are there day and night on the moon?

A: No, there is only night on the moon, because it's dark.

1 – partly correct answer

For example: Q: How would you explain to a friend the day and night phenomenon? A: The earth revolves around itself and around the sun. When the earth revolves, and a certain area is not lit, the sun begins to light it, since the earth also revolves around itself. (*The answer is only partly correct since it involves the fact that the earth revolves around the sun, which is not relevant for the day and night cycle*).

2 – Correct answer.

For example: Q: Are there day and night on the sun?

A: No, the sun is the source of "day", and this is why there is no night there. It is always lit, so there is always "day" there, and no "day and night".

For the grades of *elaboration*, we formed a check list of ideas that need to appear in each of the questions to receive a full answer. Each phrase received one point. Each missing or incorrect phrase that was added received zero points. We summed the number of points and divided it with the number of total needed phrases for a full answer + the incorrect phrases given by the student.

For example: Q: Explain in your own words what are day and night

Ideas checklist-

- The sun lights (on the earth)
- Day and night exist in different areas of the same celestial body
- Day = light
- Night = darkness
- The moving from day to night is created by the fact that celestial bodies revolve around themselves.

Mistakes- any other idea (contradictory or irrelevant)

Grades for elaboration will be exemplified further on.

Simplicity

The simplicity of the explanations expressed to what extent explanations for the day/night cycle became more similar when describing the day and night on earth, the moon, mars and other planets. We identified 4 levels of simplicity translated into grades for simplicity ranging from 0 to 3.

0 – Different answers: a different explanation of the same phenomena for different planets

1 – Non contradictory answers: An explanation to at least one planet and the rest is not contradictory (lack of knowledge, indecision).

2 – Identical explanation for at least two planets: the same explanation for two of three planets (earth, moon, mars).

3 – Identical answers for all of the planets: the same explanation for all planets and a different explanation for the sun.

An example of measure of simplicity will be given further on.

Identifying mental models

We analyzed all explanations provided by the students and analyzed their content in order to identify the mental model of the students. We identified six explanatory frames of the day/night and day cycles.

No model

The sun revolves around the planets

At day the earth revolves around the sun and at night around the moon

The earth revolves around the sun

The earth spins, and the sun and moon are in two opposite sides of it

The scientific model

An example of identification of mental model is given further on.

Two judges compared each of the explanations written with the explanatory frames proposed and either recognized one of them or decided that it was impossible to classify the explanation. For most of the explanations, judges recognized a suitable explanatory frame and agreed upon it. Although there was certain variability in the explanatory frames that the students used, it was possible to maintain an agreement between the judges with Cohen kappa of 0.9.

Identifying level of egocentricity

We analyzed all the explanations given by students in their questionnaires to identify something else from mental models or explanatory frames, the way people saw themselves in the day/night cycle, or what we called their level of egocentricity. Six levels could be identified:

- a. Looking only at oneself on earth, without viewing it as a sphere;
- b. Day and night can only happen on earth;
- c. Day and night can only happen in the earth's environment;
- d. Ability to see the phenomenon as happening in distant planets that are similar in a trait (being lit) with no explanation;
- e. Partially understanding the law – there is a theoretical explanation which is not correct/incomplete;
- f. Understanding the law in a scientific manner.

An example of level of egocentricity is given further on.

Example of an analysis of the questionnaire:

To better explain how the analysis took place we bring you an example of a questionnaire in which all variables were measured:

An example of analysis of data:

We bring an example for analysis of data. It will be a full analysis of the pretest – in order to demonstrate how to calculate and determine the grades for each variable.

Example 1:

Details of the questionnaire:

1. Q- Define in your own words what are day and night
A- Day is when the sun light the area where the state is, night is when the sun lights another place (area) in the world, so that the sun lights cannot illuminate this area. This happens when earth revolves around itself and around the sun.

Correctness: the grade is 1, since the answer is partly correct and partly incorrect.

Elaboration:

Phrases checklist-

- The sun lights (on the earth) - V
- Day and night exist in different areas of the same celestial body - V
- Day = light - V
- Night = darkness - V
- The moving from day to night is created by the fact that celestial bodies revolve around themselves - V

Mistake – Linking the day and night phenomena to the fact that the earth revolves around the sun – X

Calculation of the grade –

5 correct answers out of 6 ideas (one incorrect) – $5/6 = 83.3\%$

2. Q- How would you explain to a friend the reason why day and night happens?

A- The earth spins around itself and around the sun. When the earth spins, and a certain area is not lit, the sun begins to light it due to the fact that the earth spins around itself. When the earth spins the area of the state that was towards the sun (lit) turns with its "back" to the sun, and becomes night instead of day.

Elaboration:

Phrases checklist-

- The sun lights (on the earth) - V
- Day and night exist in different areas of the same celestial body - V
- Day = light - V
- Night = darkness - V
- The moving from day to night is created by the fact that celestial bodies revolve around themselves - V

Mistake – Linking the day and night phenomena to the fact that the earth revolves around the sun. – X

Calculation of the grade –

5 correct answers out of 6 ideas (one incorrect) – $5/6 = 83.3\%$

Correctness: the given grade is 1, since the answer is partly correct and partly incorrect.

3. Q: Are there day and night on the moon? Explain.

A- The moon revolves around the earth, and the earth around the sun, so when the moon is between the earth (and the sun), it is lit and there's day. When the moon isn't between the earth and the sun but behind the earth, the sun light doesn't reach it and there's night.

Elaboration:

Phrases checklist-

The moon revolves around the earth and the sun lights it when it is between the earth and the sun – V

Day and night exist on the moon - V

Day = the moon is lit - V

Night = the moon is dark – V

The phenomenon is caused by the sun lighting the earth– X

A lack of connecting between day and night on earth and on the moon – X

Mistakes – connecting day and night on the moon with eclipses of the earth – X

Calculation of the grade –

4 correct answers out of 7 ideas – $4/7 = 58\%$

Correctness: the given grade is 1, since the answer is partly correct and partly incorrect.

4. Q- Are there day and night on Mars? Explain.

A- If Mars revolves there are day and night, since rays from the sun reach it, and if it doesn't revolve, then there's always day at one place and night in another.

Elaboration:

Phrases checklist-

Mars spins around itself - V

Day and night exist on Mars - V

Day = Mars is lit - V

Night = Mars is dark - V

The phenomena is identical to the one that happens on earth - V

Mistakes – Since there is an understanding of how the process works and just a lack of information on whether Mars spins, we didn't consider it as a mistake.

Calculation of the grade –

5 correct answers out of 5 ideas – $5/5 = 100\%$

Correctness: the given grade is 2, since the answer is correct.

5. Q- Are there day and night on the sun? Explain.

A- There is always day on the sun, since the sun sheds light, which creates day. There's always light on the sun so there's always day.

Elaboration:

Phrases checklist-

The sun is the source of light - V

Not saying that the sun spins (in connection with the change of day and night) - V

Calculation of the grade –

2 correct answers out of 2 ideas – $2/2 = 100\%$

Correctness: the given grade is 2, since the answer is correct.

6. Q- Is the day and night phenomena unique to the earth? Explain.

A- No, it exists in any planet that revolves around itself and around the sun.

Elaboration:

Possible correct answers (choose at least one):

- Happens in all planets of the solar system
- Exists in any place that the sun lights
- Examples for other planets in which day and night exist
- Happens on every planet that spins around itself - V

Mistakes – Linking the day and night phenomena to the fact that planets orbit around the sun - X

Calculation of the grade –

1 correct answers out of 2 ideas – $1/2 = 50\%$

Correctness: the given grade is 1, since the answer is partly correct and partly incorrect.

Mental model – The mental model that arises from all of the student's answers is one that links the day and night phenomenon to the fact that the earth/planets revolve around the sun. This is why the chosen mental model is the fourth one.

Egocentricity – it seems that the student in the example has a way of explaining the day and night phenomena in a way that is sometimes similar and sometimes different on the earth and other places (Mars and Moon), and does that with a clear explanation/rule – day and night happens in any planet that revolves around the sun and around themselves. Since there is a rule that is not fully correct but applicable for explaining the phenomena in many settings the chosen egocentricity level is 5.

Simplicity – the student gave the same explanation (planets that revolve around the sun and around themselves) to two of the three planets in the questionnaire – the earth and Mars. The Moon received a somewhat different explanation, involving eclipses from the earth as a reason for day and night. This is why the grade for simplicity is 2.

Analysis of the discussions

The second research question related to the analysis of the discussions that took place in the various groups. We have examined the influence of the mediation on discussions. Over 180 mediation moves of the teachers and experimenter were gathered and analyzed according to the following parameters:

Mediator: teacher or experimenter.

Location of contributions in the discussion: Beginning, middle, end

Type of reference: General – to all participants, Personal – to a specific participant.

Type of relatedness: Wide – relating to the wide topic of discussion, focused: relating to a specific point in the discussion.

Number of students to which the mediation move is directed

Quality of students' interventions: Shallow - unserious or irrelevant interventions to the topic, Deep – a serious and related interventions to the topic.

Type of mediation: Content – relates to the topic of discussion (Such as when the teacher asks if it is day or night in the presented picture), Organizational – relates to aspects such as encouraging students to participate, and a correct implementation of the task (such as when the teacher asks the students to focus on the main question, and not to relate to personal matters etc.).

The analysis of variables was qualitative (such as the type of mediation – organizational or content) and were evaluated by two judges using agreed upon rules (in the case of the mediation type – checking if the mediation move deals with the topic of discussion or with maintaining the discussion). The inter rater variability was high (Kappa = 0.9).

RESULTS

In order to check whether there were differences between classes before the activity we conducted a MANOVA analysis. There were no differences between the classes prior to the activity in any of the independent variables.

Another MANOVA of 2 (class 1, 2)* 2 (time – before, after) *3 (mediator – none, teacher, experimenter) was conducted in order to confirm the first research question. Results showed an improvement in all dimensions of the first research question following the Thinking Journey activity, except for the correctness of the answers that showed only a tendency towards improvement ($F = 3.61$, $p = 0.068$). Students' answers were more elaborated ($F = 7.85$, $p = 0.009$): students knew more correct details after the activity compared to the situation before the activity. Most students (over 60%) did not hold the scientific model after the activity, a fact which explains why not all answers were correct. Still, there was an improvement in the model ($F = 7.64$, $p = 0.01$), which is a substantial progress in the structure of knowledge that was obtained through argumentation in the TJ interactions. There was an increase in the universality of the day and night concepts following the activity ($F = 18.40$, $p < 0.001$) – students could see it as less related to the earth and more general. A correlation between the type of mental model and egocentricity was also found (RPearson = 6.06, $p < 0.001$), so that the less egocentric someone is, the more advanced is his/her mental model. No effect for class or group was found. Finally, students answers became simpler and more parsimony ($F = 4.64$, $p = 0.041$), and they gave closer explanations to the same phenomenon in different contexts.

The results of the first research question brought good news: conceptual learning of a scientific concept in an environment integrating argumentation with TJ mediated interactions.

Concerning the second research question, the type of mediation was found to be in interaction with two of the variables – elaboration ($F = 3.70$, $p = 0.038$) and egocentricity ($F = 5.44$, $p = 0.011$). It appears that there was a greater improvement in those parameters when there was no mediation, or when the experimenter mediated, than when the teacher was the mediator. At first glance, these findings can seem surprising, since we would have expected the teachers to help more in students' cognitive gains as they are more experienced I teaching and usually have a better scientific knowledge. However it can be

explained by the fact that the teachers had more technical problems in mediating through the use of computers than experimenters, who were university students and had a much better mastery of the computers technology.

As aforementioned, we also analyzed the mediation moves (such as presenting the main questions, challenging students' views, encouraging participation, focusing the discussion, enforcing the discussion rules) in the discussion by the following parameters: Mediator, Mediation type (content/organization), Location (beginning/middle/end), Type of approach (general/personal), Type of relating in mediation (wide/specific), Directedness of the teacher, and Quality of interventions of students (deep/ superficial).

The findings show that there was no effect of the location of the mediation on the quality and number of responses it received. Also, all mediators were very active in all parts of the discussions, and their involvement was in many times crucial for the continuation and development of the discussion. The mediation moves that dealt with content (referred to the task) received deeper responses ($F = 22.24$, $p < 0.001$; $Beta = 0.405$, $p < 0.001$) but fewer responses ($F = 29.66$, $p < 0.001$; $Beta = -0.263$, $p < 0.001$) as compared to organizational mediation moves. The same is true for a personal approach in mediation, which received deeper responses ($F = 22.24$, $p < 0.001$; $Beta = 0.371$, $p < 0.001$) but fewer ($F = 22.24$, $p < 0.001$; $Beta = -0.495$, $p < 0.001$) as compared to a general approach. Finally, wider mediation moves received deeper ($F = 22.24$, $p < 0.001$; $Beta = 0.326$, $p < 0.001$) and more ($F = 29.66$, $p < 0.001$; $Beta = -0.432$, $p < 0.001$) responses than a specific approach.

The second research question enabled us to see that mediation was essential for the continuation of the discussions. If the mediator focused on content it enabled the students to better understand the concepts, but organizational mediation enabled the students to get more responses. The ability to focus the mediation towards specific students enabled students to give deep responses. When the mediators were able to see the wide picture of the conceptual development they got deeper responses from the students.

Examining a mediated discussion

We are bringing a discussion with human mediation in order to show the details of TJ interaction in the classroom with the use of computers and with the Digalo as a monitor of the discussions. All the dialogues were written on the computer screens by the students and the mediator and sent to the other members of the same group. All the discussion maps were saved.

The following discussion starts with each of the students observes a picture of the earth seen from the moon. The moon's surface is lit, and the students of the group are asked to determine whether there is day or night on the part of the moon seen in the picture. As the sky of the moon is black (there is no air there), and the earth seems close to the moon in the picture, students find it difficult to determine if it is a day on the moon. According to the TJ idea, this is the first picture presented to the students in the course of their learning about the day-night cycle. The faraway environment enables students to ask questions and to try and orient their way through the use of scientific principles.

In this discussion, the mediator was an experimenter. Two students, Ortal and Ariel, participated in the discussion. Ariel gained the highest grades for almost all variables even before the activity, and stayed the same after it. Ortal improved on correctness of her responses, egocentricity and mental model.

Discussion

1. Mediator, Question, *is there day or night on the moon in the picture?*
2. Ariel Opinion, *there's day in the picture* (link to 1, support to 7)
3. Ortal, Opinion, *you can't tell from the picture* (link to 1, object to 2)
4. Ariel, Question, *why?* (link to 3)
5. Ortal, Explanation, *because you can't see that there's light. The light can come from the camera* (link to 3, 4, object to 7)
6. Mediator, Question, *why do you think so? What in the picture made you think so?* (link to 2)

7. Ariel, Explanation, *because there's light on all of the moon, (not including shadows from the mountains) so I don't think it's from the camera* (link to 6)
8. Mediator, Question, *which camera?* (link to 5)
9. Ortal, Explanation, *the one they took the picture with* (link to 8)
10. Mediator, Question, *you say on the one hand that you can't see there's light, but on the other hand, you say that there's light that may be coming from the camera? What do you think, is there light or not?* (link to 5)
11. Ariel, Opinion, *it's Ortal, you addressed her as a male* (link to 10)
12. Ortal, Explanation, *there's light, not day* (link to 6)
13. Mediator, Comment, *you're right, sorry* (link to 11)
14. Ariel, Opinion, *the sun* (link to 10)
15. Mediator, Question, *the light doesn't come from the camera's flash* (link to 9)
16. Ariel, Comment, *is that a question? Because I don't think so, and it's in a form of a question* (link to 15)
17. Mediator, Comment, *it's a comment, not a question* (link to 16)
18. Ariel, Comment, *so why put it as question and not as a comment?* (link to 17)
19. Mediator, Question, *Ortal, if I tell you that the light doesn't come from the camera, will you still think that you can't tell if it's day or night?* (link to 9)
20. Ortal, Question, *so where does it come from?* (link to 18)
21. Mediator, Explanation, *a mistake, thanks for the correction* (link to 19)
22. Mediator, Question, *what do you think?* (link to 18)
23. Ortal, Opinion, *yes* (link to 19)
24. Ariel, Opinion, *from the sun, like it was in the last picture* (link to 20)
25. Mediator, Question, *and what would be your answer?* (link to 22)
26. Mediator, Question, *so why is the sky dark?* (link to 24)
27. Ortal, Opinion, *'cause it's night* (link to 25)
28. Ariel, Explanation, *as in the last class, I think that since there is nothing, then there's light only on objects* (link to 26)
29. Ortal, Opinion, *since space is empty* (link to 26)
30. Mediator, Question, *what makes you think it's night?* (link to 27)
31. Mediator, Question, *I ask from each of you to write a final answer, do you think that there's day or night on the moon in the picture, and explain why*
32. Ariel, Opinion, *day – I think since there's nothing-empty, so there's light only on objects* (link to 31)
33. Ortal, Argument, *There's day on the moon, because you see light* (link to 31)

The discussion begins with a presentation of the main question in a broad and general manner (contribution 1), which receives different replies from the students. Ariel claims it is day (contribution 2), while Ortal claims there is no way of telling from the pictures (3). This forces the mediator to move to more focused and personal mediation, in order to challenge each student in his/her own position. Ariel is being asked to explain and elaborate his response (6), and Ortal is being asked to explain hers – which camera is she referring to (8). In the mean time, the students communicate among themselves (contributions 4, 7). A following interaction on the existence and source of light is raised. The mediator tries to check a possible contradiction to Ortal's claims: on the one hand she says there is no light and on the other hand she speaks of light from the camera (10). Ortal explains she meant that there is light but not day (12). Ariel replies to the question on the source of light, and says to Ortal he doesn't think it comes from a camera (14, 24). The mediator agrees and gives Ortal a piece of information – the fact that the light doesn't come from a camera (19). In parallel, the mediator challenges Ariel's answer that there's day by asking why the sky is black (26). Both students reply to this question (28,29), and when asked to give their final opinions they both agree that in the picture, there is day on the moon (32,33).

We can see that the mediator (an experimenter) was quick enough to write on the computer's screen and to keep up with the pace of the students. He accompanies each student through their path of thinking, almost hand in hand in a specific and focused manner, and tries to see exactly where each student

stands. He keeps alert to any new idea and comments on it. He does not leave subjects unattended, unless they are addressed by one of the students themselves, and demands participation and reply. It seems that he truly cares about the students and their gains, and invests a lot of efforts in that endeavor. One could see that TJ interactions in the computerized version allow students to mediate efficiently to their peers.

Guidelines for good mediation with the use of Digalo e-discussions:

A good mediator through the use of computers is not different in the general features from a face to face one. He has to deal with a lot of demands at the same time: to be alert, organize the discussion, to respond quickly, understand the students' needs and, scaffold learning. The most important feature of a good mediator is to be able to listen carefully to the place of the learners and to respond on time to their specific needs.

The analysis of the discussion shows that good mediation calls for flexibility from the mediator. The mediator needs to have a quick understanding of the students' needs and responding to them, as happened in the discussion, where the mediator reacted quickly to the students needs, according to their pace. When this type of flexibility is missing, and the mediator responds mostly to one student, and there are other students who need his feedback and guidance, the discussion may get stuck. It seems that generally, a good discussion needs to begin with a general and broad presentation of the topic/question, and observing students' replies and condition. In the case of consensus between students, the mediator should continue deepening and elaborating their understanding, and challenge everyone with broad and general mediation contributions. In the case of disagreement, as in the example we showed, there is no choice but to move to a focused and personal mediation that forces the mediator to relate and challenge each student separately. Still, a cooperation and discussion between the students themselves should be encouraged, and the mediator should try to support mutual questions and debate between them.

Additionally, when there are difficulties in understanding, problems with the operation of the technological tools and not enough participation, the mediator should use organizational mediation to promote the discussion.

DISCUSSION

General discussion

The present study has shown that a complex environment based on argumentative and Thinking Journey mediated interactions can lead to conceptual change in the understanding of students of the day/night cycle concept. The research was not designed according to an orthodox experimental setting but rather was quasi-experimental. For example, we did not compare the effects of the use of Digalo to face-to-face discussions. The success of this experiment is in itself very important because it shows the tangibility in the use of complex environments integrating enquiry (TJ mediated interactions) and argumentation for learning scientific concepts. Egocentricity level was lowered by presenting multiple perspectives and discussing them. The visibility of evidence and of discussions could lessen egocentricity level since evidence and collective discussion was made part of the individual's cognitive space. By doing so, students could elaborate superior mental models. And indeed, we found a correlation of $r=6.06$ between egocentricity and mental model. One can consider that this result can be explained from the specific way in which TJ mediated interactions are constructed to enable students to observe phenomena from a variety of perspectives and to connect scientific concepts with observation of specific environments.

Teachers and students' mediation

Teachers had difficulties in mediation through the use of computers. In oral discussions, teachers are able to react very quickly but in e-discussions where they have to write their interventions they have difficulties to engage. In addition, it was very difficult for the teachers to identify students' mental models on the computer's screen in order to focus their teaching actions.

Concerning spontaneous mediation by peers, the fact that the environment invited collaboration, the fact that students felt that they were not supervised, invited them to organize themselves. This unexpected finding of spontaneous role taking of organizing synchronous e-discussions is worthwhile further research. It is worthwhile noting that TJ interactions are constructed in a way to enable peer mediation. The computerized version of TJ allows students to listen more carefully to each other and react in real time, as it takes more time to write down their words than to say them aloud, so they have time to react to their friends before answering.

Our study suggests several mediations advices whose effectiveness should be checked in further research. First of all, in order to achieve a serious approach the mediator should prefer a mediation that is wide (deals with the larger issues), and relates to the content of the discussion, but directed towards each of the students. Organizational mediation which deals with maintaining ground rules of critical thinking (encouraging participation, encouraging raising challenges, etc.) may induce more responses, but this kind of mediation may lead to superficial communication. Still, all types of mediation are necessary, since discussions need to be organized, and most of the time the discussion is not purely on topic. The quality of a discussion needs to find balance between content and organizational mediation. Content mediation is crucial for maintaining quality to discussion as it responsible for its depth but integrating this hardcore mediation with organizational mediation is a must: Wider mediations receive deeper and more responses, but the mediator shouldn't stay at this level alone. It is probably preferable for the mediator, as seen in most discussions, to begin with a wider approach, and to move down to the details with more specific questions.

Students' conceptual difficulties and the process of conceptual change

In the mediated discussion we described above and in the answers of students to the pre and post questionnaires, it was possible to peek at processes that students undergo when learning scientific concepts. Two obstacles and their overcoming were salient. The first concerns the difficulty students have to understand that a scientific principle can be used to explain different phenomena: Students that could explain the day-night cycle on earth had difficulties in understanding that the same principle governs what happens on the moon. Explaining the day-night cycle on the moon through an eclipse of the earth is commonplace, and suggests the need to teach scientific principles in a variety of contexts, since each context challenges students and often leads them to give erroneous answers (see also Schur, Galili & Shapiro, 2009 for the earthy perception of students of day-night cycle and Schur & Galili, 2009, for the earthy perception of students of gravity and weight). Of course this tendency to stick to one familiar context naturally led to the second obstacle in learning the day and night cycle, egocentricity. Many Grade 8 students thought that the day-night cycle exists only on earth. Others said that the moon is always dark, because "it appears only at night". Others said that there is no day-night cycle on mars and on the moon because they are "outside of the earth's range". The Thinking Journey approach meets students with other contexts and the teacher's mediation helps in integrating these different contexts, leading to the elaboration of the scientific principle that stands behind the day-night cycle. Students could explore views of the day-night phenomenon in a variety of astronomical environments such as the moon, mars and the earth. The use of visual images enabled them to learn essential features of the concept and to see how the same phenomenon is seen differently in different places. Students compared the various environments with that of the earth and the mental voyage to other celestial environments enabled them to get out of their egocentric understanding of the day-night cycle and to adopt a universal point of view. Naturally, their explanations turned to simpler and less context-bound.

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Yaron Schur
Lander Institute
and Science Education Department
The Hebrew University of Jerusalem
Email: schurfa@netvision.net.il

Haim Pensso
School of Education
The Hebrew University of Jerusalem
Email: pensso@yahoo.com

Baruch Schwarz
School of Education
The Hebrew University of Jerusalem
Email: msschwar@mscc.huji.ac.il